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Assessment of Roughhead Grenadier, *Macrourus berglax*, in NAFO Subareas 2 and 3

by

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ABSTRACT

The revised catch history after 1987 is presented, total SA 2+3 roughhead grenadier catch in 2002 was 3 657 tons. The trends in biomass estimates from four survey series are examined: Canadian fall, Canadian spring, Canadian Deepwater and EU summer div. 3M. Only the Canadian fall surveys are considered to cover adequately the species distribution range. The biomass index from this survey in 2002 was 35 282 tons, 43 % of it in Div. 3L.

Commercial catch include mainly ages between 5 and 12, with a peak at age 8, in Spanish and Russian catches; and ages between 3 to 9, with a peak in 5-6, in the Portuguese catches. The C/B index using data from the 2002 Canadian fall survey is 0.1 ($C/B_{2001} = 0.07$).

COMMERCIAL CATCHES

It has been recognised that the recent catches of grenadiers by EU-Portugal and EU-Spain in Subarea 3, previously reported to NAFO as roundnose grenadiers, correspond to roughhead grenadier (Alpoim *et al.*, 1994; Power and Parsons, 1998; Junquera, 1998). The reason for this misclassification could be mainly because roundnose grenadier was the only name that appears in the statistical data reporting forms. The misreporting has not yet been resolved in the official statistics before 1996, but the species are reported correctly since 1997. Beginning in 1990, more roughhead grenadier has been caught than roundnose grenadier (Atkinson, 1995). Roughhead grenadier is taken as by-catch in the Greenland halibut fishery in the Regulatory Area mainly in Div. 3LMN.

The revised catch history after 1987 is presented in Table 1 and Fig. 1. Catches increased sharply from 1989 (333 tons) gradually until the highest level of 7 231 tons observed in 1998; since then, it has continued decreasing steadily up to 2002 (3 657 tons). At present most catches are taken in Div. 3LMN and no catches are recorded in SA 2. The largest proportion of those catches by country corresponds to Spain (Table 2).

RESEARCH SURVEY DATA

• Canadian fall survey

Stratified random bottom trawl surveys have been conducted in Div. 2GHJ and 3KL in fall since 1978, usually in October-November. Since 1990 the survey also covered Div. 3NO. Until 1995 an Engel trawl was used, changed since then to a Campelen 1800. Surveys depth is up to 1500m in Div. 2GHJ and 3K and to 730 m in Div. 3LNO, extended to 1 463 m after 1995. A description of those surveys is in McCallum and Walsh (1996) and Power and Parsons (1998). In 2002 Div. 2G and H were not covered by the survey and in Div. 3M a total of 26 hauls were made at depths between 732-1 463 m.

The roughhead biomass indexes from this series of surveys are presented in Table 3 and Fig. 2. The aggregated biomass estimates in 1978 was 24 048 tons, increased to a level about 30 000 tons in 1996 and it has been around

30 000 and 40 000 tones from that year onward. In 2002 the biomass index was 35 282 tons. However the estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. In addition, in the last three years of the survey Div 2G and H were not covered. According to the biomass estimates from this series of surveys (Table 3), the main part of the stock used to be distributed mainly in Div. 3K, followed by Div. 2J and 3L. Since 1984 the proportion of the biomass in 3L is increasing, as it does also in Div. 3N since 1993. In 2002, 43% of the total roughhead biomass surveyed was found in Div. 3L. Divs. 3K and 3L combined account for 62% of the total. As has been observed in recent years (Junquera *et al.*, 1999), the largest biomass indexes were obtained at depths between 1 000-1 200 m. in all areas.

- **Canadian spring survey**

Stratified random bottom trawl surveys have been conducted in Div. 3L, 3N and 3O in spring since 1978. A description of those surveys is found in McCallum and Walsh (1996). Until 1996 an Engel trawl was used, changed to a Campelen 1800 since then. The depth range of the surveys is up to 731 m.

Roughhead biomass obtained in this series of surveys, are presented in Table 4 and Fig. 2. The biomass estimate slightly decreased to 3 116 tons comparing with the highest level of 5 070 tons in 1998. However, a general increasing trend in biomass is observed from 1995 onwards. But again in this case a direct comparison of the biomass levels through the whole time series is not possible due to the change in the survey gear in 1995. Biomass is largely concentrated in Div. 3L. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the fall series, as the first surveys cover only the southern divisions and the shallower depths, where according to the other results this species is less abundant.

- **Canadian deepwater survey**

Canada conducted deepwater bottom trawl surveys (750-1 500 m.) in 1991, 1994 and in 1995 in Div. 3KLMN. The 1991 survey was carried out in August, the 1994 in February and the 1995 in spring. The results of those surveys were reported by Atkinson *et al.* (1994) and Bowering *et al.* (1995), and are presented in Table 5 and Fig. 2. It is observed an increasing trend from 16 215 tons in 1991 to 46 668 tons in 1995. Most part of the biomass was taken in Div. 3L and 3M, which confirms that the stock in those Divisions are distributed beyond the depths covered by the spring surveys in those Divisions. The increased estimates for Div. 3L and 3M in 1994 were probably due, at least in part, to the increased survey area (Atkinson *et al.*, 1994). The results suggest somewhat higher biomass in southern Div. 3L and 3N.

- **EU (Spain and Portugal) summer survey**

EU- Spain and Portugal conduct a stratified bottom trawl survey in Div. 3M since 1988, up to depths of 730. The survey procedure is described in Saborido-Rey and Vázquez (2003). The roughhead grenadier biomass indexes and mean catch per standardised tow from this survey series, updated from Murua (2003), are presented in Table 6 and Fig. 2. A peak biomass of 3 595 tons was observed in 1993, but since then has been somewhat stable, at between 1 500 and 2 000 tons. In 2002 the total biomass index was 1 440 tons. Roughhead significant biomass only is found at depths beyond 500 m every year. The mean catch per tow in the survey shows the same trend, with a peak in 1993 of 7.88 (s.d \pm 0.69) and a decreasing trend to stabilize around 1.8 to 3. In 2002 the mean catch per standardized tow was 1.79 (s.d \pm 0.26).

BIOLOGICAL DATA

Roughhead length frequencies from the Spanish, Portuguese and Russian trawl catches in Div. 3LMNO are available from Gonzalez *et al.* (2003), Vargas *et al.* (2003) and Rikhter and Sigaev (2003), respectively. The Spanish and Portuguese lengths frequencies are presented as pre-anal fin length, while the Russian ones as total lengths. The roughhead length composition from the Russian catches have been converted to AFL using the total length / AFL relationship presented by Murua and Motos (1997). The mean pre-anal fin lengths from the Spanish, Portuguese and Russian commercial catches are presented since 1995 in Fig. 3. Mean pre-anal fin lengths are higher every year in the Spanish and Russian catches, and they maintain rather stables since 1995. In 2002 the proportion of both sexes in the Spanish commercial fishery was similar, females made up to 52% of the catches. Females attain larger sizes than do males, and from 24 cm (AFL) all the individuals are females (Fig. 4).

Catch at age data of the Spanish, Portuguese and Russian commercial catches are presented in Table 7, based in the Spanish age-length key used in Gonzales *et al.* (2003), and in data from Vargas *et al.* (2003) and Rikhter and Sigaev (2003). Most of the Spanish and Russian catches are from ages between 5 and 12, with a mode at age 8, while the modal age in the Portuguese ones are age 5.

The total catch at age in 2002 (Table 7) has been used to obtain a synthetic catch curve (Fig 5) and according to it, a total mortality of 0.39 was estimated. In previous studies Murua (2002 and 2003) suggested a difference in M between sexes. The proportion of sexes at length shown in Fig. 4 could also support this view, as males disappear from 24 pre-anal fin length onwards in the Spanish catches, and there is no indication of an increase in fishing mortality on males at previous lengths. In order to analyse this, an estimate of Z by sexes have been performed using the catch at age by sexes of Spanish catch (Fig. 6). The results indicate a total mortality values of 0.3 and 0.9 for females and males respectively, both values higher than the ones obtained by Murua (2003) based upon data collected on the Flemish Cap survey, which covers the shallowest distribution of roughhead grenadier.

ASSESSMENT

The Canadian fall survey series is the best input for the assessment of this stock, because it provides a synoptic view of the species distribution over a wide geographic and depth range, in spite the objections that has been pointed to this series, regarding the changing depth coverage and the change of the survey gear (Anon., 1998). In 2002 most of the biomass concentrated in Div. 3L, 3K and 3N, at depths between 1 000-1 200 m.

According the fall Canadian survey the roughhead grenadier total biomass indices would indicate a general increasing trend. The rest of the survey series analysed, the total biomass indexes were stable in the last year, although in the EU Flemish Cap survey the index slightly decreases. The catch / biomass (C/B) index obtained using the Canadian fall survey biomass index (Fig. 7) is 0.1 which is at the same level as in 2001 ($C/B_{2001} = 0.07$). The trend in this index shows a great increase in 1992-1994 period, then decrease to an average value of 0.2 between 1996-2000 and in the last two years decrease again to a level of 0.1, due to an increasing trend in the survey biomass and a decreased of catches.

The Z estimate from the 2002 Spanish catches is 0.3 for females and 0.9 for males. A yield per recruit has been performed using the input data presented in Table 8. The partial recruitment vector comes from Cárdenas *et al.* (1995), the maturity curve at age from Murua and Motos (1997) and the mean weight at age from the 2002 age-length key. The input value of M has been set for males and females separately, and it has been estimated as the difference between Z by sex and the C/B index. The results of the yield-per-recruit appears in Fig. 8. The estimated $F_{0.1}$ is 0.12 and F_{max} is 0.22. The $F_{0.1}$ and F_{max} value are in the same level than previous years ($F_{0.1} = 0.13$ and $F_{max} = 0.24$). In this regard, considering the reference F obtained from the C / B index, the stock would exploited at level around $F_{0.1}$.

No changes in the mean length (Fig. 3), that could suggest an excessive fishing pressure, are observed on the catch since 1995. The available time series of catches at age is too short to analyse trends in the SSB, however it can be noted that in 2002 only about 4% of the catch in abundance and 20% in weight was above the female age at maturity (15 years). We have scarce information at the moment to assess an appropriate exploitation level.

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Table 1. Revised grenadier catches, updated from Power and Parsons (1998), Gonzalez *et al.* (2003), Vargas *et al.* (2003) and Rikhter and Sigaev (2003).

Year	STATLANT RHG Nominal catches (t) by Division									TOTAL
	2G	2H	2J	3K	3L	3M	3N	3O	Other	
1987					912	7	82			1001
1988		1			907		52			960
1989		2		3	289	28	11			333
1990		1	32		2211	688	312			3244
1991 ^a			12	113	2543	497	1093	10		4268
1992			23	274	2582	2961	760	125		6725
1993			10	193	996	1428	1680	61	27	4395
1994	1		2	35	585	2301	1062	28	9	4023
1995	22	6	16	16	1199	1625	1074	20	4	3982
1996					1945	888	1300	2		4135
1997	36	5	63	100	1774	922	1797	43		4740
1998					2652	2180	2289	18	92 ^c	7139
1999 ^b				61	2037	3127	1705	180	49 ^c	7160
2000 ^b				139	1382	2109	888	38		4767
2001 ^b				97	1465	753	754	48		3117
2002 ^b				147	1905	869	700	36		3657

^a Catch could not be well estimated; based on revised data is estimated to be 8000 to 14000 t. mixed roundnose and routhead grenadiers. (Power and Parson 1988).

^b Provisional.

Table 2.- Roughhead grenadier nominal catches (t) in Subarea 2+3, updated from Power and Parsons (1998), Gonzalez *et al.* (2003), Vargas *et al.* (2003) and Rikhter and Sigaev (2003).

	1991	1992	1993	1994	1995	1996	1997	1998	1999 ^a	2000	2001	2002
Canada	215	595	345	79	84		240		108	201	164	244
EU-ESP		4125 ^b	2054 ^b	1720 ^b	2521 ^b	3090 ^b	3738	6050	5704	3948	2562	2588
EU-PRT	4486 ^b	2000 ^b	1969 ^b	2223 ^b	1402 ^b	784 ^b	762	1089	1299	396	241	438
Russia								92 ^c	49	211	150	228
Japan												120
Estonia										1		25
Lituania										1		
TOTAL	4701	6720	4368	4022	4007	4131	4740	7231	7160	4767	3117	3657

^a Provisional.

^b First reported as roundnose grenadier

^c Reported as roundnose grenadier in STATLANT 21A.

Table 3. Roughhead biomass indexes from the fall survey series and percentages of the biomass by Division. ns = not surveyed.

Year	Biomass (t.)	Percentages of biomass (%)							
		2G	2H	2J	3K	3L	3M	3N	3O
1978	24048			31	46	24			
1979	15962			37	63				
1980	17229			49	51				
1981	19451			29	43	28			
1982	22762			33	36	31			
1983	16597			38	49	13			
1984	26301			22	28	50			
1985	15661			14	31	55			
1986	6733			61	39				
1987	20763			14	15	71			
1988	9734			28	24	48			
1989	6433			34	14	52			
1990	12455			24	30	46			
1991	8900			16	36	47		2	
1992	2848			44	14	41			
1993	2779			20	30	31		16	3
1994	1915			23	23	37		14	3
1995	6933			8	44	25		21	2
1996	33453		4	8	14	53	20	1	0
1997	32968	6	5	9	16	38	20	5	0
1998	41440	1	4	7	15	38	13	20	1
1999	31851	2	5	10	17	49	12	6	1
2000	29139	ns	ns	10	21	36	14	17	2
2001	44918	ns	2	9	23	39	13	13	2
2002	35282	ns	ns	9	19	43	9	16	3

Table 4. Roughhead biomass indexes (tons) from the Canadian spring survey series and percentages of biomass in the Divisions surveyed. ns = not surveyed.

Year	Biomass (t.)	Percentages of biomass (%)		
		3L	3N	3O
1978	2754	38	62	
1979	2105	93	7	
1980	4070	89	11	
1981	3115	91	9	
1982	608	84	16	
1983	ns	ns	ns	
1984	50	ns	100	
1985	2432	97	3	
1986	1096	98	2	
1987	2080	88	12	
1988	805	98	2	
1989	1439	99	1	
1990	475	98	2	
1991	264	95	5	
1992	1129	98	2	
1993	539	84	16	
1994	952	93	7	
1995	347	93	7	
1996	2882	96	3	1
1997	3063	88	12	0
1998	5070	83	14	3
1999	4043	74	19	7
2000	5006	71	25	4
2001	4948	75	23	2
2002	3116	81	16	3

Table 5. Roughhead grenadier biomass index (tons) from the deepwater Canadian surveys and percentages of biomass by Divisions (from Bowering *et al.*, 1995)

Year	Biomass (t.)	Percentage of biomass (%)			
		3K	3L	3M	3N
1991	16215	26	39	34	
1994	26588	16	34	39	11
1995	46668	15	48	25	13

Table 6. Rouhhead grenadier mean catch per tow (Kg.) per depth intervals, in parenthesis the corresponding total biomass indexes (t.), from the EU summer survey in Div. 3M.

Depth (m):	Bimass indexes (t.)			Total
	266 - 380	381 - 570	571 - 760	
1988	2.4	11.25	69.4	2.98 (2390)
1989	0.47	10.27	24.79	1.29 (1024)
1990	0	5.49	28.39	1.26 (996)
1991	0.27	7.33	55.96	1.97 (1587)
1992	1.4	10.92	51.67	2.33 (1878)
1993	1.06	28.11	209.75	7.88 (3595)
1994	0.19	7.09	89.52	2.92 (2350)
1995	1.19	13.61	57.05	2.31 (1855)
1996	8.65	10.35	30.23	2.01 (1619)
1997	0.98	7.99	42.44	1.77 (1424)
1998	2.02	13.62	54.82	2.5 (2012)
1999	2.77	15.4	38.76	1.85 (1487)
2000	2.78	10.17	30.16	1.55 (1246)
2001	2.24	21.71	71.75	3.08 (2474)
2002	0.04	14.74	40.55	1.79 (1440)

Table 7. Spain, Portugal and Russia roughhead grenadier catch at age in Div. 3LMN in 2002.

AGE	SPAIN	PORTUGAL	RUSSIA	TOTAL
2	1306	4982	186	6475
3	17300	127924	4256	149480
4	56012	333218	10323	399552
5	180713	456598	32383	669695
6	657736	447349	71589	1176674
7	747756	182990	69394	1000140
8	964570	132094	67035	1163699
9	691093	59677	41947	792718
10	371011	24646	23026	418683
11	327476	24554	30173	382203
12	235788	22466	32382	290636
13	125324	14027	19972	159323
14	85771	9669	8788	104228
15	52403	5304	9770	67478
16	50728	3431	5414	59573
17	58012	2088	4924	65023
18	44239	726	3459	48424
19	25380	149	2296	27825
20	13578	13	479	14071
21	12440	27	0	12466
22	5220	1	47	5269
23	4798	19	47	4864
24	2062		62	2124
25	550			550
Total	4731267	1851952	437953	7021172
Catch (t.)	2588	438	228	3254

Table 8. Input parameters of the roughhead grenadier yield per recruit analysis.

AGES	Partial R.	Mean W (Kg)	M females	M males	Mat. Og.
2	0.22	0.037	0.2	0.8	0.000
3	0.30	0.084	0.2	0.8	0.000
4	0.36	0.119	0.2	0.8	0.000
5	0.41	0.167	0.2	0.8	0.000
6	0.58	0.239	0.2	0.8	0.000
7	0.69	0.313	0.2	0.8	0.000
8	0.81	0.383	0.2	0.8	0.001
9	0.87	0.467	0.2	0.8	0.002
10	0.93	0.569	0.2	0.8	0.004
11	0.96	0.634	0.2	0.8	0.009
12	0.98	0.761	0.2	0.8	0.025
13	0.99	0.901	0.2	0.8	0.048
14	1.00	1.201	0.2	0.8	0.106
15	1.00	1.356	0.2	0.8	0.602
16	1.00	1.712	0.2	0.8	0.948
17	1.00	1.991	0.2	0.8	0.981
18+	1.00	2.749	0.2	0.8	0.999

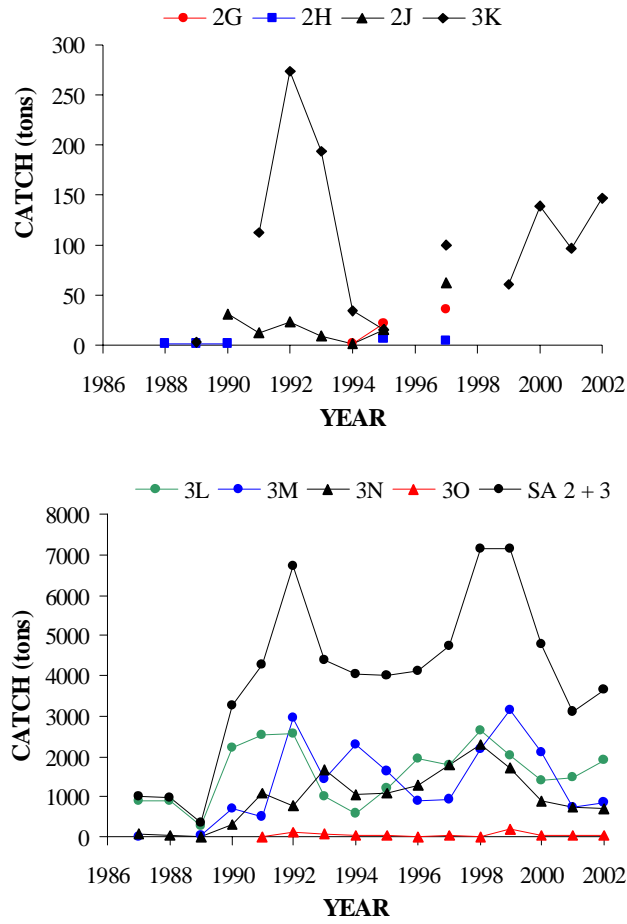


Fig. 1. Roughhead grenadier nominal catches by Division and the total for Subareas 2+3.

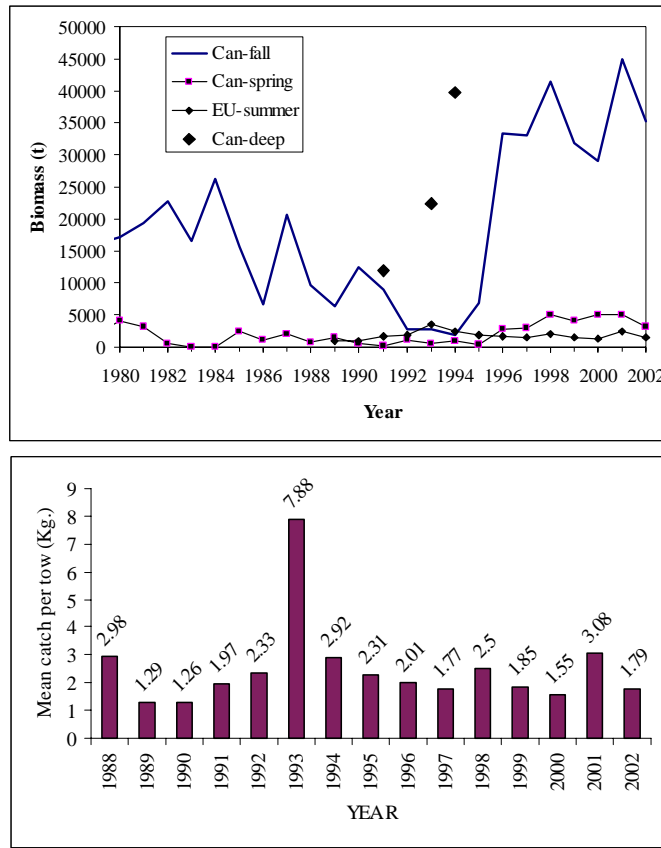


Fig. 2. Roughhead grenadier survey biomass indexes from Canadian fall survey, Canadian spring survey and deepwater survey in Subareas 2 + 3 and mean catch per tow from the EU bottom summer survey.

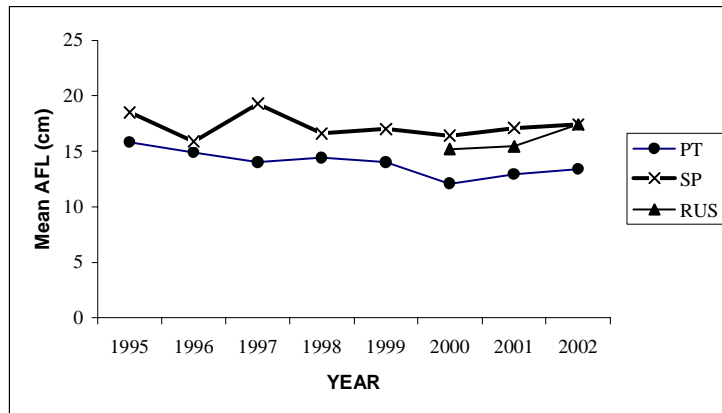


Fig. 3. Roughhead grenadier mean pre-anal fin lengths in the Spanish (SP), Portuguese (PT), and Russian (RUS) catches.

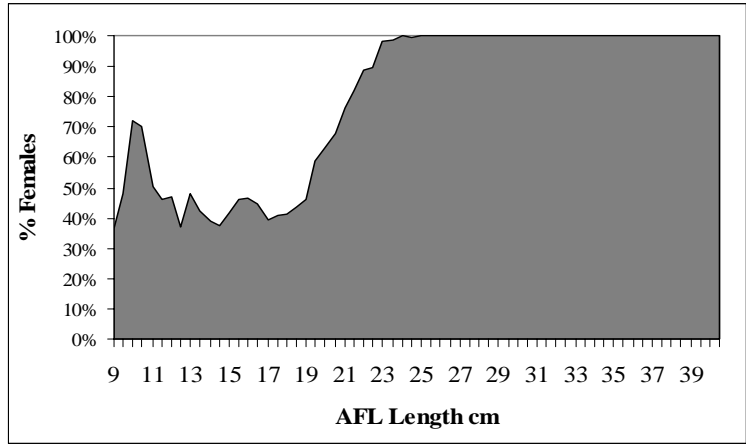


Fig. 4. Percentages of females at pre-anal fin length in the Spanish roughhead grenadier commercial catches in 2002.

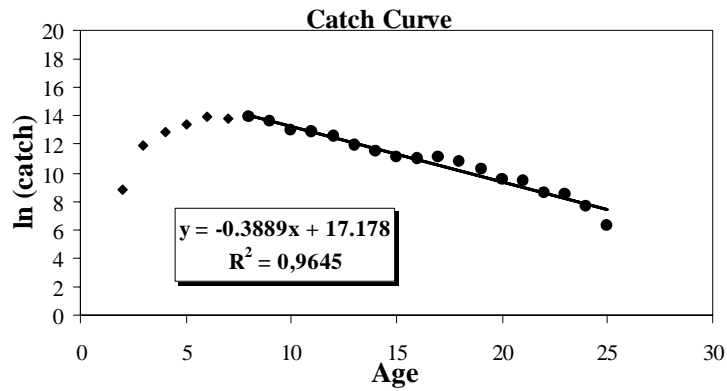


Fig. 5. Roughhead grenadier synthetic catch curve estimated based upon data of international total catches of 2002. Z is estimated as the slope of the regression line for the fully recruited ages (ages 8 and older).

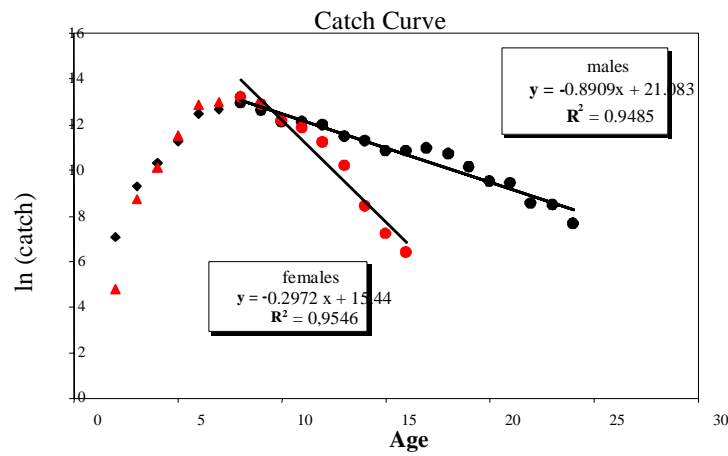


Fig. 6. Roughhead grenadier synthetic catch curve by sex from the total Spanish catch of 2002. Z is estimated as the slope of the regression line for the fully recruited ages (ages 8 and older).

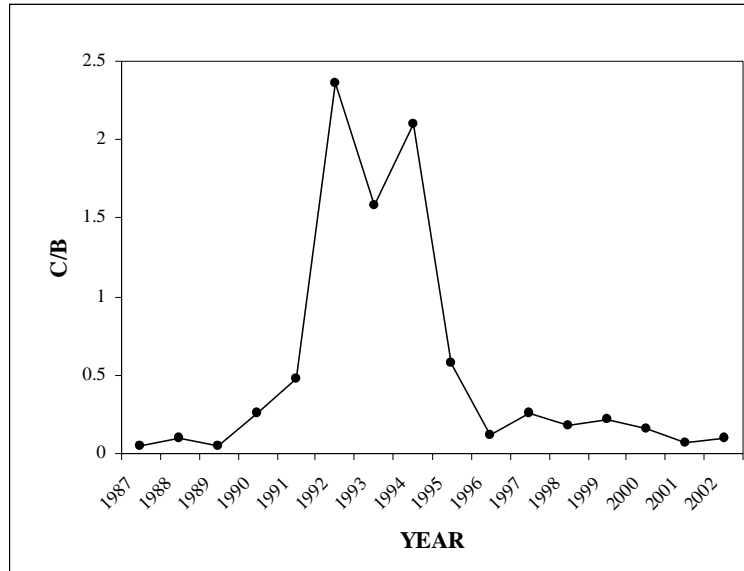


Fig. 7. Roughhead grenadier C/B Index based upon Canadian Fall survey.

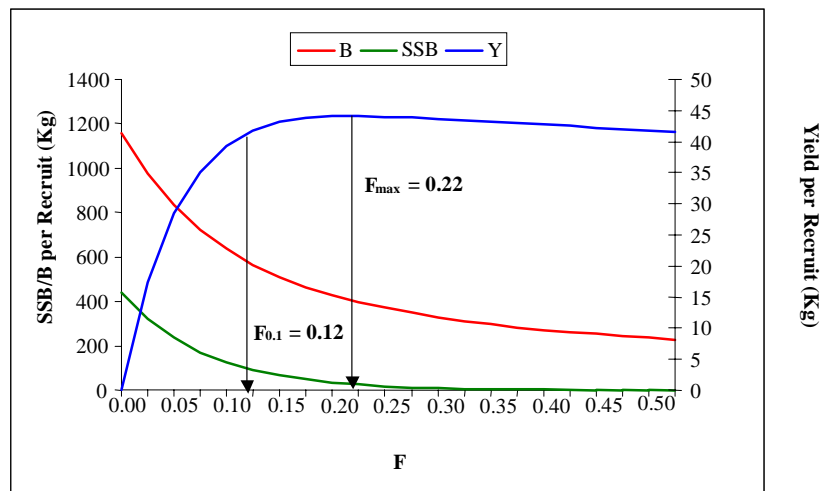


Fig. 8. Roughhead grenadier yield per recruit analysis for roughhead grenadier in 2002.