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An Assessment for Roughhead Grenadier (*Macrourus berglax*) in NAFO Subareas 2 and 3.

by

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ABSTRACT

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. Roughhead grenadier is taken as by-catch in the Greenland halibut fishery in the Regulatory Area mainly in Divisions 3LMN. Catches increased gradually and the largest proportion by country correspond to Spain and Portugal, with 6050 t. and 1089 t. respectively in 1998.

A review of the biomass estimates from the available research surveys in Subareas 2 and 3 is presented. According to the Canadian fall surveys, it seems that the main part of the stock shifted from the northern Divisions (2GJand 3K) to the southern ones (3LN), and to greater depths (beyond 1000 m.) since early 90s. A review of the biological information available for this stock is also presented. Mean lengths (preanal fin lengths) of the catches show no decreasing trend since 1995. The age o fully recruitment to the fishery is 8, and the total mortality estimate (1997-1998) is Z = 0.43. Female age at maturity is 15, corresponding to a PFL of 26.5 cm.

The Canadian fall survey series seems to be the best input for the assessment of this stock. At present the higher part of biomass is found in Div. 3L and 3N and at depths between 1000-1200 m. A yield per recruit has been performed using the input data presented in table 13. 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 1998 age-length key. M is assumed as constant through the ages with a value of 0.2. The results of the yield per recruit analysis appears in Fig. 6. The estimated F_{max} is 0.27 and $F_{0.1}$ is 0.13. However it must be noted that this output is sensitive to possible changes in M, as if for instance M would be different between sexes, as suggest the results from Murua et al. (1999) and as it has been shown in the Greenland halibut (Anon. 1998).

Any decreasing trend in the mean lengths, that would be an index of an excessive fishing pressure, is observed in the mean lengths of the catches since 1995 up to now. The available time series of catches at age is too short to analyse trends in the SSB, however it can be noted that only a 18 % and 10 % percent of the 1997 and 1998 catches respectively were above the female age at maturity (15 years). We have scarce information at the moment to assess an appropriate exploitation level, though survey series shows that at the current exploitation rate the biomass is increasing since 1994.

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 is 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 have 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 Divisions 3LMN. The revised catch history after 1987 is presented in table 1 and fig.1. Catches increased gradually and the largest proportion by country correspond to Spain and Portugal (table 2), with 6050 t. and 1089 t. respectively in 1998.

It is uncertain the level of roughhead grenadier catches in Subareas 2 and 3 prior to the start of the deep-water Greenland halibut fishery in the Regulatory area, in 1988. Parsons (1975) indicate that in Northwest Atlantic only the roundnose grenadier has been subjected to exploitation since about 1967, while the roughhead grenadier was a much more disperse resource, occurring only in limited numbers in the commercial grenadier catches off Northeast Newfoundland and Labrador. However it can be noted that those results refer to depths above 730 m, a much shallower depth than where the fishery is being conducted at present (up to 1700, mostly between 900 and 1200 m). Savvatimsky (1983) reported that roughhead grenadier amounted to 66 % by number and 49 % by weight of the total grenadier catch taken by long-line in Newfoundland and Flemish Cap area in 1982 (depths 310 to 1000 m).

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 1463 m after 1995. A description of those surveys is in McCallum and Walsh (1996) and Power and Parsons (1988).

The roughhead biomass indexes from this series of surveys are presented in table 3 and fig. 2. The aggregated biomass estimates in 1978 was 24048 t., increased to 26300 t. in 1984, and then decreased slowly to a minimum value of 1978 t. in 1994. After increased again to 31803 t. in 1998. However the estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. 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 Divisions 2J and 3L. Since 1984 the proportion of the biomass in 3L is increasing, as it does also in Div. 3N since 1993. At present, most part of the survey biomass is caugth in Div. 3L.

In table 4 are presented the roughhead biomass indexes desegregated by depth intervals and Division in the period 1980-88. In Subarea 2 only results from Division 2J are available. This survey series covers properly the roughhead distribution range in Div. 2J and 3K, as the survey depth was up to 1000 m till 1990 and to 1500 m. since then. However, in Div. 3L and 3N, the survey depth is only up to 695 m, while according to the distribution of the commercial catches at present in those areas, the largest part of the stock is expected to occur beyond 700 m.. Hence the biomass estimates for those Divisions would underestimate the stock size.

In Division 2J up to 1987, the main proportion of the biomass was not found in the deepest strata but at depths between 300 – 500 m. The 300 m. strata had the peak abundance and biomass for most of the years in this period (table 4). Since 1988, the highest biomass indexes were found progressively deeper, first at the 750 m. strata (1988 – 1992), then at the 1000 m. strata (1993 – 1994), at the 1250 m. (1995 – 1997) and finally at the deepest strata (1500 m) in 1998.

A similar pattern is observed in Div. 3K (table 4), though here the highest biomass estimates were found at 400 m. up to 1988. Since then to 1995, they were at 1000 m. and from 1995 to 1998 the main part of the biomass was taken in the deepest strata, between 1000 – 1500 m, though only in 1995 the largest biomass was found at 1500 m.

In Div. 3L and 3N, the highest biomass indexes were generally found in the 366 m strata. since 1991, as observed in the other Divisions, the larger biomass indexes are found at progressively greater depths. In Div. 3O the biomass estimates are very low compared to other Divisions, though increasing since 1977. The larger biomass are found at depths between 700 – 900 m.

It can be concluded from those data some points about the stock distribution: it seems that the main part of the stock shifted from the northern Divisions (2GJand 3K) to the southern ones (3LN)and to greater depths (beyond 1000 m.)since early 90s.

- **Canadian spring survey.**

Stratified random bottom trawl surveys have been conducted in Div. 3L and 3N 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 914 m.

The roughhead biomass indexes obtained in this series of surveys are presented in table 5 and fig. 2 (B. Atkinson pers. comm.). The biomass estimate is the highest at the end of the series, with 4919 t., ad the minimum (50 t.) in 1984. An increasing trend in biomass is observed between 1996 – 1998. But again in this case a direct comparison of the biomass levels through the whole time series is not possible because of the change in the survey gear since 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.

In table 6 are presented the desegregated roughhead biomass estimates by depth strata. Maximum biomass indexes were found first between 270 – 366 m. and since 1991 biomass concentrates between 549 – 731 m. Compared to the common Divisions and depths from the fall survey series, the spring survey biomass indexes are lower. As pointed before, this can be explained because de main part of the stock could be at present distributed beyond 1000 m. depth, specially in the southern Divisions.

- **Canadian deepwater surveys.**

Canada conducted deepwater bottom trawl surveys (750 –1500 m) in 1991, 1994 and in 1995 in Divisions 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 7 and fig. 2. It is observed an increasing trend from 16215 t. in 1991 to 46668 in 1995. Most part of the biomass was taken in Div. 3L and 3M, what 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 1994 results suggest somewhat higher biomass in southern 3L and 3N. The 3N biomass estimate in 1994 was the lowest of the three divisions, but was about six times higher than the estimate for roundnose grenadier.

The depth desegregated biomass indexes indicate that most part of the biomass is found at depths beyond 1000 m. and in Div. the highest estimates were from the deepest strata (table 8).

- **Japanese survey.**

In August 1996 Japan conducted an stratified bottom trawl survey in Div. 2GH at depth between 201 – 1500 m (Yokawa and Satani 1997). Total biomass estimate for roughhead was 2290 t, the 80 % of this biomass taken in Div. 2G. The largest biomass index was found at the 400 – 500 depth strata, while in 2H the biomass were spread over all depths in a similar proportion (table 9).

- **Spanish spring survey.**

Since 1995, an stratified bottom trawl survey is conducted in April – May in Div. 3NO Regulatory Area (Paz et al. 1995, 1996 and 1997; Durán et al. 1998). The depth range of this survey were progressively increased every year, as indicated in table 10, to a maximum depth of 1463 in 1998. A parallel increase in the biomass estimates was observed in the survey series (table 10 and fig.2), very pronounced in 1998 were 50843 t. have been taken. Biomass estimates largely concentrates at depths beyond 500 m. in every year.

- **EU (Spain-Portugal) longline deepwater survey.**

Spain conducted a deepwater longline survey in May 1995 in Div. 3LMN in depth between 562 and 3028 m. The results of this survey are reported by Cárdenas et al. (1996). This survey do not provide a quantitative biomass index for roughhead grenadier, but gives information on the species bathimetric distribution. Roughhead was the most abundant species in the catches, accounting for 32 % of the total. Roundnose grenadier were not available to the longline. In table 11 can be observed that roughhead occurred mostly beyond 1000 m, with maximum yields between 1000 – 1599 m. At 2000 m. depth this species becomes progressively less abundant and disappear completely at 2200 m, where is substituted by other Macruridae (*Nematonurus armatus*).

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

EU- Spain and Portugal conducted an stratified bottom trawl survey in Div. 3M since 1988, up to depths of 730. The survey procedure is described in Vázquez (1998). The roughhead grenadier biomass indexes from this survey series are presented in Sarasua et al. (1999), and appears in table 12 and fig.2. A peak biomass of 3595 has been taken in 1993, apart of this, the biomass estimates from this survey are rather stable about a mean of 1700 tons. Roughhead significant biomass only is found at depths beyond 500 m every year.

Murua et al. (1999) and Sarasua et al. (1999) provide a review of the population structure in Div. 3M between 1991 – 1998, up to depths of 720 m. Based on the survey results age and length composition of the catches showed clear differences between sexes. The proportion of males in the catches decreases progressively as length increases. The bulk of the catches is composed of ages 6 – 8. The oldest male found was 14 years and the oldest female 18. The catches are now dominated by the 1990 year class. Estimates of Z by sexes for a synthetic catch curve for all the period are provided. Z for males was 0.47, while that for females was 0.28.

BIOLOGICAL DATA

Roughhead length frequencies from the Spanish and Portuguese trawl catches in Div. 3LMNO are available from Cárdenas et al. (1996), Godinho et al. (1996), Alpoim et al. (1997, 1998 and 1999), Junquera et a. (1997, 1998 and 1999). In the commercial fishery, specially in 3L, the proportion of females is larger than the one of males, and females attain larger lengths. The analyses of the mean lengths (preanal fin lengths) from the commercial catches (Fig. 3) shows that there are rather stable from 1995 to 1998.

Catch at age data from the Spanish commercial catches in 3LMN are available for 1997 and 1998 (Junquera et al. 1998 and 1999). The same age-length key has been applied to obtain the catches at age of the 1997 and 1998 Portuguese catches. The combined 1997 and 1998 Portuguese and Spanish catches at age have been used to obtain a synthetic catch curve (fig 4). According to it, fully recruitment to the fishery occurs at age 8 and the total mortality estimate (from ages 9+) is 0.43.

Murua and Motos (1997a and 1997b) studied the reproductive biology of the roughhead grenadier in 3LMN, and provided a maturity curve based on histological analysis for this species. According to their results the female roughhead grenadier age at 50 % maturity is at age 15 corresponding to a PFL of 26.2 cm.

ASSESSMENT

The Canadian fall survey series seems to be 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). According to this survey results, the stocks apparently shifted to deeper waters and southern Divisions since early 90s. At present the higher biomass is found in Div. 3L and 3N and at depths between 1000-1200 m.

According to all the survey series analysed, the roughhead biomass show an increasing trend even though fishing pressure may be relatively high. The catch / biomass (C/B) index obtained with the Canadian fall survey are presented in fig. 5. Starting in 1987 with low exploitation rates, this index increased dramatically in 1992-1994 and then decrease again to an average value of 0.2 between 1996-1998, probably related to the decrease in effort in the Greenland halibut fishery. The trend observed in the C/B index is similar to the observed in the Greenland halibut fishery (Cárdenas et al. 1999), as expected being associated species.

The Z estimate from the 1997-1998 commercial catches is 0.43. A yield per recruit has been performed using the input data presented in table 13. 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 1998 age-length key. M is assumed as constant through the ages with a value of 0.2. The results of the yield per recruit analysis appears in Fig. 6. The estimated F_{max} is 0.27 and $F_{0.1}$ is 0.13. However it must be noted that this output is sensitive to possible changes in M, as if for instance M would be different between sexes, as suggest the results from Murua et al. (1999) and as it has been shown in the Greenland halibut (Anon. 1998).

Any decreasing trend in the mean lengths, that would be an index of an excessive fishing pressure, is observed in the mean lengths of the catches since 1995 up to now. The available time series of catches at age is too

short to analyse trends in the SSB, however it can be noted that only a 18 % and 10 % percent of the 1997 and 1998 catches respectively were above the female age at maturity (15 years). We have scarce information at the moment to assess an appropriate exploitation level, though survey series shows that at the current exploitation rate the biomass is increasing since 1994.

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Table 1.- Revised grenadier catches, updated from Power and Parsons (1998).

	STATLANT RHG Nominal catches (t) by Division									
Year	**2G**	**2H**	**2J**	**3K**	**3L**	**3M**	**3N**	**3O**	**Other**	**TOTAL**
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		6724
1993			10	193	996	1428	1680	61	27	4395
1994[b]	1		2	35	585	2301	1062	28	9	4023
1995[b]	22	6	16	16	1199	1625	1074	20	4	3982
1996[b]					1945	888	1300	2		4134
1997[b]	36	5	63	100	4054	1894	2283	43		8478
1998[b]					2652	2180	2289	18	92[c]	7231

[a] Catch could not be well estimated; based on revised data is estimated to be 8000 to 14000 t. mixed roundnose and roughhead grenadiers. (Power and Parsons 1998).

[b] Provisional.

[c] Russian catches reported for Divisions 3LMN together. From Vaskov et al. (1999).

Table 2.- Roughhead grenadier nominal catches (t.) in Subarea 2+3, updated from Power and Parsons (1998), Alpoim et al. (1998 and 1999) and Vaskov et al. (1999).

	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994***	**1995***	**1996***	**1997***	**1998***
Canada				31	215	595	345	79	84		240	
Former GDR		49	43									
EU-ESP						4125**	2054**	1720**	2521**	3090**	3738	6050
EU-PRT	1001**	914**	290**	3211**	4486**	2000**	1969**	2223**	1402**	784**	762	1089
Norway				2								
Russia												92***
TOTAL	1001	963	333	3244	4701	6720	4368	4022	4007	4131	4740	7231

* Provisional.

** First reported as roundnose grenadier

*** Reported as roundnose grenadier in STATLANT 21A.

Table 3.- Roughhead biomass indexes from the fall survey series and percentages of the biomass by Division.

		Percentages of biomass (%)						
Year	**Biomass (t.)**	**2G**	**2H**	**2J**	**3K**	**3L**	**3N**	**3O**
1978	24048	0	0	31	46	24	0	0
1979	15962	0	0	37	63	0	0	0
1980	17229	0	0	49	51	0	0	0
1981	19451	0	0	29	43	28	0	0
1982	22762	0	0	33	36	31	0	0
1983	16597	0	0	38	49	13	0	0
1984	26301	0	0	22	28	50	0	0
1985	15661	0	0	14	31	55	0	0
1986	6733	0	0	61	39	0	0	0
1987	20763	0	0	14	15	71	0	0
1988	9734	0	0	28	24	48	0	0
1989	6433	0	0	34	14	52	0	0
1990	12455	0	0	24	30	46	0	0
1991	8900	0	0	16	36	47	2	0
1992	2848	0	0	44	14	41	0	0
1993	2779	0	0	20	30	31	16	3
1994	1915	0	0	23	23	37	14	3
1995	6933	0	0	8	44	25	21	2
1996	27276	2	5	10	17	64	1	0
1997	25784	4	7	12	21	49	6	1
1998	31803	1	5	11	20	35	26	2

Table 4.- Biomass indexes (t.) from the Canadian fall surveys series by depth intervals and Divisions (B. Atkinson pers. com.)

					Div. 2G				
Depth (m)	**200**	**300**	**400**	**500**	**750**	**1000**	**1250**	**1500**	**Total**
1996	0	0	19	235	328	-	-	-	582
1997	0	16	48	734	332	-	-	-	1130
1998	0	0	7	5	63	98	239	-	412
					Div. 2H				
Depth (m)	**200**	**300**	**400**	**500**	**750**	**1000**	**1250**	**1500**	**Total**
1996	0	0	5	112	173	216	285	499	1290
1997	0	0	68	29	166	523	340	655	1781
1998	13	0	11	61	161	349	191	867	1653
					Div. 2J				
Depth (m)	**200**	**300**	**400**	**500**	**750**	**1000**	**1250**	**1500**	**Total**
1978	69	3333	1638	1145	846	96	250	8	7385
1979	0	1653	1625	1554	1015	-	-	-	5847
1980	125	3582	2151	1279	969	307	-	-	8413
1981	51	1182	1207	1518	1637	46	-	-	5642
1982	342	2758	2108	1160	984	177	-	-	7530
1983	0	2835	1184	1192	765	307	-	-	6284
1984	62	2037	1378	1270	819	242	-	-	5807
1985	0	531	673	512	344	143	-	-	2203
1986	0	581	845	1351	1113	244	-	-	4132
1987	0	1245	192	860	536	87	-	-	2919
1988	0	335	302	418	1469	219	-	-	2743
1989	0	323	690	610	429	122	-	-	2174
1990	0	334	139	811	1092	617	-	-	2993
1991	0	95	67	235	657	346	-	-	1401
1992	0	77	95	236	601	253	-	-	1263
1993	0	7	5	195	138	218	-	-	563
1994	0	0	4	34	84	310	-	-	433
1995	0	0	41	15	134	369	-	-	559
1996	0	7	38	74	551	445	1074	507	2695
1997	0	40	60	200	704	661	785	648	3098
1998	0	2	20	424	448	890	646	1209	3638
					Div. 3K				
Depth (m)	**200**	**300**	**400**	**500**	**750**	**1000**	**1250**	**1500**	**Total**
1978	0	3322	3744	767	523	1435	811	346	10948
1979	0	1771	5309	1146	912	136	345	496	10115
1980	0	2135	4066	1436	474	706	-	-	8817
1981	0	1884	3334	2306	335	595	-	-	8454
1982	0	1988	2757	1133	657	1569	-	-	8105
1983	0	1683	4214	1664	622	0	-	-	8184
1984	0	1557	2391	1735	987	652	-	-	7322
1985	0	867	2187	836	373	583	-	-	4847
1986	0	258	1697	646	0	0	-	-	2600
1987	0	479	773	410	868	545	-	-	3075
1988	0	342	1546	469	0	0	-	-	2357
1989	0	150	531	249	0	0	-	-	930
1990	0	13	497	312	674	2235	-	-	3730
1991	0	17	231	239	367	2320	-	-	3173
1992	0	0	89	46	49	228	-	-	412
1993	0	3	22	22	82	467	236	-	832
1994	0	0	4	4	12	422	-	-	443
1995	0	5	31	11	36	182	1200	1601	3067
1996	0	4	91	72	475	1548	1779	801	4770
1997	0	0	79	79	445	1349	1927	1539	5419
1998	0	2	67	121	522	2280	2090	1179	6260

Table 4.- (continued)

Div. 3L											
Depth (m)	**91**	**183**	**274**	**366**	**549**	**731**	**914**	**1097**	**1280**	**1463**	**Total**
1978	-	-	2095	2018	935	667	-	-	-	-	5715
1979	-	-	-	-	-	-	-	-	-	-	
1980	-	-	-	-	-	-	-	-	-	-	
1981	0	347	2598	2411	-	-	-	-	-	-	5355
1982	0	117	1670	4743	597	-	-	-	-	-	7127
1983	0	0	1419	549	0	161	-	-	-	-	2129
1984	0	0	3641	8214	847	470	-	-	-	-	13172
1985	0	48	1361	4867	1664	671	-	-	-	-	8611
1986	-	-	-	-	-	-	-	-	-	-	
1987	0	63	8119	6587	-	-	-	-	-	-	14769
1988	0	0	473	4161	-	-	-	-	-	-	4634
1989	0	0	1219	2110	-	-	-	-	-	-	3329
1990	34	0	902	2112	1873	791	-	-	-	-	5712
1991	0	93	512	734	1194	1613	-	-	-	-	4146
1992	0	0	13	196	248	706	-	-	-	-	1163
1993	0	0	4	41	132	687	-	-	-	-	864
1994	0	0	0	7	182	528	-	-	-	-	717
1995	0	0	6	80	455	1100	14	58	-	-	1713
1996	0	0	5	315	641	2181	1802	4062	5993	2563	17563
1997	0	0	1	101	273	1188	2026	3011	4583	1417	12600
1998	0	0	100	239	609	1363	2102	4166	538	1996	11113
Div. 3N											
Depth (m)	**91**	**183**	**274**	**366**	**549**	**731**	**914**	**1097**	**1280**	**1463**	**Total**
1990	0	0	0	21	0	0	-	-	-	-	21
1991	0	0	29	42	23	62	-	-	-	-	156
1992	0	0	0	10	0	-	-	-	-	-	10
1993	0	0	14	81	222	124	-	-	-	-	441
1994	0	0	0	21	57	196	-	-	-	-	274
1995	0	0	19	164	432	819	-	-	-	-	1434
1996	0	0	0	5	21	302	-	-	-	-	328
1997	0	0	78	419	645	407	-	-	-	-	1549
1998	0	0	216	707	1075	790	1495	1552	1209	1152	8195
Div. 3O											
Depth (m)	**91**	**183**	**274**	**366**	**549**	**731**	**914**	**1097**	**1280**	**1463**	**Total**
1991	0	0	0	0	19	6	-	-	-	-	25
1992	0	0	0	0	-	-	-	-	-	-	0
1993	0	0	0	0	22	57	-	-	-	-	79
1994	0	0	0	0	2	46	-	-	-	-	48
1995	0	0	0	0	49	111	-	-	-	-	160
1996	0	0	0	0	4	45	-	-	-	-	49
1997	0	0	0	0	66	141	-	-	-	-	207
1998	0	0	0	0	33	61	291	146	-	-	531

Table 5.- Roughhead biomass indexes(t) from the Canadian spring survey series (B. Atkinson pers. com.) and percentages of biomass in the Divisions surveyed. ns = not surveyed.

		Percentage of biomass (%)	
Year	**Biomass (t.)**	**3L**	**3N**
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	2854	97	3
1997	3125	88	12
1998	4919	86	14

Table 6.- Biomass indexes from the Canadian spring surveys series by depth intervals and Divisions (B. Atkinson pers. com.)

	Div. 3L							
Depth (m)	**91**	**183**	**274**	**366**	**549**	**731**	**914**	**Total**
1978	0	113	410	533	-	-	-	1056
1979	0	79	1065	806	-	-	-	1950
1980	0	111	1935	1555	-	-	-	3602
1981	0	0	1344	1323	163	-	-	2829
1982	0	0	110	404	-	-	-	513
1983	-	-	-	-	-	-	-	
1984	-	-	-	-	-	-	-	
1985	0	0	50	506	676	1117	-	2348
1986	0	0	301	769	-	-	-	1070
1987	0	0	662	1164	-	-	-	1827
1988	0	0	63	725	-	-	-	788
1989	0	0	361	1067	-	-	-	1428
1990	0	0	39	425	-	-	-	464
1991	0	0	0	121	10	119	-	250
1992	0	0	22	6	213	870	-	1111
1993	0	0	0	25	164	266	-	455
1994	0	0	0	18	324	269	273	884
1995	0	0	0	0	66	257	-	323
1996	0	0	0	112	1440	1225	-	2777
1997	0	0	21	59	1026	1643	-	2749
1998	0	0	0	328	2159	1734	-	4221

	Div. 3N							
Depth (m)	**91**	**183**	**274**	**366**	**549**	**731**	**914**	Total
1978	0	167	1088	443	-	-	-	1698
1979	0	0	127	28	-	-	-	155
1980	0	11	287	169	-	-	-	468
1981	0	5	139	142	-	-	-	286
1982	0	0	94	1	-	-	-	95
1983	0	0	0	0	-	-	-	0
1984	0	0	22	28	-	-	-	50
1985	0	0	0	84	-	-	-	84
1986	0	0	0	26	-	-	-	26
1987	0	0	17	236	-	-	-	253
1988	0	0	0	17	-	-	-	17
1989	0	0	0	11	-	-	-	11
1990	0	0	0	11	-	-	-	11
1991	0	0	0	0	0	14	-	14
1992	0	0	0	0	0	18	-	18
1993	0	0	0	0	7	77	-	84
1994	0	0	0	0	2	26	40	68
1995	0	0	0	0	5	19	-	24
1996	0	0	0	0	41	35	-	76
1997	0	0	0	45	193	138	-	376
1998	0	0	9	38	325	326	-	698

Table 7.- Roughhead grenadier biomass indexes from the deepwater Canadian surveys and percentages of biomass by Divisions (from Bowering et al. 1995).

		Percentage of biomass (%)			
Year	**Biomass (tons)**	**3K**	**3L**	**3M**	**3N**
1991	16215	26	39	34	0
1992	26588	16	34	39	11
1993	46668	15	48	25	13

Table 8.- Roughhead grenadier biomass estimates (tones) by depth from the deepwater Canadian survey series (from Bowering et al. 1995).

				Div. 3K			
Depth (m)	**367 – 549**	**501 - 750**	**751 - 1000**	**915 - 1097**	**1001 – 1250**	**1251 - 1500**	**Total**
1991	-	0	1236	-	1594	1443	4273
1994	-	0	0	-	1424	2713	4137
1995	-	456	602	-	2092	2508	6844
				Div. 3L			
Depth (m)	**367 – 549**	**550 - 731**	**732 - 914**	**915 - 1097**	**1098 – 1280**	**1281 - 1463**	**Total**
1991	-	960	882	775	3138	600	6354
1994	-	34	870	1161	6455	438	8960
1995	-	45	228	2925	14078	4899	22176
				Div. 3M			
Depth (m)	**367 – 549**	**550 - 731**	**732 – 914**	**915 - 1097**	**1098 – 1280**	**1281 - 1463**	**Total**
1991	0	0	1541	2449	1478	119	5588
1994	5	26	667	3165	5929	671	10465
1995	0	27	493	2907	7954	147	11526
				Div. 3N			
Depth (m)	**367 – 549**	**550 – 731**	**732 - 914**	**915 - 1097**	**1098 – 1280**	**1281 - 1463**	**Total**
1991	-	0	0	0	0	0	0
1994	-	2	203	827	886	1110	3026
1995	-	0	18	605	2600	2900	6122

Table 9. – Biomass indexes by depth strata in the bottom trawl Japanese survey in Div. 2GH in 1996 (From Yokawa and Satani 1997)

Depth (m)	**Biomass (t.) by Division**	
	2G	**2H**
201 – 300	9	0
301 – 400	77	46
401 – 500	590	46
501 – 750	91	53
751 – 1000	29	78
1001 – 1250	156	76
1251 – 1500	182	64
Total	1827	363
Total Biomass (t.)	**2290**	
% Total Biomass	80	20

Table 10.- Roughhead grenadier biomass indexes (t.) from the Spanish spring surveys in Div. 3NO.

	Year			
Depth (m)	**1995**	**1996**	**1997**	**1998**
55 - 92	0	0	0	0
93 - 184	0	12	0	0
185 - 274	0	0	0	0
275 - 366	12	0	35	11
367 - 549	0	45	42	64
550 - 731	363	213	73	701
732 - 914		630	1504	1924
915 - 1097		3943	5079	8399
1098 - 1280			12882	23243
1281 - 1463				16502
Total	374	4842	19615	50843

Table 11.- Roughhead grenadier results from the EU (Spain and Portugal) longline survey in Div. 3LMN in 1996 (from Cárdenas et al. 1996). Mean L = Mean total length (cm); Yield = mean weigth (kg) per 1500 hooks; Numbers= mean number per 1500 hooks.

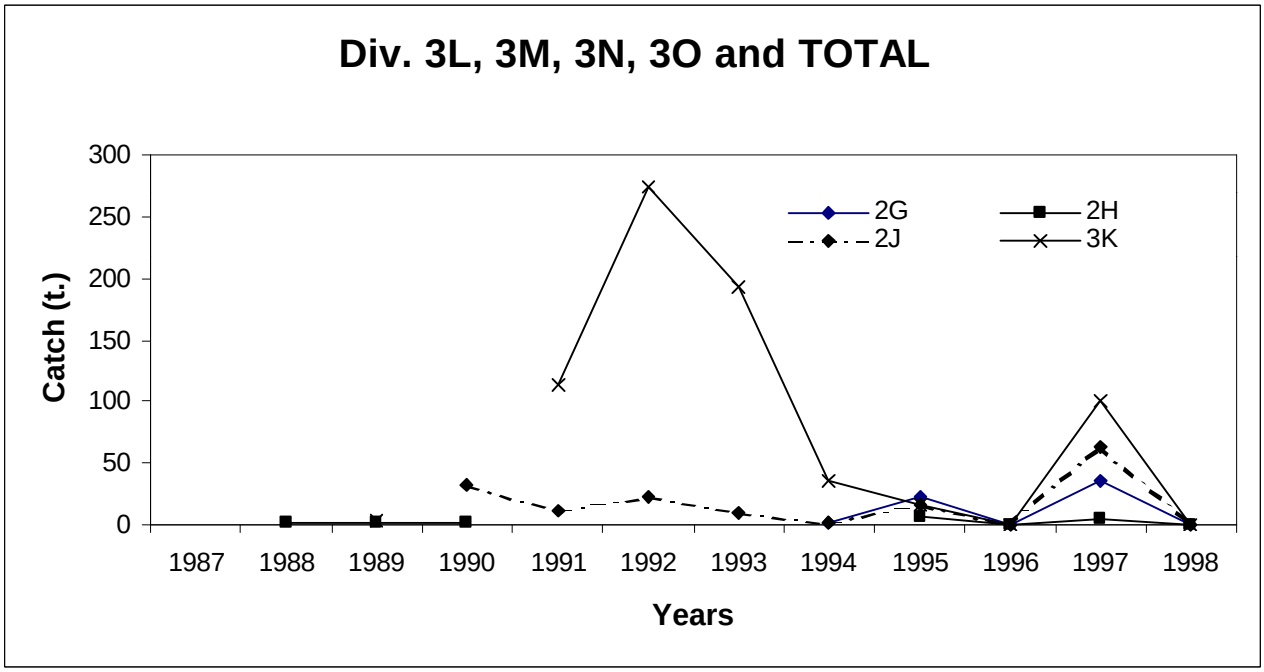
Depth (m.)	**Mean Length (cm)**	**Yield**	**Numbers**
700 - 999	52.6	73.8	87
1000 - 1299	53.8	258.7	282
1300 - 1599	55.6	119.7	115
1600 - 1899	57.2	106.5	93
1900 - 2199	58.7	50.1	40
2200 - 2499		0	0
2500 - 2799		0	0
2500 - 2799		0	0
2800 - 3100		0	0

Table 12.- Rouhhead grenadier biomass indexes (t.), and biomass per depth intervals from the EU summer survey in Div. 3M.

Depth (m)	**266 - 380**	**381 - 570**	**571 - 760**	**Biomass (t.)**
1988				2390
1989	17	364	642	1024
1990		241	773	1014
1991	7	327	1254	1587
1992	33	417	1426	1878
1993	25	895	2675	3595
1994		288	2058	2350
1995	35	533	1286	1855
1996	228	482	910	1619
1997	26	359	1039	1424
1998	48	510	1454	2012

Table 13.- Input parameters of the roughhead grenadier yield per recruit analysis.

AGES	Partial R.	Mean W	M	Mat. Og.
2	0.22	0.053	0.2	0.000
3	0.30	0.091	0.2	0.000
4	0.36	0.125	0.2	0.000
5	0.41	0.150	0.2	0.000
6	0.58	0.239	0.2	0.000
7	0.69	0.309	0.2	0.000
8	0.81	0.404	0.2	0.001
9	0.87	0.477	0.2	0.002
10	0.93	0.582	0.2	0.004
11	0.96	0.693	0.2	0.009
12	0.98	0.847	0.2	0.025
13	0.99	0.959	0.2	0.048
14	1.00	1.118	0.2	0.106
15	1.00	1.693	0.2	0.602
16	1.00	2.412	0.2	0.948
17	1.00	2.774	0.2	0.981
18+	1.00	3.124	0.2	0.999



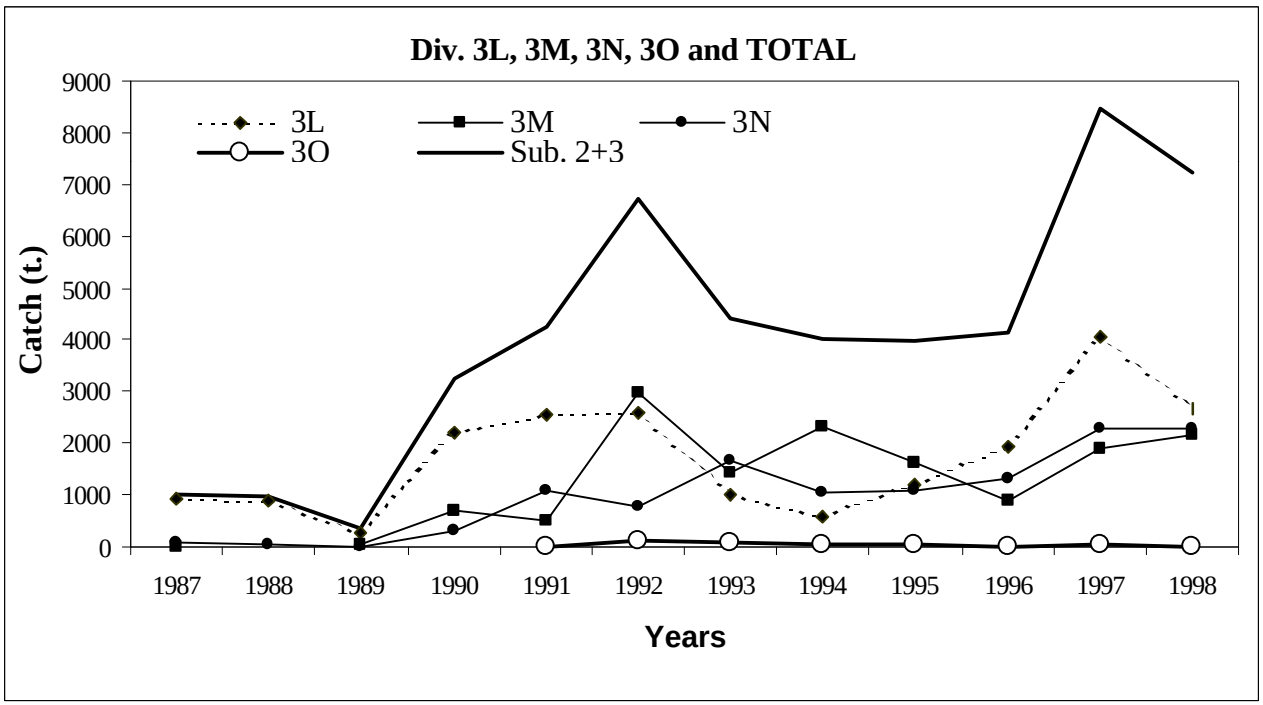


Figure 1.- Roughhead grenadier nominal catches by Division and the total for Subareas 2+3.

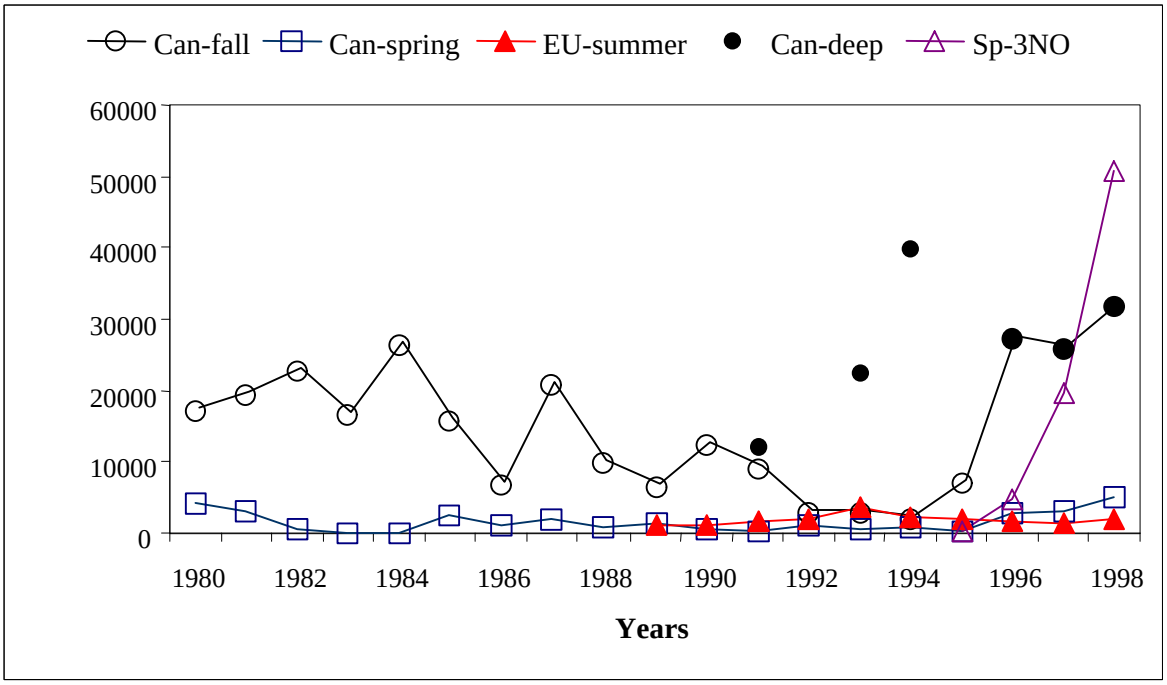


Figure 2.- Roughhead grenadier survey biomass indexes from Subareas 2 + 3.

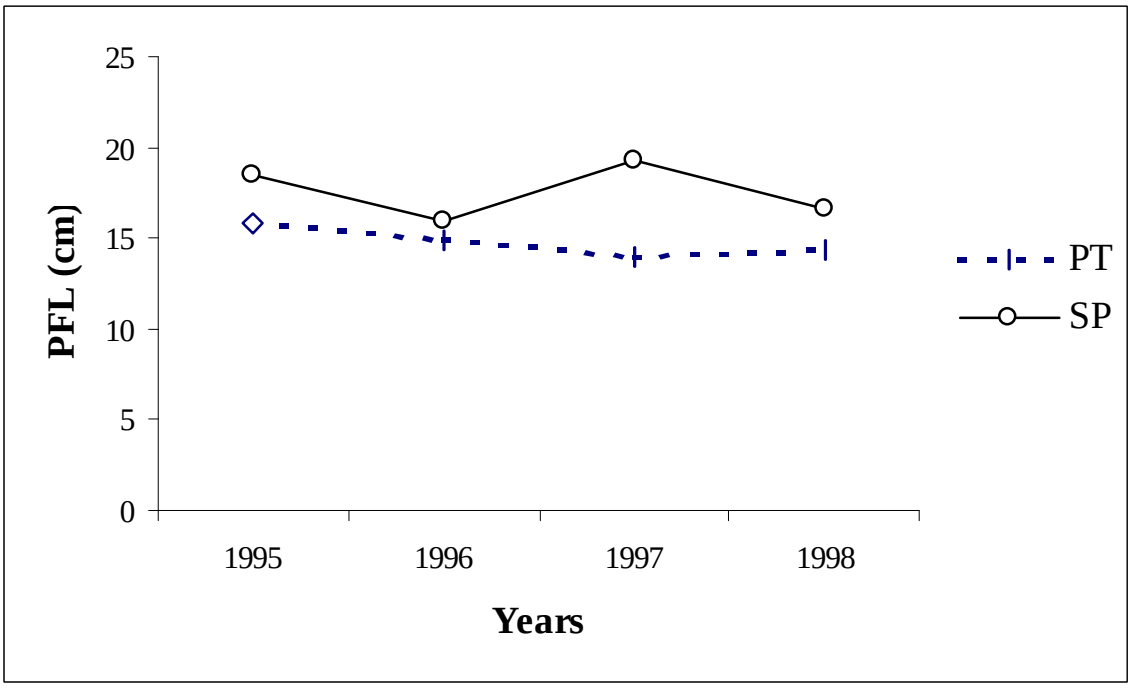


Figure 3.- Roughhead grenadier mean lengths (preanal fin length) in the Spanish (SP) and Portuguese (PT) catches.

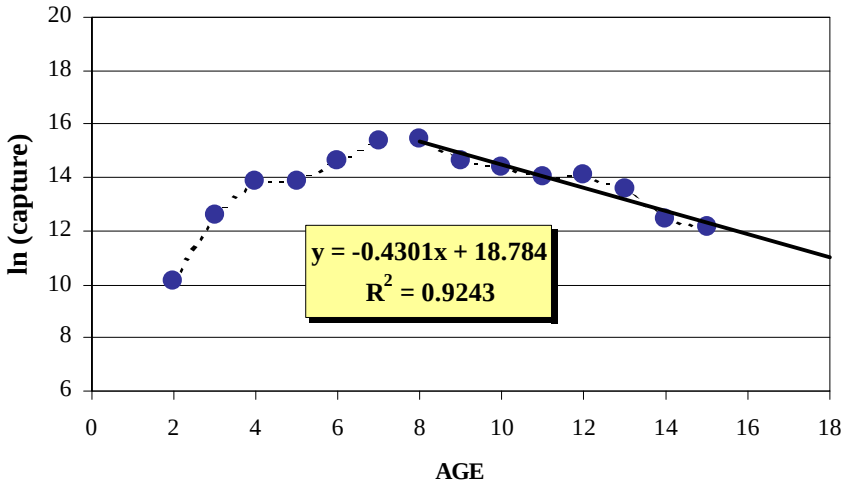


Figure 4.- Roughhead grenadier catch curve (1997 – 1998) and Z estimate as the slope of the regression line for ages 9 and older.

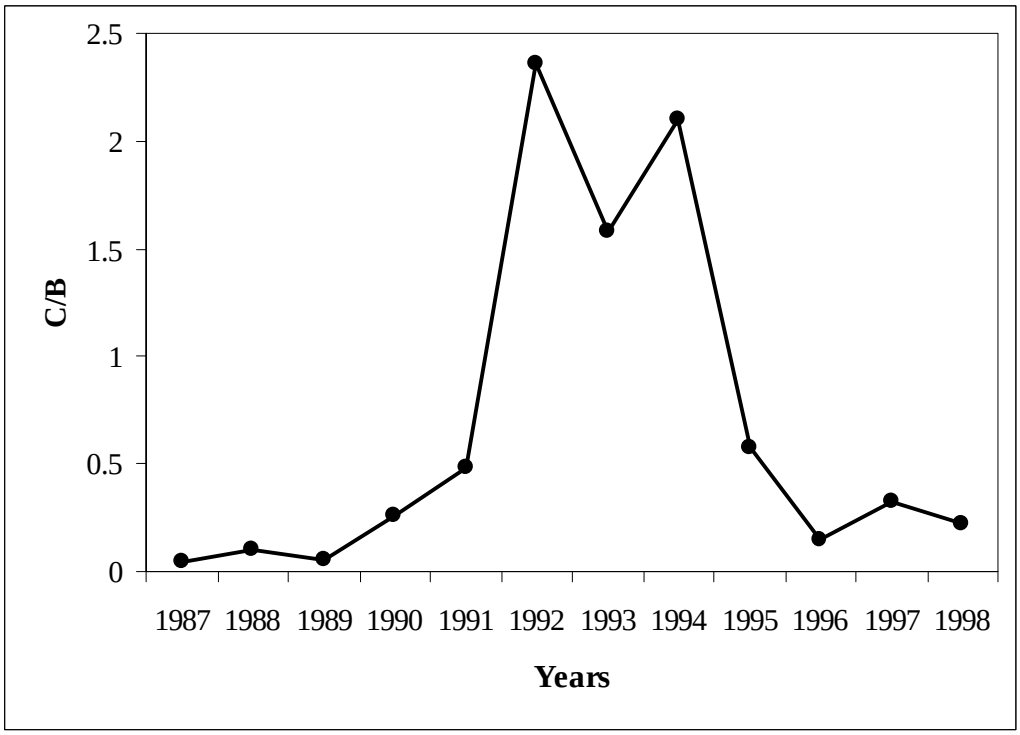


Figure 5.- Roughhead grenadier C/B Index.

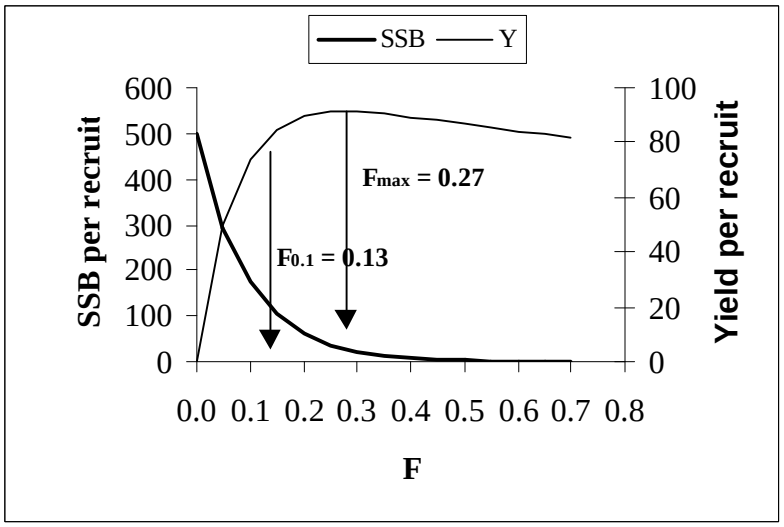


Figure 6.- Roughhead grenadier yield per recruit analysis.