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Roughhead Grenadier (*Macrourus berglax*) Population Structure on Flemish Cap, 1998

by

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ABSTRACT

The European Union has conducted in 1998 a random-stratified bottom trawl survey in Flemish Cap (NAFO Div. 3M) in the 200-720 m depth range. Age-length key, length composition, age composition, sex-ratios, distribution of captures and total biomass estimated by the swept area method for roughhead grenadier (*Macrourus berglax*) are presented in this paper.

Age and length composition of the catches showed clear differences between both sexes. The importance of males in the capture declines in larger fish and they disappear from the capture in largest length classes. The 8-year age class dominates captures. The oldest male found was 14 years old, while oldest female was 17 years old. For larger classes, females grow faster than do males. Results confirmed the relatively slow growth and multiaged structure of *Macrourus berglax* in the sample area

INTRODUCTION

The population dynamics and biology of roughhead grenadier (*Macrourus berglax*) have been proved difficult to study due to its distribution in depths greater than 500 m and its relatively few importance as a commercial species in the Northwest Atlantic (Casas, 1994). Nevertheless, the importance of grenadiers in the Spanish commercial fishery catch in relation to target species increased in the period 1991-1997. At the beginning of the fishery grenadiers were usually discarded. Since then, its commercial importance increased and it has become the main component in the by-catch of the Spanish and Portuguese Greenland halibut fishery (Paz and Iglesias, 1994; Cardenas et al., 1996; Alpoim et al., 1997). Total catches of roughhead grenadier in Div. 3LM averaged about 5100 t from 1991 to 1994 (Atkinson, D.B. et al. 1994). The impact of the fishing pressure is unknown at present.

Since 1988 EU has conducted a random-stratified bottom trawl survey in Flemish Cap, in the 200-720 m depth range. The objective of this scientific survey is to obtain abundance indices and to study the population structure of the main species. Since 1994 roughhead grenadier is considered a target species within this project and its population structure and biological parameters are being studied (Casas, 1994; Sainza, 1996; Alpoim, 1997; Sarasua et al., 1998a).

The estimated biomass and age structure of roughhead grenadier (*Macrourus berglax*) on Flemish Cap in 1998 are presented in this paper. The results are presented taking into account that the survey only covers the shallowest distribution area of *Macrourus berglax*. Roughhead grenadier inhabits depths between 300-2000 m (Snelgrove and Haedrich, 1985; Cardenas et al. 1996) and it has been found in depths up to 2700 m (Savvatimsky, 1989).

MATERIAL AND METHODS

Total biomass of *Macrourus berglax* on Flemish Cap was estimated by the swept area method based on the random-stratified bottom trawl survey carried out by the European Union on the area in July-August 1998 (for methodology, see Vázquez, 1998). Distribution and description of strata and number of hauls by strata are presented in Table 1 and Figure 1.

Individuals were measured from tip of snout to base of first anal-fin ray, in 0.5 cm intervals, as adopted by NAFO in June 1980 (Atkinson, 1991) as a standard measurement for roundnose and roughhead grenadiers. Length is presented as anal-fin length (AFL) and data are given in 1-cm intervals. Total weight was recorded accurate to the nearest 10 g.

Otoliths were broken through the nucleus and read by transmitted light (Casas, 1994). Many difficulties in reading Macrouridae age from otoliths and scales have been reported previously (Savvatimsky, 1984). Age reading in larger fish (more than 9 years old) is more complicated since many rings are present and they lie close to each other. Nevertheless, intercalibration of readings between three readers was done within this project in 1997 and 80% of agreement was reached. Differences were ± 1 year in otoliths between 2-10 years and 1, 2 years in older individuals (Rodríguez-Marín et al., 1998).

RESULTS and DISCUSSION

Table 2 and Figure 2 show length distribution of roughhead grenadier on Flemish Cap for 1998. Captures are dominated in 1998 by the 13-19 cm length classes. The importance of males in the capture declines in larger fish and they disappear from the capture in largest length classes (>24 cm). Females reach 34 cm long. Mean length for both sexes together was 15,3 cm. This value lies very close to the average for the 1991-1997 period in Flemish Cap, which is 15,52 cm (Sarasua et al., 1998b).

The AFL-Age key, as well as mean length at age and standard deviation are given by sex in Table 3 and the mean AFL at age by sex is presented in Figure 3. Table 4 and Figure 4 show age composition by sexes for *Macrourus berglax* on Flemish Cap in 1998. The 8 year age class dominates capture. The strength of this year-class has been cited in previous surveys (Alpoim, 1997; Sarasua et al., 1998a) and is confirmed by the 1998 survey. *Macrourus berglax* has a prolonged life cycle and multiaged population structure.

Differences between sexes are also seen in the age composition of the capture. The oldest male found in the 1998 survey was 14 years old, while oldest female was 17 years old. Similar differences have been also observed in previous surveys in Flemish Cap (Sainza, 1996; Alpoim, 1997; Sarasua et al., 1998a). Jorgensen (1996) in Subdivisions 1ABCD, and Savvatimsky (1994) in Subdivisions 0, 2GHJ and 3K found the oldest female to be 19 and 22 years old, respectively. The oldest male found by both authors was 13 years old.

Mean length at age was similar for males and females for ages under 9 years. Males grow slower from this length onwards, as well as they start disappearing from the capture. These differences in AFL have been found in many fish species and they seem to be related with reaching maturity (Scott, 1988; Cárdenas, 1996; Murua and Motos, 1997). Savvatimsky (1994) and Jorgensen, (1996) using scales for ageing fish described similar growing pattern for roughhead grenadier, although they found differences in growth to be from 10 years upwards. The complex multy-mode length structure corresponds to a typical deepwater slow-growing species (Casas, 1994; Savvatimsky, 1994). All these results must be taken with care due to the small proportion of the roughhead grenadier distribution area covered by the survey.

Figures 5a, b and c show how length, weight and age increase with depth. With an increase in depth from 200 m to 700 m, the mean AFL grew from 12.8 cm to 19.3 cm; mean weight increased from 252.5 g to 662.6 g; and mean age from 7.0 to 10.2 years. An opposite trend has been pointed out by some authors (Atkinson & Power, 1987; Parsons, 1975; Parsons, 1976). However, most studies on vertical distribution of grenadier in Northwest Atlantic waters for the period 1969-1989 have shown that larger specimens use to congregate at deeper waters (Savvatimsky, 1998). Increase in size at depth is also typical of other deep sea fish species, specially Greenland halibut (Bowering, 1987; de Cárdenas et al., 1996; Gorchinsky, 1996) and roundnose grenadier (Atkinson & Power, 1987; Savvatimsky, 1987).

Female-ratio in the whole capture is 51%. Figures 6 and 7 present sex-ratio by length and by age respectively. Females are more abundant in most length-classes. Males dominate the central part of the length distribution (11-19 cm AFL). In the sex-ratio by age, female proportion fluctuates around 45%-50% the first 11 years. It increases from age 12 upward. Female-proportion reaches 67% in year-group 13 and 76% in year-group 14. Females are 100% of the capture after that. Similar sex-ratio, with males being more abundant in the central part of the population, is described by Savvatimsky (1994) for Northwestern Atlantic.

Length-weight relationship is shown in Figure 8-a for females and 8-b for males. The relationship between fish length (AFL) and fish weight was assumed to be adequately expressed by the exponential function. Differences were noted between males and females. Relationship for females is $W(g) = 0.1199 * AFL(cm)^{2.9015}$. For males, $W(g) = 0.1389 * AFL(cm)^{2.8476}$.

Length frequency and age composition of the capture by strata are shown in Table 5 and Table 6 respectively. Figure 9 shows total biomass estimated by the swept area method from 1988 to 1998. Biomass increased from 1989 to 1993 and it has been continuously decreasing since then. Data from 1998 survey show a small increase of biomass. The biomass increase from 1990 to 1993 coincides with the dominance of relatively abundant 1985 and 1986 year-classes (Alpoim, 1997; Sarasua et al. 1998a). The importance of these annual classes has declined sharply during last 4 years and the abundant 1990 cohort now dominates the captures.

ACKNOWLEDGEMENTS.

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Table 1. Distribution and description of strata and number of valid hauls by strata.

Strata	Depth range (fathoms)	Area (squared miles)	Valid Hauls
1	70-80	342	4
2	81-100	838	10
3	101-140	628	7
4	101-140	348	4
5	101-140	703	8
6	101-140	496	6
7	141-200	822	9
8	141-200	646	7
9	141-200	314	3
10	141-200	951	11
11	141-200	806	9
12	201-300	670	7
13	201-300	249	3
14	201-300	602	7
15	201-300	666	8
16	301-400	634	7
17	301-400	216	2
18	301-400	210	2
19	301-400	414	5
Total		10555	119

Table 2. AFL frequency of roughhead grenadier, *Macrourus berglax*, on Flemish Cap, 1998 (,000)

AFL (cm)	Males	Females	Ind.	Total
3	26	13	74	113
4	13	20		33
5	28	54	13	95
6	20	38	7	65
7	14	43		57
8	22	44		66
9	112	96		208
10	79	98		177
11	79	42		121
12	104	51		155
13	98	119		217
14	305	184	7	496
15	327	250		577
16	273	216		489
17	154	191		345
18	142	55		197
19	145	70		215
20	68	91		159
21	63	81		144
22	20	137		157
23		50		50
24	7	81		88
25		68		68
26		38		38
27		23		23
28		7		7
29		23		23
30		17		17
34		7		7
Total	2099	2207	101	4407

ind=sex not determined, M=males, F=female

17.5								8	3										11
18						1		1	1	1									4
18.5								1	2	1									4
19									1	3									4
19.5								1	3	1		1							6
20								1	1	3		2							7
20.5									1	1	2	2							5
21									1	3	2	1							7
21.5										1	1	1	2						5
22											3	2	1	2					8
22.5											2	6	2						10
23												1	2		1				4
23.5													2		1				3
24												1	2	2					5
24.5													5		1				6
25													3	4					7
25.5												1	1						2
26												1				1			2
26.5												1			1	1			3
27																	1		1
27.5															2				2
28																			0
29														1	1	1			3
30															1				1
30.5																	1		1
34																1			1
Total	2	19	18	16	7	27	45	58	22	17	10	20	20	9	8	4	2		304
%	0.65	6.25	5.92	5.26	2.30	8.88	14.80	19.07	7.23	5.59	3.28	6.57	6.57	2.96	2.63	1.31	0.65		100
Mean Length	3.0	6.0	8.6	10.0	10.7	13.5	15.1	16.3	17.5	19.2	21.6	22.4	23.7	24.6	26.4	28.9	28.8		16.3
St. Dv.	0.00	1.26	1.24	0.69	0.57	1.00	1.02	1.24	1.80	1.71	0.76	1.95	1.22	2.07	2.56	3.66	2.47		

Table 4. Age composition by sex of roughhead grenadier (,000). Flemish Cap, 1998.

AGE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total	%
F	13	130	135	121	49	201	322	410	155	120	73	149	147	68	61	31	15	2200	0.50
M	26	63	119	125	90	141	411	549	125	156	101	99	60	34				2099	0.48
Ind.	74	18	3	0	0	2	3	2	0	0	0	0	0	0	0	0	0	102	0.02
Tot.	113	211	257	246	139	344	736	961	280	276	174	248	207	102	61	31	15	4401	

Table 5. AFL frequency (,000) by strata. Flemish Cap, 1998

AFL (cm)	9	12	13	14	15	16	17	18	19	Total
3			64	20	13	7		8		113
4			12	7	6	7				33
5			19	7	19	30			20	95
6	8		6		6	22	9		13	65
7			6	13	6	14	9		7	57
8			6	13		15	18		13	66
9			13	20	6	7	149		13	208
10			6	26		14	93	17	20	177
11		15	12	20		44	9		20	121
12	16	15	13	26		22	28	8	27	155
13	40	7	19	27	13	37	47	8	20	217
14	16	37	26	112	26	81	102	17	80	496
15	40	30	39	92	71	81	56	17	153	577
16	8	22	64	126	52	89	56		73	489
17	16	14	26	20	52	51	37	8	120	345
18	8	7	12	27	32	29	19	8	54	197
19	8		12	14	19	52	18	25	67	215
20				14		59	38	16	33	159
21		22		20	6	22	19	8	47	144
22				20		37	9	25	67	157
23				13				17	20	50
24					6	29		25	27	88
25						29		25	13	68
26						15		17	7	38
27						15		8		23
28									7	7
29						7	9		7	23
30						7	9			16
31										
32										
33										
34						7				7

Table 6. Age composition (.000) by strata. Flemish Cap, 1998

Age	9	12	13	14	15	16	17	18	19	Total
1			64	20	13	7		8		112
2	5		39	20	32	57	22		33	208
3	3		19	31	9	35	125	4	29	255
4	1	4	12	37	3	29	123	10	26	245
5	5	10	9	26		36	23	6	23	138
6	31	29	30	54	16	54	66	10	54	344
7	50	40	56	143	58	112	113	25	142	739
8	42	46	83	163	108	162	118	17	223	962
9	10	10	23	42	32	47	33	7	76	280
10	7	6	12	34	31	59	34	19	73	275
11	3	5	4	22	15	41	19	20	45	174
12	1	14	2	22	7	65	26	38	74	249
13	1	6	1	17	7	52	12	49	61	206
14				3	2	26	4	20	46	101
15				4	1	21	8	16	11	61
16+						24	8	9	5	46
Sets	3	5	3	7	7	7	2	2	5	41

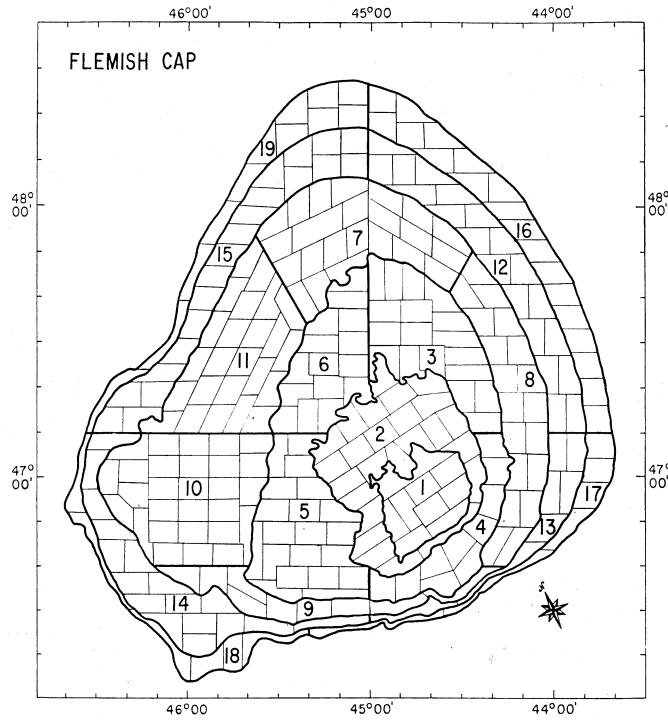


Figure 1. Distribution of strata and study areas in Flemish Cap.

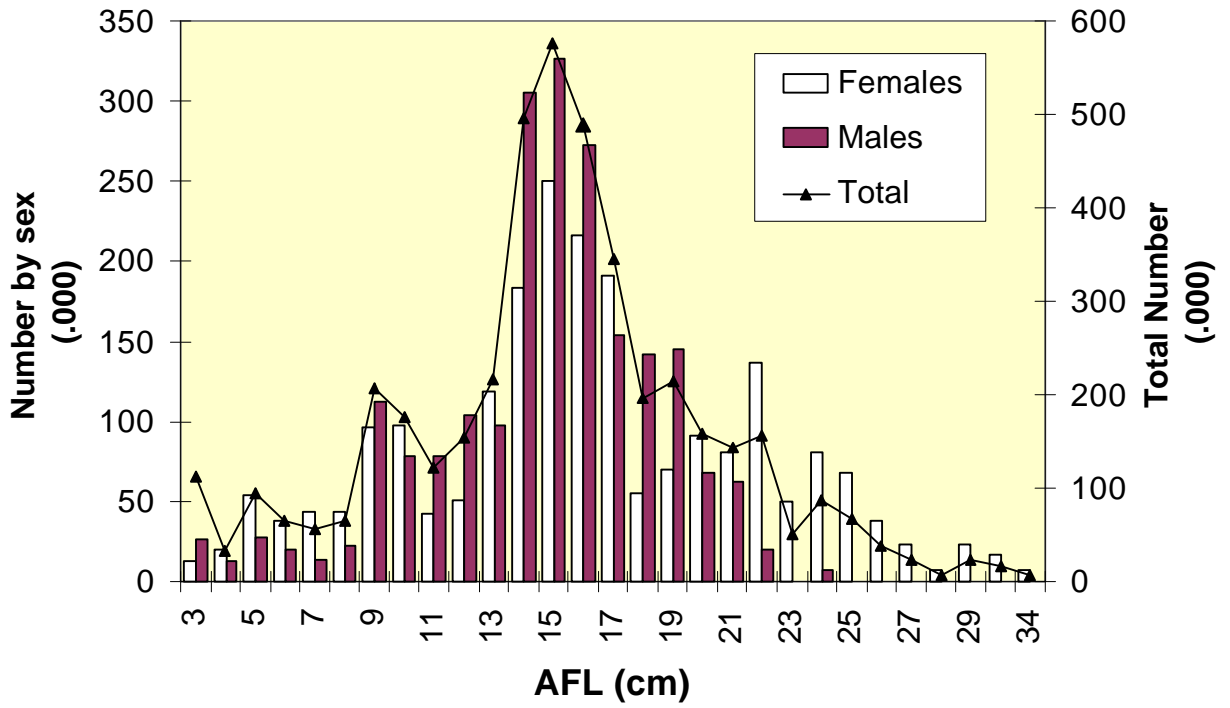


Figure 2. Roughhead grenadier anal-fin length frequency in Flemish Cap, 1998. M=males, F=females.

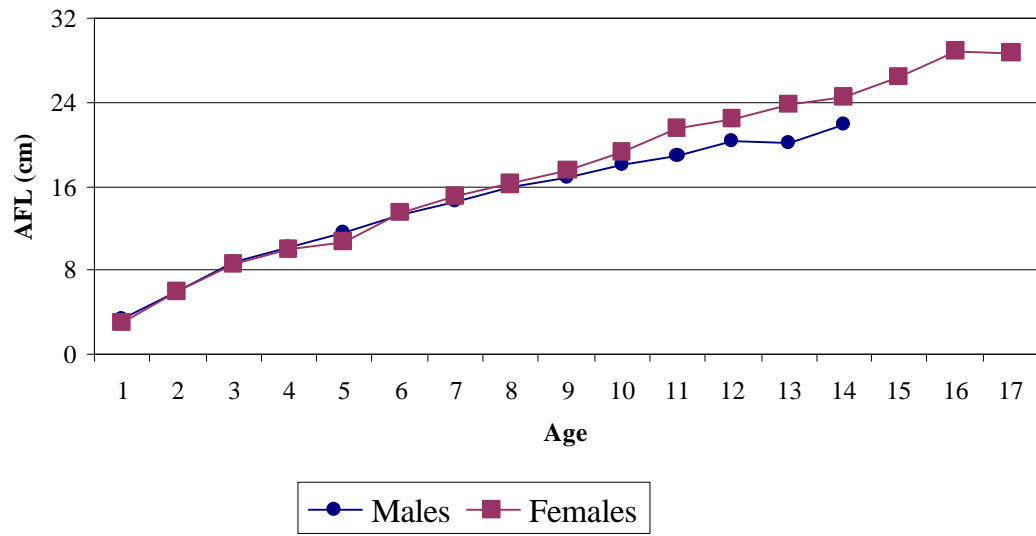


Figure 3. Mean AFL at age by sex for the survey.

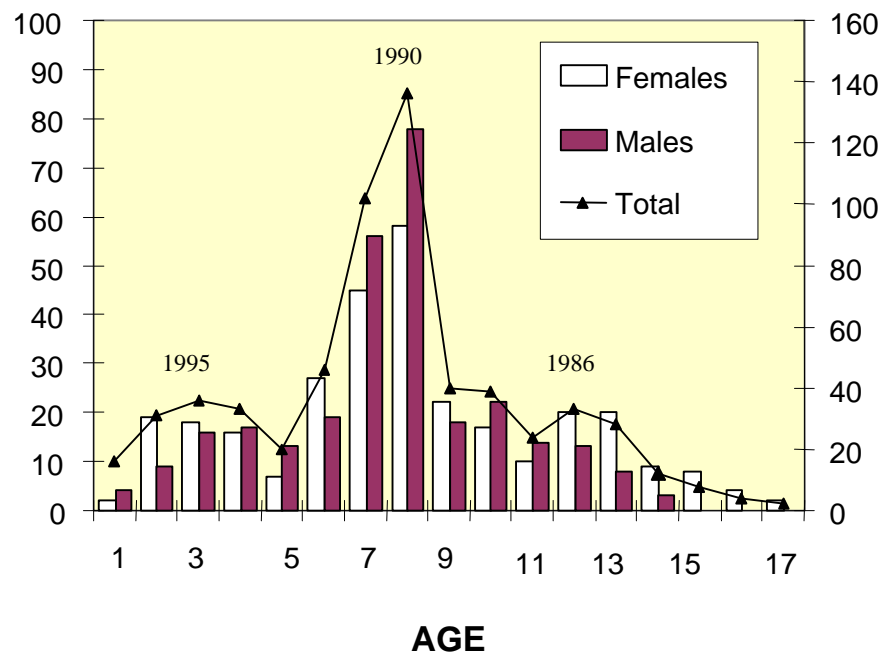
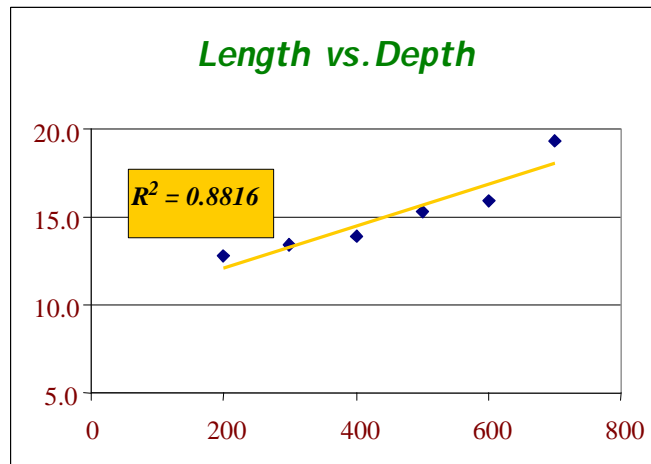
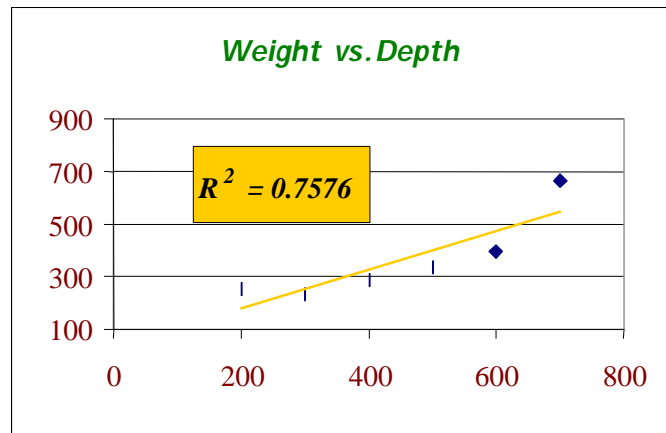


Figure 4. Roughhead grenadier age composition (,000) in Flemish Cap, 1998. By sex and total.

a/



b/



c/

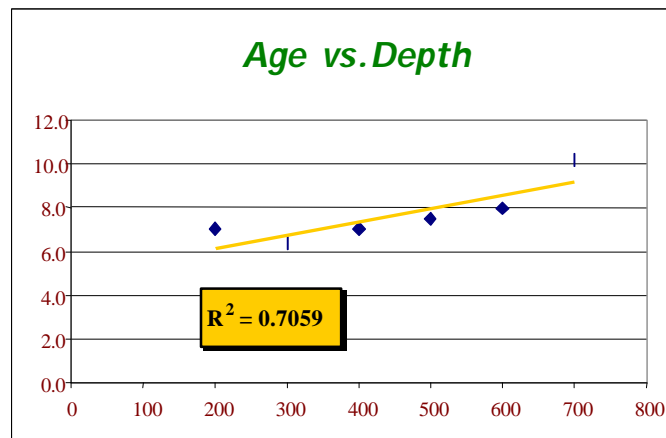


Figure 5. (a) Length at depth; (b) Weight at depth; (c) Age at depth.

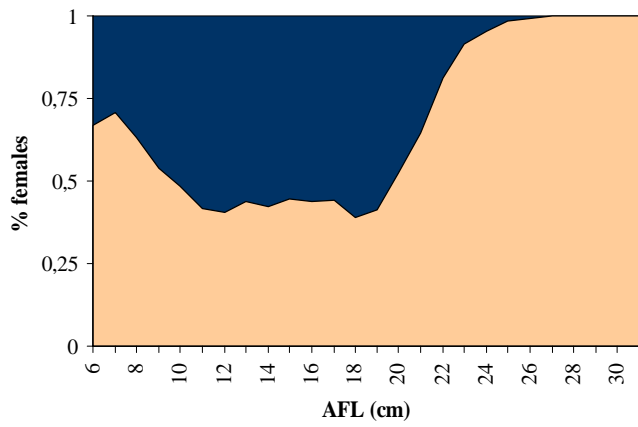


Figure 6. Female proportion by length in Flemish Cap survey, 1998.

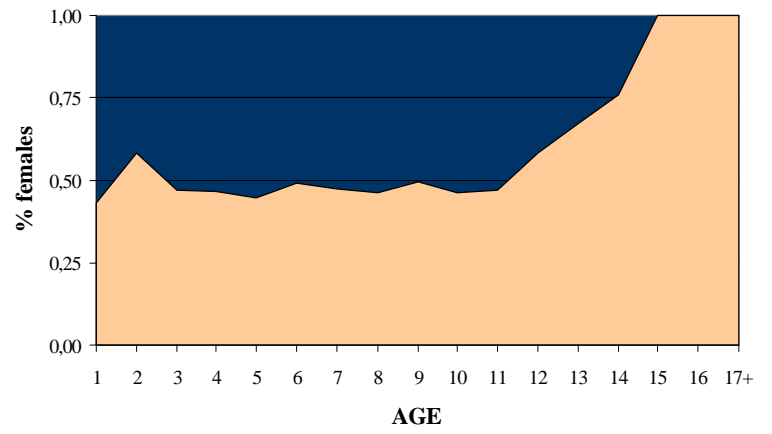
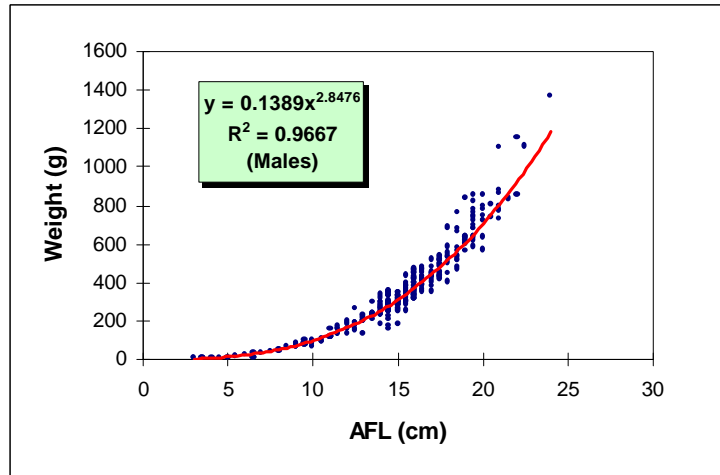
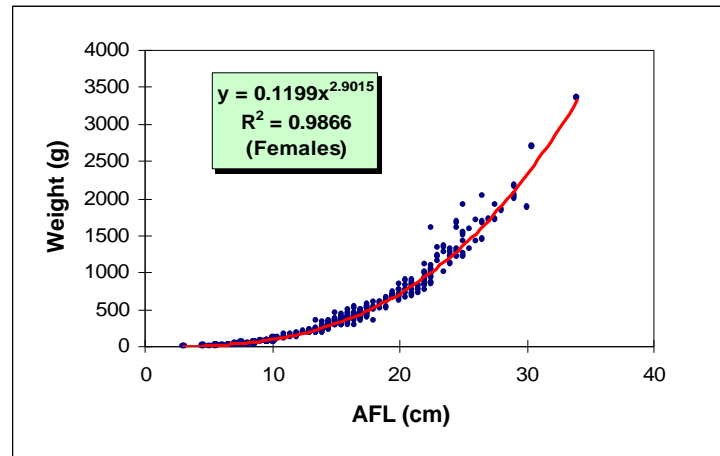


Figure 7. Female proportion by age in Flemish Cap survey,



(A)



(B)

Figure 8. Length-weight relations for roughhead grenadier in Flemish Cap Survey, 1998. (A) Males (B) Females.

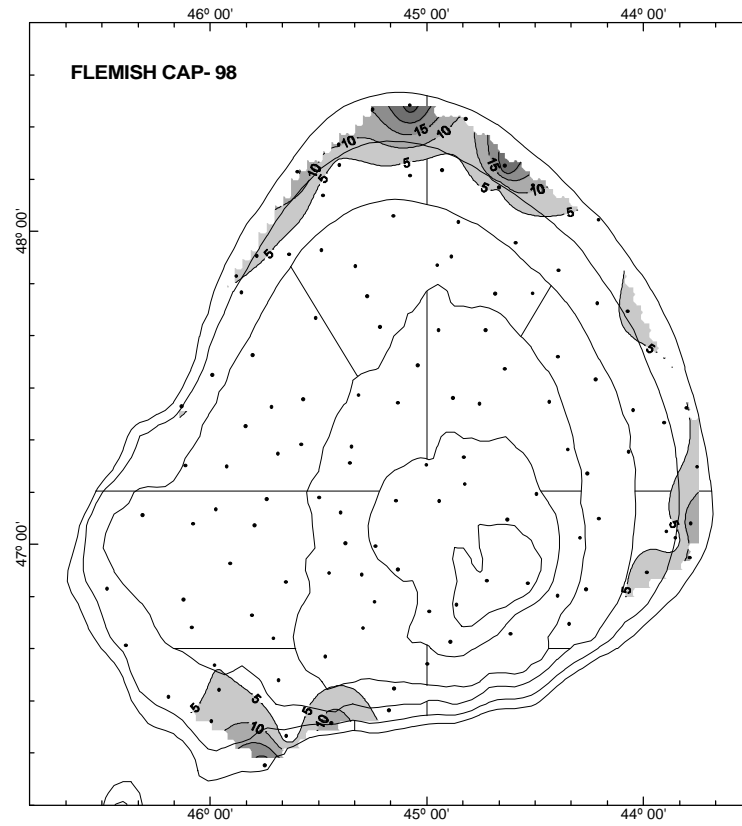


Figure 9. Distribution of captures on Flemish Cap survey, July-August 1998.

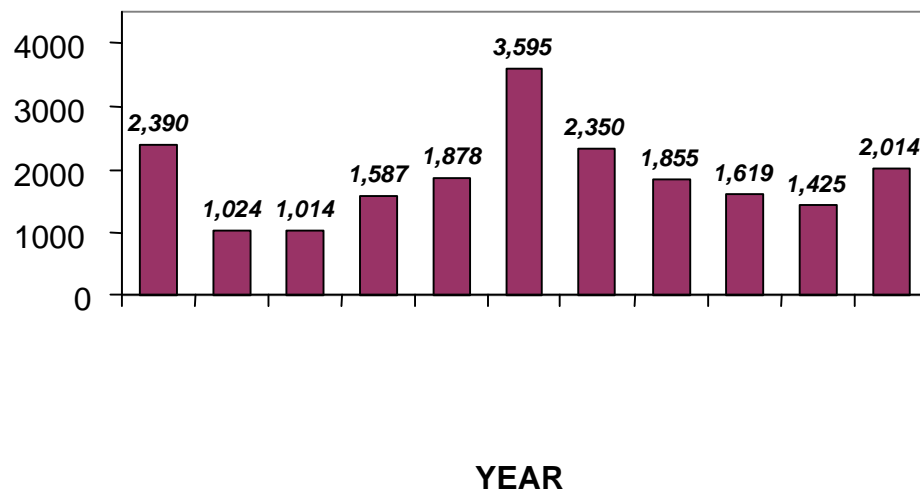


Figure 10. Roughhead grenadier biomass estimates by the swept area method, in European Bottom Trawl Surveys in Flemish Cap, 1988-1998.