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Population Structure of Roughhead Grenadier (*Macrourus berglax*) on Flemish Cap in 1997

A. Sarasua
AZTI, Technological Institute for Fisheries and Food
Satrustegi 8, 20008 San Sebastian-Donostia, Spain

M. Ruiz and E. Rodríguez-Marín
Instituto Español de Oceanografía
Aptdo. 240, 39080 Santander, Spain

ABSTRACT

The European Union has conducted 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.

Age and length composition of the catches showed clear differences between the two sexes. The importance of males in the capture declines in larger fish and they disappear from the capture in largest length classes. The 7-year age class dominates capture. The oldest male found was 14 years old, while oldest female was 18 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 small importance as a commercial species in the Northwest Atlantic (Casas, 1994). Nevertheless, the importance of grenadiers in the Spanish commercial fishery catch increased in the period 1991-1993 (Paz and Iglesias, 1994). At the beginning of the fishery grenadiers were usually discarded. However, its commercial importance increased subsequently to eventually become the main component in the by-catch of the Spanish and Portuguese Greenland halibut fishery (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, et al. 1994). The impact of the fishing pressure on the population 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 presented in the area. 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).

The estimated biomass and age structure of roughhead grenadier (*Macrourus berglax*) on Flemish Cap in 1997 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 down 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 1997 (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. 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 has been done and 80% of agreement has been reached. Differences were $\pm$ 1 year in otoliths between 2-10 years and 1, 2 years in older than 10 years (Rodríguez-Marín et al., 1998).

RESULTS and DISCUSSION

Table 2 and Figure 2 show length distribution of roughhead grenadier for 1997. Length is presented as anal-fin length (AFL). Captures are dominated in both sexes by the 12-16 cm length classes. The importance of males in the capture declines in larger fish and they disappear from the capture in largest length classes (>23 cm). Females reach 32 cm long. Mean length for both sexes together was 15.8 cm. This value lies very close to the average for the 1991-1997 period in Flemish Cap, which is 15.5 cm (Sarasua et al., 1998).

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 1997. The 7 year age class dominates capture. The strength of this year-class has been cited in previous surveys (Alpoim, 1997) and is confirmed by the 1997 survey.

Differences between sexes are also seen in the age composition of the capture. The oldest male found in the 1997 survey was 14 years old, while oldest female was 18 years old. Mean length at age was similar for males and females for ages under 8 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). *Macrourus berglax* has a prolonged life cycle and multiaged population structure with differences in growth between males and females. All these results must be taken with care due to the small proportion of the roughhead grenadier distribution area covered by the survey.

Female-ratio in the whole capture is 59%. Figures 5 and 6 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 (17-20 cm AFL). In the sex-ratio by age, female proportion fluctuates around 54%-64% the first 12 years. It increases from age 13 upward. Female-proportion reaches 70% in year-group 13 and 80% 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 North-western Atlantic.

Length-weight relationship for both sexes is shown in Figure 7-a for females and 7-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) = $0.1203*AFL(cm)^{2.8895}$. For males W (g) = $0.5352*AFL\ (cm)^{2.3843}$.

Distribution of captures are presented in Figure 8, and 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 1997. Biomass increased from 1989 to 1993 and is being continuously decreasing since then. The biomass increase from 1990 to 1993 coincides with the dominance of relatively abundant 1986 and 1987 year-classes (Alpoim, 1997; Sarasua et al. 1998). The importance of these annual classes has declined sharply during last 4 years and the abundant 1990 cohort now dominates captures.

Acknowledgements. This study was supported by the European Commission (DG XIV, Study 96-030) IEO and Basque Government.

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

Strata	Depth range (fathooms)	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	7
16	301-400	634	7
17	301-400	216	2
18	301-400	210	2
19	301-400	414	4
Total		10555	117

Table 2. AFL frequency of roughhead grenadier, *Macrourus berglax*, on Flemish Cap, 1997 (,000)

AFL (cm)	Ind	M	F	Total
3		7		7
4	14	7	14	35
5	16			16
6	22	15	15	52
7		29	82	111
8		39	59	98
9		16	60	76
10		40	54	94
11			31	31
12	7	107	59	173
13		100	95	195
14		171	224	395
15	8	139	170	317
16		106	102	208
17		45	45	90
18		69	58	127
19		96	67	163
20		88	60	148
21		70	37	107
22		14	99	113
23		7	76	83
24			82	82
25			45	45
26			52	52
27			53	53
28			22	22
29			15	15
30			0	0
31			7	7
32			8	8
Total	67	1165	1691	2923

ind=sex indeterminated, M=males, F=females

Table 3. AFL-age key by sex of roughhead grenadier in Flemish Cap, 1997. (a) Males.

MALES	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
3.5	1													**1**
4.5	1													**1**
6.5	1	1												**2**
7		1												**1**
7.5		3												**3**
8		3												**3**
8.5			2											**2**
9		1												**1**
9.5			1											**1**
10			1											**1**
10.5			2	2										**4**
12				1	5	1								**7**
12.5				3	4									**7**
13				2	5	3								**10**
13.5			1	1	2	1								**5**
14					7	4								**11**
14.5				1	4	7	1							**13**
15					3	4	2							**9**
15.5					2	6	1							**9**
16					1	7	1							**9**
16.5						1	2	2						**5**
17							1	2						**3**
17.5						1			3					**4**
18							1	3		2	1	1		**8**
18.5								2						**2**
19								3	2	3	1			**9**
19.5									2		2			**4**
20									1	2	4			**7**
20.5									1		2	1	1	**5**
21									1	3	1	2		**7**
21.5											1	1		**2**
22												1		**1**
22.5											1			**1**
23												1		**1**
Total	3	9	7	10	33	35	9	12	10	10	13	7	1	159
%	1.9	5.7	4.4	6.3	20.8	22.0	5.7	7.5	6.3	6.3	8.2	4.4	0.6	100
Mean Length	4.8	7.7	10.1	12.5	13.6	14.9	16.0	17.9	19.1	19.6	20.2	21.0	20.5	15.3
St. Dv.	1.53	0.71	1.70	1.23	1.15	1.16	1.12	0.95	1.26	1.17	1.13	1.55		

Table 3. Cont.. AFL-age key by sex of roughhead grenadier in Flemish Cap, 1997. (b) Females.

FEMALES	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	Total
4.5	2																2
5	1																1
6.5		2															2
7		6															6
7.5		5															5
8	1	2	1														4
8.5		3	1														4
9		2	2														4
9.5			3	1													4
10			3	1													4
10.5			2	1													3
11			2														2
11.5				2													2
12				1	1												2
12.5				1	3	1	1										6
13				2	3	2											7
13.5				2	3	2											7
14					6	7											13
14.5					9	8	1										18
15					1	9	2										12
15.5					2	6		1									9
16						5	3										8
16.5						4	1										5
17						2	2										4
17.5						1	1	1									3
18						1		2									3
18.5							2	2									4
19							1	2	2								5
19.5								3			1						4
20								1	1	1							3
20.5								2	1	2	1						6
21										3	1						4
21.5									1	1							2
22										3	3	1					7
22.5									1	3	2						6
23										2	4						6
23.5									1			2					3
24									1	2	2	4					9
24.5											1	2					3
25										1		1	1	1			4
25.5												2					2
26											2	1	1	2			6
26.5														2			2
27												2	2				4
27.5													2	1			3
28												1			1		2
28.5													1	1			2
29														2	1		3
31.5																1	1
Total	4	20	14	11	28	48	14	14	8	18	17	16	7	9	2	1	231
%	1.7	8.7	6.1	4.8	12	21	6.1	6.1	3.5	7.8	7.4	6.9	3	3.9	0.9	0.4	100
Mean Length	5.5	7.6	9.7	11.9	13.9	15.1	16.4	18.8	21.3	22.1	22.9	24.9	26.9	27.1	28.5	31.5	17.0
St. Dv.	1.68	0.77	0.89	1.40	0.90	1.19	1.77	1.32	1.95	1.36	1.73	1.55	1.13	1.45	0.71		

Table 4. Age composition by sex of roughhead grenadier (.000) in Flemish Cap, 1997.

AGE	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Tot.	%
F	21	149	106	89	230	309	110	111	63	130	127	110	55	56	18	0	18	1684	0.586
M	14	83	53	73	214	284	59	71	78	74	103	44	15	0	0	0	0	1165	0.397
Ind.	37	16	0	2	6	5	0	0	0	0	0	0	0	0	0	0	0	66	0.017
Tot.	72	248	160	164	450	598	170	182	141	204	229	153	70	56	18	0	18	2915	

Table 5. AFL frequency (.000) by strata in Flemish Cap, 1997

length	8	9	12	13	14	15	16	17	18	19	total
3-						7					7
4-	7					21				7	35
5-								8		7	16
6-			31		7	7	7				52
7-			31			21	28	8	8	14	111
8-	14			7	7		21	34	8	7	98
9-			31				21	8	8	7	76
10-			8		14		7	50		15	94
11-			23							7	31
12-	7		31		21	14	21	33	16	30	173
13-	7	16	8		34	14	35	50	16	15	195
14-		8	62		107	21	57	42	39	59	395
15-		8	62	20	40	42	42	25	55	22	317
16-			38	7	27	28	21	34	16	37	208
17-		8	16		13	7	14	16	8	7	90
18-		8	16	14	7	14	7	17	24	22	127
19-		8	8	14	7	7	49	17	31	22	163
20-					7	21	14		46	60	148
21-							14	8	47	37	107
22-			31		7		28	17	23	7	113
23-			8				21	8	23	22	83
24-							35	8	16	22	82
25-			15			7	7		8	7	45
26-			8				14		16	15	52
27-								8		45	53
28-										22	22
29-							7		8		15
30-											
31-										7	7
32-								8			8
Sets:	1	1	7	2	7	2	7	2	2	4	35

Table 6. Age composition (.000) by strata in Flemish Cap, 1997

age	8	9	12	13	14	15	16	17	18	19	total
1 :											
2 :	8		2	1	3	28	4	10		15	71
3 :	9		69	4	10	29	53	35	16	21	246
4 :	5	1	36	2	11	1	25	47	10	21	159
5 :	3	4	32		24	7	20	41	10	22	163
6 :	7	13	66	5	88	34	65	67	47	56	448
7 :	3	15	97	16	102	62	84	76	71	72	598
8 :		6	29	9	22	19	22	22	19	22	170
9 :		9	19	12	15	12	28	23	31	34	183
10 :		3	12	6	10	7	25	15	33	31	142
11 :		1	20	2	5	9	41	15	60	50	203
12 :		2	22	4	7	14	50	20	60	50	229
13 :		1	12	1	1	5	35	13	31	54	153
14 :			5		1	4	4	5	11	40	70
15 :			6			1	13	1	14	20	55
16+:							2		3	13	18
Sets:	1	1	7	2	7	2	7	2	2	4	35

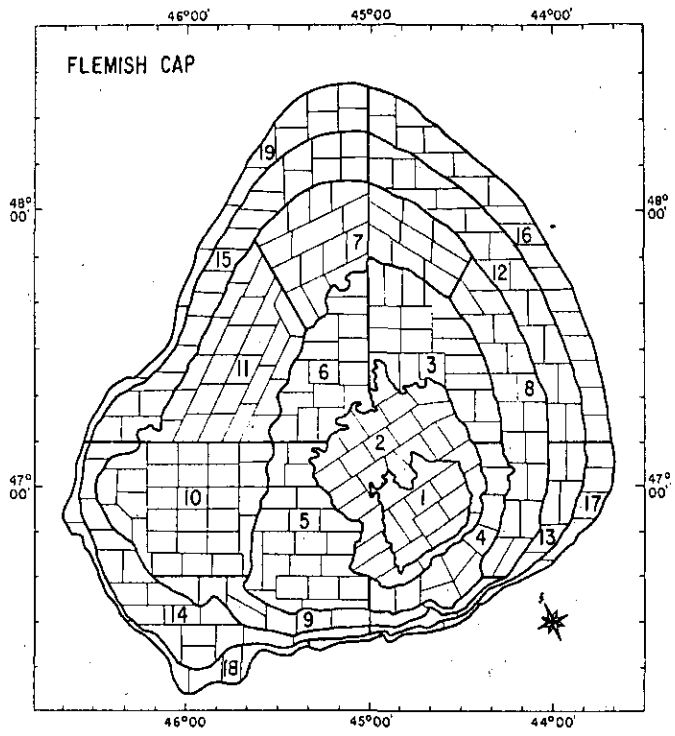


Figure 1. Distribution of strata and study areas in Flemish Cap.

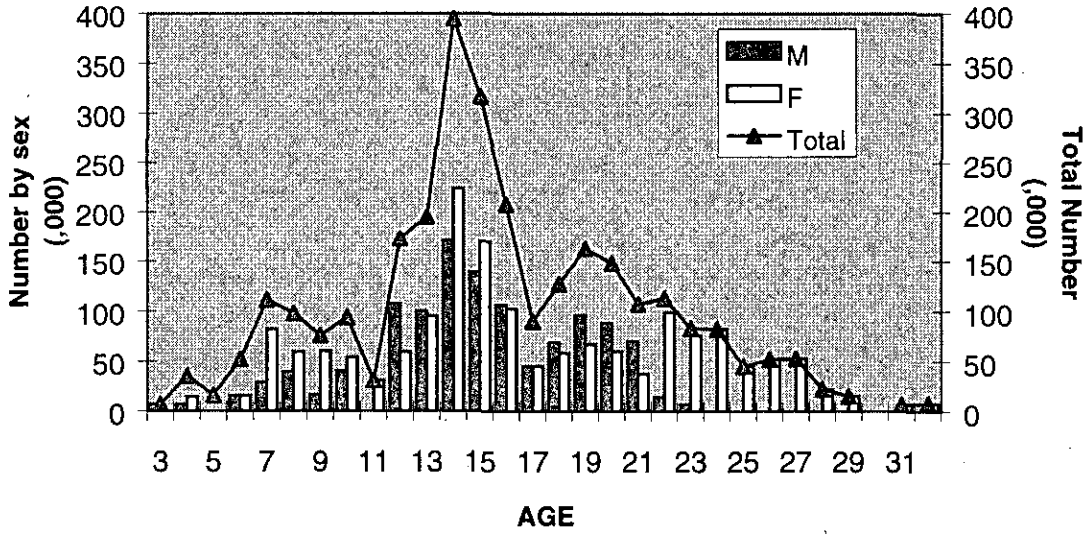


Figure 2. Roughhead grenadier anal-fin length frequency in Flemish Cap, 1997. M=males, F=females.

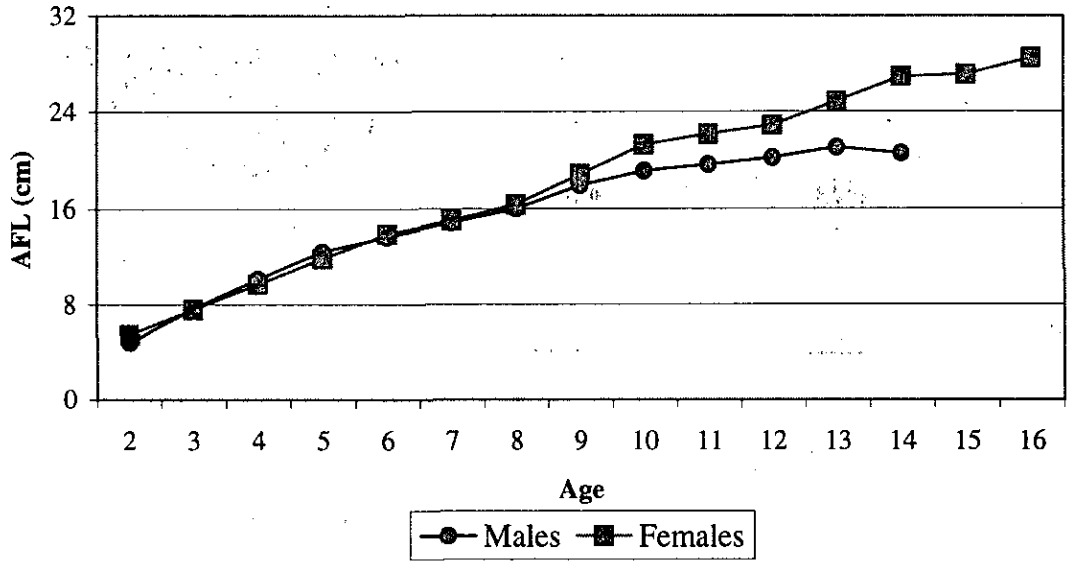


Figure 3. Mean AFL at age by sex.

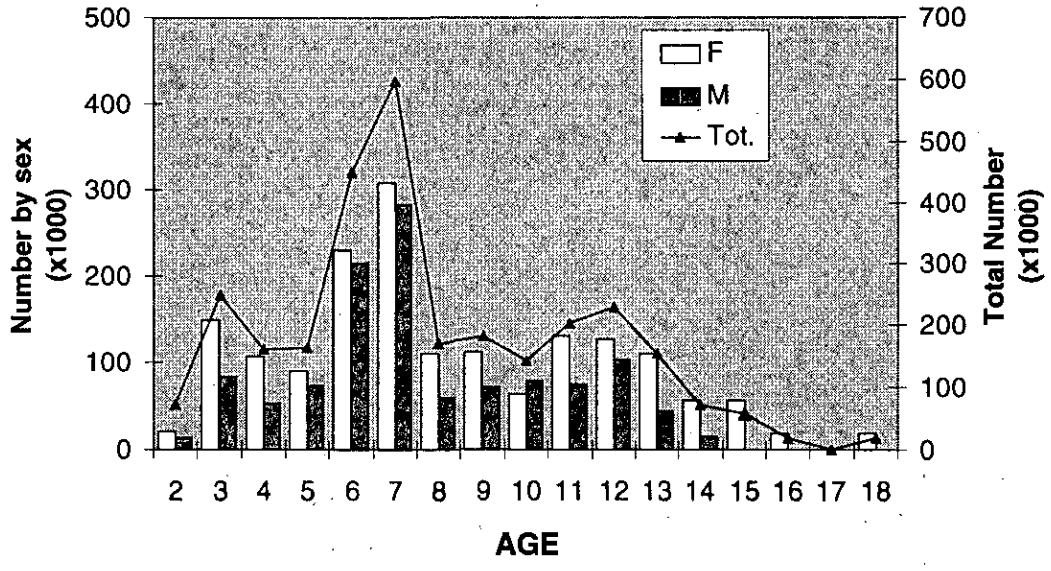


Figure 4. Roughhead grenadier age composition (.000) in Flemish Cap. 1997. By sex and total.

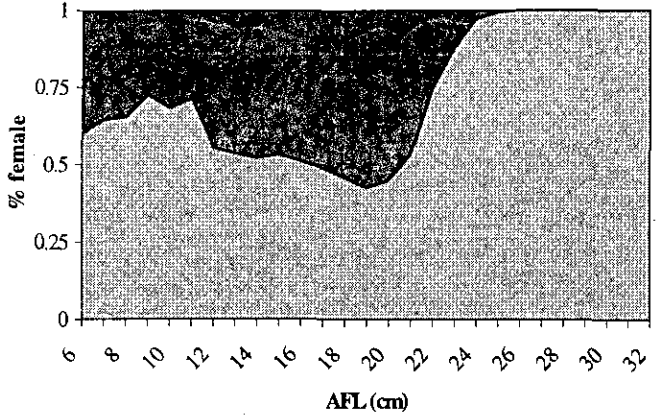


Figure 5. Female proportion by length in Flemish Cap, 1997.

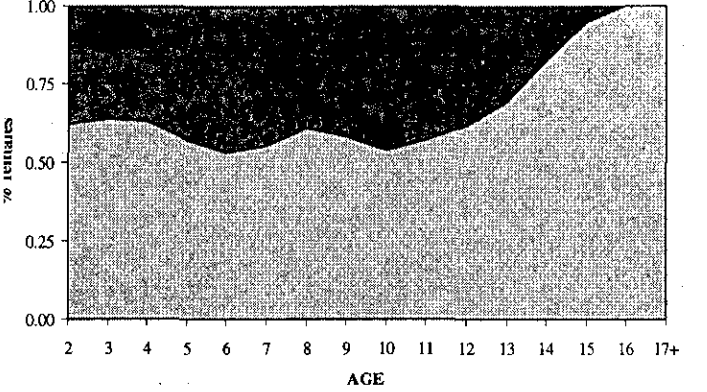
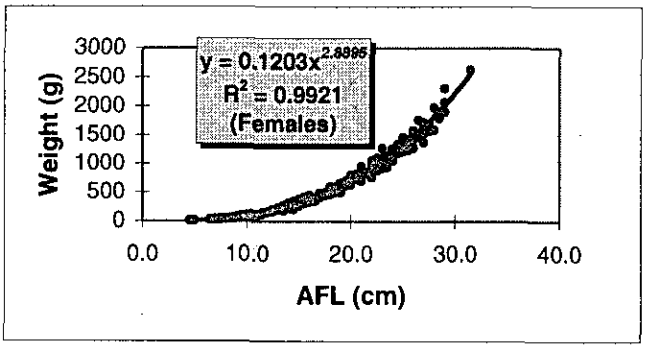
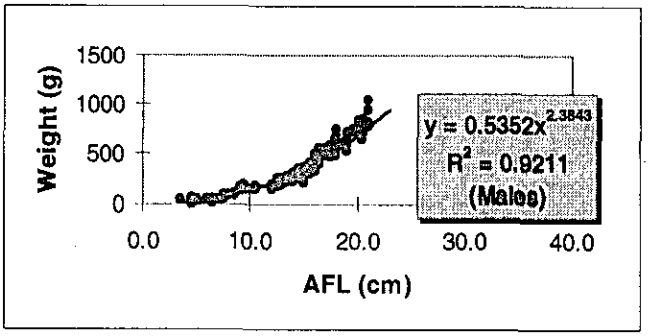


Figure 6. Female proportion by age in Flemish Cap, 1997.



(A)



(B)

Figure 7. Length weight relationship for roughhead grenadier in Flemish Cap, 1997. (a) females (b) males

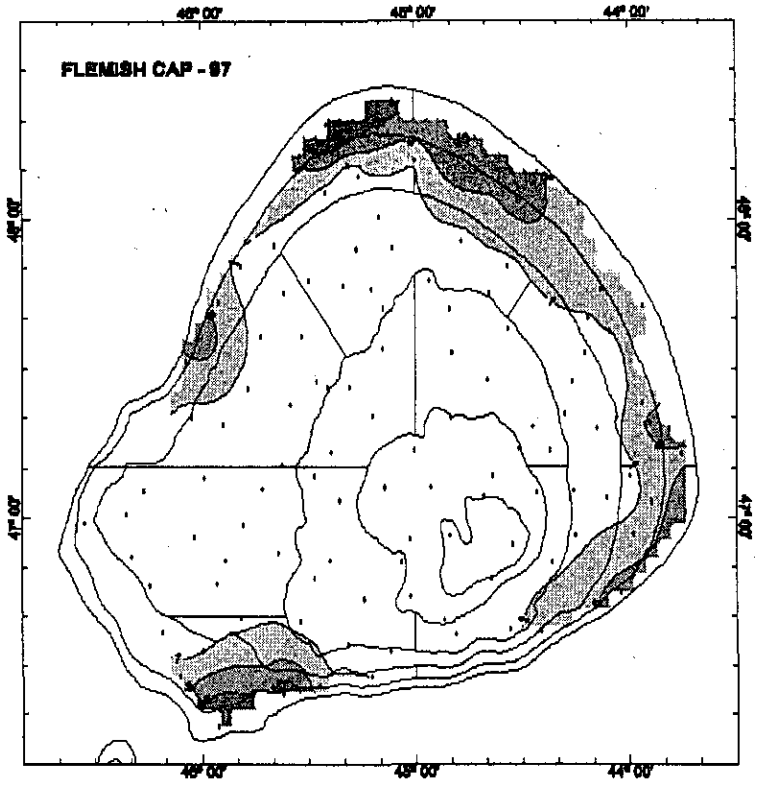


Figure 8. Distribution of captures on Flemish Cap-97 Survey, July 1997.

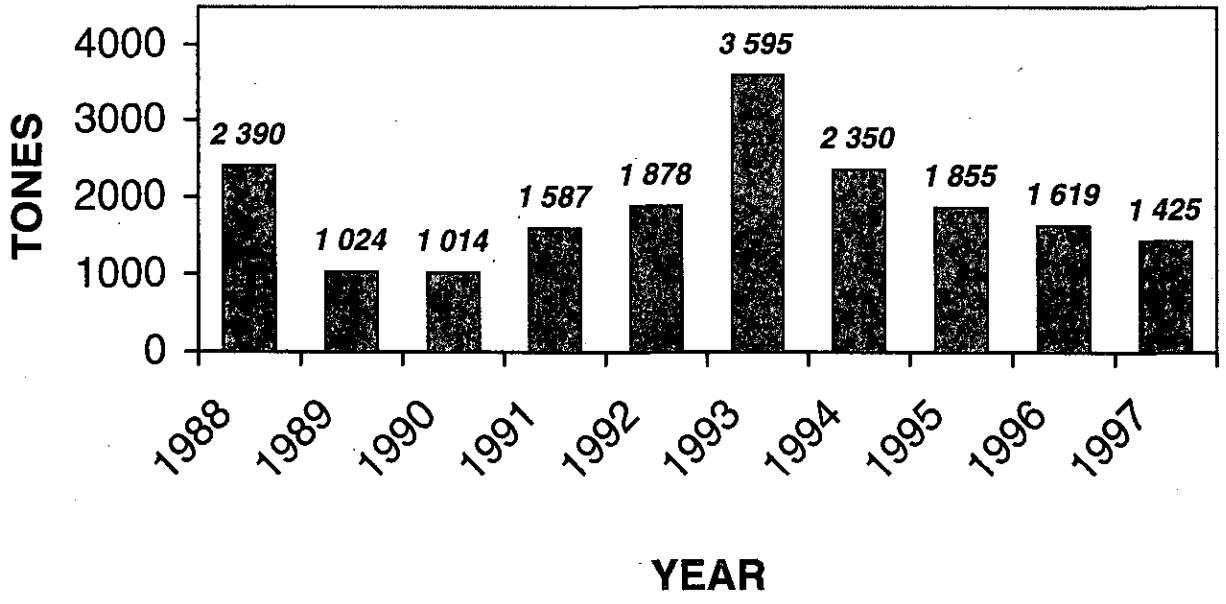


Figure 9. Biomass estimates by the swept area method, in Flemish Cap, 1988-1997.