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A review on roughhead grenadier (*Macrourus berglax*) biology and population structure on Flemish Cap (NAFO Division 3M) 1991-2007 based upon EU Flemish Cap bottom survey data

by

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### ABSTRACT

The European Union has conducted since 1988 an annual bottom trawl survey in Flemish Cap (NAFO Div. 3M) in the 200-720 m depth range. The information on roughhead grenadier population structure recorded during the last 17 EU surveys (1991-2007) in Flemish Cap is presented. Depth and length/age distribution of captures, sex-ratios, catch curves, and abundance/biomass estimated by the swept area method are presented.

In general, the biomass index increased from low levels to a peak of about 3000 tons in 1993, then decreased steady till 1997, since then remained around 1500 and 2000 tons till 2002. It increased again in 2003 to reach highest levels of the time series in 2004 and 2006 with 3575 and 3993 tons respectively. The biomass index in 2007 dropped sharply to 1367 tons.

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, disappearing from the capture in largest length classes.

Results show that roughhead grenadier has a prolonged life cycle and multiaged population structure with differences in growth and mortality between males and females.

### INTRODUCTION

The roughhead grenadier (*Macrourus berglax* Lacépède, 1802) is an abundant and widespread fish species in the north Atlantic and is usually found both on the shelf and on the continental slope (Scott and Scott, 1988; Savvatimsky, 1994). It is predominant in depths ranging from 400 to 1200 m, although they may inhabit depths between 200-2000 m (Snelgrove and Haedrich, 1985; Murua and de Cardenas, 2005). It has, however, been found in depths up to 2700 m (Wheeler, 1969).

Roughhead grenadier is becoming an important commercial fish in NAFO Regulatory Area and reliable information is needed for its assessment. The fishery for roughhead grenadier is unregulated as it has been mainly taken as by-catch in Greenland halibut fishery. Commercial catches of roughhead grenadier increased sharply from 1989 (333 tones) to 1992 (6 725 tons), since then until 1997 total catches has been about 4 000 t. In 1998 and 1999 catches increase and were in the level of 7 000 tons. After then, catch decreased to the level 3 000 – 4 000 tones in the period 2001-2004, and to 1 400 t in 2005-2006. In 2007 the catches decreased again up to 664 tons.

Since 1988 EU has conducted an annual random-stratified bottom trawl survey in Flemish Cap (NAFO Div. 3M) in the 200-720 m depth range. From 2003 onwards the survey was extended to depths down to 1 400 meters

and was carried out with a new R/V Vizconde de Eza, which replaced the former C/V Cornide de Saavedra. In order to make comparable both series, comparative fishing trials were carried out to calibrate both series in 2003 and 2004 (González-Troncoso and Casas, 2005). The objective of this scientific survey is to obtain abundance indices and to study the population structure and biological parameters of the main species in the area.

Limited information on age structure and growth rate of *M. berglax* is available in scientific literature. Savvatimsky (1971, 1984, 1989, 1994) and Jorgensen (1996) have carried out studies on this species in the NW Atlantic (NAFO Divisions 0, 2GHJ, 3K and 1ABCD respectively), basing findings on age readings from scales. The age structure and growth parameters of roughhead grenadier have been estimated by Murua (2003) from otolith readings of specimens captured in NAFO Divisions 3LMN. Validation of age estimates derived from otolith reading has been presented by Rodríguez-Marín *et al.* (2002). Eliassen (1983) also performed age estimation by otolith reading from roughhead caught in the continental slope of Norway.

This paper presents the abundance indices and biomass estimates by the Flemish Cap survey as well as some biological and population structure information of roughhead grenadier in Flemish Cap during the period 1991-2007. The results presented are only those restricted to depths up to 720 meters to make the comparison consistent in the time series; therefore, it should take into account that the survey only covers the shallowest distribution area of roughhead grenadier. The information is presented as an update of continued analyses of the Flemish Cap survey results (Murua *et al.*, 2005; Murua and González-Costas, 2006; Murua and González, 2007).

## MATERIAL AND METHODS

Data on roughhead grenadier for the 1991-2007 period were collected on the annual random-stratified bottom trawl surveys carried out by the European Union on the area (Vazquez and González, 2007). In order to maintain the data series, comparative fishing trials were carried out to develop conversion factors for the species sampled in 2003 and 2004. In total, 130 paired hauls with Cornide de Saavedra and Vizconde de Eza were done (in which 23 roughhead grenadier appeared) and the conversion factor to transform the Cornide values to Vizconde de Eza equivalents were estimated (González-Troncoso and Casas, 2005). As the depth coverage increased from 2003 onwards, the data presented here refers to survey results of depth < 720 meters, i.e. the common depth coverage in all the time series. Data on length distribution by sex is only available from 1993 onwards and age structure data is only available for the 1994-2007 period. Annual length-age keys have been applied for each year.

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 even more complicated, because 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.*, 2002).

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 pre-anal-fin length (AFL) and data are given in 1 cm intervals. Total weight was recorded accurate to the nearest 10 g.

## RESULTS AND DISCUSSION

Total biomass of roughhead grenadier estimated by the swept area method by strata is presented in Table and Figure 1. Biomass increased from 1989 to 1993, since then the biomass has decreased steadily till 1997 to 1 200 tons. In the period 1998-2002 the biomass index did not show a clear trend around 1 500 ton. Since 2002 the biomass index increased, reaching the maximum value of the time series in 2006 (3 933 tons). Between 2006 and 2007 the biomass value dropped from 3933 to 1367 tons. Total and by strata mean catch per trawl data are presented in Table 2. The results indicate that roughhead grenadier occupies the deepest part of the area studied and the abundance and biomass increase with depth, as is evidenced by other authors (de Cardenas *et al.*, 1996; Murua and de Cárdenas, 2005).

Table 3 shows length distributions of roughhead grenadier for the 1991-2007 period. Captures are dominated by the 13-22 cm length classes, around 60 % of the total abundance on average, for the whole time series. However, in 2003 – 2005 period, the abundance were dominated by the < 14 cm lengths, around 60 % in 2003 and 2004 and 50 % in 2005, which may be interpreted as a sign of a good recruiting to the population (Table 3). The percentage of smallest individuals (< 14 cm) in the 2006 survey were similar to 1991-2002 period, around 40%. In 2007 this percentage was the smallest of the hole time series (27%). The average AFL for all period is 15.2 cm. This value is smaller than the values found by Savvatimsky (1994) and de Cardenas *et al.* (1996). The former gives an average AFL of 19.8 cm (51.25 cm total length) for Div. 3K, and the latter gives a mean AFL of 21.12 cm (54.39 cm TL) for specimens caught in a long-line survey in Div. 3LMN. These differences are related to the fishing gear employed and depth where fish were caught, because length has a tendency to increase with depth, from the shallowest stratum to the deepest (Murua and de Cárdenas, 2005). The mean AFL in 2007 was 18.2 cm, the highest value of the time series. This height mean AFL was result of the very low abundance of the individuals less than 14 cm.

Annual length frequencies by sex are presented in Figure 2. The importance of males in the capture declines in larger fish and they disappear from the capture in largest length classes. Largest male found in the scientific surveys was 29 cm while females are larger reaching 36 cm long. Average AFL for females is also greater than for males. Female's mean AFL for the 1993-2007 period in Flemish Cap was 16.1 cm, while mean AFL for males was 14.7 cm. This sexual difference is consistent with data found in the literature (Murua and González-Costas, 2006). Savvatimsky (1989) gives an average AFL of 18 cm (47 cm total length) and 21.2 cm (54.6 cm total length) for males and females respectively in 3LKN. Those differences have also been seen in the commercial fleet in 3LN, where females are larger than males (Junquera *et al.*, 2001).

The AFL-age key for 2007 is given by sex in Table 4. Table 5 shows age composition by sexes for roughhead grenadier in Flemish Cap in 1994-2007. The oldest male found in the period studied was 19 years old and the oldest female 21 years old. Mean age for females in Flemish Cap in the 1994-2007 period was 7.4 years, while mean age for males was 7.0 years.

Interannual differences in length and age are shown in Figure 2 and 3. The 1990-1991 cohorts were the most important cohorts in abundance during the 1995-1999 period. The importance of these annual classes has declined sharply during last years. In 2003 and 2004, 23 % and 27 % of the individuals, respectively, were composed by individuals of 2001 year-class; this 2001 year-class is by far the most abundant year-class either at age 2 or age 3 in the time series. However, the big pulse of 2001 year-class in 2003 and 2004, was not as high as one would expect in 2006 and 2007 were the abundance of the ages 5 and 6 respectively were less than the 1994-2007 average for these ages. Moreover, the 2006 year class observed in the 2007 survey was one of the less abundant of the time series.

Female-ratio in the whole study period was 50 %. This value was lower that the one found by de Cardenas *et al.* (1996) in 3LMN, where females made up 71.4 % of the abundance. However, this difference could be explained due to the different area and depth covered by both surveys. As length increases in relation to depth in many species, the 'bigger deeper' distribution (Merrett *et al.*, 1991; Gordon & Bergstad, 1992), the female ratio might increase also in the deeper water areas.

Figures 4 presents sex-ratio by age for the 1994-2007 period. In the sex-ratio, female proportion fluctuated around 40%-50% the first 10 years, from 10 to 15 years old the proportion increased steadily to 90%. For older ages, the females proportion is around 90%. Similar sex-ratio, with males being more abundant in the central part of the population, is described by Savvatimsky (1994) for north-western Atlantic.

The increment in the female-ratio can be due to different reasons: sexual differences in growth rate, in mortality or a combination of both. In this case, there are certainly sexual differences in growth, which are reflected in the mean length at age and in the different growth curves presented in this study.

Figure 5 shows the mean length at age by sex for 2007 data. The mean length at age is similar for males and females for ages under 10 years, but males grow slower from this age onwards. Mean lengths at age are higher than those obtained by Savvatimsky (1994) for NAFO Divs. 0B, 2GH and 3K. Savvatimsky (1994) and Jorgensen (1996) described similar growing pattern using scales for ageing fish; they found that the differences between sexes in size

at age come about from 10 years onwards. This fact could be explained due to the different ageing method used or due to different latitude of the sampling areas where specimens were obtained, because temperature differences would cause slower growth and a delay in reaching sexual maturity (Rodríguez-Marín *et al.*, 2002).

On the other hand, it seems that there are some differences in mortality between both sexes, since males disappear from the capture in larger length-classes. Total mortality by sex was calculated from catch curves, fitting regression lines by sex to ages fully recruited to the survey gear, using data of 14 years (1994-2007). Both sexes are fully recruited at age 7 and the total mortality obtained is different for both sexes: 0.38 for females and 0.57 for males (Figure 6). For the whole population the total mortality was 0.43.

Length-weight relationships by sex are shown in Table 6 for all the years studied. The relationship between fish length (AFL) and fish weight was assumed to be adequately expressed by the exponential function.

Data available show that roughhead grenadier has a prolonged life cycle and multiaged population structure with differences in growth and mortality between males and females. The complex multi-mode length structure and a slow growth are characteristic of deepwater fishes, including grenadiers (Hureau *et al.*, 1979; Savvatimsky, 1994). All this results must be taken with care due to the small proportion of the roughhead grenadier distribution area covered by the survey.

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## TABLES

**Table 1.-** Total biomass of roughhead grenadier estimated by the swept area method by strata during the EU bottom survey (1991-2007); biomass series transformed to Vizconde de Eza equivalents from 1988-2002.

<b>Biomass estimated by the swept area meted (tons)</b>																		
Strata	Depth (m)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1 – 6	125-252					8	22							9	10			
7	253-360										3				10			
8	253-360	1					11	3		7		16	2	13	28	65	13	
9	253-360	5	28	21	3	21	153	18	40	45	29	29		30	282	82	181	17
10	253-360						6	1		18	68	18			48	38	21	
11	253-360									3	8	6			3	2		
12	261-540	108	100	413	55	126	46	137	55	191	81	236	154	165	292	207	97	22
13	261-540	18	60	18	32	75	5	18	78	92	50	116	121	123	299	94	154	80
14	261-540	85	139		73	67	270	77	194	135	103	292	124	346	877	379	362	223
15	261-540	64	52	321	82	180	84	69	101	72	103	60	16	87	259	16	85	55
16	541-720	229	432	1333	523	256	397	211	405	150	225	338	272	352	594	426	1391	242
17	541-720	180	123		98	129	27	116	204	96	67	370	380	101	244	124	603	70
18	541-720	356	215		756	414	154	224	189	313	219	383	27	877	423	588	435	491
19	541-720	289	429	915	352	282	187	322	424	129	92	216	116	245	228	366	592	167
<b>TOTAL</b>		<b>1335</b>	<b>1577</b>	<b>3021</b>	<b>1975</b>	<b>1558</b>	<b>1362</b>	<b>1197</b>	<b>1691</b>	<b>1250</b>	<b>1047</b>	<b>2079</b>	<b>1211</b>	<b>2348</b>	<b>3597</b>	<b>2387</b>	<b>3933</b>	<b>1367</b>
Error biomass		250	270	487	169	223	277	169	243	338	196	284	176	611	362	281	700	310
Mean AFL (cm)		16.4	15.8	15.8	16.6	15.3	15.8	16	15.6	16.3	16.5	16.5	16.1	12	13.3	14.9	16.6	18.2

**Table 2.-** Mean catch per trawl by strata and whole bank (1991-2007); series transformed to Vizconde de Eza equivalents.

Strata	Area	Depth (m)	Average weight per trawl (Kg.)																
			1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1 – 6	467	125-252					0.13	0.58						0.34	0.19				
7	108	253-360												0.04					
8	82	253-360		0.2		0.02					0.22	0.05		0.14		0.32	0.03	0.26	
9	34	253-360	1.97	0.18		0.21	1.16	0.88	0.14	0.88	6.39	0.77	1.69	1.9	1.23	1.23		7.13	0.69
10	128	253-360	0.01								0.08	0.01		0.24	0.94	0.24		0.28	
11	107	253-360												0.04	0.12	0.1			
12	90	261-540	2.19	2.03	0.77	2.12	1.96	8.08	1.07	2.47	0.91	2.68	1.09	3.74	1.58	4.63	3.01	1.78	0.41
13	31	261-540	1.11	3.37	0.93	0.93	3.15	0.97	1.68	3.94	0.27	0.97	4.12	4.83	2.66	6.11	6.38	7.17	4.19
14	72	261-540	4.36	3.15	2.33	1.85	3.02		1.59	1.47	5.88	1.69	4.23	2.95	2.25	6.36	2.69	6.29	4.76
15	85	261-540	1.81	0.1	0.58	1.26	1.03	6.33	1.62	3.54	1.66	1.36	1.99	1.42	2.02	1.18	0.31	1.44	1.05
16	82	541-720	7.22	2.91	4.38	4.75	8.94	27.6	10.82	5.31	8.21	4.37	8.39	3.11	4.66	6.99	5.64	25.08	4.87
17	23	541-720	8.12	2.71	1.89	10.93	7.46		5.98	7.81	1.63	7.05	12.41	5.82	4.09	22.47	23.08	33.88	3.63
18	22	541-720	19.44	7.98	8.93	22.22	13.45		47.28	25.84	9.61	14.03	11.82	19.54	13.66	23.95	1.68	21.75	29.8
19	54	541-720	23.55	7.19	8.66	9.17	13.59	29.02	11.16	8.95	5.94	10.21	13.43	4.08	2.9	6.85	3.68	15.74	5.14
Weighted averaged per trawl (Kg)			<b>1.66</b>	<b>1.96</b>	<b>3.76</b>	<b>2.46</b>	<b>1.94</b>	<b>1.69</b>	<b>1.49</b>	<b>2.1</b>	<b>1.56</b>	<b>1.31</b>	<b>2.58</b>	<b>1.5</b>	<b>2.92</b>	<b>4.47</b>	<b>2.97</b>	<b>4.89</b>	<b>1.70</b>
S. D.			0.31	0.34	0.61	0.21	0.28	0.34	0.21	0.3	0.42	0.24	0.35	0.22	0.76	0.45	0.35	0.87	0,39
N° of valid tows			117	117	101	116	121	117	117	119	117	120	120	120	114	124	117	115	117

**Table 3.-** Roughhead grenadier length distribution (,000) and mean AFL by year for 1991-2007 period (transformed series to Vizconde de Eza equivalents).

AFL (cm)	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	Total
1		7	3															10
2		13											99	21	10	10		153
3	4	16				3	3	48	9	3	65	40	369	294	127	79	16	1076
4	6	57	42		16	26	15	14	8	15	12	16	119	59	54	123	7	589
5	16	232	200	28	24	127	9	53	15	42	133	118	1220	566	147	341	30	3301
6	26	73	77	22	31	45	36	44	16	35	56	59	881	481	100	177	21	2180
7	69	121	380	53	46	25	87	45	14	31	65	90	437	705	142	202	18	2530
8	25	64	184	154	61	51	86	57	20	34	133	99	506	1576	177	188	22	3437
9	43	45	98	96	126	45	71	194	33	63	71	60	319	495	467	339	7	2572
10	45	46	167	237	325	116	92	173	92	28	57	23	520	493	575	225	44	3258
11	111	63	146	207	289	123	32	121	209	89	98	48	321	420	299	410	30	3016
12	248	69	190	125	521	171	176	157	105	110	139	54	337	631	301	473	75	3882
13	291	128	168	107	267	271	198	220	144	152	168	87	332	584	306	368	157	3948
14	312	334	288	269	128	323	396	495	193	177	399	177	393	635	348	418	143	5428
15	231	374	513	243	176	217	310	563	321	129	404	199	611	592	373	507	154	5917
16	238	312	790	212	253	306	197	462	428	290	430	283	666	697	335	416	162	6477
17	280	219	610	408	294	233	82	314	363	279	367	235	511	746	328	447	148	5864
18	311	221	499	429	348	222	111	171	290	196	468	194	583	696	550	473	173	5935
19	223	147	349	341	310	238	120	158	150	171	336	206	359	519	470	414	200	4711
20	190	199	251	192	201	209	109	117	106	111	269	156	225	376	294	487	103	3595
21	72	106	195	129	108	88	79	106	95	79	158	136	180	266	198	502	98	2595
22	68	77	133	78	53	78	83	115	35	67	70	77	111	202	130	240	122	1739
23	38	71	168	55	12	24	61	37	41	28	60	54	121	143	81	312	32	1338
24	26	33	66	57	19	36	61	64	24	30	65	23	20	115	88	154	42	923
25		33	35	56	19	16	33	50	29	28	79	27	10	85	74	157	45	776
26	18	59	54	33	13	23	39	28	0	28	35	18	8	72	64	188	57	737
27	14	28	21	19	20	16	39	17	7	6	37	28	14	31	30	177	52	556
28	21	28	40	6	9	6	16	5	11	10	48	6		28	9	130	47	420
29	14	20	40	36	0	0	11	17	6	5	12	23		10	22	88	35	339
30	14	41	12	14	6	6	0	13	19	5	34	6		19	19	76	23	307
31		9		24	4	5	5			5	12			19	0	33	10	126
32		13		8	5	11	6				6					20		69
33	6											5		9		12		32
34	7							5		6		6	8					32
35										5						11		16
36		6		8														14
<b>Total</b>	<b>2967</b>	<b>3264</b>	<b>5719</b>	<b>3646</b>	<b>3684</b>	<b>3060</b>	<b>2563</b>	<b>3863</b>	<b>2783</b>	<b>2257</b>	<b>4286</b>	<b>2553</b>	<b>9280</b>	<b>11585</b>	<b>6118</b>	<b>8197</b>	<b>2070</b>	<b>77895</b>
<b>Mean length</b>	<b>16.3</b>	<b>15.8</b>	<b>15.8</b>	<b>16.6</b>	<b>15.3</b>	<b>15.8</b>	<b>16.0</b>	<b>15.6</b>	<b>16.4</b>	<b>16.5</b>	<b>16.6</b>	<b>16.1</b>	<b>12.0</b>	<b>13.3</b>	<b>14.9</b>	<b>16.6</b>	<b>18.2</b>	<b>15.2</b>



**Table 4.-** Age-Length key for roughhead grenadier gathered in Flemish Cap 2007.

		Males															
AFL(cm)/age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	Total	
3	1															1	
4																0	
5		3														3	
6	1	3														4	
7		4	1													5	
8			4	2												6	
9			4	2												6	
10			1	4												5	
11				3	3											6	
12				1	4	1										6	
13					2	4										6	
14					2	3	1									6	
15						3	3									6	
16						1	3	2								6	
17							4	2								6	
18							1	1	4							6	
19								2	4							6	
20									1	2	3					6	
21										2	3	1				6	
22										3	1	1				5	
23													1			1	
24												1		1		2	
25																0	
26															1	1	
27																0	
28																0	
29																0	
30																0	
Total	2	10	10	12	11	12	12	7	9	7	7	3	1	1	1	105	

Table 4.- (continued)

		Females																						Total	
AFL(cm)/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total	
3	1																							1	
4		1																							1
5		1	1																						2
6			6																						6
7			5	1																					6
8			2	4																					6
9				3	3																				6
10				2	4																				6
11					5	1																			6
12					1	5																			6
13					1	1	4																		6
14						5	1																		6
15						1	3	2																	6
16							2	3	1																6
17								4	2																6
18								1	2	3															6
19								1		5															6
20									1	5															6
21											3	2	1												6
22										2	4														6
23											5	1													6
24										2	2	1	1												6
25											2	4													6
26											1	2	3												6
27												2	2	1			1								6
28													3	1	2										6
29													1	2	2						1				6
30														2	1	2	1								6
31															2	3	1								6
32															2	2		1	1						6
33																	2	1							3
34																		1	1	2					4
35																			1	2	2	1			6
36																			1	1	2				4
37																				1	1				2
38																	1		1						2
39																					3				3
40																					1				1
42																								1	1
Total	1	2	14	10	14	13	10	11	6	15	14	8	10	10	8	9	9	5	5	7	9	1	1		192

**Table 5.-** Roughhead grenadier age composition (,000) in Flemish Cap 1994-2007.

Age	1994				1995				1996				1997				1998			
	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total
1	0	0	0	0	0	0	0	0	0	0	129	129	0	0	0	0	14	6	32	51
2	0	12	34	46	16	26	65	107	25	14	16	56	11	13	21	46	36	82	10	128
3	14	32	90	136	85	93	32	209	29	66	15	110	56	121	9	186	108	118	2	227
4	145	122	221	488	181	235	51	467	117	86	21	225	51	102	0	153	121	116	0	237
5	114	147	245	506	353	433	75	861	158	183	11	352	74	80	2	157	90	49	0	139
6	189	103	278	570	306	245	40	592	381	202	3	586	241	204	6	451	142	202	2	346
7	213	96	257	566	332	156	27	516	192	155	4	350	252	355	6	613	406	314	4	725
8	148	111	234	493	267	177	15	458	219	116	3	338	63	98	1	163	523	383	1	907
9	98	124	157	379	117	139	7	263	144	69	3	216	73	85	0	158	115	135	0	250
10	32	103	46	181	29	80	4	113	163	99	2	264	56	42	0	98	131	95	0	226
11	0	88	22	109	6	28	0	35	179	75	0	254	56	95	0	151	81	54	0	135
12	32	39	11	82	0	23	0	23	53	40	0	93	72	93	0	164	73	109	0	182
13	0	36	4	40	0	20	0	20	12	26	0	37	39	85	0	124	44	108	0	152
14	0	15	0	15	0	5	0	5	0	33	0	33	5	37	0	42	25	51	0	76
15	8	17	1	27	0	15	0	15	0	4	0	4	0	42	0	42	0	48	0	48
16	0	8	0	8	0	0	0	0	0	11	0	11	0	8	0	8	0	22	0	22
17	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6	0	12	0	12
18	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	993	1054	1600	3647	1693	1674	317	3684	1672	1179	208	3060	1051	1469	45	2565	1908	1903	51	3862
Mean Age	6.8	7.8	6.3	6.9	6.2	6.3	4.6	6.1	7.4	7.3	2.2	7.1	7.4	7.9	3.7	7.6	7.5	8.0	2.1	7.6
Age	1999				2000				2001				2002				2003			
	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total
1	5	0	11	15	0	0	3	3	29	6	28	63	17	3	19	39	86	31	351	467
2	0	25	12	36	18	30	29	77	99	90	20	208	84	71	34	189	953	1038	149	2140
3	18	29	2	49	59	49	0	108	94	172	5	271	96	124	0	220	482	576	19	1077
4	128	82	6	215	36	14	0	50	42	77	1	120	14	43	0	57	305	367	0	672
5	111	86	1	198	151	132	0	283	124	159	0	283	62	46	0	108	281	336	0	617
6	97	150	0	247	135	142	0	277	225	218	2	445	75	114	0	189	380	254	0	635
7	303	142	0	445	97	121	0	218	261	273	7	540	142	148	0	290	483	359	0	843
8	358	258	0	616	108	123	0	231	280	217	8	505	165	119	0	283	620	281	0	901
9	248	174	0	422	226	114	0	339	285	220	5	509	131	110	0	241	309	226	0	535
10	110	87	0	197	183	155	0	338	294	369	3	666	118	148	0	266	255	220	0	475
11	69	41	0	109	18	55	0	72	63	167	0	231	120	84	0	204	227	245	0	472
12	36	44	0	79	33	62	0	95	54	77	0	131	99	145	0	243	115	120	0	236
13	19	36	0	56	17	40	0	57	7	74	0	81	30	45	0	75	52	36	0	88
14	26	35	0	61	22	33	0	55	6	98	0	104	10	53	0	63	18	12	0	30
15	4	29	0	33	6	16	0	22	7	48	0	55	8	12	0	19	0	17	0	17
16	0	3	0	3	12	5	0	17	0	30	0	30	20	18	0	39	17	0	0	17
17	0	0	0	0	0	0	0	0	0	29	0	29	0	9	0	9	25	14	0	39
18	0	0	0	0	0	11	0	11	6	6	0	12	0	10	0	10	0	0	0	0
19	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	10	0	0	10
20	0	0	0	0	0	0	0	0	0	6	0	6	0	5	0	5	0	8	0	8
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1531	1221	32	2784	1120	1107	32	2259	1876	2335	78	4288	1191	1306	53	2550	4617	4141	519	9277
Mean Age	7.8	8.0	2.2	7.8	7.8	8.2	1.9	7.9	7.4	8.3	3.6	7.8	7.9	8.4	1.6	8.0	6.0	5.5	1.4	5.5

**Table 5 (continued).**- Roughhead grenadier age composition (,000) in Flemish Cap 1994-2007

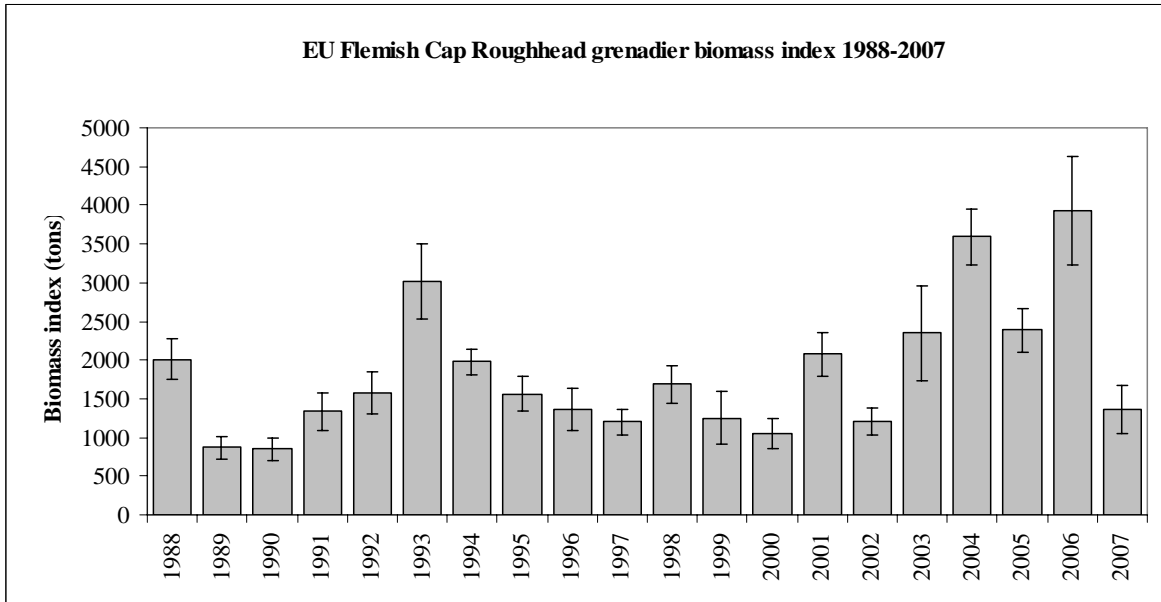
Age	2004				2005				2006				2007				1994-2007			
	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total	M	F	Ind	Total
1	69	26	121	215	0	0	109	109	5	5	0	10	0	7	5	12	224	83	809	1105
2	181	205	79	465	118	52	97	267	171	182	0	353	0	18	4	22	1711	1858	571	3788
3	1322	1798	0	3119	186	162	14	362	268	170	0	439	7	52	0	59	2822	3561	189	6134
4	406	604	0	1009	253	509	0	762	183	208	0	392	12	23	0	36	1995	2587	300	4491
5	379	498	0	877	229	399	0	628	325	177	0	501	23	64	0	87	2475	2789	334	5096
6	670	432	3	1105	303	242	0	545	243	318	0	561	67	135	0	202	3454	2963	333	6189
7	495	308	7	810	262	237	0	499	352	367	0	719	129	137	2	268	3918	3169	313	6682
8	606	346	5	956	257	337	0	594	189	330	0	519	160	135	3	298	3962	3030	270	6742
9	498	461	3	962	226	187	0	413	296	191	0	488	108	68	2	178	2874	2303	176	4866
10	519	374	3	896	248	331	0	579	311	265	0	577	149	197	0	345	2598	2564	57	4643
11	258	206	0	465	145	226	0	371	260	467	0	727	46	126	0	172	1530	1955	23	2780
12	200	190	1	391	51	116	0	167	123	272	0	395	52	56	0	107	992	1387	12	1996
13	22	125	0	147	95	132	0	227	79	213	0	293	17	78	0	95	434	1053	4	1199
14	23	66	0	90	94	97	0	191	16	195	0	211	0	78	0	78	246	808	0	843
15	0	18	0	18	0	21	0	21	12	184	0	195	3	36	0	39	48	506	1	360
16	0	21	0	21	0	9	0	9	28	73	0	101	0	34	0	34	78	241	0	218
17	0	23	0	23	0	17	0	17	9	21	0	30	0	21	0	21	33	152	0	155
18	0	6	0	6	0	3	0	3	0	39	0	39	7	5	0	12	13	86	0	59
19	0	6	0	6	0	0	0	0	9	21	0	29	0	0	0	0	18	31	0	20
20	0	3	0	3	0	3	0	3	0	16	0	16	0	6	0	6	0	46	0	30
21	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	2	0	2
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	5648	5715	222	11585	2466	3080	221	5767	2879	3715	0	6595	780	1274	16	2070	29425	31174	3393	63992
Mean Age	6.334	6.04	2.054	6.107	7.3	7.5	1.6	7.2	7.4	9.1	0.0	8.3	8.7	9.3	4.1	9.0	7.0	7.4	4.2	6.2

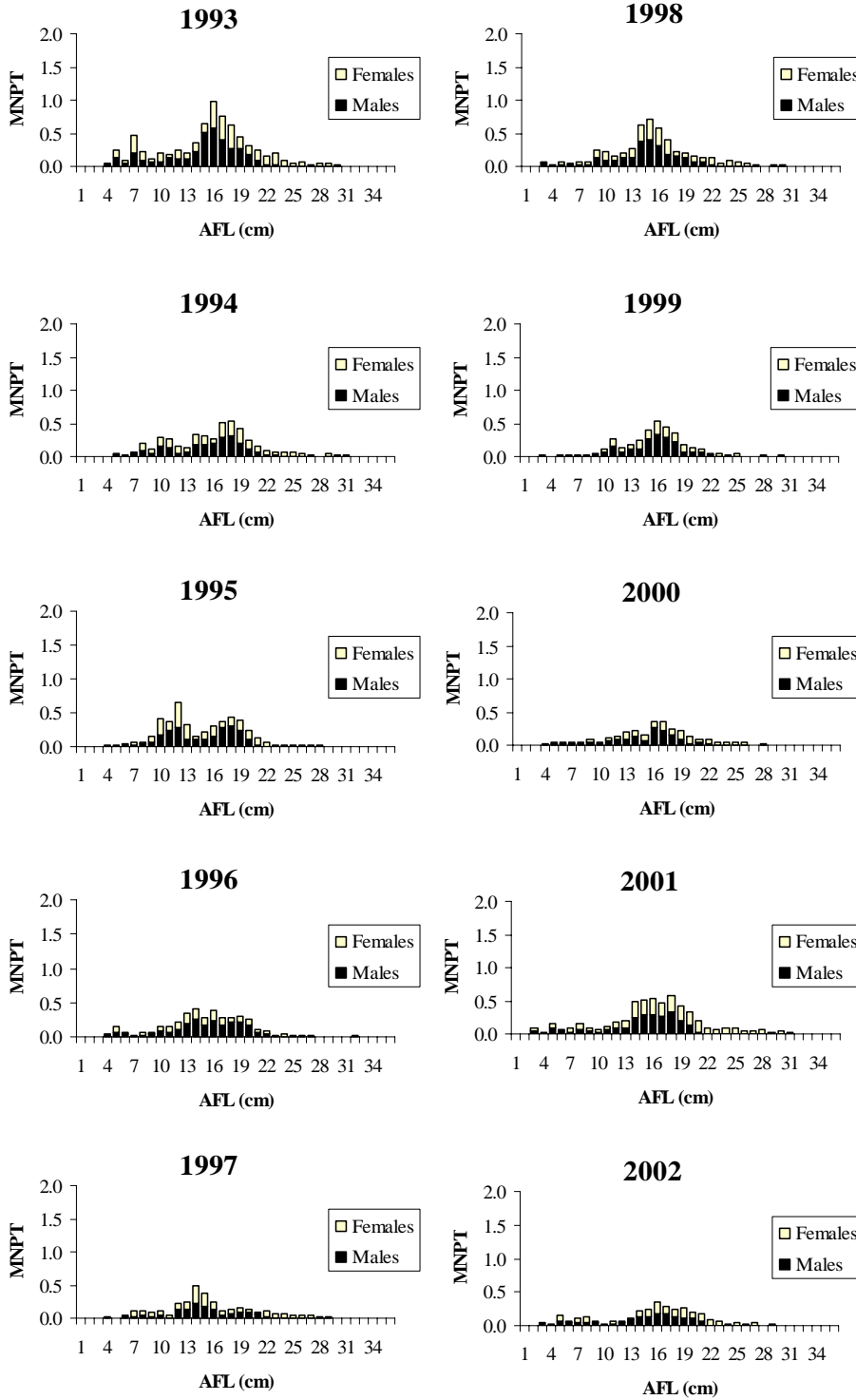
**Table 6.-** Length weight relationship for roughhead grenadier males and females from EU Survey (1993-2007).

Year	MALES		FEMALES	
	Regression	r <sup>2</sup>	Regression	r <sup>2</sup>
1993	W (g) = 0.0793 * AFL (cm) <sup>3.0883</sup>	0.9734	W (g) = 0.1016 * AFL (cm) <sup>2.9934</sup>	0.9895
1994	W (g) = 0.1489 * AFL (cm) <sup>2.8437</sup>	0.9694	W (g) = 0.1015 * AFL (cm) <sup>2.9935</sup>	0.9895
1995	W (g) = 0.1131 * AFL (cm) <sup>2.9409</sup>	0.9818	W (g) = 0.1139 * AFL (cm) <sup>2.9344</sup>	0.9859
1996	W (g) = 0.1244 * AFL (cm) <sup>2.8889</sup>	0.9802	W (g) = 0.1367 * AFL (cm) <sup>2.8536</sup>	0.9851
1997	W (g) = 0.1209 * AFL (cm) <sup>2.8840</sup>	0.9812	W (g) = 0.1202 * AFL (cm) <sup>2.8898</sup>	0.9923
1998	W (g) = 0.1338 * AFL (cm) <sup>2.8621</sup>	0.9669	W (g) = 0.1199 * AFL (cm) <sup>2.9015</sup>	0.9866
1999	W (g) = 0.1290 * AFL (cm) <sup>2.8670</sup>	0.9718	W (g) = 0.1174 * AFL (cm) <sup>2.8950</sup>	0.9866
2000	W (g) = 0.1423 * AFL (cm) <sup>2.8148</sup>	0.9776	W (g) = 0.1708 * AFL (cm) <sup>2.7537</sup>	0.9744
2001	W (g) = 0.2747 * AFL (cm) <sup>2.5821</sup>	0.9637	W (g) = 0.1922 * AFL (cm) <sup>2.716</sup>	0.9859
2002	W (g) = 0,143 * AFL (cm) <sup>2.8218</sup>	0.9878	W (g) = 0,119 * AFL (cm) <sup>2.884</sup>	0.9921
2003	W (g) = 0,103 * AFL (cm) <sup>2.9376</sup>	0.9797	W (g) = 0,101 * AFL (cm) <sup>2.9391</sup>	0.9911
2004	W (g) = 0,109 * AFL (cm) <sup>2.9125</sup>	0.9879	W (g) = 0,0096 * AFL (cm) <sup>2.9512</sup>	0.9924
2005	W (g) = 0,102 * AFL (cm) <sup>2.9462</sup>	0.9806	W (g) = 0,0975 * AFL (cm) <sup>2.9555</sup>	0.9755
2006	W (g) = 0,161 * AFL (cm) <sup>2.7753</sup>	0.9692	W (g) = 0,1329 * AFL (cm) <sup>2.8531</sup>	0.9842
2007	W (g) = 0,125 * AFL (cm) <sup>2.8500</sup>	0.9786	W (g) = 0,1075 * AFL (cm) <sup>2.9176</sup>	0.9872

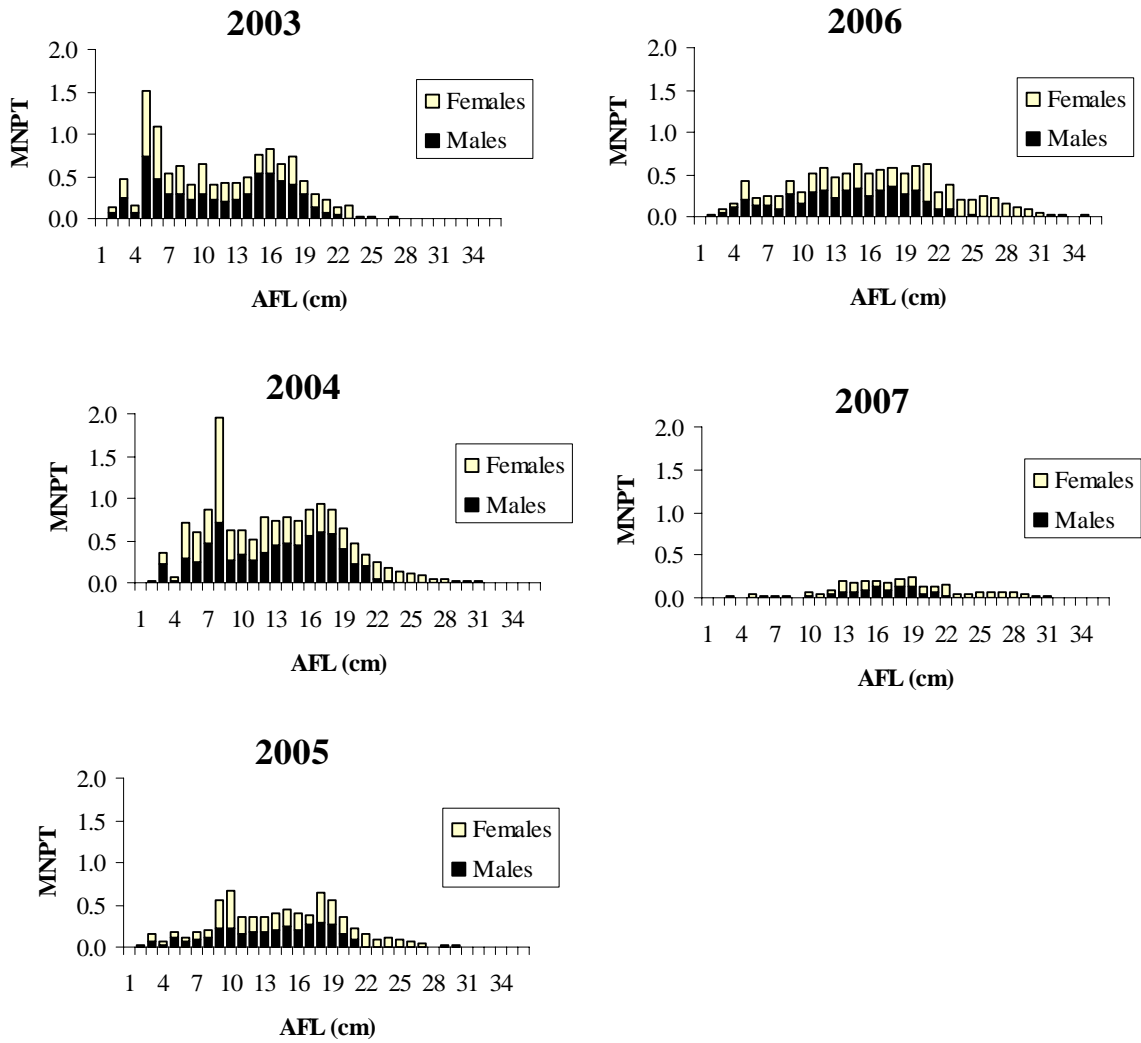
**FIGURES**

**Figure 1.-** Total biomass estimated by the swept area method during the EU Flemish Cap bottom trawl survey (1988-2007).





**Figure 2.-** Annual length distribution by sex in Flemish Cap 1993-2007.



**Figure 2 (continued).**- Annual length distribution by sex in Flemish Cap 1993-2007.

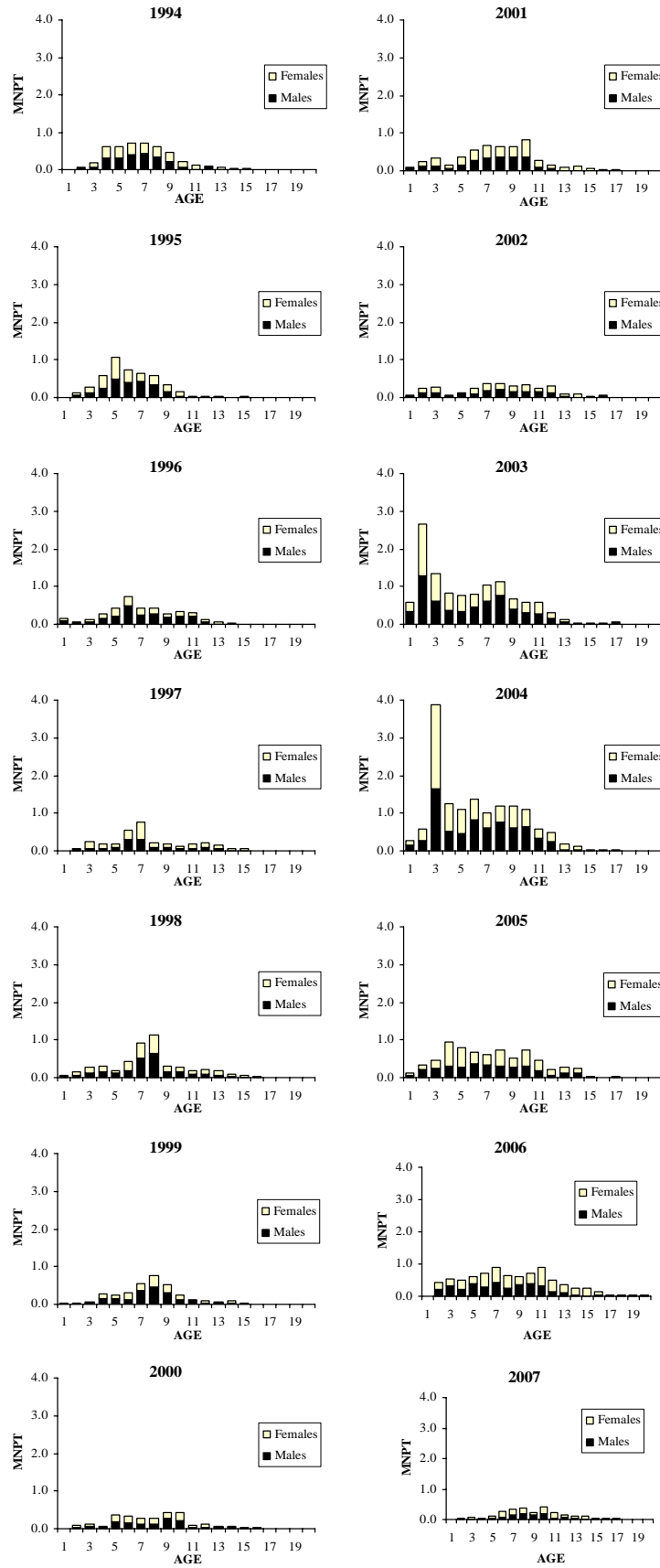
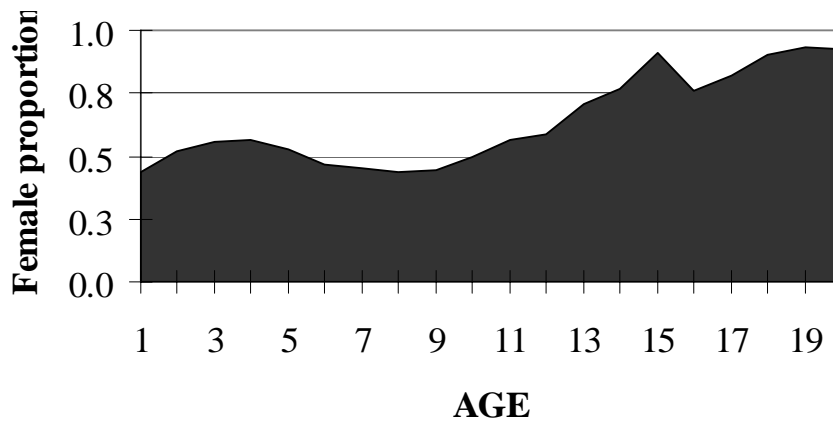


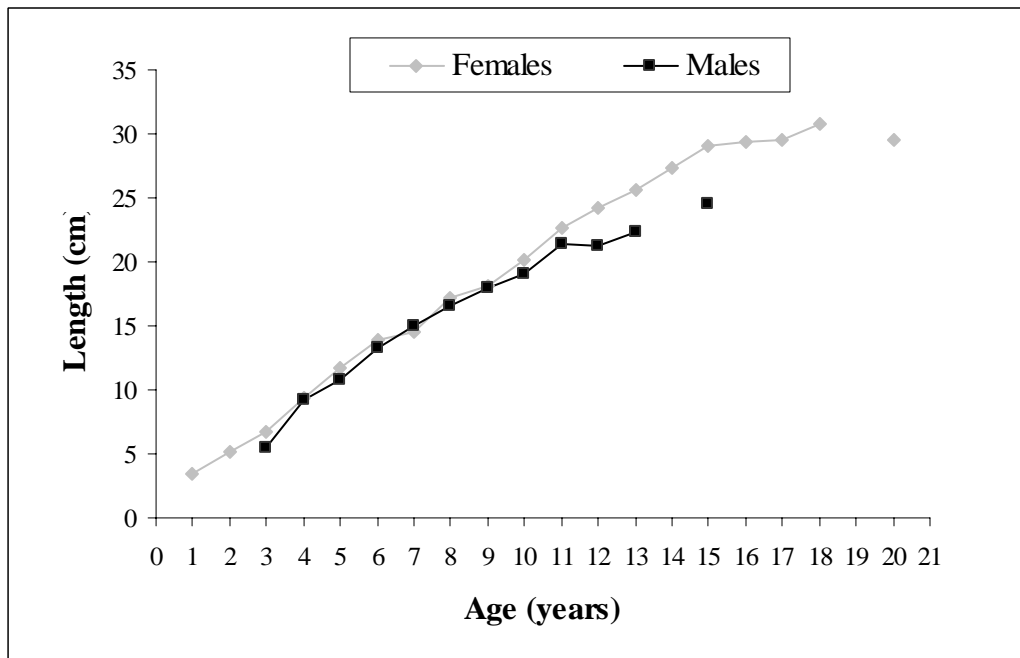
Figure 3.- Annual age composition by sex in Flemish Cap 1994-2007.



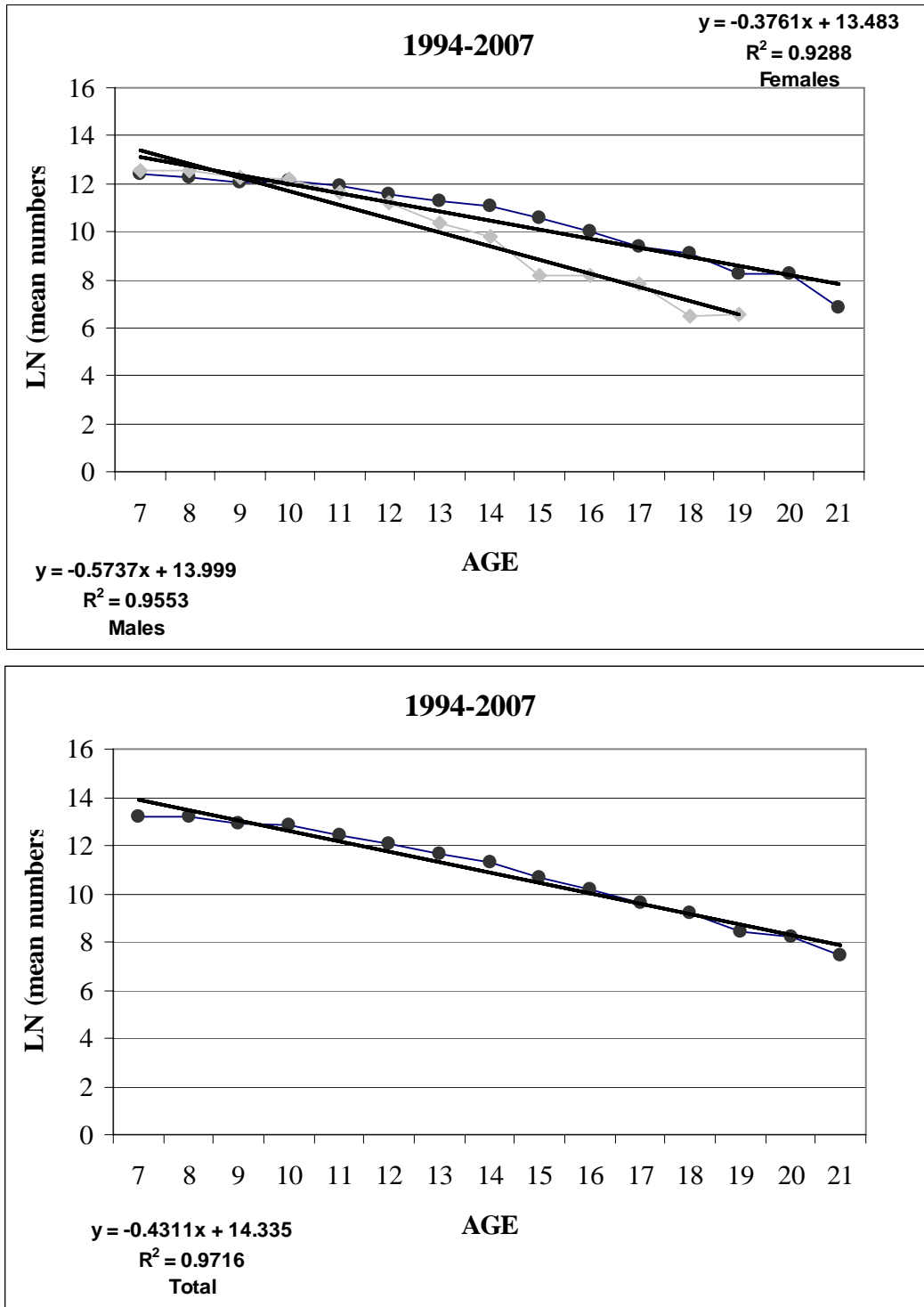
### TOTAL 1994-2007



**Figure 4.-** Female ratio by age in Flemish Cap 1994-2007.



**Figure 5.-** Mean length (AFL cm) at age by sexes in Flemish Cap 2007.



**Figure 6.-** Catch curves by sex for roughhead grenadier in Flemish Cap 1994-2007.