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Northern Shrimp (*Pandalus borealis*) on Flemish Cap in June 2003

by

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Abstract

Since 1988, a stratified random summer bottom trawl survey in Flemish Cap (NAFO Regulatory Area of Div. 3M) was conducted by UE. In June 2003, the survey was carried out by the new research vessel R/V *Vizconde de Eza*. For this reason during the first ten days of the survey a comparative Fishing Trial (calibration) was conducted between the old research vessel R/V *Cornide de Saavedra* and the new research vessel R/V *Vizconde de Eza* in order to calibrate the new ship. The corresponding Factor Power Correction (FPC) was calculated by generalized linear regression model by haul, and a length conversion method. The transformed entire series of abundance, biomass, mean catch per tow and length distribution for northern shrimp (*Pandalus borealis*) are presented for the period 1988-2002, and the no-transformed data for the year 2003. Also the standard error was shown for mean catch per tow. This year a decreasing in shrimp biomass was observed. It was mainly due to declining of female biomass. Also the youngest model group (age 1) appeared well represented, predicting a good recruitment in next years.

However, all these results must be taken carefully because the scarce number of hauls carried out during the calibration.

Keywords: Survey, Flemish Cap, shrimp.

Material and Methods

Change of vessel and calibration

The survey was carried out from May 31th to July 27th following the same procedures as in previous years (Saborido-Rey and Vazquez, 2003). However, since this year, the traditional research vessel used will be replaced by the R/V *Vizconde de Eza* using the same bottom trawl net *Lofoten,* with a cod-end mesh size of 35 mm.

In order to establish a link between the two sets of survey data, during the present survey comparative fishing trials were conducted to develop factors between the two vessels. A series of 51 valid paired hauls was carried out. Direct comparison of catches from vessel fishing side by side is based on the assumption that the number of fish in the trawl paths is more or less the same. The vessels conducted fishing operations at the same time, along parallel courses at a speed of 3.0 knots and a tow length of 30 minutes.

To convert data series it was necessary to calculate the factor power correction (FPC), typically estimated by use of catch per unit of effort (CPUE) observations for two vessels. In this case, a multiplicative model solved by

using generalized linear regression model by haul was adjusted to convert mean catch, and biomass. This model was proposed by Robson (1966) to establish the relationship between two CPUEs for two ships:

$$CPUE_{ij} = e^{\mu + t_i + \varepsilon_{ij}}$$

where: t_i is the effect of the ship i , i =1,2
h_j is the effect of the haul j , j =1,..., 51
μ is the model parameter
ε is the model error

A logarithmic transformation is performed in order to obtain a linear expression:

$$\ln(CPUE_{ij} + 1) = \mu + t_i + h_j + \varepsilon_{ij}$$

This equation was adjusted by generalized linear regression assuming the following restrictions necessary to estimate all parameters:

$$\sum_{i=1}^{2} t_i = 0 \Rightarrow t_1 = t = -t_2 \qquad \sum_{j=1}^{51} h_j = 0$$

giving the following estimation of the FPC (Sissenwine and Bowman, 1978):

$$FPC = \frac{CPUE_2}{CPUE_1} = e^{2t(1+0.5s^2)}$$

where 2 s is the variance obtained in the estimate of t. This model was applied to convert mean catches and biomass.

In the other hand, to convert the length distribution and abundance, the following multiplicative model, proposed by Warren (1997) was adjusted:

$$Ratio = \alpha\, l^{\beta} e^{\delta l}$$

where:

$$Ratio = \frac{R/V\ Vizconde\ de\ Eza\ (catch\ number)}{R/V\ Cornide\ de\ Saavedra\ (catch\ number)}\ by\ length$$

l is length
α, β and δ are the estimated parameters.

Sampling

Samples of approximately 1.5 kilogram shrimp were taken in each tow where this species was present for length frequency determination. Some samples were frozen for length-weight analysis at the laboratory.

Shrimps were separated into males and females according to the endopod of the first pleopod (Rasmussen, 1953). Individuals changing sex phase, according to this criterion, were included with males. Females were further separated as primiparous (first time spawners) and multiparous (spawned previously) based on the condition of the external spines (McCrary, 1971). Ovigerous females were considered as a group and were not included with multiparous females.

Oblique carapace length (CL), the distance from the base of the eye to the posterior dorsal edge of the carapace (Shumway *et al.,* 1985), was measured to the lower 0.5 mm length-classes. Sampling length data were used to obtain an estimate of population length distributions in the whole area and to compare it with the estimates of the other years.

The length-weight relationship was calculated from individuals caught. 2192 individuals were weighed to the nearest 0.1 g after a little draining time.

Skúladóttir and Diaz (2001) present the first age assessment by Modal analysis using the Mix software (MacDonald and Pitcher, 1979) of the shrimp caught in the EU survey in the years 1988-2001. In 2003 a modal analysis of the length distribution to estimate age structure was carried out using the same method and compared with previous results in 2002 (del Río *et al*., 2002).

Results

A total of 114 valid bottom trawls were completed with Lofoten trawl gear in Flemish Cap. Shrimp appeared in 109 sets and catches per tow were highly variable (from 22 g to 175 kg). Mean
catch per tow in 2003 was 27.80 kg.

Biomass

Total shrimp biomass estimated by swept area method and mean catch per tow from 1988 to 2003 are presented in Table 1. The biomass estimated from 1988 to 2002 was transformed by the FPC obtained in the calibration. The biomass index obtained this year decreased from 31 602 tons in 2002 to 22 359 tons in this survey.

Biomass distributions estimated by strata from 1988 to 2002 (corrects by FPC) and 2003 are shown in Table 2. The presence of shrimp in shallowest strata, with depths less than 140 fathoms (257 m), was scarce in the first years (1988-1994). However, since 1995, a noticeable amount of shrimp occurred in these strata and the estimated biomass increased from 1995 to 2003 according the following table:

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Estimated biomass (tons) **(< 140 fathoms)**	316	335	330	2326	2982	3272	6035	9305	9557
% Total biomass **(< 140 fathoms)**	3.3	3.0	3.7	7.9	13.7	19.3	24.5	29.4	42.7

This increase in shallowest strata is a consequence of the greater abundance of the youngest age classes. In this survey the 42.7% of total estimated biomass was obtained in depths less than 140 fathoms (257 m).

Biomass distribution observed during the survey is presented in Fig. 1. As previous years shrimp population have a distribution around the central area of the bank. In depths less than 80 fathoms (strata 1 and 2) and bigger than 300 fathoms (strata 16 and 19), the catches never exceeded 10 kg/tow. The three highest catch (175, 102 and 95 kg) occurred in the West of the Flemish Cap at intermediate depth strata.

Adult stock, female biomass

Total biomass estimates by the series of bottom trawl surveys on Flemish Cap from 1988 to 2003 are shown in Table 1. These estimations are quite variable due to predominant sizes of the shrimp are in the selection range of the cod-end mesh size used, so the biomass estimations are clearly affected by small changes in cod-end mesh size. To solve this problem it was proposed to use only the shrimp bigger than 20 mm CL (Table 1). The biomass for shrimp bigger than 20 mm CL tried to be an index of the adult biomass not affected by differences in the cod-end mesh size used. The 20 mm CL was chosen because it is approximately the limit between 3 and 4 years old shrimp in this season (Garabana, 1999).

The use of female biomass estimate is also an index not affected by small changes in mesh size, and it is the one used by the NAFO Scientific Council, so it was also included in Table 1.

The standard gear used in the surveys was a Lofoten with a cod-end mesh size of 35 mm with the exception of the 1994 and 1998 surveys when a 40 mm and 25 mm cod-end mesh size were used respectively. Consequently, the biomass index in 1994 is supposed to be underestimated and that of 1998 could have been overestimated by a factor of two (del Río, 1998).

In Fig. 2 the adult biomass estimates are compared with the total biomass and female biomass along the series. Differences between these quantities in each year correspond to the catch or not of small shrimp, those size classes that are more directly affected by small changes in the cod-end mesh size. The differences between the total biomass and the adult biomass were small in the 1988-1997 period ranged between 1.6 % and 12.1 % of the total. That is, the greater portion of shrimp catch was bigger than 20 mm CL. The small variations in these percentages over the period could be mainly due to the intrinsic variability of trawl catches and not to differences in small shrimp abundance. The difference between both biomass estimates was 37.8 % in 1998 when a 25 mm liner was used, and not comparable conclusions can be thrown. From 1999 to 2003 the differences increased and always were greater than 22 % and the highest observed rates were 33.7% in 2002 and 30.3% in this year. It was attributed to increase in small shrimp abundance.

Length frequencies

Length frequencies and percentages by sex from the 2003 survey are shown in Table 3. These length frequencies are split into males, primiparous females and multiparous females. The percentage of males increased from 53.33 % in 2002 to 67.66 % in 2003 (del Río *et al*., 2002). The percentage of females decreased from 46.66 % in 2002 to 32.33 % in 2003 (15.43 % primiparous and 16.90 % multiparous). The ovigerous females are not present in the catches because the spawning period in Flemish Cap begins between the end of July and the beginning of August (Mena, 1991) and this year the survey finished on June 27th. Males presented a CL between 7.5 and 24.5 mm. Females presented a CL between 16.5 and 31.0 mm comprising the groups: 17.5-28.5 mm primiparous and 16.5-31.0 mm multiparous.

Length frequencies by strata in 2003 are shown in Table 4. In this survey as in previous years, the results indicate that the minimum shrimp size increases with depth. The small size individuals (males shrimp) dominated shallowest strata and the large size individuals (females shrimp) are present in deepest strata:

Strata	Depth range		Minimum observed size (mm CL)
	Meters	Fathoms	
2	147-182	81-100	7.5
3 to 6	183-256	101-140	7.5
7 to 11	257-360	141-200	8.5
12 to 15	361-547	201-300	19.0
16 to 19	548-725	301-400	21.5

Minimum observed size was 7.5 mm CL in depths less than 140 fathoms. It was 8.5 mm CL in depths between 141 and 200 fathoms. The minimum size was 19.0 mm CL in strata between 201 and 300 fathoms, and finally, it was 21.5 mm CL in depths between 301 and 400 fathoms.

Table 5 shows shrimp length frequencies on Flemish Cap from 1988 to 2002 transformed by factor correction obtained following Warren`s length conversion method. These shrimp length distribution are illustrated from 1995 to 2003 in Fig. 3. Modal groups named with the same letter belong to the same year-class (Table 6) according to the previous results of age analysis (del Río *et al.*, 2002) and the modal analysis of this year. In the 2003 the youngest modal group (age 1) appears for first time well represented with a modal length of 9.5 mm. However, the prominent peak of about 18 mm CL (age 3) in 2002 survey doesn't appear represented in the length distribution obtained this year.

Length-weight relationship

Length-weight relationship for males and females in year 2003 are illustrated in Fig. 4. Length-weight equations by sex were for this period:

For males:	$W = 0.0006*CL^{2.9899}$	(N= 1214, r^2=0.98)
For primiparous females:	$W = 0.0005*CL^{3.0245}$	(N= 365, r^2=0.95)
For multiparous females:	$W = 0.0006*CL^{2.9810}$	(N= 613, r^2=0.92)
For sexes combined:	$W = 0.0006*CL^{2.9653}$	(N= 2192, r^2=0.98)

where W is weight in g and CL is the oblique carapace length in mm.

Weight by length-class of shrimp for years 1989-2003 is shown in Fig. 5. The decrease tendencies observed in the last surveys is continued in this year, mainly at length bigger than 20 mm CL.

Age structure

Table 6 shows the preliminary and visual interpretation of shrimp modal groups and ages from length distribution.

The age assessment of the shrimp caught from 1988 to 2002 in the surveys presented by Skúladóttir and Diaz (2001) and del Río, *et al.,* 2002, always indicated the presence of four age groups, (from 3 to 6 year olds). Since 1995 the youngest age groups were present: the age group two since 1995 and age group one since 2002.

In 2003 a similar modal analysis of the length distribution to estimate age structure was realized and the proportion, average size and standard deviation of age/maturity groups are shown in Table 7, according to Unnur Skúladóttir (personal communication). The results of the modal analysis indicated the presence of six age groups shrimp in this year and age at sex change is at age 4. Contrary to the last year, in 2003 didn't appear any age groups dominant. Females were split into primiparous (age 4 and 5) and multiparous (age from 4 to 6). Figure 6 shows modal groups and age distribution of shrimp from modal analysis of length distribution obtained in the 2003 survey on Flemish Cap. Mean carapace length at age from 1988 to 2003 surveys are presented in Table 8.

Biomass estimated index by age groups in all surveys are shown in Table 9. The biomass estimated from 1988 to 2002 was transformed by the FPC obtained in the calibration. The female biomass decreased from 20 355 tons in 2002 to 10 697 tons in 2003 (Table 1). This declined was mainly due to reduction of 62 % in the biomass of age 5. In this year the age 4 was the predominant annual class (10 197 tons) and the biomass estimated for age groups 1 and 2 was the biggest in the all series predicting a good recruitment in next years.

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Table 1. Mean catch per tow in the years 1988-2003 on Flemish Cap surveys. Total biomass and Female biomass indices estimated by swept area method (from 1998 to 2002 the original values were transformed by FPC).

Year	Mean catch per tow (Kg)	Standard error	Total Biomass (tons)	Biomass CL>20mm (tons)	Female Biomass (tons)
1988	4.69	0.49	3,776	3,672	3,270
1989	4.28	0.42	3,356	3,239	2,338
1990	4.64	0.37	3,733	3,291	1,975
1991	17.82	1.24	14,329	13,710	9,357
1992	35.88	3.25	28,848	28,285	20,084
1993	18.90	1.81	16,153	14,470	11,935
1994[1]	7.24	0.61	5,823	5,727	4,926
1995	11.74	0.77	9,446	8,993	7,480
1996	14.12	0.59	11,347	9,975	7,240
1997	11.06	0.44	8,893	8,200	6,644
1998[2]	36.07	1.40	29,004	18,039	14,120
1999	26.98	1.17	21,692	16,798	15,795
2000	21.10	0.91	16,962	12,039	11,436
2001	30.61	1.13	24,616	19,589	15,666
2002	39.30	1.95	31,602	20,957	20,355
2003	27.80	1.92	22,359	15,575	10,697

[1]codend mesh-size 40 mm
[2]codend mesh 40 mm and 25 mm liner

Table 2. Total shrimp biomass estimated by strata (tons) in the years 1988-2003 on Flemish Cap surveys (from 1998 to 2002 the original values were transformed by FPC).

Stratum	Depth (Fathoms)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	70-80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	81-100	0	0	0	0	0	0	0	283	0	0	28	0	0	17	14	757
3	101-140	0	0	0	9	0	2	0	3	150	37	321	281	1016	1691	**4091**	2261
4	101-140	0	0	0	0	0	0	0	0	0	0	51	270	168	824	1127	654
5	101-140	0	0	0	7	14	0	0	10	21	99	522	1485	1532	1886	1677	3859
6	101-140	0	0	3	33	5	5	0	19	164	194	1405	946	557	1616	2396	2026
7	141-200	31	35	370	1244	3724	2450	162	522	1194	1112	2276	2509	1811	2667	3502	1440
8	141-200	16	89	80	276	1972	951	5	319	719	469	1443	2021	976	2544	3359	1166
9	141-200	99	82	42	262	154	190	0	883	565	501	3312	1140	995	1445	1688	818
10	141-200	201	77	328	2616	3975	1696	1148	1523	1234	1232	**5078**	**3286**	2246	3342	3461	**4815**
11	141-200	155	0	183	1279	4736	1386	625	789	1220	1167	4298	2578	**2771**	**3745**	3139	3128
12	201-300	**1372**	**1016**	546	**3024**	**5809**	3117	1045	1358	1588	**1520**	1803	2080	1274	1119	1902	392
13	201-300	112	101	73	110	49	209	0	49	726	688	1717	1621	66	770	326	33
14	201-300	445	380	710	1421	2862	2026	970	1103	1232	499	3103	1736	747	1059	2293	374
15	201-300	705	572	**974**	2591	4401	**3541**	**1599**	**1782**	**1609**	579	2304	1333	1960	974	1375	474
16	301-400	537	408	417	298	529	232	77	82	258	211	593	237	644	581	749	96
17	301-400	3	17	0	0	0	0	0	0	0	2	0	0	0	0	5	0
18	301-400	0	0	0	0	0	0	0	2	52	14	0	3	16	0	47	0
19	301-400	98	578	7	1157	618	284	194	719	613	571	1145	159	180	337	450	64
Total		3776	3356	3733	14329	28848	16153	5823	9446	11347	8893	29395	21692	16962	24616	31602	22359

Table 3. Shrimp length frequencies and percentages by sex and stage maturation in the 2003 survey on Flemish Cap.

LENGTH (mm CL)	MALES	FEMALES	
		Primiparous	Multiparous
7,5	58		
8	324		
8,5	666		
9	731		
9,5	804		
10	556		
10,5	132		
11	21		
11,5	8		
12	50		
12,5	204		
13	490		
13,5	963		
14	1887		
14,5	2756		
15	3057		
15,5	2310		
16	2113		
16,5	1929		78
17	1137		
17,5	1616	30	11
18	2086	89	11
18,5	1880	69	73
19	2701	78	68
19,5	2115	62	86
20	2122	527	293
20,5	1936	816	400
21	1420	871	364
21,5	828	703	493
22	224	1307	309
22,5	62	1026	591
23	77	989	942
23,5	55	437	831
24	11	501	810
24,5	8	326	845
25		148	804
25,5		181	813
26		118	400
26,5		143	283
27		51	335
27,5		31	197
28		13	165
28,5		3	45
29			35
29,5			16
30			21
30,5			3
31			4
Percentage	67,66	15,43	16,90

Frequence x 10^5

Table 4. Shrimp length frequencies by strata in 2003 on Flemish Cap survey.

LENGTH	STRATA																
mm (CL)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	19	Total
7.5	33	3			22												58
8	35	70			219												324
8.5	47	180			395					44							666
9	43	268	3		417												731
9.5	29	245	3		527												804
10	16	299			241												556
10.5	10	34			44					44							132
11	18	0	3														21
11.5	4	1	3														8
12	27	2			22												51
12.5	100	20		63	22												205
13	153	71	9	126	88					44							491
13.5	273	168	31	251	176				21	44							964
14	388	503	34	377	439		8		50	88							1887
14.5	182	914	62	502	636		8	23	253	177							2757
15	226	903	52	440	483		24	6	393	530							3057
15.5	76	781	41	251	461	21	12	11	435	221							2310
16	45	506	35	314	263		41	11	324	574							2113
16.5	2	387	18	440	219	21	17	6	148	750							2008
17	10	142	49	314	132		24	6	240	221							1138
17.5	35	193	3	816	132		38	6	258	177							1658
18	22	298	37	1005	132	21	103	45	436	88							2187
18.5	26	300	35	817	132	42	164	34	474								2024
19	12	227	53	1194	154	63	216	86	524	314	2			4			2849
19.5	43	267	83	503	154	84	249	63	592	221	2		3				2264
20	35	250	34	816	176	148	317	57	819	286	6						2944
20.5	49	278	74	691	132	190	220	113	859	545	2						3153
21	57	197	99	691	154	274	233	62	665	193	18		9	4			2656
21.5	37	221	102	628	22	127	124	62	428	243	13		6	11	1	1	2026
22	4	279	101	565	88	168	89	125	289	98	11		6	18		1	1842
22.5	29	178	70	252	110	147	132	92	322	320	15		6	8			1681
23	10	250	84	439	110	274	137	97	461	94	29		12	11	1		2009
23.5	10	42	62	63	132	295	53	57	423	121	39		15	7	2	3	1324
24		65	45		132	338	57	85	466	71	45		6	11	2	1	1324
24.5		73	14	126	154	210	25	57	302	142	46		9	15	4	3	1180
25		35	7		66	168	12	39	284	229	34	2	38	30	4	5	953
25.5		28		63	88	84	14	46	204	297	63	3	23	70	6	6	995
26		3	4			84	4	46	101	93	39	3	27	95	16	4	519
26.5		28	4		22	63	4	17	66	93	32	4	26	51	11	6	427
27					22	105	1	6	46	27	33	5	44	66	19	13	387
27.5					22	42		17	13	16	23	3	23	44	20	6	229
28						21				49	18	2	29	44	10	6	179
28.5											7		12	18	8	4	49
29							1				3		20	7	4		35
29.5											1		6	4	4	1	16
30										11	2		6		2		21
30.5													3				3
31													3		1		4

Frequencies x 10^5

Table 5. Shrimp length frequencies on Flemish Cap from 1988 to 2002 transformed following Warren´s length conversion method.

LENGTH (mm CL)	1988	1989	1990	1991	1992	1993	1994	1995
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11								
11.5								
12		1						
12.5		3						
13		2				26		1
13.5		0		2		84		12
14		2		5	22	164		21
14.5	4	2	3	39	33	445	2	57
15	36	6	3	93	251	996	5	139
15.5	48	19	20	180	583	1145	23	197
16	94	31	67	273	674	1232	22	298
16.5	155	63	191	500	578	870	48	403
17	291	115	508	874	604	445	60	356
17.5	383	201	930	884	566	110	87	205
18	319	247	1234	656	250	146	58	103
18.5	251	206	1106	278	81	176	34	46
19	120	99	636	97	69	331	11	49
19.5	58	75	335	125	299	715	20	164
20	72	134	144	496	723	522	47	271
20.5	86	169	100	1010	1330	625	129	442
21	96	225	95	1588	1547	432	189	640
21.5	162	202	152	1748	1538	424	248	759
22	364	145	234	1502	1501	211	187	665
22.5	429	102	243	1443	1522	164	122	413
23	623	69	250	1357	2219	308	83	341
23.5	558	78	186	1235	2747	483	91	249
24	573	131	167	886	3138	540	121	218
24.5	403	160	120	555	3040	560	132	299
25	384	177	88	354	2435	890	128	392
25.5	433	193	74	308	1786	1078	166	430
26	379	163	67	322	1309	1038	152	446
26.5	451	110	50	291	672	908	235	414
27	160	49	28	244	423	664	308	330
27.5	190	35	21	147	433	359	372	268
28	59	40	11	119	212	243	318	248
28.5	75	19	5	44	107	149	261	205
29	38	15	3	24	56	57	151	186
29.5	25	11	2	8	26	36	66	152
30	12	4	1	6	8	18	42	78
30.5	5	2	1	2		6	17	47
31	4	0	0	0		6	13	18
31.5	1					0	6	6
32				0			1	1
32.5				2			2	1
33							0	

Frequencex10^5

Table 5. (continuation)

LENGTH (mm CL)	1996	1997	1998	1999	2000	2001	2002
7,5							
8			10				
8,5			46	9			102
9			43				163
9,5			111		16		215
10			81		15	22	214
10,5			193		14		165
11			154			13	58
11,5			264		6	6	72
12	26		578		6	39	17
12,5	80		1708	21	16	63	42
13	143	3	2110	168	30	168	128
13,5	286	21	4506	370	65	324	199
14	318	53	4372	610	152	692	893
14,5	267	29	4992	771	123	959	1693
15	182	37	4337	780	158	1529	1695
15,5	163	56	3015	1165	226	1788	1744
16	138	88	2103	1368	375	2540	2048
16,5	109	44	1516	2074	883	2607	3191
17	137	95	2262	3029	1605	2311	4207
17,5	79	94	3370	3381	2653	1892	6925
18	165	205	5365	3571	3266	1640	7870
18,5	309	310	7490	2490	3304	1920	6973
19	567	560	6955	2105	2769	2115	5562
19,5	1206	521	5636	1391	2553	2167	4208
20	1400	531	3763	1659	2628	2610	2889
20,5	1644	343	3174	2136	2435	3094	2338
21	1476	337	2520	2338	2063	3410	2146
21,5	1403	301	2529	2704	1808	3287	2531
22	721	466	2113	2591	1509	3248	2515
22,5	573	473	2424	2723	1386	3121	3042
23	408	917	1524	2144	1284	2637	2960
23,5	328	703	1691	1905	1141	2171	2679
24	463	933	1423	1493	979	1690	2343
24,5	527	750	1310	1127	853	1122	1827
25	633	694	1004	867	744	930	1341
25,5	475	552	972	630	572	549	894
26	386	495	720	487	441	476	572
26,5	324	332	666	312	297	334	399
27	279	264	404	255	205	257	258
27,5	159	106	277	166	128	158	109
28	167	118	146	74	86	102	79
28,5	116	43	118	38	50	42	43
29	102	51	57	21	28	39	20
29,5	79	19	13	11	17	14	15
30	68	20	27	7	6	23	9
30,5	57	11	10	3	4	4	4
31	19	7	8	2	1	8	2
31,5	11	6	1		1	1	
32	5	2	1	1		3	
32,5	6	0	1				1
33	0					1	

Frequencex10^5

Table 6. Shrimp modal groups and ages in the 2003 on Flemish Cap survey interpreted from size distributions.

Age	Modal groups		Cohort
	Males	Females	
1	9.5	-	R
2	15	-	P
3	19	-	O
4	21.5	21	N
5	-	23	M
6	-	25.5	L
7	-	27	K

Table 7. Results from the modal analysis (Mix) for each sex/maturity group.

Sex and maturity group	Male		Primiparous Female		Multiparous Female	
Age	Prop.	St.Dev.	Prop.	St.Dev.	Prop.	St.Dev.
1	0.088	0.001				
2	0.329	0.003				
3	0.228	0.003				
4	0.354	0.003	0.757	0.007	0.188	0.005
5			0.243	0.007	0.567	0.009
6					0.245	0.009
7						
	Mean CL	St.Dev.	Mean CL	St.Dev.	Mean CL	St.Dev.
1	9.42	0.008				
2	14.91	0.008				
3	17.36	0.014				
4	20.11	0.010	21.82	0.016	20.69	0.144
5			24.69	0.036	23.97	0.066
6					26.52	0.128
7						
	Sigma	St.Dev.	Sigma	St.Dev.	Sigma	St.Dev.
1	0.424	Fixed CV				
2	0.671	Fixed CV				
3	0.781	Fixed CV				
4	0.905	Fixed CV	0.982	Fixed CV	0.931	Fixed CV
5			1.111	Fixed CV	1.079	Fixed CV
6					1.194	Fixed CV
7						

Table 8. Mean carapace length (mm) at age by years on Flemish Cap surveys.

Year Age group	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean CL
1															10.4	9.5	9.9
2					16.8	16.0		15.5	14.9	15.9	14.6	15.2	14.8	15.8	15.6	15.2	15.5
3	18.0	18.3	18.4	17.5	21.3	20.4	17.5	17.0	20.9	19.9	18.9	18.0	18.3	18.1	18.5	17.8	18.7
4	23.6	21.6	21.5	21.6	23.4	23.5	21.9	22.0	24.7	23.6	21.8	21.4	21.1	21.6	21.2	21.2	22.2
5	26.6	25.6	23.6	23.5	24.2	26.2	25.9	25.7	25.7	25.8	24.7	23.6	24.4	24.1	23.7	25.2	24.9
6	28.7	28.2	26.8	26.8	27.0	28.7	28.1	26.5	27.2	29.2	26.7	26.1	27.1	26.4	25.7	27.7	27.3
7					29.0			30.0	29.4		29.1	28.4		29.3	28.1		29.0

Table 9. Biomass estimated (tons) at age by gears on Flemish Cap surveys.

Year Age group	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1															13	160
2					583	937		37	142	40	1967	358	58	1044	900	2409
3	225	361	1447	862	3174	1742	65	239	4214	963	8879	3206	3045	2112	8683	2648
4	1686	770	503	4110	5511	1768	588	2410	2291	3256	7823	6275	6514	11631	5228	10197
5	1820	1937	1326	6096	13369	11040	1359	1878	2036	4129	7045	8153	5663	7213	13113	4912
6	46	288	457	3262	5686	668	3811	2539	1089	504	3269	3410	1682	2256	3137	2034
7					525			2344	1575		412	290		361	528	
Total	3776	3356	3733	14329	28848	16154	5823	9446	11347	8893	29395	21692	16962	24616	31602	22359

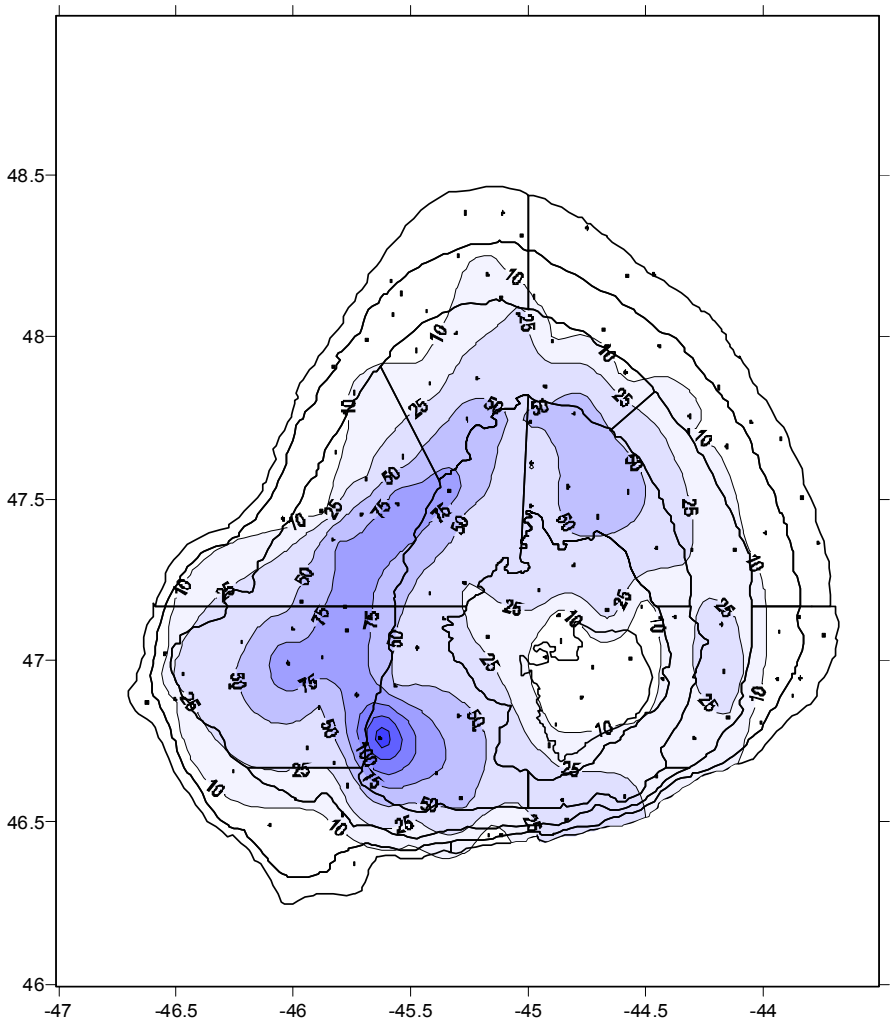

Fig. 1. Shrimp catches distribution (kg/tow) in June 2003 on Flemish Cap survey.

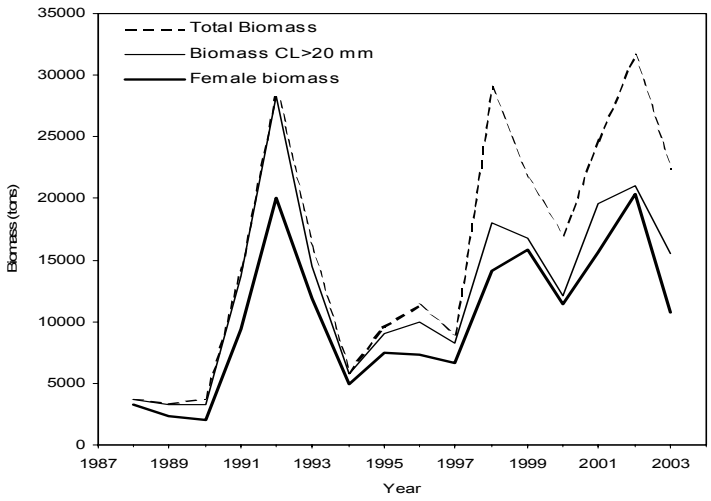

Fig. 2. Total biomass and biomass for shrimp bigger than 20 mm CL (adult stock) from Flemish Cap 1988-2003 surveys.

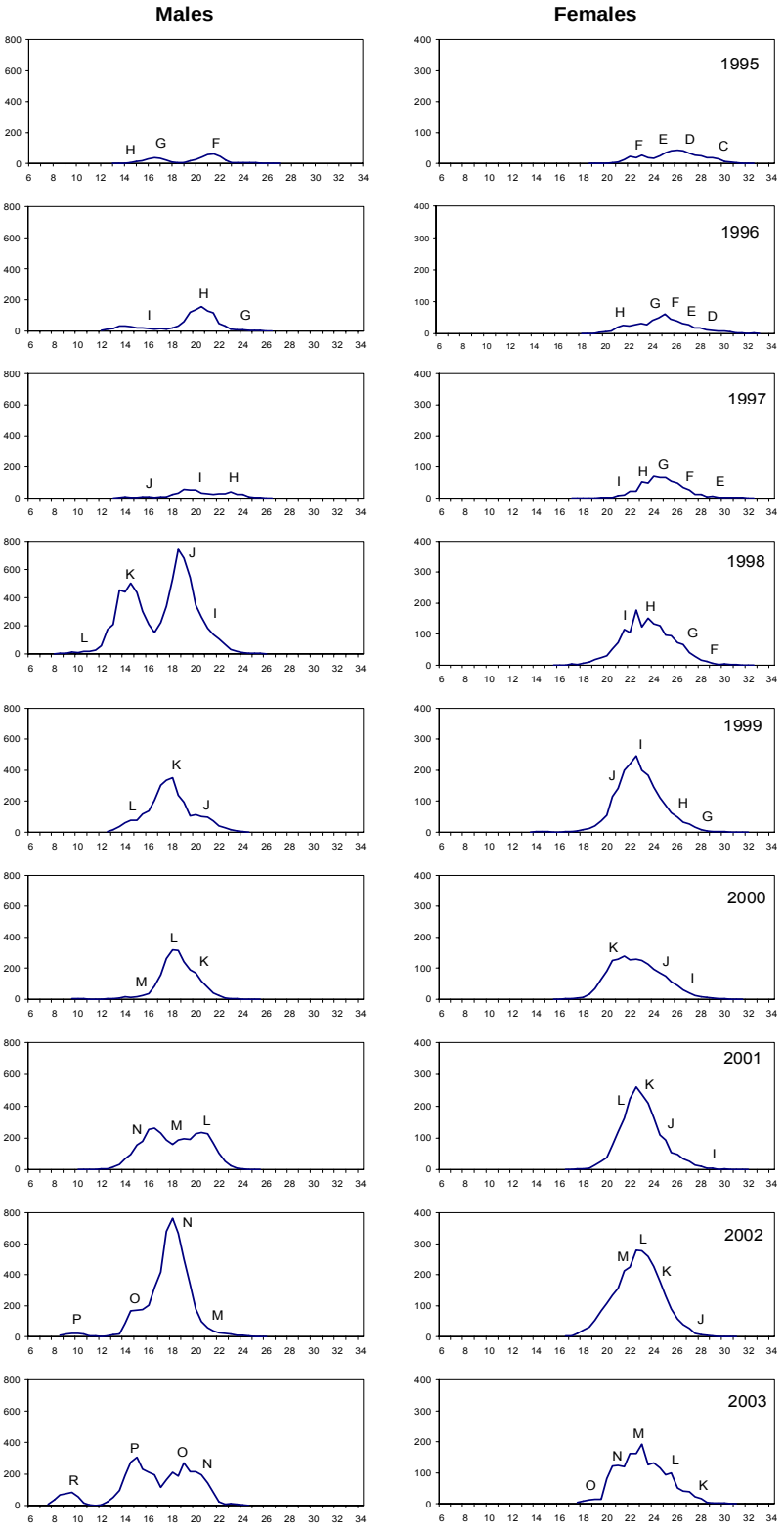

Fig. 3. Shrimp size distribution on Flemish Cap 1995-2003 surveys. Y-Axis=Frequency(10^6)X-Axis=Carapace Length (mm)

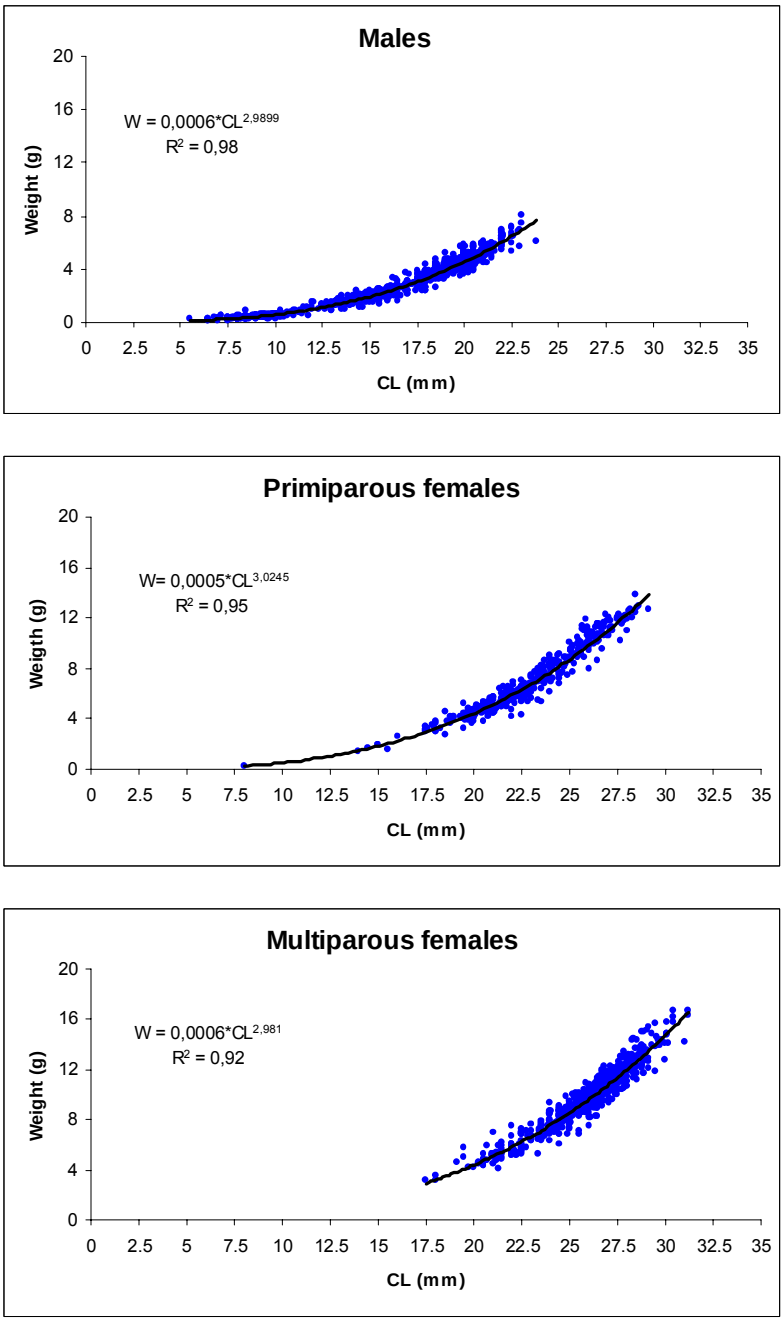

Fig. 4. Shrimp length-weight relationship by sex in 2003 on Flemish Cap survey.

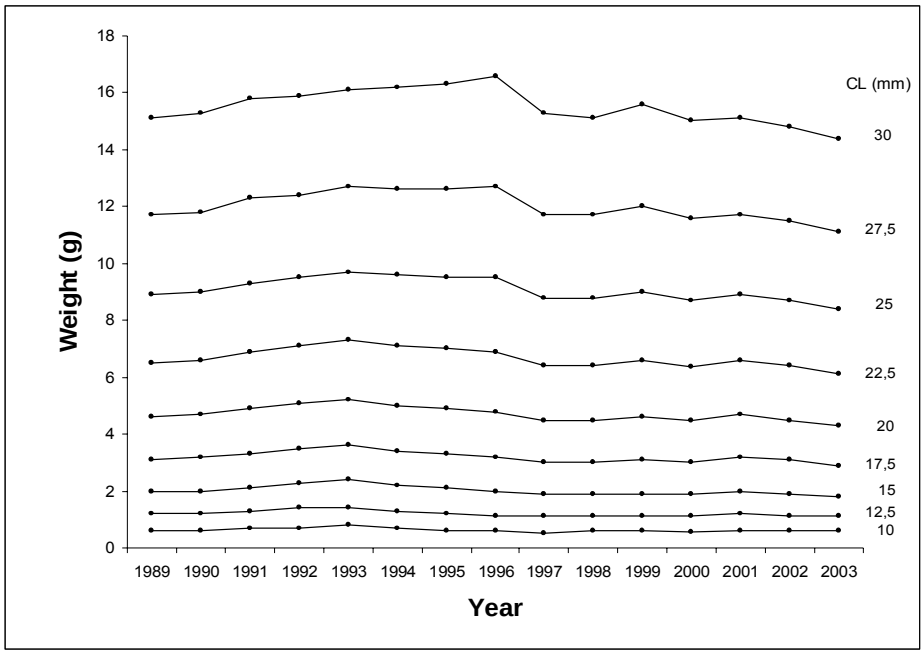

Fig. 5. Shrimp weights at length from Flemish Cap surveys 1989-2003.

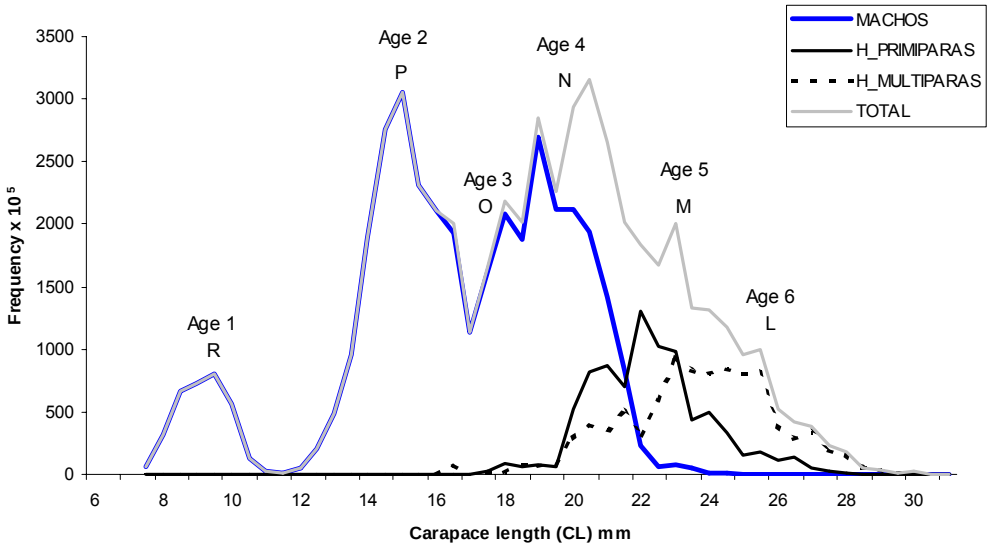

Fig. 6. Shrimp modal and age groups in the 2003 survey on Flemish Cap (letters from Table 6 and 7)