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Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2006

by

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Abstract

A stratified random bottom trawl survey on Flemish Cap was carried out from June 28th to July 27th 2006. The area surveyed was extended up to depths of 800 fathoms (1400 meters) following the same procedures as in previous years and increasing the number of hauls planned (195). A total of 179 valid hauls were made by the vessel *R/V Vizconde de Eza* with the usual survey gear (Lofoten), 115 up to 730 meters depth. The general indexes for shrimp were estimated taken into account the traditional swept area (strata 1-19, up to depths of 730 m.) and the total area surveyed (strata 1-34, up to depths of 1 400 m.).

The results concerning shrimp are presented and compared to those from previous years of the same series. The biomass and abundance have dropped significantly in 2006 at levels prior to 1998. Although this fall was produced in all age classes with the exception of age 4, the decreasing was mainly due to reduction of 3 year olds individuals (about 67% in number respect the last year). The decreasing of female biomass was less remarkable mostly due to the less importance of the 3 age-class in this sex group and the increasing of the 4 age-class respect of 2005 as a result of the 2002 strong year-class. Also, as in the last years (2004 and 2005) the youngest specimens (age 1) didn't appear in the catches, and they were weakly presents in the small mesh size bag attached to the cod-end, suggesting the absence of any strong year-classes since 2003.

Introduction

The aim of this paper is to show the results about shrimp obtained in the summer bottom trawl surveys in Flemish Cap (NAFO Regulatory Area of Div. 3M) in 2006. The indexes for this year are compared with that obtained in the past three years 2003, 2004 and 2005 by the R/V *Vizconde de Eza*, and with the transformed series previous to 2003 obtained by the R/V *Cornide de Saavedra*. Some errors were found in the catches recorded in the EU survey 2005. Because of that the indexes presented in the Scientific Council Meeting last year (Casas *et al.* 2005), have been reviewed, and the corrections are presented in this paper.

Material and Methods

Survey Design and Gear Used

The surveys on Flemish Cap (NAFO Regulatory Area of Div. 3M) was initiated by UE in 1988 and carried out in summer (June-July), on board the Spanish Research vessel R/V *Cornide de Saavedra* until 2002 year. Since 2003, the R/V *Cornide de Saavedra* was replaced by the R/V *Vizconde de Eza*. The gear used was a bottom trawl net type Lofoten during the whole of period.

In 2006 the survey was carried out from 28th of June to 27th of July. As the last years, the area prospected in Flemish Cap was spread up to 1 400 meters. The new area was sampled by means of 64 additional hauls proportionally distributed in the new 15 strata. The haul number carried out in the 19 strata with depths minor than 740 m. was of 115.

The bottom trawl surveys followed the same procedures as in previous years. The specifications about the main technical data of the survey are described in Table 1.

Sampling

Samples of approximately 1.5 kilogram shrimp were taken in each tow where this species was present for length frequency determination. Also, some samples were frozen for length-weight analysis in 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 as females. 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.

Sex reversal (L_{50F}) and Length at Maturity (L_{50MF})

In order to analyze changes in the length at maturity, from each length class the proportion (*pi*) of mature females against all specimens was calculated. The method used to estimate the maturity ogive and the length where the 50% of the specimens are mature females (L_{50FM}) was based on fitting of the sigmoid, so-called logistic curve.

The equation used was

$$Y = 1/(1+e^{-(a+bx)}).$$

with a *y b* being the intercept and slope respectively of the regression *Ln (pi/1-pi)* on length-class.

The logistic curve was fitted each year using a non-linear method to estimate the parameters by iteratively minimizing the sum of squares of the deviations between observed and predicted proportions where the mature females were presents.

In the same way the sex ratio by length classes were estimated to obtain the length at sex change where 50% of the specimens are females (L_{50F}).

Age Composition and MIX Program

As previous years the length frequency distribution by sex group were analysed by MIX program and the proportion, mean lengths and standard deviations of the mean length (sigma) are calculated for each age component and sex group. When the modal components overlap and obscure one another, was necessary to reduce the number of parameters estimated in order to get the best and reasonable adjust. We have constrained sigma very often fixing the coefficient of variation (CV) at 0.045 or keeping it constant.

After getting the proportions and mean lengths for every age/sex group the results were used to calculate the total number of individuals in every age/sex group according to the biomass estimate. This was done by transforming the CL to weight using the weight length relationship estimated each year during the survey. So, the mean lengths were converted to mean weights to calculate the number of males, primaparous females and multiparous females (Skúladóttir and Diaz, 2001).

Small Mesh Size Bag on the Cod-end

Knowing that mean size of shrimp coincides with the selection range of the 35 mm mesh currently used, a bag with 6 mm mesh size was attached as last years to the cod-end of the Lofoten gear, just in a position where escapement is believed to be the highest. The base of the bag was a square of 36 cm in each side. The whole shrimp caught in the juvenile bag was weighted and measured.

Results

Biomass

This year a total of 179 valid bottom trawls were completed with Lofoten trawl gear in Flemish Cap survey, 115 of them were carried out in the traditional strata prospected from 1988 with depths up to 740 m. (Fig. 1).

Total shrimp biomass, estimated by swept area method and mean catch per tow from 1988 to 2006 are presented in Table 2. The values presented from 1988 to 2002 year are those resultants of the Warren's transformation of the lengths distribution obtained by the R/V *Cornide Saavedra* and the length-weight relationship estimated every year (Casas *et al.*, 2005).

The increasing of biomass since 1988 to 1992, coincided with a period of time where there was not a directed fishery to shrimp and the cod stock began to decline. With the beginning of the shrimp fishery in 1993 the biomass declined up to 1997. After that the stock recovered reasonably well staying without trends in the last years showing high annual variability. The biomass index obtained in 2005 (30 675 tons), was among the highest of the series, increasing a 52% with regard to 2004. This increase contrasts with the biomass estimated this year (16 235 tons), the lowest since 1997 and about a 47% lesser than the estimated in 2005.

Biomass estimated by depth strata from 1988 to 2006 is shown in Table 3. The presence of shrimp in shallowest strata, with depths less than 140 fathoms (257 m), was scarce in the first years (1988-1995). However, since 1996, a noticeable amount of shrimp occurred in these strata and the estimated biomass increased up to 2002 year where 12 978 tons, about the 36% of the total biomass were estimated in depths lesser than 140 fathoms (Table 4). After 2002 the biomass estimated in these depths declined each year and in 2006 was only the 16% of total biomass. In accordance with this, the catch distributions observed during the 2006 survey (Fig. 2) showed a distribution around the central area of the bank but in depths higher than in previous years.

Adult stock, female biomass

Total biomass estimates by the series of bottom trawl surveys on Flemish Cap from 1988 to 2006 (Table 2) are quite variable, due to the predominant sizes of the shrimp are in the selection range of the cod-end mesh size used (35 mm), so the biomass estimations are clearly affected by small changes in cod-end mesh size between years. To solve this problem it was proposed to use the shrimp bigger than 20 mm CL (Table 2). 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 2. This index showed also the decreasing of the biomass in 2006 (Fig. 3), although was lesser affected than total biomass (20% respect to 2005 index.).

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. 3 the adult biomass estimates are compared with the total biomass and female biomass along the series. Differences between these quantities in every year correspond to the greater or smaller catch of young shrimp. Although the smaller size-classes are more directly affected by small changes in the cod-end mesh size the

differences between the total biomass and the adult biomass (>20 mm.) showed an increasing trend in the total period 1988-2005 from 6% in the beginning of the series to 58% and 46% in 2005 and 2006 respectively (Fig. 4). The greatest difference founded in 1998 (60%) was due to the lesser mesh size of the linner codend used (25 mm.), and not comparable conclusions can be thrown.

From the Fig. 3 can be also observed as the female biomass after 2004 become bigger than the adult biomass (>20 mm.). The reason for that are the low values in the length at sex-change (L_{50F}) from those years. In fact this decrease in the length at sex change is a general trend along the whole series (Fig.5a.). This trend is corresponding with a similar decrease of the length at maturity (L_{50MF}) (Fig. 5b).

Length frequencies

The length frequencies and percentages by sex for 2006 are shown in the Table 5. These length frequencies are split into males, primiparous females, multiparous females and ovigerous. The rise of the smallest sizes along the years, fit in general way with the increase of the male percentage, getting in 2005 the biggest value in the historical series (75%), with the exception of 1998 (which can not be compared as it was before said). In 2006 survey the percentage of males (43%) was between the lower of the historical series.

Length frequencies by depth strata in 2006 were shown in Table 6. As in previous years, the results indicated that the mean shrimp size increases with depth (Table 7). The small size individuals (males) dominated shallowest strata and the large size individuals (females) were present in deepest strata.

The Fig. 6 shows the length distribution by sex on EU Flemish cap 1998-2006 surveys. In 2002 year the youngest modal group (age 1) appeared for first time well represented with a modal length about 9-10 mm. With the exception of 1998, where a lesser mesh size was used in the survey (25 mm.), the most important modal size in the historical series occurred in 2002 and 2005 around 18 and 16.5 mm CL, respectively. In 2006 the importance of the youngest individuals decreased markedly.

The length distribution of shrimp obtained in the surveys since 1988 with the Lofoten gear did not record adequately the small size groups in the beginning of the historical series. Since 1996 the age 2 was present in the catches in a significant way and the introduction of the new vessel in 2003 improved the catchability of this age; mainly due to the technological advances in maintaining more stable the performance of the fishing gear.

Since 2001 the routine use of a small mesh size bag attached to the cod-end to collect a portion of the small size shrimp escaping through the meshes was a common alternative. Total catch and length frequencies obtained with the small mesh size bag in 2006 survey are presented in Table 8. The total catch was 4138 g. and the length distribution of the shrimp caught in the bag shows two modes at 12 mm and 17 mm. CL, corresponding to age-classes 2 and 3+. The age-class 1 was weakly represented (Fig. 7).

Length-weight Relationship

Length-weight relationships by sex group in year 2006 are illustrated in Fig. 8. Length-weight equations by sex group for this period were:

For males:	$W = 0.0007 \times CL^{2.91887}$	(N= 779,	r^2=0.96)
For primiparous females:	$W = 0.0002 \times CL^{3.3953}$	(N= 663,	r^2=0.94)
For multiparous females:	$W = 0.0005 \times CL^{3.0257}$	(N= 506,	r^2=0.88)
All sexes combined:	$W = 0.0006 \times CL^{2.9816}$	(N= 1950,	r^2=0.96)

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

Age Structure

Table 9 and Fig. 7 and 9 show the preliminary and visual interpretation of shrimp modal groups and ages from the length distribution of the gear Lofoten and juvenile bag used in 2006.

Age assessment was carried out using the MIX software from the shrimp length distributions estimated every year in the survey series. The results of the modal analysis for annual surveys 2005(revised) and 2006 are shown in Table 10. The proportions within each sex group are listed as well as mean lengths and standard deviation (sigma) by age-classes.

The results of Table 10 were then used to calculate the mean length, abundance and biomass at age Tables 11, 12 and 13. In spite of the important decline experimented this year in the abundance (around 57%) in general way, an increased of this index can be observed along the historical series. This increase was mainly due to the presence in the last period 1998-2006 of several and consecutive strong year classes. The biomass indexes by age (Table 13), showed similar results.

At the beginning of the series (1988-1995) the youngest shrimp were considered to be three year olds with lengths between 15.4 and 18.2 mm. Since 1996 shrimps with two years old have been present and the lengths ranged between 12.9 to 15.7 mm. The shrimps with one year old appeared at first time in 1998 and were present up to 2003 with lengths around of 10 mm. Seven years old (exceptionally eight years old in 1991) was the greatest age estimated in the whole of the series with lengths between 26.3 and 32.2 mm. In spite of the variability of the length by age along the years, it can be observed a decreasing trend in the mean length of the all age groups (Fig. 10), mainly due to the presence in the last years of the very strong 2002 year class with mean lengths at age below average.

One of the most important uncertainties in the assessment of age this year was the location of the third modal group hidden by the strong age class of 4 years olds.

Some strong year-classes may be followed according the abundance by age groups from 1988 to 2006 (Table 12) if the assignation of the age is right. The 1986 year-class stand out in the beginning of historical series with 4, 5 and 6 years olds in the years 1990, 1991 and 1992. The individuals with 4 year olds were also especially abundant in the years 1999-2002 indicating the strong of year-classes 1995, 1996, 1997 and 1998. The 1999 year-class stand out especially judging by the high number of 3 and 5 year olds in 2002 and 2005 years respectively. In these two years both the biomass and the abundance reached out the highest values in the series, especially in 2005 where the strong 2002 year class with 3 years old was also present. In the last three years 2004-2006 without presence of 1 year old individuals in the catches and with relative low values for the ages 2 and 3 show the 2003, 2004 and probably 2005 year classes as weak and below average.

As in previous years, the results of the modal analysis in 2006 indicated the presence of seven age groups and the age at sex change around 4 years old. This year the shrimp modal group with sizes around 15.5 mm (considered to be three years old) was a 90% lesser than the same age in 2005. The drastic fall in all age groups with the exception of 4 years olds made to decrease the biomass in 2006 at levels previous to 1998 year.

Considering the abundance at age 2 as indicator of recruitment, the number of shrimp of two years old in the survey and from juvenile bag (Table 10) were estimated and the index average-weighed (Fig. 11). From this figure it can be observed that in the years with strong changes (2004 and 2005) both indexes showed a similar trend but in the other years with changes less marked the trends were different.

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Table 1. Technical data of bottom trawl research surveys on EU Flemish Cap 2006.

Procedure	**Specification**
Vessel	*R/V Vizconde de Eza*
GT	1 400 t
Power	1 800 HP
Maximun trawling depth	1 400 m
Trawl winch	Automatic control on warp tension
Mean trawling speed	3.5 knots
Trawling time	30 minutes effective time
Fishing gear	type *Lofoten*
footrope / handrope	31.20 / 17.70 m
footgear	27 steel bobbins of 35 cm
mesh size in cod-end	35 mm
bridle	100 meters, 45 mm, 200 Kg/100m
trawl doors	polyvalent, 850 Kg
vertical opening	3.5 m
warp length	1.6 × depth + 430 m.
warp diameter	20
dan leno bobbin	not used
Type of survey	Stratified sampling
Station selection procedure	Random
Criterion to change position of a selected tow	- unsuitable bottom for trawling according to ecosonder register. - Information on gear damage from previous surveys.
Criterion to reject data from tow	- tears in cod-end - severe tears in the gear - less than 20 minutes tow - bad behaviour of the gear
Daily period for fishing	6.00 to 22.00 hours
Species for sampling	All fish, squid and shrimp

Table 2. Different indexes of shrimp estimated by swept area method in the years 1988-2006 on EU Flemish Cap surveys. From 1988-2002 the data were transformed by Warren method.

Year	Mean catch per tow (kg)	Total Biomass (tons)	Biomass CL>20mm (tons)	Female Biomass (tons)	Female Mean catch per tow (kg)
1988	6.98	5615	5255	4525	5.63
1989	2.80	2252	2082	1359	1.69
1990	4.23	3405	2756	1363	1.69
1991	14.12	11352	10306	6365	7.91
1992	30.48	24508	23214	15472	19.24
1993	14.52	11673	8596	6923	8.61
1994[1]	4.82	3879	3702	2945	3.66
1995	9.05	7276	6379	4857	6.04
1996	13.01	10461	8083	5132	6.38
1997	9.26	7449	6344	4885	6.07
1998[2]	48.95	39367	15562	11444	14.23
1999	30.70	24692	15073	13669	17.00
2000	23.63	19003	10649	10172	12.65
2001	33.83	27204	17462	13336	16.58
2002	45.40	36510	17319	17091	21.25
2003	26.22	21087	13070	11589	14.41
2004	25.10	20182	12027	12081	15.02
2005	38.14	30675	13609	14381	17.88
2006	20.19	16235	8578	11477	14.27

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

Table 3. Total shrimp biomass estimated by strata (tons) in the years 1988-2006 from EU Flemish Cap surveys. Between 1988 and 2002 data were transformed by Warren's method.

Stratum	Depth (Fathoms)	1988	1989	1990	1991	1992	1993	1994[1]	1995	1996	1997	1998[2]	1999	2000	2001	2002	2003	2004	2005	2006
1	70-80																3	0		
2	81-100											175			69	112	690	217	164	8
3	101-140				10					148	39	639	450	1486	2169	5527	1817	2107	1023	477
4	101-140											239	596	306	1099	1942	637	785	2395	1195
5	101-140					8				26	110	1107	1948	2135	2782	2445	3780	867	695	664
6	101-140				32	2	5		20	422	161	2915	1142	657	2112	2951	1667	1250	883	299
7	141-200		30	400	1265	3763	2704	117	506	1336	988	4056	3072	2213	3006	4632	1521	3108	2607	1370
8	141-200			88	248	1662	826	4	248	676	393	2402	2507	1140	2900	4257	1110	2043	4585	3084
9	141-200	133	69	35			135		613	459	412	3981	1139	1110	1483	1754	819	673	583	1435
10	141-200	275	75	321	2103	3235	1778	752	1315	1148	1099	7186	4052	2771	3760	3748	4685	2489	2447	614
11	141-200	263		148	1144	4096	1335	447	650	1235	1018	6049	3017	3005	4091	3460	3003	2350	2284	1086
12	201-300	2170	505	512	2361	4654	2115	636	1201	1295	1195	2042	2127	1082	845	1468	378	1222	1510	1524
13	201-300		66	64	89	38	136		28	687	554	1580	1465	43	620	217	23	230	689	691
14	201-300	618	375	623	995	2543		679	792	1076	426	3034	1717	689	843	2014	303	726	2155	923
15	201-300	963	451	855	2004	3605	2292	1078	1370	1278	478	2575	1156	1753	837	1108	483	993	1039	1539
16	301-400	777	253	355	179	420	139	49	57	237	168	515	172	464	375	506	92	696	1099	840
17	301-400						35									3			5	196
18	301-400						175			43	9			6		44		42	42	115
19	301-400	134	359		792	388		118	467	397	404	887	109	121	229	311	61	366	402	173
20	401-500																	6	250	29
28	401-500																	52	130	175
33	401-500																		5	
21	501-600																		0	
34	501-600																		13	

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

Table 4. Shrimp Biomass in depths lower than 140 fathoms (257 meters) as percentage of total biomass from EU Flemish Cap 1995 - 2006 surveys.

Year	1995	1996	1997	1998[1]	1999	2000	2001	2002	2003	2004	2005	2006
Biomass (tons) **(< 140 fathoms)**	20	596	309	5075	4136	4584	8231	12978	8594	5226	5160	2643
% of Total biomass **(< 140 fathoms)**	0%	6%	4%	13%	17%	24%	30%	36%	41%	26%	21%	16%

[1] codend mesh-size 25 mm liner

Table 5. Shrimp length frequencies (x 10^5) and percentages by sex and maturity stage from EU Flemish Cap 2006.

LENGTH (mm CL)	MALES	FEMALES		
		Primiparous	Multiparous	Ovigerous
9.5				
10	2			
10.5	29			
11	41			
11.5	93			
12	92			
12.5	116			
13	118			
13.5	162	34		
14	195	18		
14.5	283	12		
15	470	26	3	
15.5	909	71	1	
16	1286	139	8	
16.5	1851	305	23	
17	2722	454	29	
17.5	2539	777	55	
18	2215	1487	158	
18.5	1793	1618	190	
19	1007	1655	282	1
19.5	645	1706	319	1
20	406	1320	522	
20.5	224	1200	541	
21	134	950	614	
21.5	53	605	888	
22	28	546	931	
22.5	16	340	775	
23	10	266	856	
23.5	6	210	773	
24	6	126	729	
24.5	2	73	604	
25		45	386	1
25.5		17	272	
26		5	206	2
26.5		6	149	
27		4	76	
27.5			54	
28			26	
28.5			17	
29			10	
29.5			2	
30			4	
30.5				
31				
Total	17453	14015	9503	5
Percentage %	42.59	34.20	23.19	0.01

Table 6. Shrimp length frequencies (x 10^5) by strata in 2006 from EU Flemish Cap survey.

Length	STRATA																				Total
mm (CL)	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**28**	
10		1																			2
10.5		3	14				2	3	2	5											29
11		4	28	4	1				1	2											41
11.5		5	28	12		1	34		2	7	3										93
12		10	14	4		2	31		1	5	23		2								92
12.5		18	42	16	1	3	23				13		1								116
13		9	28	20	1	5	17	3	5	7	22		1								118
13.5	1	11	56	32	1	4	38		7	7	33		4		1						196
14	1	13	42	37	1	20	32	13	12	19	16		4	3	1						213
14.5	2	26	84	40	3	14	53	6	15	25	25		3								295
15	3	46	84	79	6	22	102	13	40	20	55	5	20	1	3	1					499
15.5	3	36	223	140	12	46	249	62	52	45	81	2	26		2		1				981
16	5	50	349	117	20	69	332	67	85	71	147	42	59	8	4	2	2	1			1433
16.5	3	79	573	217	11	94	491	113	95	111	217	43	80	25	14	6	3				2179
17	6	120	740	243	36	144	820	173	132	171	301	118	132	37	23	7	2				3205
17.5	4	129	516	227	36	182	1000	227	118	186	340	186	105	66	29	10	8				3371
18	3	181	517	225	80	266	1168	199	95	230	355	222	117	125	49	15	14	1			3860
18.5	2	186	349	171	84	269	979	256	93	238	333	207	124	209	61	28	14	2			3601
19		179	196	157	47	258	702	213	68	212	345	142	95	219	74	21	15	2		1	2945
19.5		88	168	123	53	255	666	223	52	159	289	172	102	195	81	27	8	5	1	3	2671
20		100	98	91	28	199	423	301	48	156	261	113	111	186	78	34	8	6	2	4	2248
20.5		75	112	43	38	162	337	203	45	139	219	114	103	253	81	20	6	6	1	4	1965
21		74	14	42	40	162	251	201	52	122	200	98	109	184	95	31	6	11	1	6	1698
21.5		66	28	44	46	161	235	192	54	76	160	83	98	184	74	22	5	8	2	9	1546
22		33	14	45	39	121	224	223	56	96	121	60	123	197	94	31	7	11	3	12	1505
22.5		42		27	35	100	129	124	59	73	112	38	92	136	88	34	9	14	3	13	1131
23		23		20	32	136	103	146	68	73	87	27	103	137	100	21	14	16	2	22	1132
23.5		8		18	53	97	71	102	62	94	52	5	100	155	95	18	9	23	4	23	989
24		5		10	30	119	80	65	48	65	44	11	80	162	72	12	11	19	4	24	861
24.5		4		8	20	53	108	42	38	68	40	15	59	109	53	13	6	18	3	22	679
25		1		8	11	49	17	15	47	42	12	5	41	85	49	8	7	12	3	16	432
25.5		3		2	9	28	26	9	14	18	9	2	37	59	40	1	4	14	2	12	289
26		1		2	1	20			17	16	13	4	22	45	34	4	7	12	1	14	213
26.5		1		2	7	11	6	6	12	16	4		14	26	25	1	4	11	1	7	155
27		3				7			8	7	1		9	14	13		2	9	1	4	80
27.5		1				5			3	3	1	2	7	9	9	3	1	6		4	54
28						2					3		2	8	6			2		2	26
28.5										2	1		2	4	2		1	2		2	17
29						2							2		2		1	1		1	10
29.5													1								2
30														2	1						4
Total	33	1634	4317	2226	782	3088	8749	3200	1506	2586	3938	1716	1990	2843	1353	370	175	212	34	205	40976

Table 7.- Mean lengths by depth range from EU Flemish Cap surveys 2006

Strata	Depth range		Mean lengths (mm CL)
	Meters	Fathoms	
2	147-182	81-100	16.4
3 to 6	183-256	101-140	17.8
7 to 11	257-360	141-200	19.2
12 to 15	361-547	201-300	19.9
16 to 19	548-733	301-400	21.8
20 to 34	734-1464	401-800	23.8
Total	147-1464	80-800	19.2

Table 8. Shrimp length frequencies taken by the small mesh size bag attached to the cod-end in 2006 survey.

Length (CL) mm	Frequency
4	1
4.5	
5	1
5.5	
6	1
6.5	13
7	15
7.5	23
8	28
8.5	24
9	25
9.5	31
10	52
10.5	80
11	111
11.5	88
12	130
12.5	90
13	64
13.5	59
14	52
14.5	46
15	68
15.5	66
16	95
16.5	96
17	114
17.5	90
18	76
18.5	50
19	24
19.5	24
20	16
20.5	8
21	3
21.5	1
22	1
22.5	
23	1
23.5	1
24	
24.5	1
Total general	1669
Catch weight (gr)	4138
Sampled weigth (gr)	2933

Table 9. Shrimp modal groups and ages with Lofoten gear and bag in the codend in 2006 from EU Flemish Cap survey interpreted from size distributions.

LOFOTEN

Age	Modal groups		Cohort
	Males	Females	
1	-	-	
2	13	-	S
3	?	?	R
4	17.5	18	P
5	-	20	O
6	-	22	N
7	-	24	M

BAG ON THE CODEND

Age	Modal groups		Cohort
	Males	Females	
1	8.5	-	T
2	12	-	S
3+	17	-	

Table 10. Results of the modal analysis (MIX) by sex and maturity stage from EU Flemish Cap surveys 2005-2006 with Lofoten gear and juvenile bag..

2005

Sex and maturity group	Juvenile bag (6mm)		Lofoten gear (35 mm.)					
			Males		Primimarous females		Multiparous females	
Age	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*
1	0.262	0.008						
2	0.103	0.011	0.025	0.003				
3	0.634	0.013	0.954	0.004	0.049	0.011		
4			0.021	0.003	0.273	0.027		
5					0.569	0.029	0.266	0.033
6					0.109	0.027	0.596	0.033
7							0.138	0.033
Age	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*
1	8.74	0.032						
2	12.50	0.1612	12.85	0.121				
3	15.89	0.050	16.54	0.017	17.52	0.200		
4			20.15	0.210	19.75	0.145		
5					21.92	0.112	21.78	0.130
6					23.98	0.225	24.10	0.132
7							26.39	0.243
Age	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*
1	0.811	Cons. CV						
2	1.159	Cons. CV	0.887	Cons. CV				
3	1.474	Cons. CV	1.142	Cons. CV	0.788	Fixed CV		
4			1.391	Cons. CV	0.889	Fixed CV		
5					0.986	Fixed CV	0.980	Fixed CV
6					1.079	Fixed CV	1.085	Fixed CV
7							1.188	Fixed CV

2006

Sex and maturity group	Juvenile bag (6mm)		Lofoten gear (35 mm.)					
	Juvenile bag* (6mm		Males		Primimarous females		Multiparous females	
Age	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*
1	0.054	0.002						
2	0.425	0.004	0.033	0.001				
3	0.520	0.004	0.144	0.004	0.026	0.002	0.012	0.003
4			0.676	0.006	0.454	0.010	0.137	0.008
5			0.147	0.005	0.413	0.009	0.390	0.013
6					0.107	0.005	0.392	0.013
7							0.068	0.008
Age	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*	*Mean CL*	*St. Dev.*
1	8.07	0.040						
2	11.90	0.020	12.58	0.027				
3	16.95	0.021	15.60	0.267	15.90	0.061	17.53	0.190
4			17.65	0.014	18.59	0.024	19.57	0.083
5			19.68	0.032	20.45	0.035	21.82	0.067
6					22.90	0.048	23.95	0.068
7							26.31	0.115
Age	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*
1	0.832	Cons. CV						
2	1.227	Cons. CV	0.566	Fixed CV				
3	1.747	Cons. CV	0.702	Fixed CV	0.718	Fixed CV	0.789	Fixed CV
4			0.794	Fixed CV	0.837	Fixed CV	0.881	Fixed CV
5			0.885	Fixed CV	0.920	Fixed CV	0.982	Fixed CV
6					1.030	Fixed CV	1.078	Fixed CV
7							1.184	Fixed CV

Table 11. Mean length (mm.) at age by years in EU Flemish Cap surveys

Year Age-class	1988	1989	1990	1991	1992	1993	1994[1]	1995	1996	1997	1998[2]	1999	2000	2001	2002	2003	2004	2005	2006	Mean CL
1											10.3	8.5	10.3	10.5	10.2	9.3				10.2
2									14.4	15.7	14.2	14.4	14.4	14.2	15.1	15.5	14.4	12.9	12.6	14.5
3	18.2	15.4		18.0	18.2	15.8	17.4	16.8	20.6	19.7	18.9	17.7	18.3	16.5	18.3	19.5	19.0	16.6	15.7	17.9
4	20.3	20.4	20.8	20.0	19.7	20.4	21.6	21.5	22.6	23.0	21.8	21.7	20.4	20.4	21.7	21.1	22.2	19.9	18.1	20.6
5	26.3	24.2	25.9	24.4	24.0	24.2	24.8	23.0	25.3	24.8	23.5	23.8	22.7	23.1	23.7	23.3	24.1	21.9	20.7	23.3
6	29.5	28.7	28.8	26.5	27.3	26.3	27.9	26.0	27.5	26.5	25.9	26.1	25.0	25.6	25.0	26.2	26.7	24.1	23.7	26.0
7	32.2	31.7	32.1	29.6	29.2	28.3	30.3	28.4	29.6	29.3	29.0	28.7	27.4	29.1	27.4	28.7	28.0	26.4	26.3	28.5
8				31.2																31.2
Total (mm)	26.4	25.2	22.5	24.9	26.2	21.4	25.3	23.0	21.5	23.1	18.1	20.1	20.5	20.1	19.6	20.2	18.9	18.5	19.79	20.0

[1]Codend mesh-size 40 mm.
[2]Codend mesh-size 25 mm.

Table 12. Abundance (10^5) at age by years in EU Flemish Cap surveys.

Year Age-class	1988	1989	1990	1991	1992	1993	1994[1]	1995	1996	1997	1998[2]	1999	2000	2001	2002	2003	2004	2005	2006
1											944	13	89	28	1806	142			
2									3424	629	54968	4735	1069	3321	11004	12572	27415	1792	582
3	133	11		472	1586	7878	427	2431	8571	2894	42349	23924	17044	18773	47872	17744	9603	69026	3005
4	1232	821	4039	2596	1459	3760	875	2764	1530	2410	7073	14962	10740	20148	11276	5484	6425	5240	19488
5	2334	809	919	4654	4396	2052	726	1203	2730	3218	7891	6008	5721	11844	10467	9073	7831	10500	12046
6	1631	828	331	3885	11289	4458	1806	2146	648	1152	4136	2043	3488	3232	3112	2426	1330	7576	5217
7	153	108	15	1025	3975	492	75	1217	437	158	152	81	605	156	545	85	206	1407	647
8				332															
total ('00000)	5482	2578	5304	12964	22705	18641	3909	9760	17339	10461	117514	51766	38757	57501	86082	47526	52810	95539	40985

[1]Codend mesh-size 40 mm.
[2]Codend mesh-size 25 mm.

Table 13. Biomass estimated (tons) at age by years in EU Flemish Cap surveys.

Year Age-class	1988	1989	1990	1991	1992	1993	1994[1]	1995	1996	1997	1998[2]	1999	2000	2001	2002	2003	2004	2005	2006
1											60	0.5	6	2	114	6			
2									609	139	9039	832	183	572	2178	2541	4660	187	57
3	44	2		166	610	2144	145	685	4552	1270	16203	7811	5924	5018	16710	7134	3730	15782	586
4	575	387	2053	1214	705	2083	554	1658	1071	1705	4099	9016	5233	9992	6436	2762	3969	2109	5882
5	2377	626	888	3843	3683	1823	681	892	2703	2853	5719	4784	3838	8321	7758	6197	6206	5702	5547
6	2334	1053	436	4094	13637	4948	2374	2313	827	1249	4038	2138	3112	3087	2696	2339	1430	5531	3606
7	285	183	28	1478	5801	675	124	1728	700	234	207	112	706	215	616	108	254	1365	621
8				557															
total (ton.)	5615	2252	3405	11352	24436	11673	3879	7276	10461	7449	39365	24695	19002	27206	36508	21087	20248	30675	16299

[1]Codend mesh-size 40 mm.
[2]Codend mesh-size 25 mm.

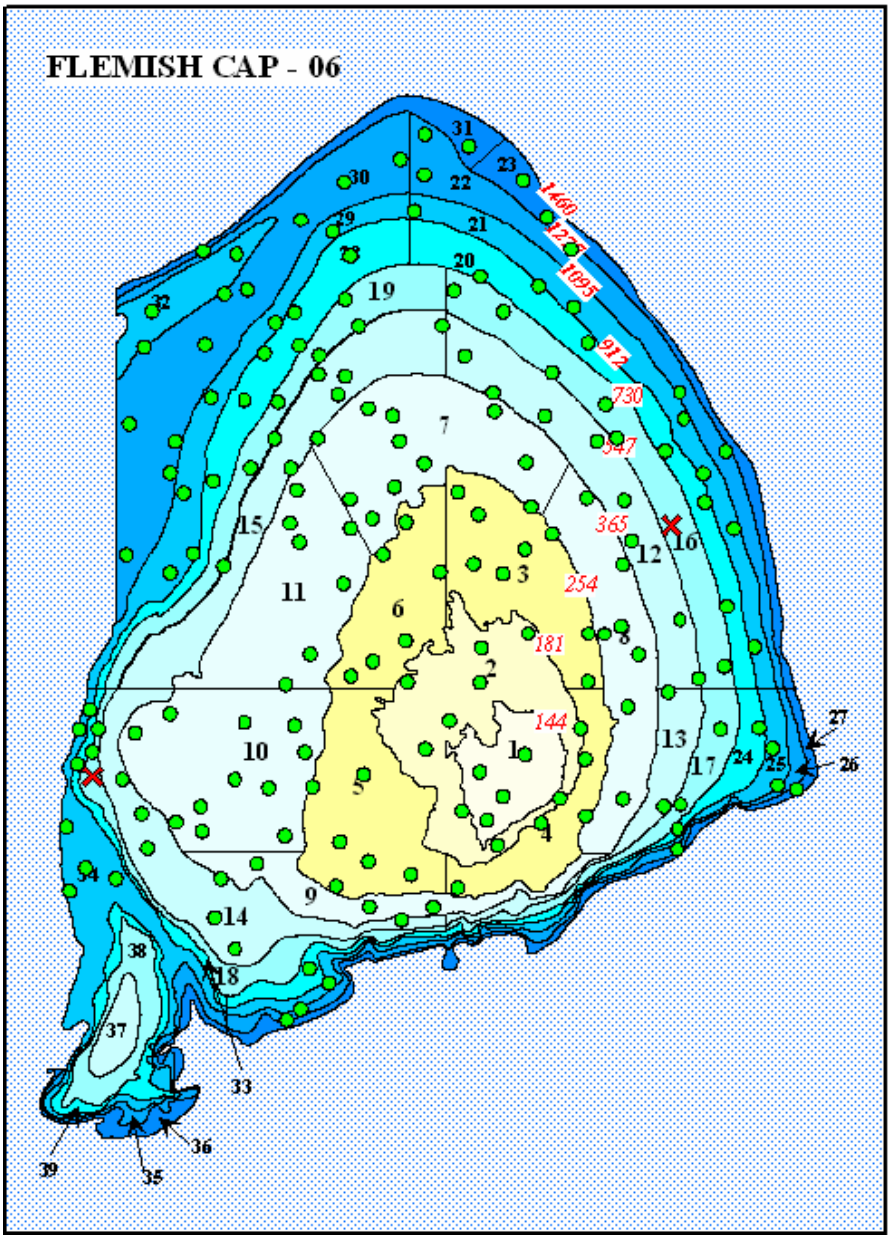

Fig. 1. Chart with the positions of the hauls carried out in EU Flemish Cap survey 2006.

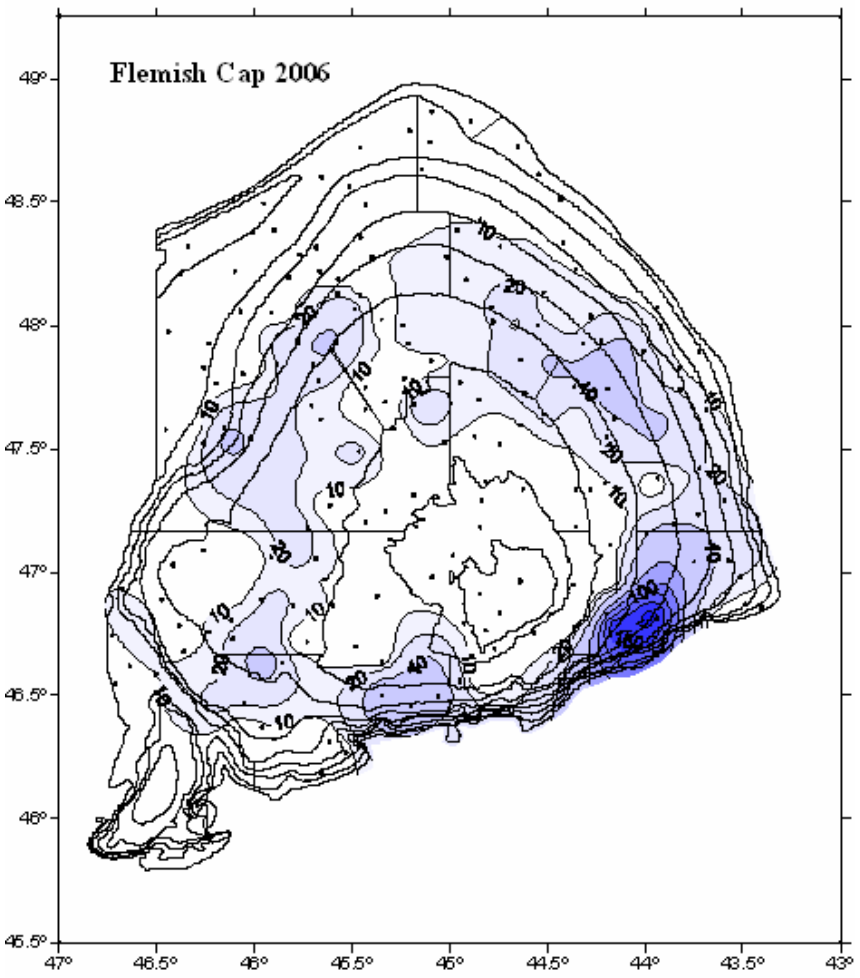

Fig. 2. Shrimp catches distribution (kg/tow) from EU Flemish Cap survey in summer 2006.

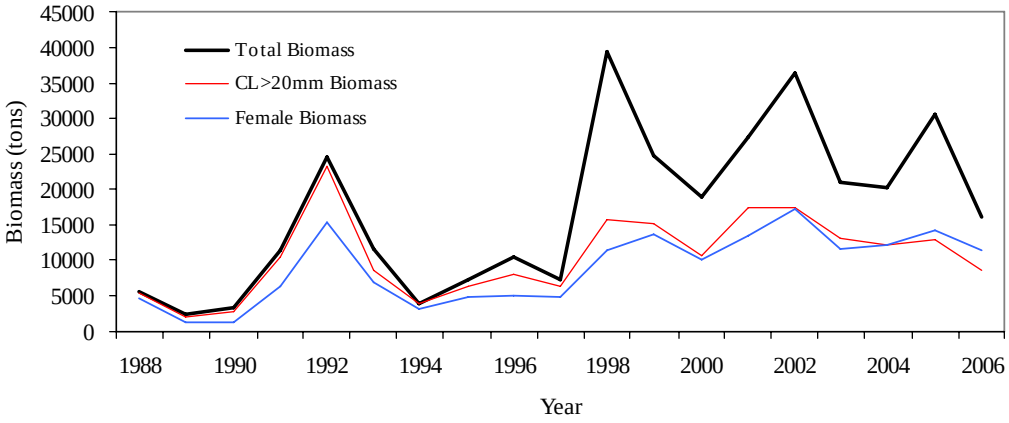

Fig. 3. Total, female and adult biomass (shrimp bigger than 20 mm CL) from EU Flemish Cap 1988-2006 surveys.

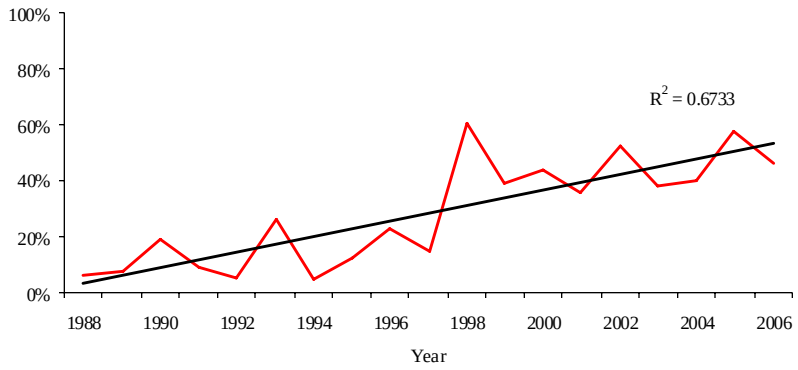

Fig. 4. Differences between total biomass and adult biomass (>20 mm.) as percentage of total biomass.

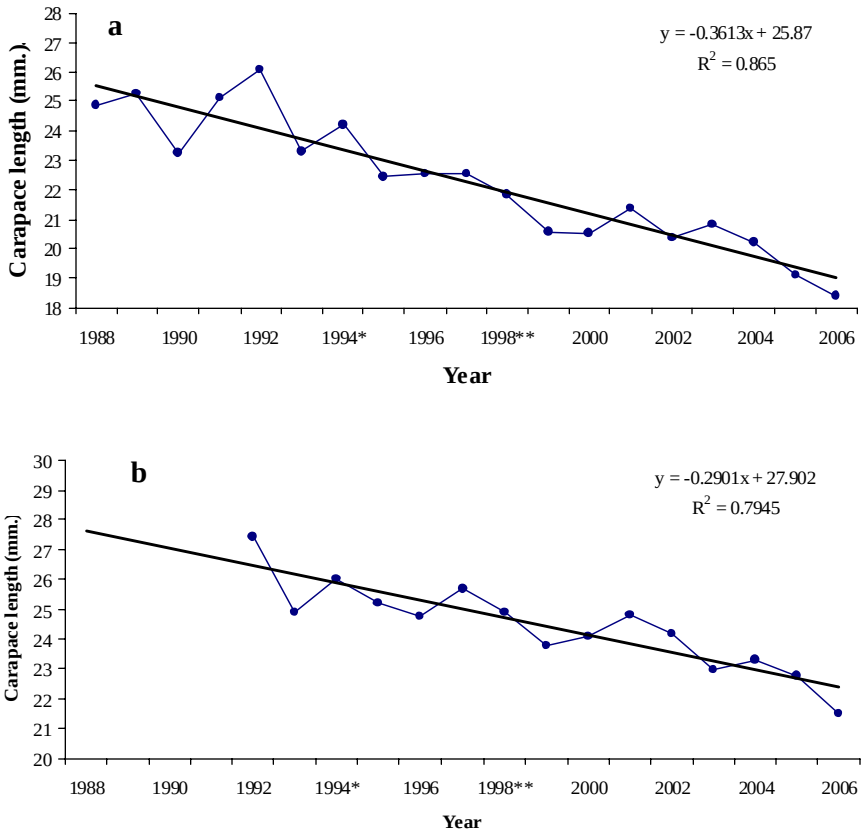

Figure 5.- Lengths (CL) at sex change (a) and maturity(b) of shrimp in the series of EU Flemish Cap surveys

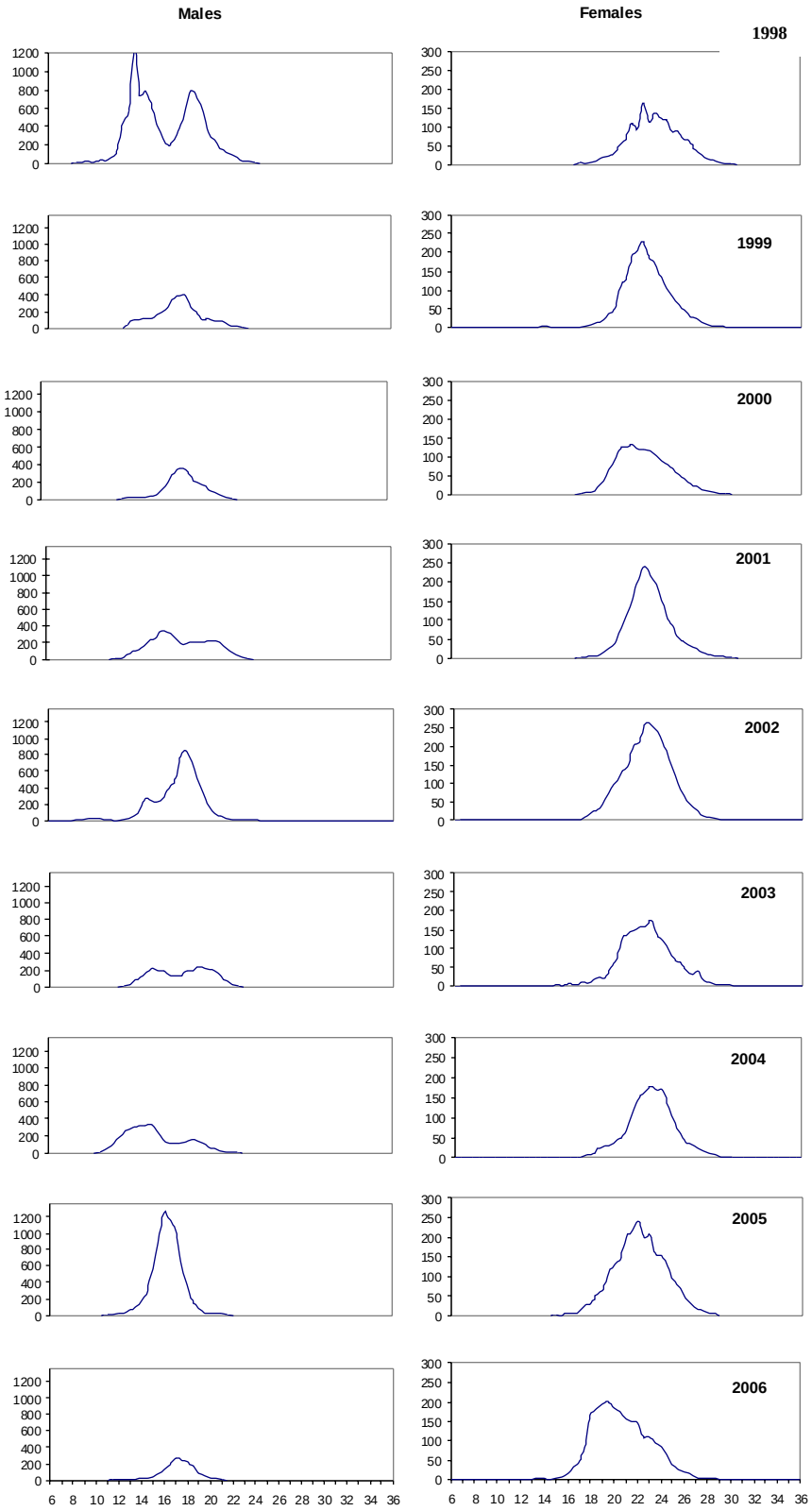

Fig. 6. Shrimp size distribution from Flemish Cap 1998-2006 surveys.Y-Axis=Frequency (10^6), X-Axis=Carapace Length (mm).

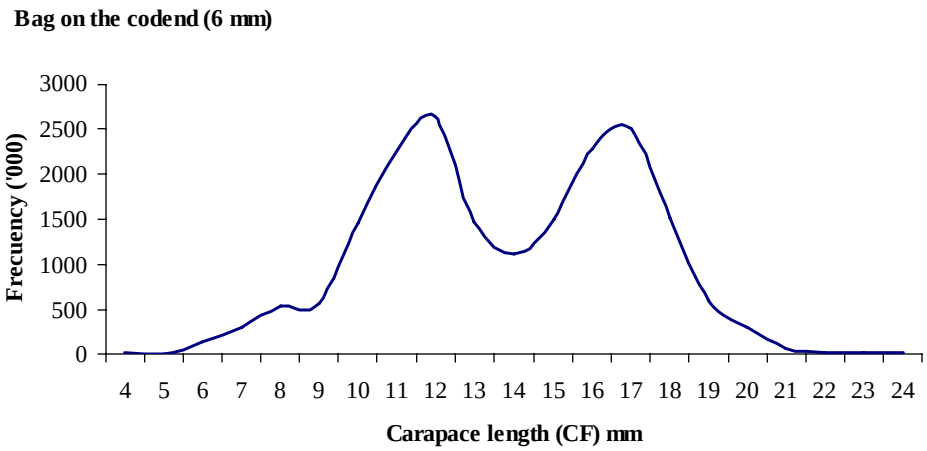

Fig. 7. Shrimp modal and age groups in 2006 EU survey on Flemish Cap from juvenile bag. (letters from Table 9) .

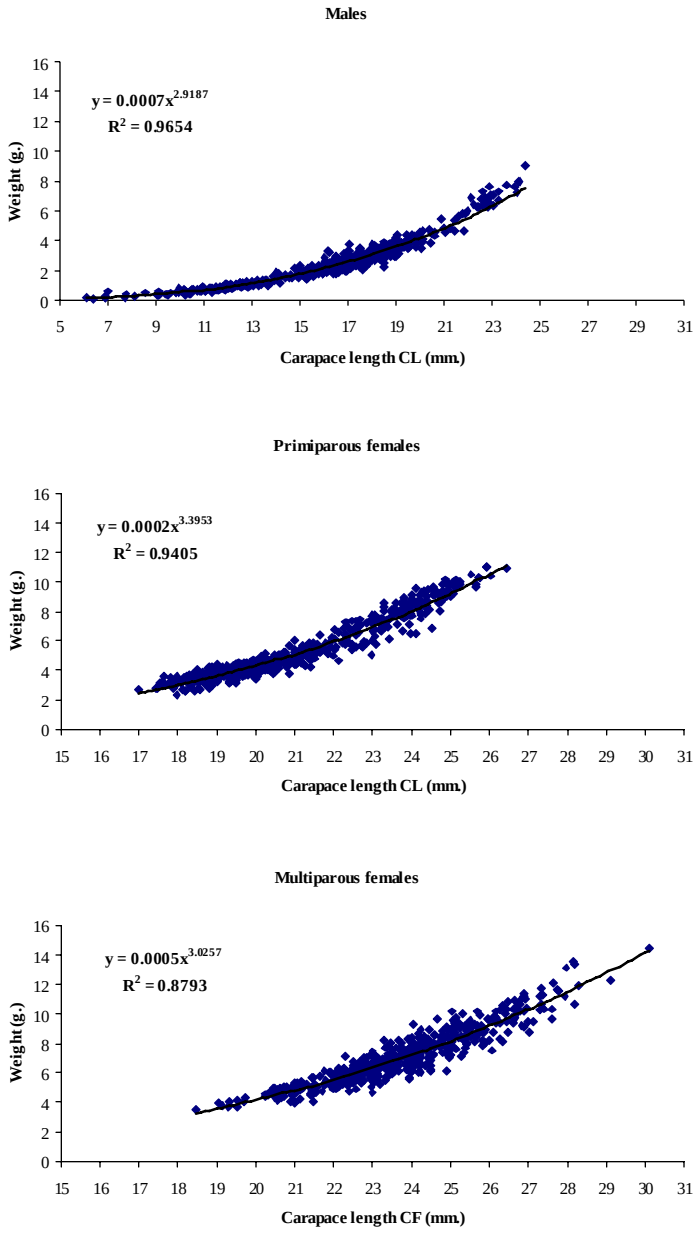

Fig. 8. Shrimp length-weight relationships by sex and maturity stages in 2006 on EU Flemish Cap survey.

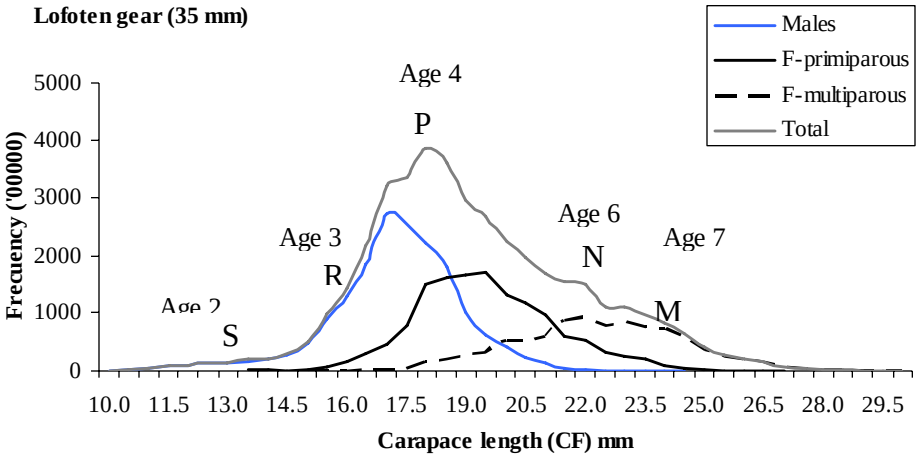

Fig. 9. Shrimp modal and age groups in 2006 EU Flemish Cap survey (letters from table 9).

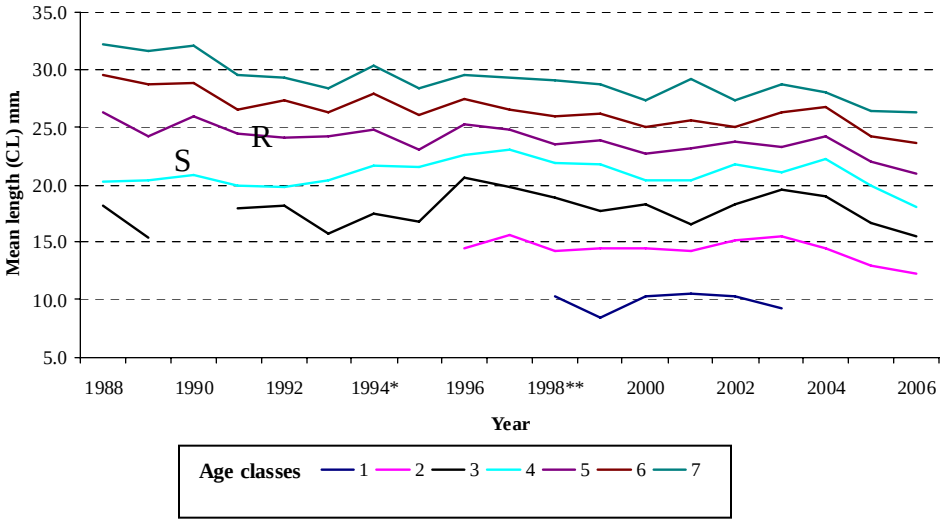

Fig. 10. Shrimp mean lengths at age in the series of EU surveys on Flemish Cap.

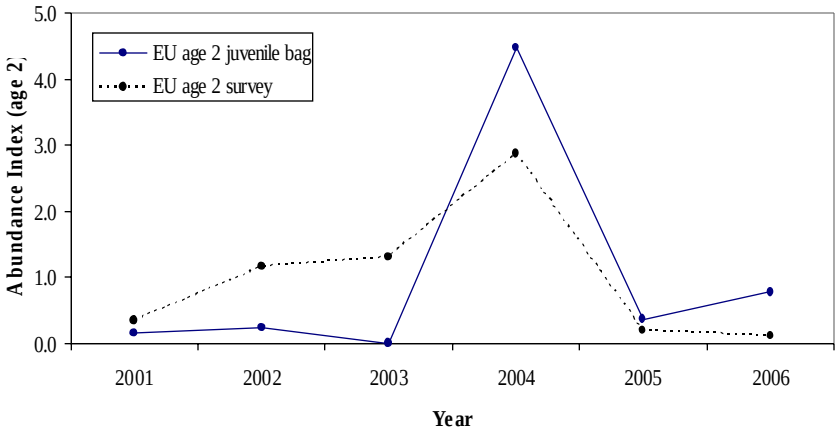

Fig. 11. Abundance indexes at age 2 obtained in EU Flemish Cap surveys from Lofoten gear (dotted line) and Juvenile bag (solid line).