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Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2007

by

J. M. Casas

[1]Instituto Español de Oceanografía, Apdo. 1552, 36200 Vigo, Spain
e-mail:mikel.casas@vi.ieo.es

Abstract

A stratified random bottom trawl survey on Flemish Cap was carried out from June 21th to July 21th 2007. 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 174 valid hauls were made by the vessel *R/V Vizconde de Eza* with the usual survey gear (Lofoten), 117 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 1400 m.).

The results concerning shrimp are presented and compared to those from previous years of the same series. The biomass and abundance in 2007 were similar to 2006 and at levels prior to 1998 . Although the abundance decreased about 11% respect to 2006, the biomass in 2007 with 17045 t. was about 5% greater than 2006. This fact was mainly due to the important presence of the oldest ages belonging to the 2000-2002 strong year classes (5-7 ages group). In the other side, as in the last years (2004-2006) 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 2007 and they are compared with that obtained in the past years 2003-2006 by the R/V *Vizconde de Eza*, and with the transformed series previous to 2003 obtained by the R/V *Cornide de Saavedra*.

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 2007 the survey was carried out from 21th of June to 21th of July. As the last years, the area prospected in Flemish Cap was spread up to 1400 meters. The new area was sampled by means of 57 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 117.

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

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

Whit 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, primiparous 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 174 valid bottom trawls were completed with Lofoten trawl gear in Flemish Cap survey, 117 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 2007 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 (30675 tons), was among the highest of the series, increasing a 52% with regard to 2004. This increase contrasts with the biomass estimated the last two years (16235 and 17046 tons respectively), the lowest since 1997 and about a 45% lesser than the estimated in 2005.

Biomass estimated by depth strata from 1988 to 2007 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 12978 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 2007 was only the 6% of total biomass. In accordance with this, the catch distributions observed during the 2007 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 2007 (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. In 2007 the estimated female biomass (12843 t.) was about 12% bigger than 2006 mainly due to the presence in the oldest ages (5-7 age groups) of 2000-2002 year classes.

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 period 1988-2005 from 6% in the beginning of the series to 56% in 2005. This increasing trend is interrupted from 2006 and 2007 with lower percentages than 2005 by second consecutive year (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 Figure 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). From 2006 the male percentage decreased showing in 2007 survey the lowest percentage of males (35%) of the historical series with 1988 survey.

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 1998-2007 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 and 2007 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 2007 survey are presented in Table 8. The estimated biomass was 20 t. and the length distribution showed two modes at 8 mm and 12-14 mm. CL, corresponding to age-classes 1 and 2 (Fig. 7).

Length-weight relationship

Length-weight relationships by sex group in year 2007 are illustrated in Fig. 8. Length-weight equations by sex group for this period were:

For males:	$W = 0.0014 \times CL^{2.6972}$	(N= 1205, r^2=0.97)
For primiparous females:	$W = 0.0011 \times CL^{2.7748}$	(N= 960, r^2=0.90)
For multiparous females:	$W = 0.0007 \times CL^{2.9316}$	(N= 870, r^2=0.95)
All sexes combined:	$W = 0.0012 \times CL^{2.7618}$	(N= 3035, r^2=0.98)

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

Age structure

Table 9 and Figures 7 y 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 2007.

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 2007 is 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.

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 12.5 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 strong 2002 year class with mean lengths at age below average.

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 years 2004-2007 without presence of 1 year old individuals in the catches and with relative low values for the ages 2 and 3 show the 2004-2005 and probably 2006 year classes as weak and below average.

As in previous years, the results of the modal analysis in 2007 indicated the presence of six age groups and the age at sex change around 4 years old with similar lengths to 2006. Although the abundance decreased about 11% respect to 2006, the biomass in 2007 with 17045 t. was about 5% greater than 2006. This fact was mainly due to the important presence of the oldest ages belonging to the 2000-2002 strong year classes (5-7 ages group). In spite of this small increase the biomass in 2007 is 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 and Table 14). Both indexes showed a similar trend with the exception of 2003 and 2006 years where the less marked changes showed different trends. From both indexes the 2003-2005 year class ought to be considered as weak year classes.

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Table 1. Technical data of bottom trawl research surveys on EU Flemish Cap 2007.

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	$10 \times \text{depth (m.)}^{0.775}$
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 1988-2007 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
2007	21.20	17046	11632	12843	15.97

[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 1988-2007 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	2007
1	70-80																3	0			0
2	81-100											175			69	112	690	217	164	8	50
3	101-140				10					148	39	639	450	1486	2169	5527	1817	2107	1023	477	20
4	101-140											239	596	306	1099	1942	637	785	2395	1195	11
5	101-140					8				26	110	1107	1948	2135	2782	2445	3780	867	695	664	558
6	101-140				32	2	5		20	422	161	2915	1142	657	2112	2951	1667	1250	883	299	462
7	141-200		30	400	1265	3763	2704	117	506	1336	988	4056	3072	2213	3006	4632	1521	3108	2607	1370	1642
8	141-200			88	248	1662	826	4	248	676	393	2402	2507	1140	2900	4257	1110	2043	4585	3084	709
9	141-200	133	69	35			135		613	459	412	3981	1139	1110	1483	1754	819	673	583	1435	1277
10	141-200	275	75	321	2103	3235	1778	752	1315	1148	1099	7186	4052	2771	3760	3748	4685	2489	2447	614	3248
11	141-200	263		148	1144	4096	1335	447	650	1235	1018	6049	3017	3005	4091	3460	3003	2350	2284	1086	2878
12	201-300	2170	505	512	2361	4654	2115	636	1201	1295	1195	2042	2127	1082	845	1468	378	1222	1510	1524	1965
13	201-300		66	64	89	38	136		28	687	554	1580	1465	43	620	217	23	230	689	691	373
14	201-300	618	375	623	995	2543		679	792	1076	426	3034	1717	689	843	2014	303	726	2155	923	1481
15	201-300	963	451	855	2004	3605	2292	1078	1370	1278	478	2575	1156	1753	837	1108	483	993	1039	1539	1597
16	301-400	777	253	355	179	420	139	49	57	237	168	515	172	464	375	506	92	696	1099	840	526
17	301-400						35									3			5	196	56
18	301-400						175			43	9			6		44		42	42	115	8
19	301-400	134	359		792	388		118	467	397	404	887	109	121	229	311	61	366	402	173	187
20	401-500																	6	250	29	20
28	401-500																	52	130	175	54
33	401-500																		5		0
21	501-600																		0		
34	501-600																		13		0

[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 - 2007 surveys.

Year	1995	1996	1997	1998[1]	1999	2000	2001	2002	2003	2004	2005	2006	2007
Biomass (tons) **(< 140 fathoms)**	20	596	309	5075	4136	4584	8231	12978	8594	5226	5160	2643	1101
% of Total biomass **(< 140 fathoms)**	0%	6%	4%	13%	17%	24%	30%	36%	41%	26%	21%	16%	6%

[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 2007.

LENGTH (mm CL)	MALES	FEMALES		
		Primiparous	Multiparous	Ovigerous
8.5	1			
9	1			
9.5	3			
10	7			
10.5	7			
11	23			
11.5	63			
12	81			
12.5	123			
13	249			
13.5	296	3		
14	439			
14.5	665	2		
15	700	6		
15.5	722	11	2	
16	682	39	9	
16.5	778	48	8	
17	805	120	23	
17.5	948	226	66	
18	1219	514	172	
18.5	1204	964	374	
19	1107	1001	680	
19.5	1159	1445	956	
20	723	1447	1287	
20.5	546	1652	1233	
21	294	1234	1193	
21.5	153	935	1015	1
22	100	718	974	
22.5	22	538	819	
23	18	370	856	
23.5	3	253	694	1
24	6	157	593	
24.5		93	452	
25		48	341	
25.5		28	244	
26		7	192	
26.5		2	125	
27		2	65	
27.5			26	
28			14	
28.5			9	
29			8	
29.5			1	
30			1	
Total	13147	11878	12432	2
Percentage %	35.10	31.71	33.19	0.01

Table 6. Shrimp length frequencies (x 10^5) by strata in 2007 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	
7									15													15
7.5																						
8																						
8.5	1																					1
9			1																			1
9.5	1					1																3
10	3		1	1					2													7
10.5	2		1	1	2		1															7
11	4		1	7	3	5	1		2													23
11.5	6	1	1	18	4	10	6		17	1												63
12	6	1	4	15	5	12	9		7	14	3		5									81
12.5	15	1	5	14	14	28	14		24	1	2		5									123
13	20	2	7	34	14	26	25	23	52	35	7	2	1		1							249
13.5	25	2	8	31	15	60	30	28	49	31	10	4	5	1								299
14	28	2	8	69	17	75	50	10	95	32	27	11	12	2	1							439
14.5	19	2	7	62	17	96	51	55	119	108	62	18	37	11	3							667
15	17	2	8	71	12	64	62	42	145	76	134	45	20	9	1							706
15.5	18	3	3	65	15	60	98	10	102	143	139	24	38	17								735
16	10	1	1	46	21	58	36	36	211	142	103	29	17	19								730
16.5	10	2	3	72	30	69	74	31	183	133	154	26	28	20	3							834
17	10	3	2	82	30	77	68	63	216	119	180	35	28	31	2							948
17.5	4	4	2	62	42	137	101	124	255	176	178	45	52	52	5							1240
18	6	5	2	116	62	240	74	216	528	226	210	82	65	64	8							1905
18.5	4	5	2	116	104	337	138	292	485	395	346	94	132	83	14			1				2542
19	4	6	1	134	126	277	163	237	639	492	402	72	93	117	22							2789
19.5	3	3		127	156	395	180	332	758	669	388	82	241	195	27			1				3560
20	3	2	1	141	122	411	180	277	740	664	389	98	179	208	39			3				3457
20.5		2		113	116	352	199	255	644	720	422	40	294	222	45	2		4		1		3432
21	1	1		48	100	346	86	259	530	545	302	31	161	236	62	4		8		2		2723
21.5	1	1		50	57	218	59	201	400	356	278	45	154	193	79	3		9		3		2107
22				30	38	142	34	162	393	259	214	34	160	225	89	2		9	1	4		1799
22.5				8	21	130	32	92	231	185	151	25	152	235	90	6		19	1	6		1387
23				9	15	83	29	86	176	239	88	18	202	184	87	10		18	1	6		1252
23.5				14	9	59	15	40	149	174	48	12	163	177	59	6		23	2	5		958
24				10	9	22	21	37	131	99	66	14	116	136	60	10		28	1	10		767
24.5					1	26	14	18	47	81	22	9	130	111	57	6		22	1	6		552
25					3	10	5	10	72	64	17	4	81	66	29	4		22	3	6		397
25.5					3	5	5	9	30	37	6		70	63	22	5		16	2	5		280
26						16			6	43	8	4	44	45	16	4		10	1	3		203
26.5						1			16	38	2		30	21	7	3		10	2	3		134
27						2			9	2	1		20	11	8	3	1	8	1	2		70
27.5													7	11	1	1	1	5	1	1		29
28						2				1		1	5	3				2	1	1		16
28.5				3							2		1			1	1	1				10
29									2			1	2		1	1	1	1				9
29.5																		1				1
30													1									1
Total	221	51	69	1569	1183	3852	1860	2945	7480	6300	4361	905	2751	2768	838	71	4	221	18	64		37551

Table 7.- Mean lengths by depth range from EU Flemish Cap surveys 2007

Strata	Depth range		Mean lengths (mm CL)
	Meters	Fathoms	
2	147-182	81-100	14.6
3 to 6	183-256	101-140	18.3
7 to 11	257-360	141-200	19.5
12 to 15	361-547	201-300	20.4
16 to 19	548-733	301-400	22.8
20 to 34	734-1464	401-800	24.2
Total	147-1464	80-800	19.7

Table 8. Shrimp length frequencies taken by the small mesh size bag attached to the cod-end in 2007 survey.

Length (CL) mm	Frequency
6	2
6.5	8
7	24
7.5	71
8	165
8.5	194
9	143
9.5	86
10	67
10.5	64
11	116
11.5	110
12	142
12.5	140
13	129
13.5	121
14	134
14.5	112
15	82
15.5	37
16	31
16.5	22
17	17
17.5	13
18	17
18.5	8
19	14
19.5	9
20	4
20.5	1
21	
21.5	1
22	
22.5	
23	
23.5	
24	
24.5	
25	
25.5	1
Total general	2085
Catch weight (gr)	2888
Sampled weigth (gr)	2222

Table 9. Shrimp modal groups and ages with Lofoten gear and bag in the codend in 2007 from EU Flemish Cap survey interpreted from size distributions.

LOFOTEN

Age	Modal groups		Cohort
	Males	Females	
1	-	-	
2	13.5	-	T
3	16.5	16.5	S
4	18.5	18.5	R
5	-	20.5	P
6	-	23	O
7	-	-	

BAG ON THE CODEND

Age	Modal groups		Cohort
	Males	Females	
1	8.5	-	U
2	13.5	-	T

Table 10. Results of the modal analysis (MIX) by sex and maturity stage from EU Flemish Cap surveys 2007 with Lofoten gear and juvenile bag..

	Juvenile bag (6mm)		**Lofoten gear (35 mm.)**					
Sex and maturity group	**Juvenile bag* (6mm**		**Males**		**Primimarous females**		**Multiparous females**	
Age	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***
1	0.351	0.004						
2	0.262	0.007	0.024	0.004				
3	0.333	0.007	0.292	0.006	0.010	0.002		
4	0.054	0.002	0.684	0.007	0.301	0.015		
5					0.545	0.013	0.542	0.015
6					0.144	0.007	0.351	0.013
7							0.107	0.016
Age	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***
1	8.69	0.012						
2	11.74	0.037	12.52	0.141				
3	14.07	0.035	15.25	0.048	16.57	0.133		
4	17.93	0.073	18.85	0.023	19.13	0.046		
5					20.83	0.040	20.48	0.039
6					23.13	0.050	23.05	0.111
7							25.19	0.133
Age	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***
1	0.709	Cons. CV						
2	0.958	Cons. CV	0.969	Cons. CV				
3	1.148	Cons. CV	1.180	Cons. CV	0.745	Fixed CV		
4	1.464	Cons. CV	1.459	Cons. CV	0.861	Fixed CV		
5					0.937	Fixed CV	1.154	Cons. CV
6					1.041	Fixed CV	1.298	Cons. CV
7							1.419	Cons. 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	2007	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	12.5	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	15.3	17.8
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	18.9	20.5
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	20.6	23.0
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	23.1	25.7
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	25.2	28.2
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	20.2	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	2007
1											944	13	89	28	1806	142				
2									3424	629	54968	4735	1069	3321	11004	12572	27415	1792	582	301
3	133	11		472	1586	7878	427	2431	8571	2894	42349	23924	17044	18773	47872	17744	9603	69026	3005	3866
4	1232	821	4039	2596	1459	3760	875	2764	1530	2410	7073	14962	10740	20148	11276	5484	6425	5240	19488	12213
5	2334	809	919	4654	4396	2052	726	1203	2730	3218	7891	6008	5721	11844	10467	9073	7831	10500	12046	12758
6	1631	828	331	3885	11289	4458	1806	2146	648	1152	4136	2043	3488	3232	3112	2426	1330	7576	5217	5882
7	153	108	15	1025	3975	492	75	1217	437	158	152	81	605	156	545	85	206	1407	647	1287
8				332																
total ('00000)	5482	2578	5304	12964	22705	18641	3909	9760	17339	10461	117514	51766	38757	57501	86082	47526	52810	95539	40985	36306

[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	2007
1											60	0.5	6	2	114	6				
2									609	139	9039	832	183	572	2178	2541	4660	187	57	38
3	44	2		166	610	2144	145	685	4552	1270	16203	7811	5924	5018	16710	7134	3730	15782	586	837
4	575	387	2053	1214	705	2083	554	1658	1071	1705	4099	9016	5233	9992	6436	2762	3969	2109	5882	4764
5	2377	626	888	3843	3683	1823	681	892	2703	2853	5719	4784	3838	8321	7758	6197	6206	5702	5547	6330
6	2334	1053	436	4094	13637	4948	2374	2313	827	1249	4038	2138	3112	3087	2696	2339	1430	5531	3606	3971
7	285	183	28	1478	5801	675	124	1728	700	234	207	112	706	215	616	108	254	1365	621	1105
8				557																
total (ton.)	5615	2252	3405	11352	24436	11673	3879	7276	10461	7449	39365	24695	19002	27206	36508	21087	20248	30675	16299	17045

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

Table 14. Abundance at age 2 average-weighed as indicator of recruitment (R) in the survey (lofoten gear) and from juvenile bag.

year	**R (age 2) juvbag**	**R (age 2) lofoten**	**R(2)juvbag Av_weighed**	**R(2)lofoten Av_weighed**
2001	1361	3321	0.16	0.41
2002	2125	11004	0.25	1.35
2003	0	12572	0.00	1.54
2004	41818	27451	4.85	3.37
2005	3741	1792	0.43	0.22
2006	7498	582	0.87	0.07
2007	3824	301	0.44	0.04

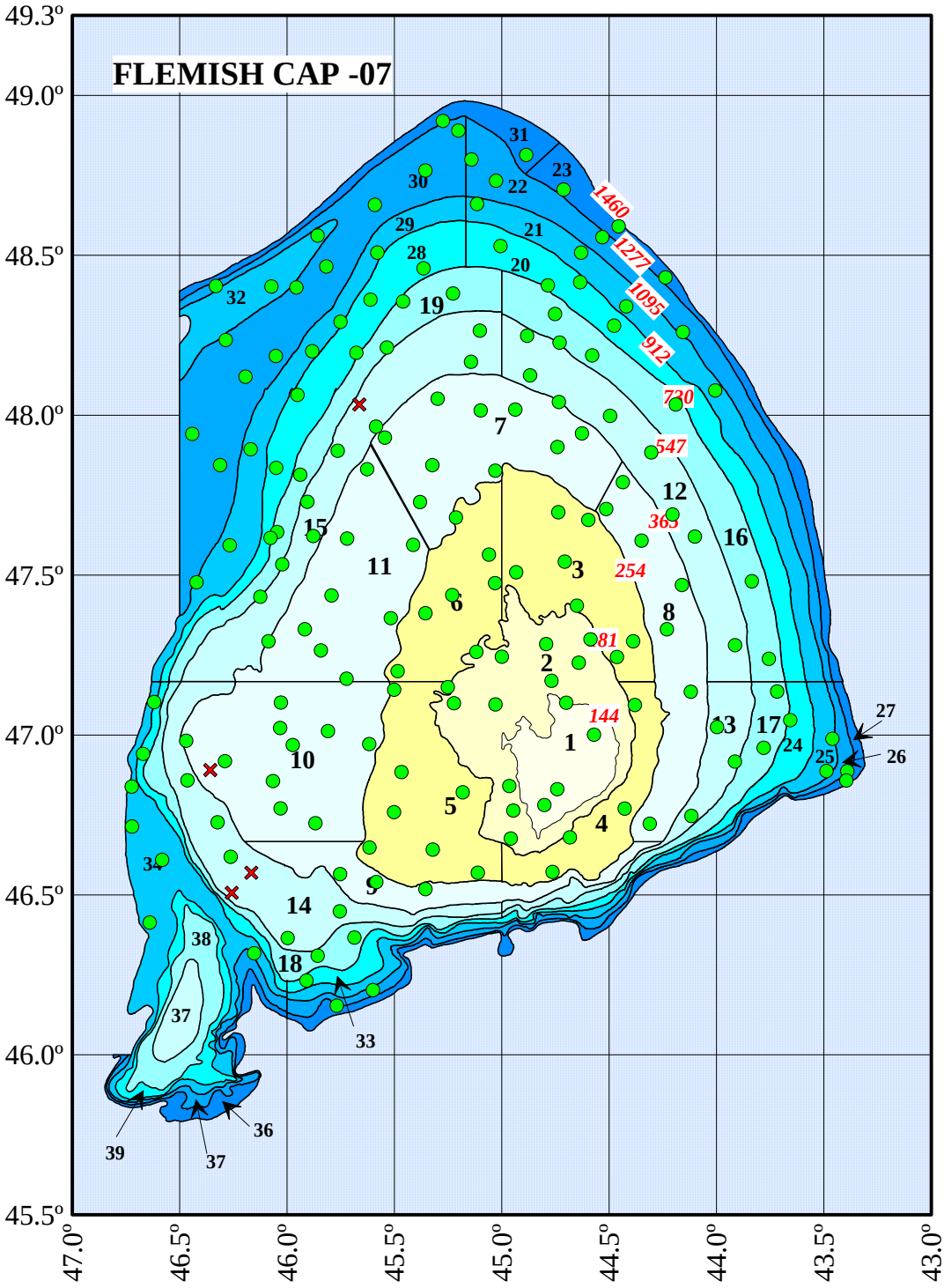


Figure 1. Chart with the positions of the hauls carried out in EU Flemish Cap survey 2007.

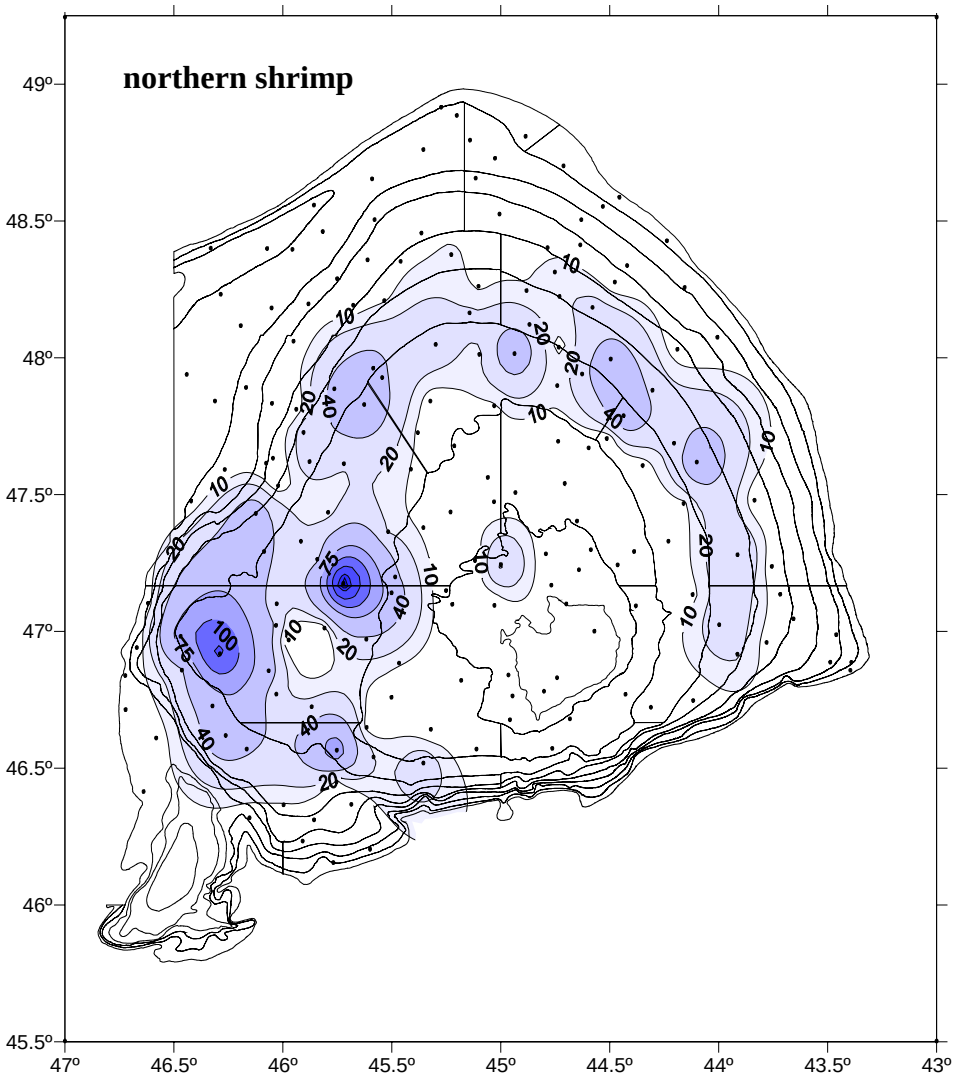


Figure 2. Shrimp catches distribution (kg/tow) from EU Flemish Cap survey in summer 2007.

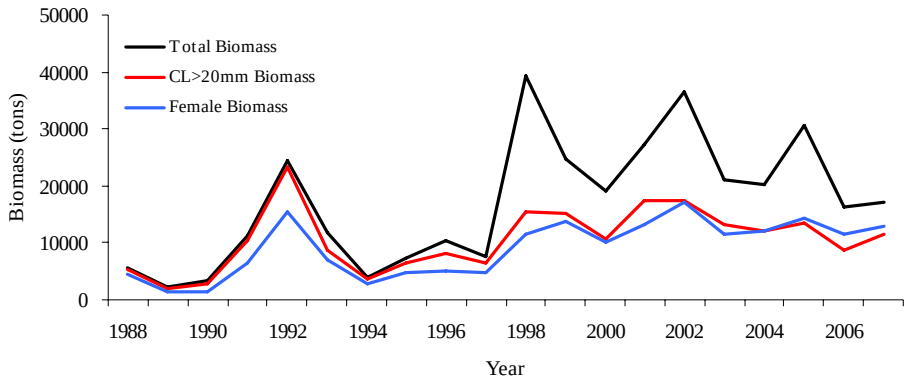


Figure 3. Total, female and adult biomass (shrimp bigger than 20 mm CL) from EU Flemish Cap 1988-2007 surveys.

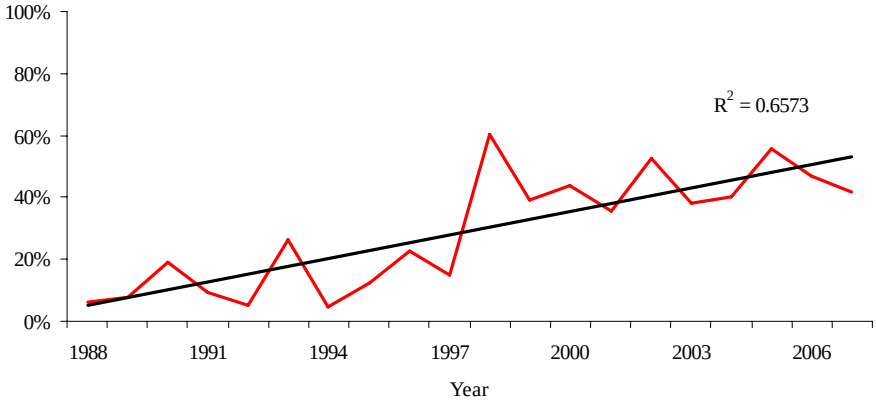
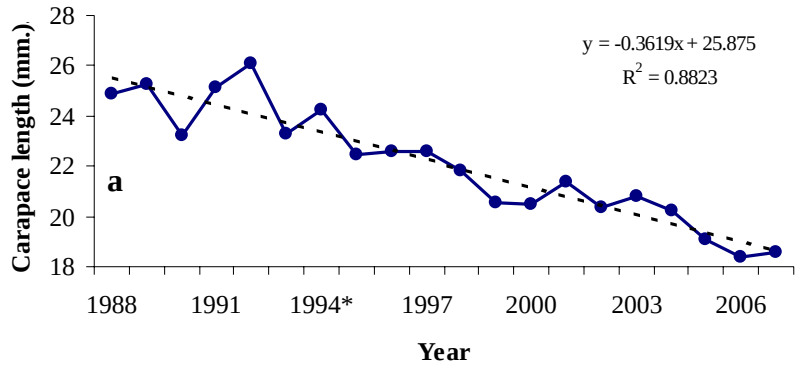


Figure 4. Differences between total biomass and adult biomass (>20 mm.) as percentage of Total biomass.



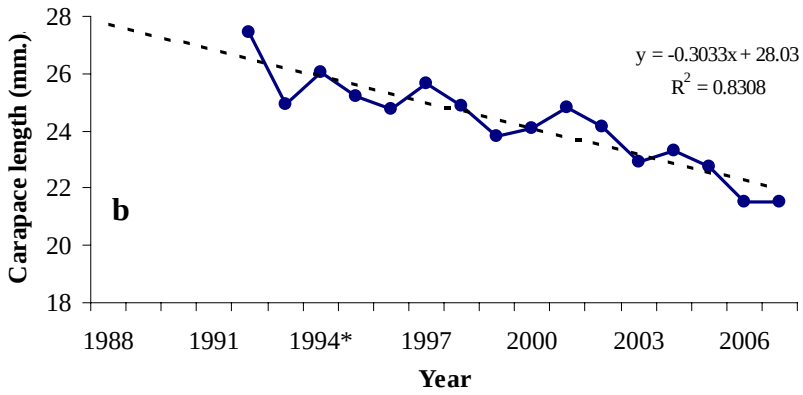


Figure 5.- Lengths (CL) at sex change (a) and maturity (b) of shrimp in the series of EU Flemish Cap surveys

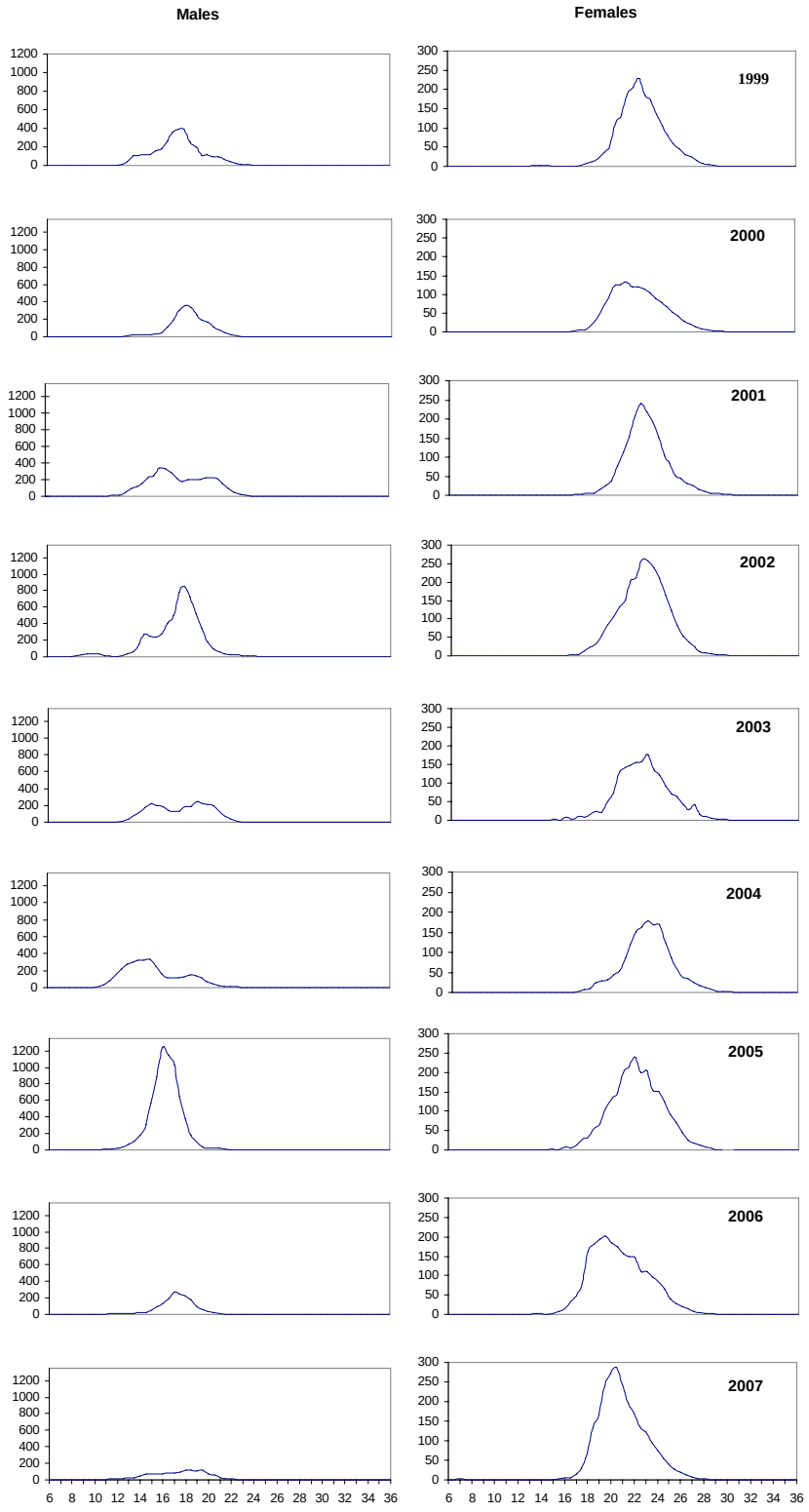


Figure 6. Shrimp size distribution from Flemish Cap 1998-2007 surveys. Y-Axis=Frequency (10^6), X-Axis=Carapace Length (mm).

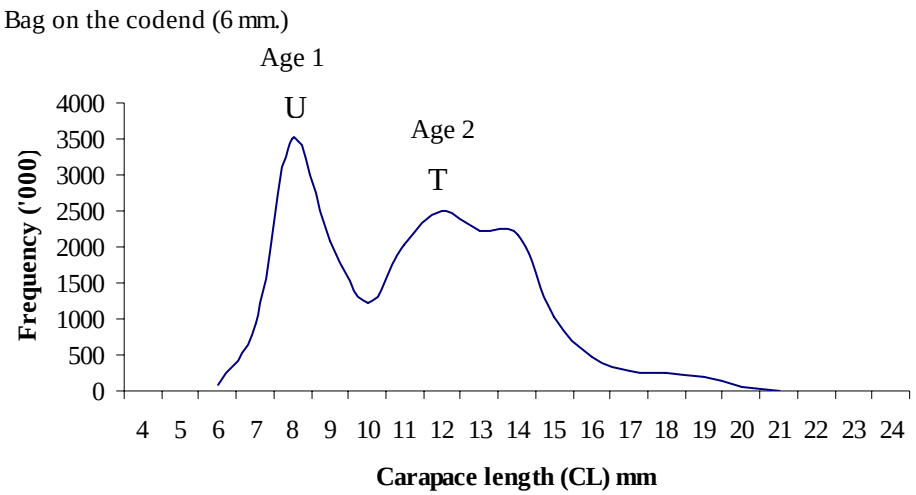


Figure7. Shrimp modal and age groups in 2007 EU survey on Flemish Cap from juvenile bag. (letters from Table 9) .

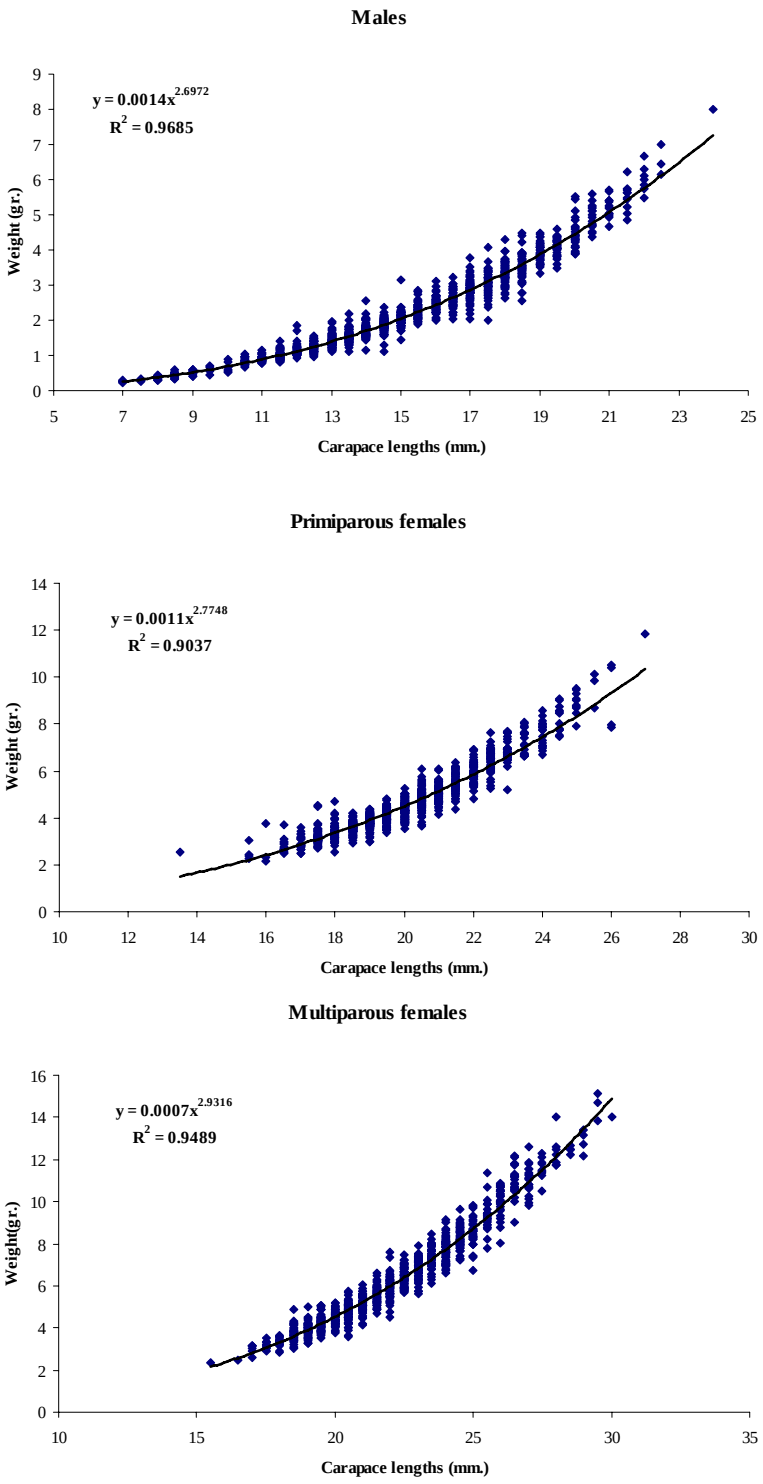


Figure 8. Shrimp length-weight relationships by sex and maturity stages in 2007 on EU Flemish Cap survey.

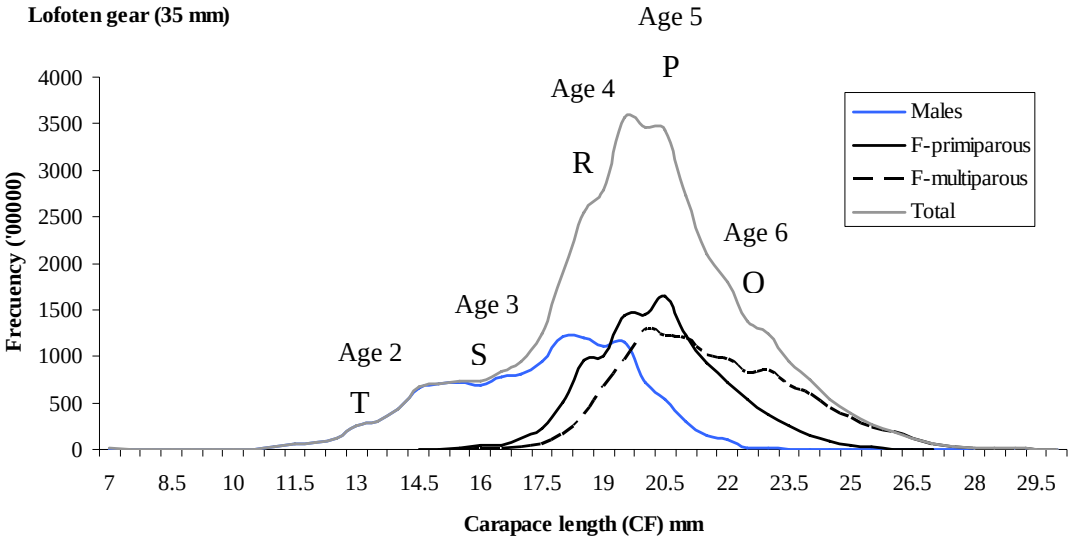


Figure 9. Shrimp modal and age groups in 2007 EU Flemish Cap survey (letters from table 9).

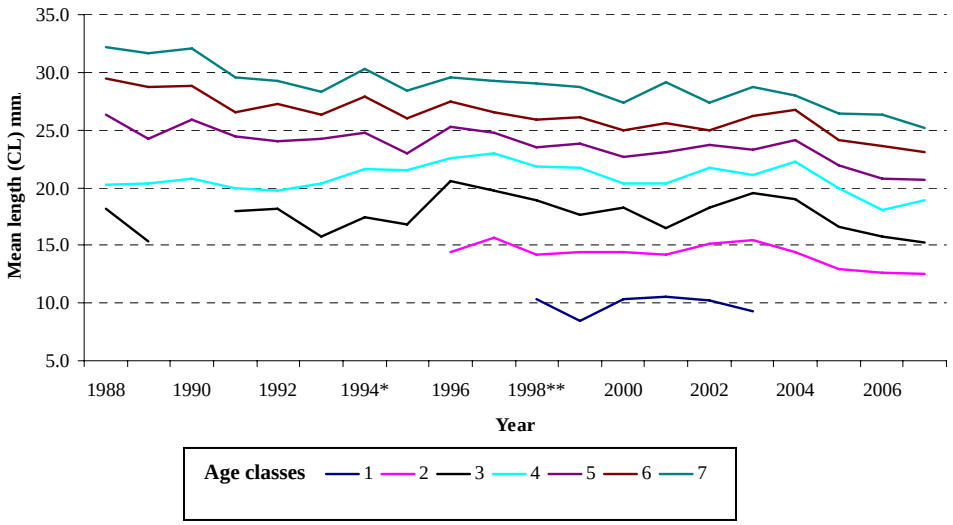


Figure 10. Shrimp mean lengths at age in the series of EU surveys on Flemish Cap.

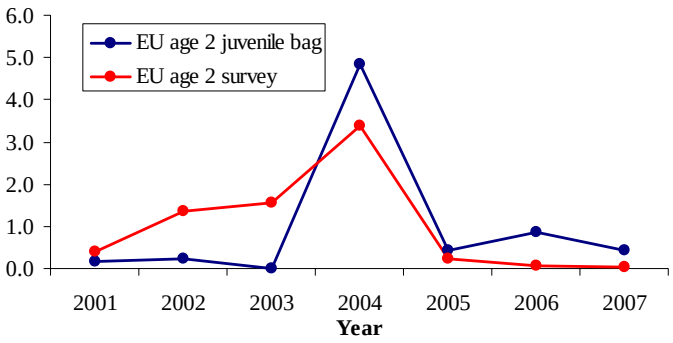


Figure 11. Abundance indexes at age 2 obtained in EU Flemish Cap surveys from Lofoten gear (red line) and Juvenile bag (blue line).