Northwest Atlantic   Fisheries Organization

SCIENTIFIC COUNCIL AND STACFIS SHRIMP ASSESSMENT MEETING - September 2023

Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2023

by

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Abstract

A stratified random bottom trawl survey on Flemish Cap was carried out from July 5th to August 4th 2023. The area surveyed was extended up to depths of 800 fathoms (1450 meters) following the same procedures as in previous years. This year a total of 181 valid hauls were made by the vessel *R/V Vizconde de Eza* with the usual survey gear (Lofoten)*,* 120 up to 730 meters depth. The surveyed area has properly prospected the 32 strata planned. The general indexes for shrimp were estimated considering 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 1450 m). As the last years the strata 26 and 27sited in the southeast of the bank with depths from 600 to 800 fathoms (1100-1400 m) will not be surveyed due to the presence in the bottoms of great quantities of mud and sponges.

The results concerning shrimp are presented and compared to those from previous years of the same series. Although the total biomass index increased by 2% the stock continues at a very low level, confirming the poor state of stock that remains bellow B_{lim}. The abundance at age 2 since 2021 is among the lowest of the series and reveal the weaknesses of the last yearly classes and the recruitment process.

The stock remains below B_{lim} and it is in the collapse zone defined by the NAFO PA framework. To be consistent with the precautionary approach, fishing mortality should be kept as close to zero as possible when a stock is in the collapse zone. Therefore, considering the decline of the stock and the poor prospects for recruitment to the fishable stock in the coming years, Scientific Council advises that the fishing mortality and catch be set as close to zero as possible by 2024.

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 2023. Also, they are compared with that obtained between years 2003-2022 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 2023 the survey was carried out from July 5th to August 4th. The area prospected in Flemish Cap was spread up to 1450 meters. In 2023 as in previous years the strata 26 and 27 in the southeast of the Flemish Cap with depths between 1095 and 1450 m were not prospected due to the presence in the bottoms of great quantities of mud and sponges. The haul number carried out in the traditional 19 strata with depths minor than 740 m was of 120. The area with depths higher than 740 m was sampled by means of 61 additional hauls proportionally distributed in the new 13 strata.

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

Wherever it was possible 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 further 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.

Age composition and MIX program

The length frequency distribution by sex group were analysed by package for fitting finite mixture distribution *Rmix* 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 (FCV) at 0.045 or keeping it constant (CCV).

Also, the analysis by *Rmix* of the historical length distribution from the survey series was reviewed and mean lengths, abundance and biomass by age estimated.

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 from 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 10 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 weighed and measured.

Results

Biomass

This year a total of 181 valid bottom trawls were completed with Lofoten trawl gear in Flemish Cap survey, 120 of them were carried out in the traditional strata prospected from 1988 with depths up to 740 m (400 fth) (Fig. 1).

Total shrimp biomass, estimated by swept area method and mean catch per tow from 1988 to 2023 are presented in Table 2 and Figure 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 shrimp biomass declined up to 1997. After that the stock recovered reasonably well although with high annual variability (historical maximums in 2002 and 2005 were followed by years with lower biomass but at a relative high level). In 2009 the biomass decreased sharply with values close to the lowest of the historical series in that year. In 2010 despite of the biomass increase about 77% compared to 2009 this was still among the lowest in the total of the historical series. From 2011 to 2014 the total and female biomass decreased successively and were recorded the lowest values in the historical series showing the worsening and depletion state of the shrimp stock. Since 2015 the biomass indexes increased year after year, and they were above B_{lim} from 2018. In 2020 the shrimp fishery was resumed, and the female biomass experienced some decrease but remained above B_{lim}. In 2021 the total and female biomass decreased for the second consecutive year and they were bellow B_{lim}. This downward trend and depletion state were confirmed in 2022 (862 and 705 tons) and continues in 2023 (876 and 738 tons).

Biomass estimated by depth strata from 1988 to 2023 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, from 1996, a noticeable amount of shrimp occurred in these strata and the estimated biomass increased up to 2002 and 2003 years where the 36% and 41% respectively of the total biomass were estimated in depths lesser than 140 fathoms. After these years the biomass estimated in these depths declined each year and from 2008 to 2011 they were residual (0.1% of the total biomass in 2011). In 2012 the biomass in these strata increased strongly (20%) mainly due to the presence of shrimp in only one tow in the shallowest strata (70-80 fth). Since 2013, the biomass has once again been among the lowest recorded (< 2%). According to this, the catch distributions observed during the 2023 survey (Fig. 3) showed a patched distribution around the central area of the bank but with greater presence in depth strata 201-300 fth and 301-400 fth (61.1% and 28.6% of the biomass respectively).

Adult stock, female biomass

Total biomass estimates by the series of bottom trawl surveys on Flemish Cap from 1988 to 2023 (Table 2 and Fig. 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. 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 biomass estimated for shrimp bigger than 20 mm in 2023 was 709tons

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 2023 the estimated female biomass (738 t) was about 5 % higher than 2022 but remains among the lowest values and well below the average value of the EU survey series.

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 the figure 2 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. These differences are showed as percentage of the total biomass in the figure 4 and from the male and shrimps smaller than 20mm CL percentages (Table 5). 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. From 2006 to 2010 the increasing trend changes and difference between total biomass and adult biomass decreased to levels prior 1997 year. Since then the differences have varied without a clear trend. The male percentages along the years showed a similar picture. The high value estimated in 1998 was due to the lesser mesh size of the linner codend used (25 mm), and not comparable conclusions can be thrown.

Length frequencies

The length frequencies and percentages by sex for 2023 are shown in the Table 4. These length frequencies are split into males, primiparous females, multiparous females and ovigerous.

The figure 5 shows the length distribution by sex on EU Flemish cap 2006-2023 surveys. 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 mm and 16.5 mm CL respectively. The importance of the youngest individuals decreased markedly from 2006 and since 2009 the lack of strong year classes and the successive bad recruitments caused a drastic fall in the frequencies of practically all the length groups compared with those obtained in previous years.

The biomass estimated in 2023 was mainly represented by female and specimens with sizes around 17-26 mm (Figure 6). Young specimens (mainly males) decreased (around 67% in number) compared to 2022 and remain well below average.

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. The estimated biomass and length distributions obtained with the small mesh size bag in 2023 survey are presented in Table 6. The estimated biomass was 2 tons and the length distribution showed one mode at 11 mm CL, corresponding to age-classes 1 (Table 7 and Fig. 6).

Age structure

The Table 7 and the Figures 6 y 7 show preliminary and visual interpretation of shrimp modal groups and ages from the length distribution obtained by the gear Lofoten and juvenile bag used in 2023.

Age assessment was carried out using the Rmix library from the shrimp length distributions estimated every year in the survey series. The result of the modal analysis for annual survey 2023 is shown in Table 8. The proportions within each sex group are listed as well as mean lengths and standard deviation (sigma) by age-classes.

The results of Table 8 were then used to calculate the mean length, abundance and biomass at age Tables 9, 10 and 11. The modal analysis in 2023 identified 6 age groups (ages 2 to 7). The total biomass in 2023 (876 tons) remains at the same level than 2022 and the estimated values by age remain at very low level.

At the beginning of the series (1988-1997) the youngest shrimp were considered to be two year olds with lengths between 14.5 and 18.0 mm. The shrimps with one year old appeared at first time in 1998 and were present up to 2003 with lengths around 9-10 mm. Since then this age class was rarely present in the main gear and many years could not to be identified from the length distributions. In spite of the variability of the length by age along the years, from the beginning of the series to 2007 it can be observed a decreasing trend in the mean length of the main age groups (Fig. 8). This trend was mainly pronounced from 2004 to 2007, due to the presence in these years of the strong 2002 year class with mean lengths at age below average. Since 2007 this trend changed and the mean lengths at age increased up to 2010. From 2010 to 2018 varied without a clear trend and since then up to 2022 decreased. In 2023 there was a general and notable increase of the mean length in all age classes.

In the Flemish Cap survey series some strong year-classes may be followed according the abundance by age groups from 1988 to 2006 (Table 10 and 11). If the assignation of the age is right, the 1987 year-class stand out in the beginning of historical series with 4 and 5 years old in the years 1991 and 1992. The individuals with 3-6 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 6 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. From 2004 the residual presence of age group 1 in the catches and very low values for the ages 2 and 3 showed the absence of strong year classes between 2004 and 2023.

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 8) were estimated and the index average-weighted (Fig. 9 and Table 12). Since 2005, the survey indices from Lofoten gear have showed high variability in the estimated values but at lower level than in previous years, confirming the absence of strong year classes. A similar trend can be observed from juvenile bag's indexes. From 2015 although the recruitments (age 2) were rather weak, they improved somewhat, allowing the recovery of the stock. The significant increase of shrimps with one year old recorded from the juvenile bag in 2019 (Table 13 and Fig. 10) was confirmed in 2020 indicating the entry of a relative strong year-class 2018 (age 2 in 2020, Fig. 9). In 2021, the abundance at age 3 estimated from the main gear (Table 10), corresponding to the relatively strong 2018 year class, was not so stronger than expected (43% lower than estimated in 2020) and revealed a weaker recruitment than expected. Although the abundance at age 2, estimated this year from the main gear increased by 39% compared with 2022, the estimated values remains very low and show the weakness of 2021 year class.

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Table 1.   Technical data of bottom trawl research surveys on EU Flemish Cap 2023.

Procedure	Specification
Vessel	*R/V Vizconde de Eza*
GT	1 400 t
Power	1 800 HP
Maximun trawling depth	1 450 m
Trawl winch	Automatic control on warp tension
Mean trawling speed	3-3.5 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	2 * Depth (m) + 250m
warp diameter	20
dan leno bobbin	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	6.30 to 18:30 hours
Species for sampling	All fish, squid and shrimp

Table 2. Different indexes of shrimp estimated by swept area method in the years 1988-2023 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
2008	13.79	11092	7857	8630	10.73
2009	3.48	2797	1782	1764	2.19
2010	6.09	4894	4171	3818	4.31
2011	2.02	1621	1322	1132	1.39
2012	1.31	1055	795	791	0.98
2013	1.05	844	714	691	0.86
2014	1.12	900	757	717	0.89
2015	1.93	1551	1068	1079	1.34
2016	3.08	2520	1994	1982	2.46
2017	3.54	2885	2208	2304	2.86
2018	5.31	4394	3628	4051	4.90
2019	11.53	9273	7753	8486	10.6
2020	8.37	6734	5444	6048	7.52
2021	2.61	2101	1445	1792	2.23
2022	1.07	862	407	705	0.88
2023	1.09	876	709	738	0.92

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

Table 3. Total shrimp biomass by strata (tons) and percentage (%) of biomass in depths lesser than 140 fth estimated in 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	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	70-80																3			
2	81-100											175			69	112	690	217	193	8
3	101-140				10					148	39	639	450	1486	2169	5527	1817	2107	1207	477
4	101-140											239	596	306	1099	1942	637	785	2739	1195
5	101-140					8				26	110	1107	1948	2135	2782	2445	3780	867	847	664
6	101-140				32	2	5		20	422	161	2915	1142	657	2112	2951	1667	1250	1080	299
7	141-200		30	400	1265	3763	2704	117	506	1336	988	4056	3072	2213	3006	4632	1521	3108	3202	1370
8	141-200			88	248	1662	826	4	248	676	393	2402	2507	1140	2900	4257	1110	2043	5747	3084
9	141-200	133	69	35			135		613	459	412	3981	1139	1110	1483	1754	819	673	808	1435
10	141-200	275	75	321	2103	3235	1778	752	1315	1148	1099	7186	4052	2771	3760	3748	4685	2489	2935	614
11	141-200	263		148	1144	4096	1335	447	650	1235	1018	6049	3017	3005	4091	3460	3003	2350	2728	1086
12	201-300	2170	505	512	2361	4654	2115	636	1201	1295	1195	2042	2127	1082	845	1468	378	1222	1980	1524
13	201-300		66	64	89	38	136		28	687	554	1580	1465	43	620	217	23	230	903	691
14	201-300	618	375	623	995	2543		679	792	1076	426	3034	1717	689	843	2014	303	726	2750	923
15	201-300	963	451	855	2004	3605	2292	1078	1370	1278	478	2575	1156	1753	837	1108	483	993	1374	1539
16	301-400	777	253	355	179	420	139	49	57	237	168	515	172	464	375	506	92	696	1587	840
17	301-400						35									3			10	196
18	301-400						175			43	9			6		44		42	56	115
19	301-400	134	359		792	388		118	467	397	404	887	109	121	229	311	61	366	530	173
20	401-500																	6	353	29
21	501-600																		2	
22	501-600																			
24	401-500																			
25	501-600																			
28	401-500																		138	175
29	501-600																	52		
30	601-700																			
31	601-700																			
32	501-600																			
33	401-500																		6	
34	501-600																		12	
%	<140 fth	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.3	5.7	4.2	12.9	16.8	24.2	30.2	35.6	40.8	25.8	19.5	16.1

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

Table 3. cont.

Stratum	Depth (Fathoms)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	70-80						198					0	1					
2	81-100	50			1	0	0	0		0		1	0	0	1	0		0
3	101-140	20	11	1	21	1	0	5	0	1	12	14	13	51	2	7	2	1
4	101-140	11	1	3	15	0	1	0	1	0	1	4	6	0	0	0		0
5	101-140	558	11	28	21	1	8	5	2	1	5	23	24	116	3	4	1	1
6	101-140	462	23	1	43	0	3	7	1	3	18	19	30	14	13	6	3	2
7	141-200	1642	468	32	495	8	46	81	29	74	277	635	245	366	76	39	18	12
8	141-200	709	1938	308	326	6	31	56	17	65	364	206	261	444	262	31	11	12
9	141-200	1277	1159	48	235	31	21	32	10	36	32	137	122	386	266	37	7	2
10	141-200	3248	671	154	467	58	31	36	25	223	246	428	359	968	315	57	19	27
11	141-200	2878	368	174	712	16	64	48	73	124	113	358	478	639	271	27	9	13
12	201-300	1965	1585	569	1060	242	208	204	263	219	649	488	857	1729	1208	485	177	251
13	201-300	373	1080	149	80	56	67	92	152	378	275	122	376	709	317	126	35	92
14	201-300	1481	1593	215	305	460	79	118	141	150	158	110	308	825	900	347	182	55
15	201-300	1597	1944	649	824	407	133	101	113	177	257	243	1027	2197	2319	310	133	151
16	301-400	526	108	145	188	208	115	34	37	60	30	59	69	531	374	381	170	141
17	301-400	56	33	2		8	0	0		1	33	2	10	0	39	82	40	1
18	301-400	8	10	3	20	9	0	0		0		0			1	15	0	0
19	301-400	187	61	278	77	172	35	25	36	16	8	35	209	298	367	146	56	115
20	401-500	20	5	1	0	39	0		0		0				51	77	1	0
21	501-600					0		0	0							0		
22	501-600											1						
24	401-500					0						0		3	11		4	
25	501-600						0											
28	401-500	54	71	26		11	7	11	0			11	10	49	73	68	35	21
29	501-600				1				0						0		0	2
30	601-700				0			0	0		0			0			0	0
31	601-700						0											
32	501-600				0													
33	401-500			7				0		0						0		0
34	501-600		1		0		0				0		0	0	1	0		0
%	<140 fth	6.4	0.4	1.2	2.1	0.1	20.1	2.0	0.4	0.3	1.4	2.1	1.7	1.9	0.3	0.8	0.7	0.4

Table 4. Shrimp length frequencies (x 10⁴) and percentages by sex and maturity stage from EU Flemish Cap 2023.

LENGTH (mm CL)	MALES	FEMALES Primiparous	Multiparous	Ovigerous
8.5				
9				
9.5				
10				
10.5				
11				
11.5	1			
12				
12.5				
13	4			
13.5	7			
14	11			
14.5	25	6		
15	68	4		
15.5	80			
16	110	9		
16.5	107	14		
17	163	15		
17.5	166	50		
18	242	74		
18.5	293	165	2	
19	366	258	7	
19.5	444	433	5	
20	376	676	13	
20.5	300	1008	35	
21	205	995	97	
21.5	67	1234	136	
22	105	1178	133	
22.5	44	1125	169	
23	21	901	119	
23.5	17	851	145	
24	6	620	122	
24.5	4	471	107	
25		231	83	1
25.5	1	114	40	
26	5	48	28	
26.5	1	29	9	
27	4	21	7	
27.5	4	25	12	
28		3		
28.5		2		
29			4	
29.5		2	4	
30				
30.5				
31		3		
31.5		2		
32				
32.5				
33				
33.5				
34				
Total	3250	10569	1278	1
Percentage %	21.5%	70.0%	8.5%	0.0%

Table 5.　Males percentage as total biomass of northern shrimp from EU Flemish Cap 1988 - 2023 surveys.

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998[1]	1999	2000	2001	2002	2003	2004	2005	2006
Males (%)	6.4	7.5	19.1	9.2	5.3	26.4	4.6	12.3	22.7	14.8	60.5	39.0	44.0	35.8	52.6	38.0	40.4	55.6	47.2
<20mm CL (%)	19.4	39.7	60.0	43.9	36.9	40.7	24.1	33.2	50.9	34.4	70.9	44.6	46.5	51.0	53.2	45.0	40.1	53.1	29.3

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Males (%)	31.8	29.2	36.3	14.8	24.9	30.4	15.4	15.9	31.1	20.9	20.1	7.8	8.5	10.2	14.7	18.2	15.8
<20mm CL (%)	24.7	22.2	36.9	22.0	28.9	25.0	18.1	20.3	30.4	21.3	20.1	17.4	16.4	19.2	31.2	52.8	19.1

[1] codend mesh-size 25 mm liner

Table 6.　Shrimp length frequencies (x 10³) estimated from the small mesh size bag attached to the cod-end in 2023 survey.

Length (CL) mm	Frequency ('000)
5.5	
6	3
6.5	
7	
7.5	
8	
8.5	
9	6
9.5	15
10	22
10.5	62
11	54
11.5	50
12	12
12.5	12
13	6
13.5	
14	
14.5	3
15	6
15.5	6
16	
Total	258
Biomass (tons)	2

Table 7. Shrimp modal groups by sexes and ages with Lofoten gear and bag in the codend in 2023 from EU Flemish Cap survey interpreted from size distributions.

LOFOTEN

Age	Modal groups		Cohort
	Males	Females	
1	-	-	K
2	16.5	-	J
3	19.5	20.5	I
4	22.0	22.5	H
5	-	24.5	G
6	-	26.0	F
7	-	27.5	E

BAG ON THE CODEND

Age	Modal groups	Cohort
1	11	K
2	-	J
3	-	I

Table 8. Results of the modal analysis (MIX) by sex and maturity stage from EU Flemish Cap surveys 2023 with Lofoten gear and juvenile bag.

Sex and maturity group	Juvenile bag (6mm)		Lofoten gear (35 mm)					
			Males		Primimarous females		Multiparous females	
	Juvenile bag* (6mm							
Age	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*	*Prop.*	*St. Dev.*
1	0.9435	0.0048			0.0161	NaN		
2	0.0565	0.0048	0.1714	0.01081	0.2936	NaN	0.0062	0.0048
3			0.8093	0.02157	0.4755	0.0146	0.6178	0.0259
4			0.0193	0.01936	0.2093	NaN	0.3580	0.0324
5					0.0000	0.0005	0.0000	0.0002
6					0.0055	0.0014	0.0181	0.0080
7								
Age			*Media CL*	*St. Dev.*	*Media CL*	*St. Dev.*	*Media CL*	*St. Dev.*
1	11.16	0.0185			17.71	NaN		
2	15.38	0.0424	16.43	0.07817	20.56	NaN	19.01	0.7893
3			19.76	0.05436	22.43	NaN	22.50	0.0388
4			22.20	0.76527	24.04	NaN	24.49	0.1543
5					25.13	NaN	25.99	NaN
6					27.09	0.2798	27.50	0.5768
7								
Age			*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*	*Sigma*	*St. Dev.*
1	0.8464	0.0138			0.7970	FCV		
2	0.4180	0.0401	1.1019	0.0329	0.9253	FCV	0.9613	0.0316
3			1.3253	CCV	1.0096	FCV	1.1376	CCV
4			1.4888	CCV	1.0816	FCV	1.2382	CCV
5					1.1309	FCV	1.3143	CCV
6					1.2192	FCV	1.3907	CCV
7								

Table 9. Mean length (mm) at age by years in EU Flemish Cap surveys

Age	1988	1989	1990	1991	1992	1993	1994*	1995	1996	1997	1998**	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1											10.6	8.5	10.4	10.5	10.2	9.3						11.1	11.7	11.4		12.5	10.7		12.1			9.9				
2		14.5		18.0		15.8	17.4	16.8	14.4	16.0	14.3	14.4	14.5	14.2	15.1	15.7	14.4	12.9	13.0	12.5	14.0	16.2	17.6	16.8	16.0	17.4	15.6	16.8	16.3	16.4	16.7	15.8	15.0	14.1	14.4	16.7
3	20.1	20.5	20.7	20.0	18.9	20.4	21.6	21.5	20.8	20.2	18.9	17.7	18.3	16.6	18.2	19.7	19.0	16.6	15.3	17.2	18.8	20.8	20.6	20.1	19.5	18.0	20.2	19.7	20.2	20.9	20.8	19.2	17.8	20.2		
4	24.9	23.9	23.4	24.4	24.2	24.2	24.8	23.1	24.6	24.2	21.9	21.7	20.7	20.4	20.4	21.1	22.2	19.9	19.3	18.9	19.9	20.9	23.3	22.6	23.4	21.8	21.4	22.4	21.7	23.2	23.0	23.7	22.6	22.0	20.1	22.4
5	26.7	25.5	26.2	26.6	27.6	26.3	27.9	26.0	25.7	26.3	24.8	23.8	23.8	22.8	22.5	23.4	24.1	21.9	21.9	20.6	22.0	23.0	24.5	24.4	25.1	23.8	23.5	24.4	24.3	24.4	25.1	26.5	25.1	24.3	22.7	24.1
6	29.6	28.8	29.3	29.7	30.6	28.3	30.3	28.4	27.5	28.0	26.6	26.1	25.1	25.4	24.6	26.3	26.7	24.1	24.0	23.1	23.9	25.2	26.3	28.0	28.0	25.7	25.7	26.2	26.9	28.0	28.3	28.0	26.8	26.7	25.1	25.8
7	32.3	31.8	32.4	31.2					29.6	30.1	29.1	28.7	27.3	30.6	27.4	29.0	28.0	26.4	26.3	25.2	26.4	27.3				27.5	26.7					29.5	27.6			27.2
8																																31.5				
9																																33.5				
10																																35.0				
Total (mm)	25.9	24.7	22.3	24.5	25.9	20.5	24.8	23.1	20.8	22.7	17.4	19.6	20.2	19.7	19.1	19.7	18.0	18.0	19.4	20.0	20.7	19.7	21.2	21.0	21.0	21.9	22.1	20.2	21.2	21.6	21.8	22.2	21.3	20.5	19.6	21.6

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

Table 10. Abundance (10^6) at age by years in EU Flemish Cap surveys.

Age	1988	1989	1990	1991	1992	1993	1994*	1995	1996	1997	1998**	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1											1220	13	94	27	1806	146						6	77	2		10	0		2			9			0	0
2		8		435		7878	427	2359	3424	695	56080	4735	1148	3711	11004	13869	27415	1792	809	301	473	1506	1106	611	216	63	15	1090	230	662	1048	1010	1449	125	61	74
3	1363	816	3647	2651	3043	3760	875	2682	9557	3372	38922	23924	17135	18668	44684	16648	9603	69026	18127	3866	4708	1783	4185	893	889	186	338	393	1089	1100	2479	5923	2598	1702	552	581
4	548	692	389	4677	4751	2052	726	1278	1828	5078	13786	14962	12744	17331	7167	5589	6425	5240	10561	12213	5027	1236	2747	1063	536	606	180	916	2141	2018	1939	5445	5723	1620	1055	592
5	1815	193	910	3882	13728	4458	1806	2146	1523	980	5341	6008	5342	13880	12874	9089	7831	10500	7449	12758	6865	1004	243	330	148	377	689	151	492	612	1558	1439	1746	707	218	269
6	1635	738	273	1000	1282	492	75	1217	571	258	2006	2043	1651	3875	8003	2306	1330	7576	3698	5882	4013	241	0	3	5	42	179	159	61	25	37	42	152	39	60	
7	126	131	10	318					437	77	145	81	669	7	545	49	206	1407	616	1287	282	70	0									21	0			8
8										0																						8				
9																																0				
10																																14				
Total ('00000)	5487	2579	5229	12964	22804	18640	3909	9682	17339	10461	117501	51766	38783	57500	86082	47516	52810	95541	41260	36306	21367	5846	8358	2903	1795	1284	1401	2710	4014	4418	7061	13911	11666	4193	1945	1523

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

Table 11. Biomass estimated (tons) at age by years in EU Flemish Cap surveys.

Age	1988	1989	1990	1991	1992	1993	1994*	1995	1996	1997	1998**	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1		0									84	0.5	6	2	114	7						1	9	0.2		1	0		0			1				
2		1		151		2144	145	665	609	161	9367	832	201	638	2178	2913	4660	187	88	38	80	410	373	181	59	22	4	352	65	188	285	229	281	21	11	21
3	615	389	1824	1240	1304	2083	554	1609	5174	1590	14892	7811	6005	5049	15341	6773	3730	15782	5047	837	1407	720	2230	461	446	87	121	213	535	569	1301	3085	1044	550	172	272
4	475	519	280	3868	4065	1823	681	962	1654	4197	8146	9016	6417	8491	3423	2830	3969	2109	3866	4764	2255	668	2054	705	408	386	103	666	1395	1549	1357	4254	3706	943	489	370
5	1933	173	906	4107	17010	4948	2374	2313	1593	1045	4557	4784	4118	9410	8233	6250	6206	5702	4037	6330	4075	702	227	267	136	306	505	140	450	546	1402	1569	1541	547	140	205
6	2356	946	376	1453	2130	675	124	1728	731	333	2122	2138	1483	3605	6602	2250	1430	5531	2669	3971	2995	216	0	4	6	42	168	181	75	33	48	55	161	39	51	0
7	236	224	19	534					700	123	199	112	772	11	616	64	254	1365	592	1105	279	78	0			0	0					32	0			9
8																																				
9																																				
10																																				
Total (ton.)	5615	2252	3405	11352	24508	11673	3879	7276	10461	7449	39365	24695	19002	27206	36508	21087	20248	30675	16299	17045	11092	2794	4893	1619	1055	844	900	1551	2521	2885	4394	9273	6734	2101	863	876

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

Table 12. Abundance at age 2 and average-weighted as indicator of recruitment (R) in the survey (lofoten gear) and from juvenile bag.

year	R (age 2) juvbag ('000)	R (age 2) Lofoten ('00000)	R(2)juvbag Av_weighed	R(2)lofoten Av_weighed
2001	1361	3711	0.28	1.24
2002	2125	11004	0.44	3.67
2003	0	13869	0.00	4.63
2004	41818	27415	8.64	9.15
2005	3741	1792	0.77	0.60
2006	7498	809	1.55	0.27
2007	3824	282	0.79	0.09
2008	4969	473	1.03	0.16
2009	3011	1514	0.62	0.51
2010	954	1106	0.20	0.37
2011	2440	611	0.50	0.20
2012	160	216	0.03	0.07
2013	102	63	0.02	0.02
2014	56	242	0.01	0.08
2015	427	1111	0.09	0.37
2016	390	230	0.08	0.08
2017	1411	676	0.29	0.23
2018	552	1048	0.11	0.35
2019	3536	1010	0.73	0.34
2020	25332	1449	5.23	0.48
2021	6582	125	1.36	0.04
2022	894	53	0.18	0.02
2023	125	74	0.03	0.02

Table 13.   Abundance at age 1 and average-weighted in the survey from juvenile bag.

year	R (age 1) juvbag ('000)	R(age1)juvbag Av_weighed
2001	380	0.06
2002	6044	0.97
2003	48165	7.73
2004	2314	0.37
2005	9515	1.53
2006	953	0.15
2007	5123	0.82
2008	5916	0.95
2009	1504	0.24
2010	6102	0.98
2011	1050	0.17
2012	42	0.01
2013	195	0.03
2014	239	0.04
2015	61	0.01
2016	1592	0.26
2017	6669	1.07
2018	327	0.05
2019	31594	5.07
2020	5912	0.95
2021	4729	0.76
2022	2836	0.46
2023	2081	0.33
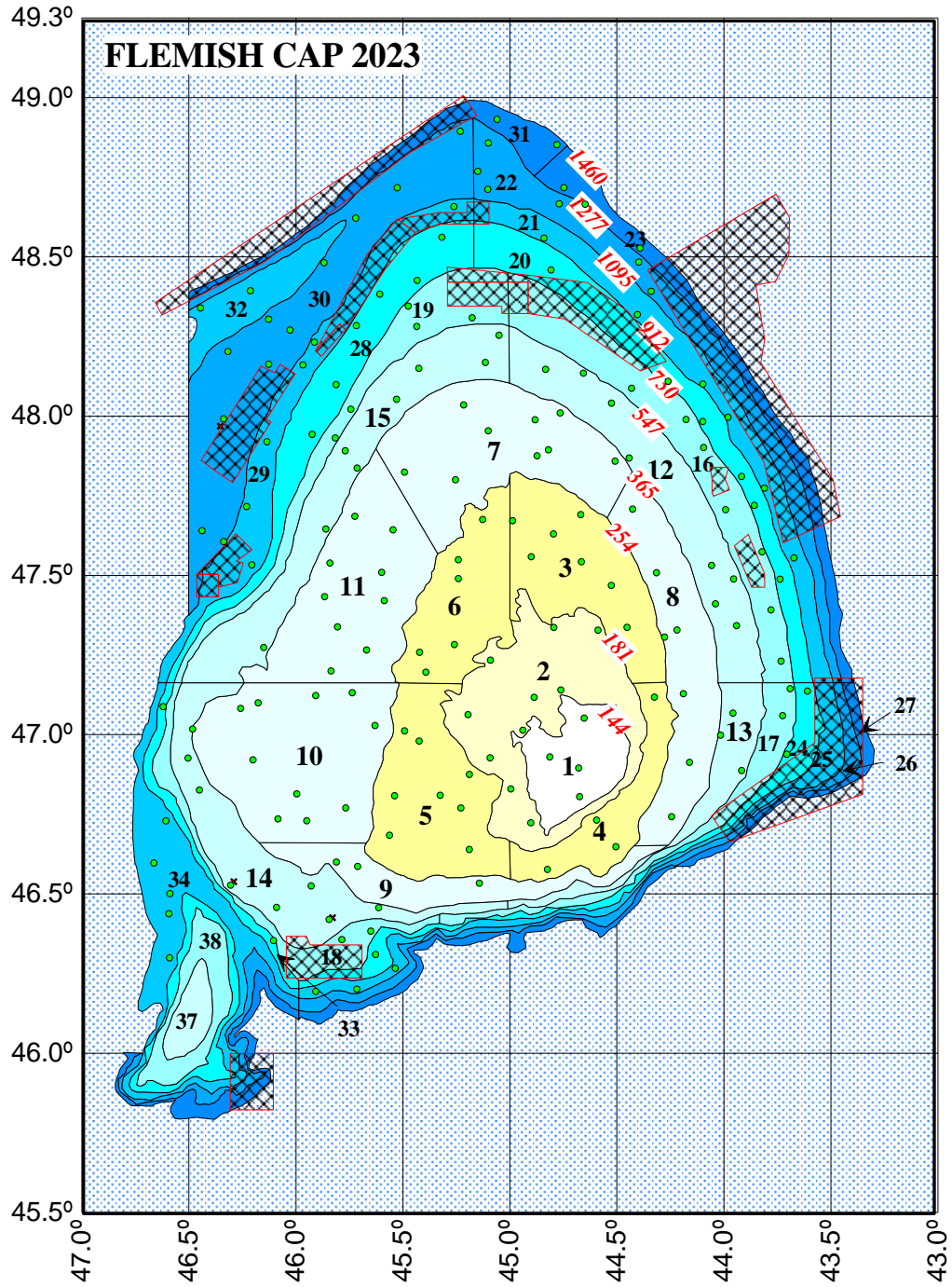
Figure 1.   Chart with the positions of the hauls carried out in EU Flemish Cap survey 2023.
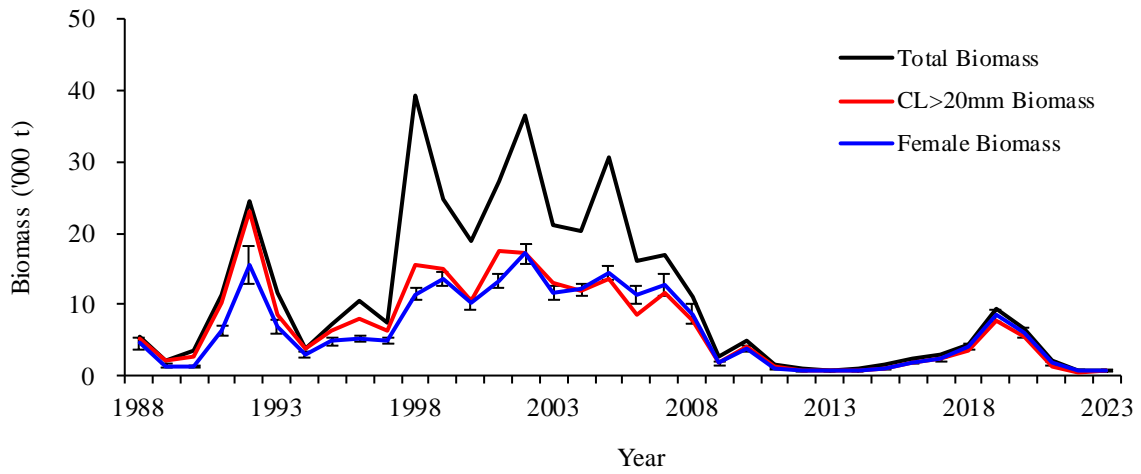
Figure 2. Total, female and adult biomass (shrimp bigger than 20 mm CL) from EU Flemish Cap 1988-2023 surveys.
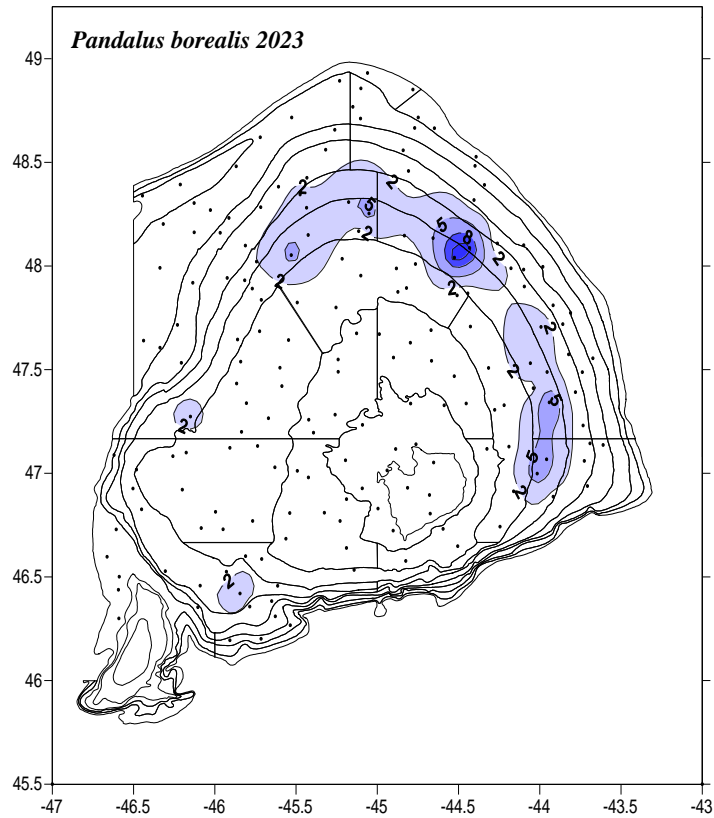
**Figure 3.** Shrimp catches distribution (kg/tow) from EU Flemish Cap survey in summer 2023.
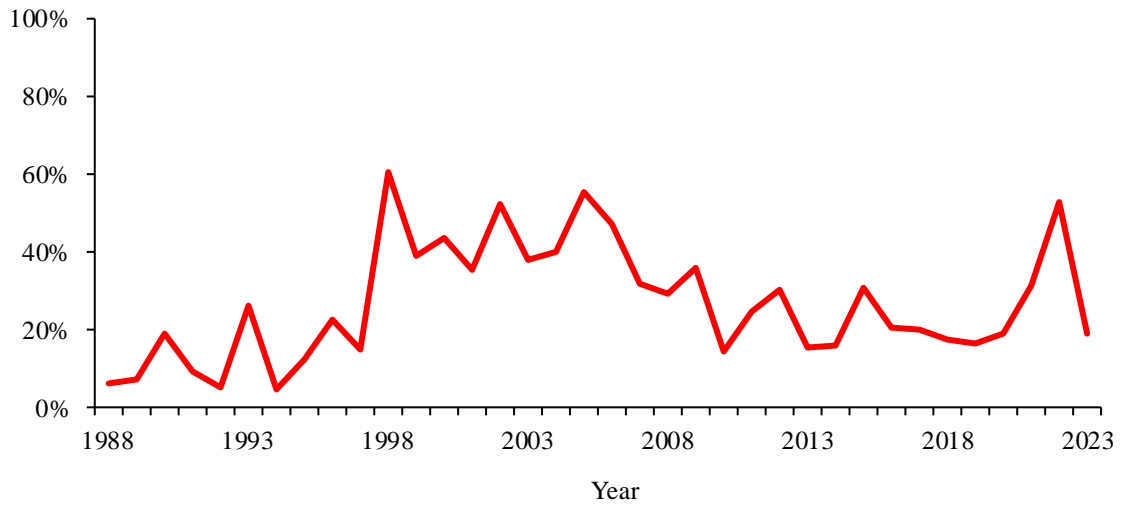
Figure 4. Differences between total biomass and adult biomass (>20 mm CL) as percentage of Total biomass from EU Flemish Cap 1988-2023 surveys.
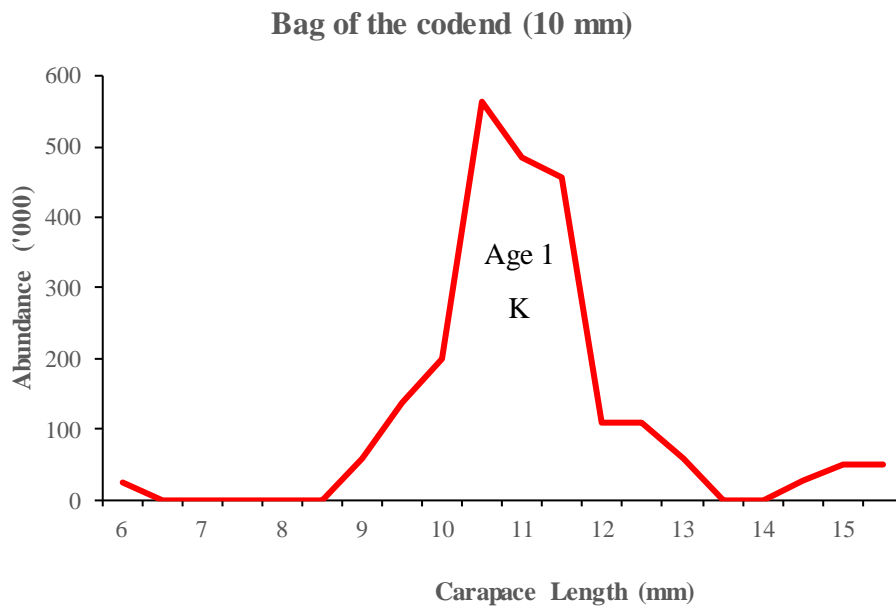
Males

Females

2006

2007

2008

2009

2010

2011

2012

2013

2014
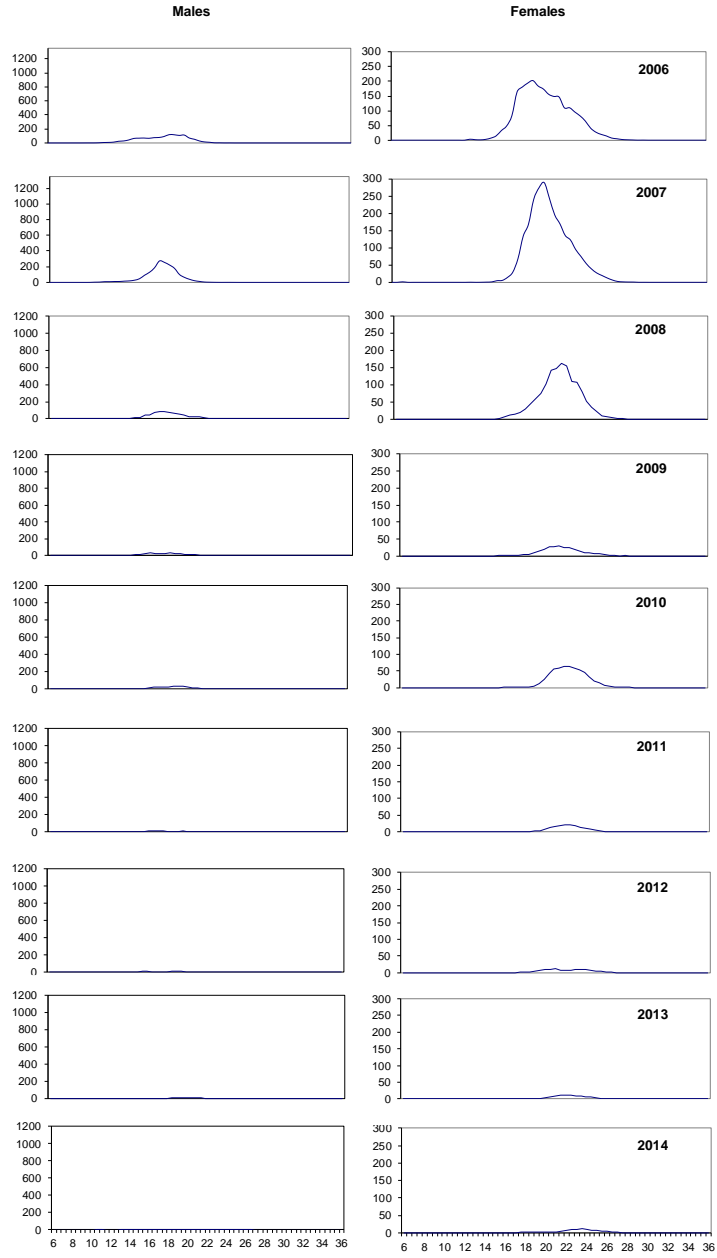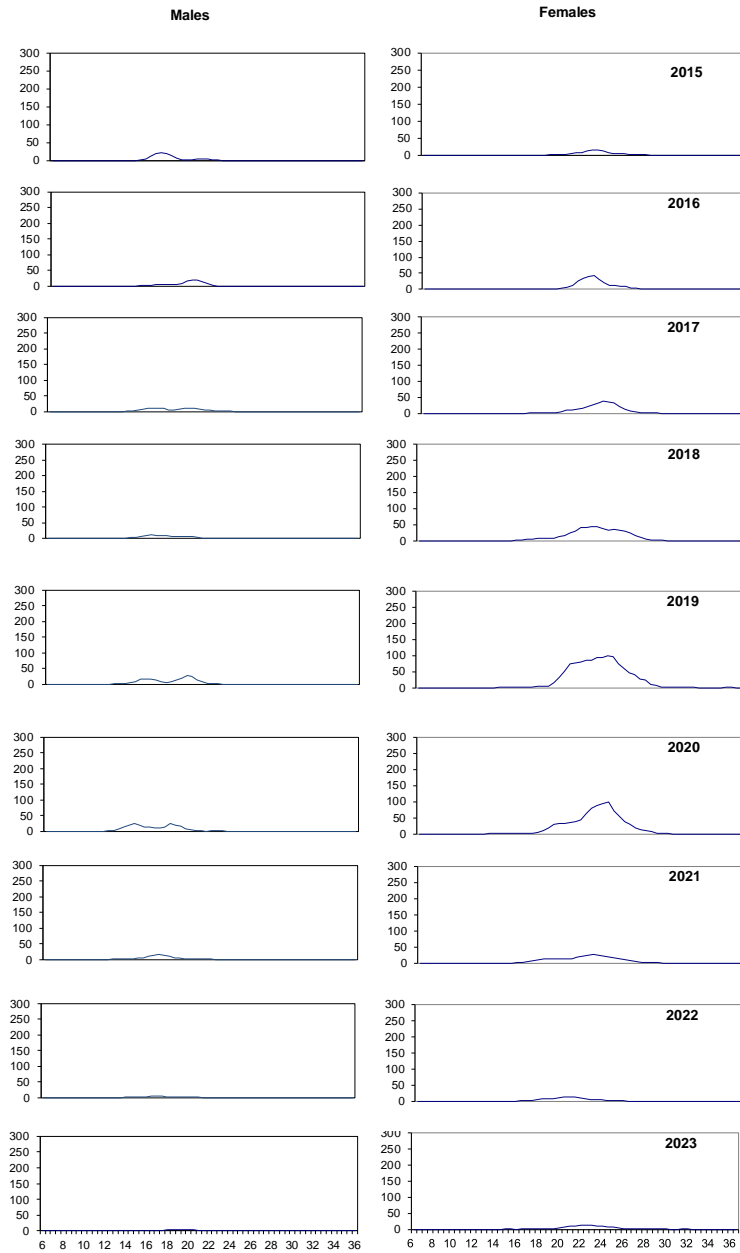
Figure 5. Shrimp size distribution from Flemish Cap 2006 -2023 surveys. Y-Axis=Frequency (10^6), X-Axis=Carapace Length (mm).
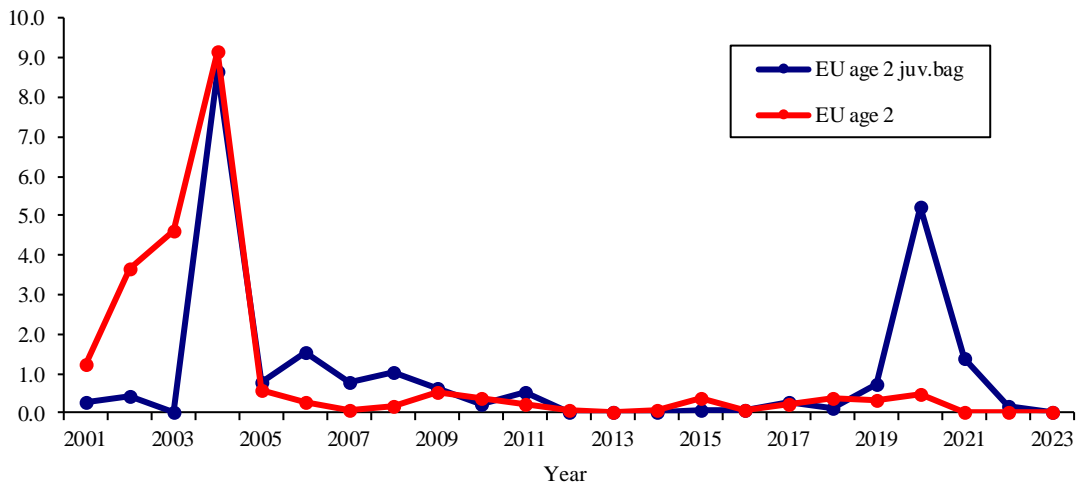
Lofoten gear 35mm
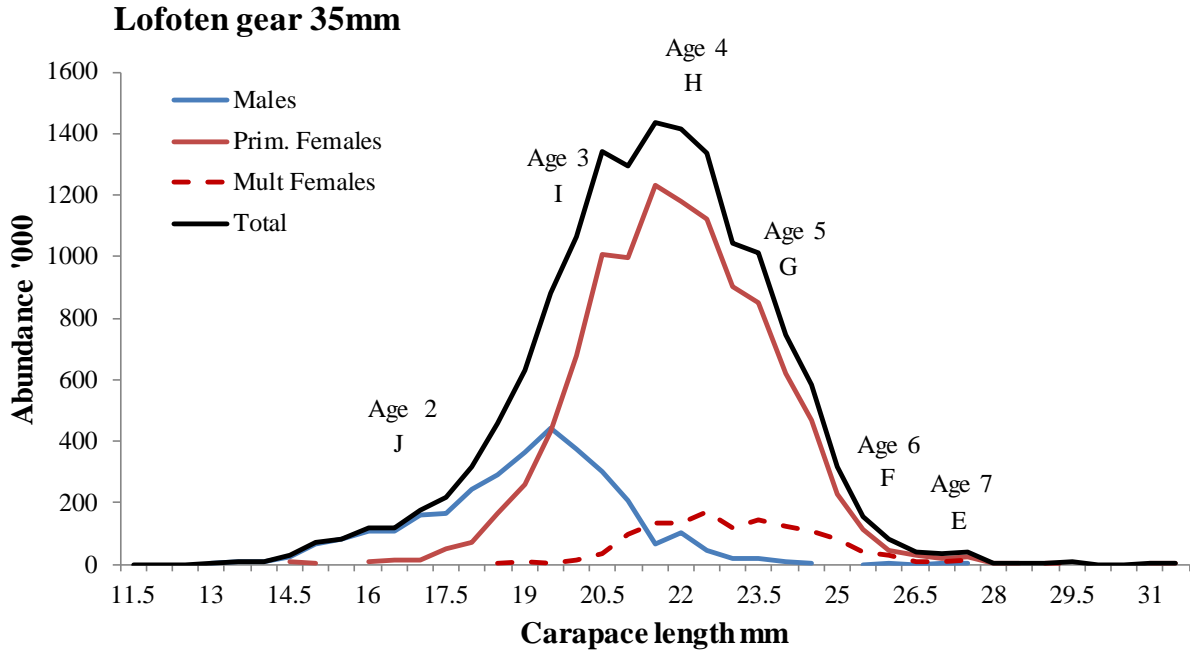
Figure 6. Shrimp modal and age groups in 2023 EU Flemish Cap survey (letters from table 7).

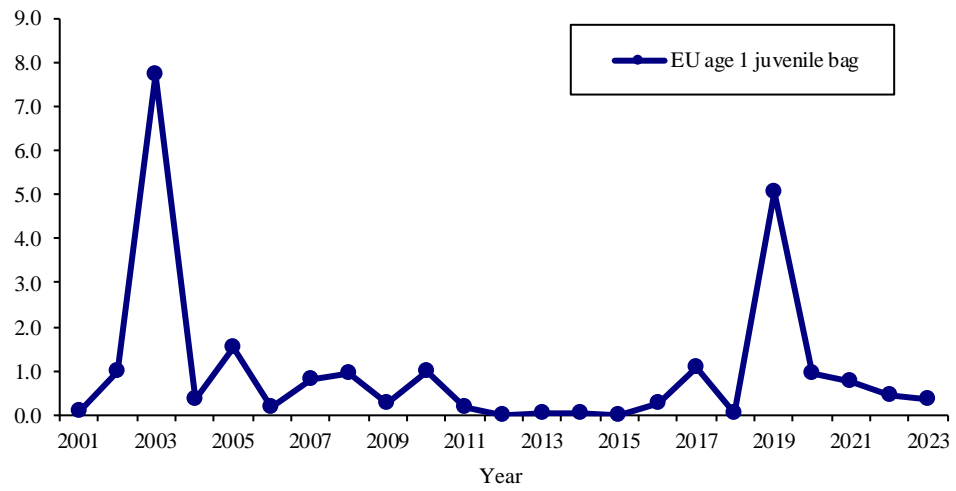## Bag of the codend (10 mm)

Figure 7. Shrimp modal and age groups in 2023 EU survey on Flemish Cap from juvenile bag. (letters from Table 7).
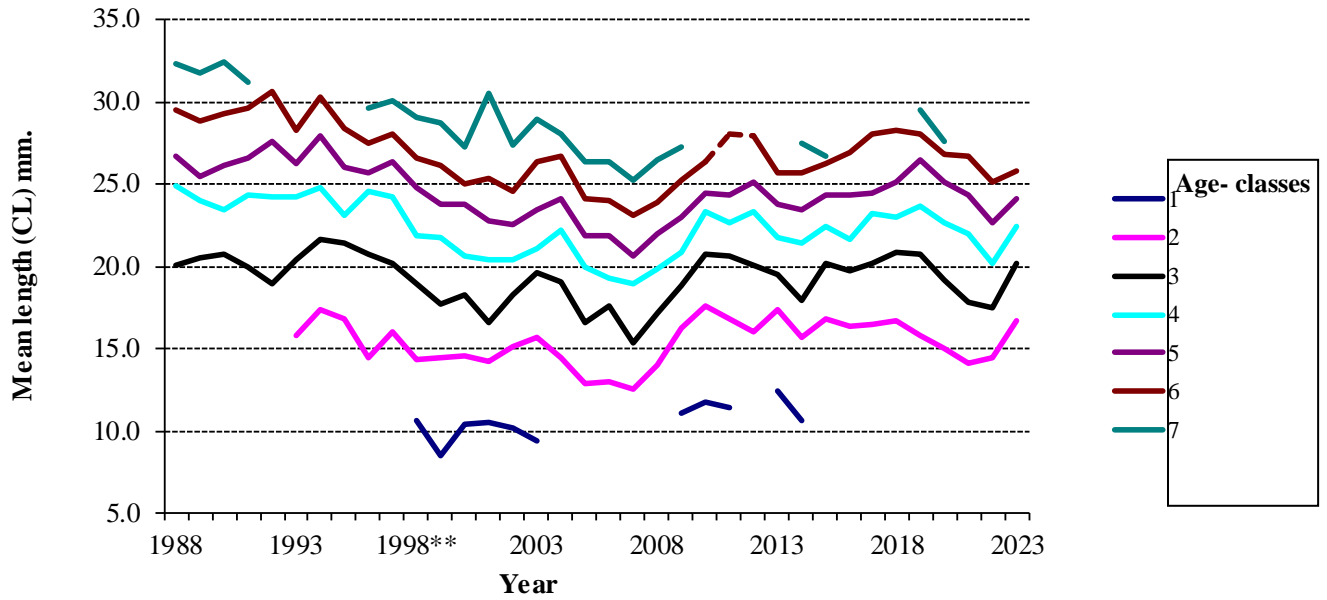
Figure 8.   Shrimp mean lengths at age in the series of EU surveys on Flemish Cap.

Figure 9. Abundance indexes at age 2 (weigthed-average) obtained in EU Flemish Cap surveys from Lofoten gear (red line) and Juvenile bag (blue line).

Figure 10. Abundance indexes at age 1 (weigthed-average) obtained in EU Flemish Cap surveys from Juvenile bag .