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Northern Shrimp (*Pandalus borealis*) on Flemish Cap in July 1999

by

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Abstract

Results on shrimp from the EU survey on Flemish Cap in 1999 are presented and compared to those from previous surveys of the same series. The adult stock biomass (shrimp bigger than 20 mm of carapace length) remains high and only slightly bellow the 1998 maximum. It is dominated by age 5 shrimp.

A comparative trial between the Lofoten gear, the one used in the survey, and a Campelen gear, indicates that the catch of large shrimp is 2.5 times bigger in the Campelen gear. This gear also catches large amounts of shrimp due to its smaller cod-end mesh size.

Keywords: Shrimp, Flemish Cap, survey.

Material and Methods

The survey was conducted following the same procedures as in previous years (Vázquez, 1999). The Lofoten gear used was the same as in previous surveys, with a cod-end mesh size of 35 mm.

Samples of approximately one-kilogram shrimp were taken in each tow where this species was present. Samples were immediately frozen for further analysis at the laboratory.

Shrimps were separated into males and females according to the endopod of the first pleopod (Rasmussen, 1953). Individuals changing sex phase, according to this criterion, were included with males. Females were further separated as immatures (first time spawners) and matures (spawned previously) based on the condition of the sternal spines (McCrary, 1971). Ovigerous females were considered as a group and were not included with mature 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. Sampling length data were used to obtain an estimate of population length distribution in all the area and to compare it with the estimates of the other years.

4058 individuals were weighed to the nearest 0.1 g after a little draining time to calculate the length-weight relationship.

In order to compare the catchability of both Lofoten and Campelen gears, 17 additional bottom trawls were made with a Campelen gear with a cod-end mesh size of 20 mm, repeating previous Lofoten hauls. Main results on the shrimp stock status in the present paper came from the survey with the Lofoten gear as in previous years. Data obtained with Campelen gear have been only used to compare the length distribution in both types of gears.

Results

A total of 117 valid bottom trawls were completed with Lofoten trawl gear in Flemish Cap. Shrimp appeared in 95 sets and catches per tow were highly variable (from 18 g to 98 kg).

Biomass

Total shrimp biomass estimated by swept area method and average catch per mile from 1988 to 1999 are presented in Table 1. The biomass index obtained this year, 12430 tons, is the third highest in the series.

The presence of shrimp in strata with the shallowest water -depths lower than 257 m- increased from 1333 tons estimated in 1998 to 1709 tons in 1999 (Table 2), even the cod-end mesh size used in 1999 (35 mm) is bigger than the one used in 1998 (25 mm). Shrimp appeared for the first time in stratum 4 last year, and biomass increased approximately fivefold in the same stratum this year.

Biomass distribution observed during the survey is presented in Figure 1. The results show that shrimp occurred mainly in intermediate depths (between 253 m and 447 m). Catches never exceeded 10 kg / tow in the shallowest area in the centre of the bank and in the highest depths of the slope. Shrimp occurs mainly in the south portion of the bank. The highest catch (>70 kg) occurred in the Southeast of the Cap but most of the best catches (>30 kg) took place in the Southwestern slope of the Cap.

Adult stock

Total biomass estimated in the sequence of bottom trawl surveys made on Flemish Cap between the years 1988 and 1999 is shown in Table 1. The standard gear used in those surveys was a Lofoten with a cod-end mesh size of 35 mm with the exception of the 1994 survey when a 40 mm cod-end mesh size was used, and the 1998 survey, when a liner of 25 mm was used.

The biomass index in 1994 is supposed to be underestimated because the mesh size of the cod-end was bigger (40 mm) than the one normally used. On the contrary, the biomass index in 1998 could have been overestimated by a factor of two (del Río, 1998) because the mesh size used that year was smaller (25 mm) than the one normally used. In order to make comparable the biomass indices of all surveys, the variations due to the different cod-end mesh size must be removed.

The biomass for shrimp bigger than 20 mm CL, a proxy of the adult stock biomass, is compared in Figure 2 with the total biomass. The difference between these two quantities corresponds to the shrimp smaller than 20 mm CL, those size classes that are more directly affected by variations of the cod-end mesh size. The biomass for shrimp bigger than 20 mm CL tries to be an estimation 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.

The differences between the total biomass and the biomass for shrimp larger than 20 mm CL were small in the analysed period 1988-1997. The differences ranged between 3.5 % and 10.4 % of the total, that is, the greater portion of shrimp catch was larger than 20 mm CL. The small variations in these percentages over the period could be mainly due to the intrinsic variability of trawl catches and not to differences in small shrimp abundance. However, the difference between both biomass estimates was 37.8 % in 1998 due to the 25 mm liner used that year. Again we attribute this difference to the gear effect and not to changes in small shrimp abundance. In 1999 survey the biomass difference was 22.5 % and the nominal cod-end mesh size was 35 mm, but the effective mesh size was somewhat smaller. Once again we attribute this difference to a gear effect, not to variations in small shrimp abundance. In summary, our survey results did not prove the abundance of small shrimp in any case.

The biomass index for shrimp bigger than 20 mm CL appears more stable than the survey total biomass index and it is presumably free of mesh size effects. However it corresponds to the adult stock instead the total biomass. The increase observed from 1997 to 1998 in the adult stock is smaller than previously assumed for the total stock but it is also a very important jump. The adult stock in 1999 roughly remains at the same high level.

Length frequencies

Length frequencies and percentages by sex from the 1999 survey are shown in Table 3. These length frequencies are split into males, immature females, mature females and ovigerous females. The 1999 survey catches contained 45% males and 55% females (30.5% immature, 24.2% matures and 0.16% ovigerous). The percentage of ovigerous females is smaller than in the last two years, because the survey finished on July 21st, that is, early for the spawning period in Flemish Cap, which begins between the end of July and the beginning of August (Mena, 1991). Males presented a CL between 8.5 and 24.5 mm. Females presented a CL between 13.5 and 32 mm comprising the groups: 13.5-32 mm immature, 18-32 mm mature and 19.5-26.5 mm ovigerous.

Length frequencies by strata are shown in Table 4. Figure 3 shows shrimp length distribution on Flemish Cap from 1991 to 1999. Modal groups named with the same letter belong to the same year-class. In the 1998 EU survey, length frequencies by strata also show an increase of small shrimp in shallower water, but it could be explained by the small size of the cod-end mesh used that year (25 mm instead of 35 mm), as it was already commented.

In this survey as in previous years, the results indicate that the minimum shrimp size increases with depth:

Strata	Depth range		Minimum observed size (mm CL)
	Meters	Fathoms	
3 to 6	183-257	101-140	8.5
7 to 11	257-360	141-200	12.5
12 to 15	360-545	201-300	14.0
16 to 19	545-725	301-400	17.5

Minimum observed size was 8.5 mm CL in those strata between 183 and 257 m (101-140 fathoms). It was 12.5 mm CL in depths between 257 and 360 m (141-200 fathoms). The minimum size was 14.5 mm CL in strata between 360 and 545 m (201-300 fathoms), and finally, it was 17.5 mm CL in depths between 545 and 725 m (301-400 fathoms).

Mean weights by length-class

Mean weight by length-class of shrimp for years 1989-1999 is shown in Table 5. It was observed that mean weights of this year are roughly equal or lightly higher than those observed in 1998.

The lowest mean weights of the last 5 years were observed in 1998. Even with the increase occurred in 1999, the mean weights at all length-classes didn't reach the levels observed before 1997.

Comparison of Lofoten and Campelen gears

Catchability. To compare catchability of Campelen and Lofoten gears, 17 hauls were made with both gears. Haul positions were selected to cover the widest depth range. Each haul was repeated with the other gear in less than 24 hours. The test we use to compare catchability is a straightforward tow by tow comparison, without taking into account the stratified scheme of the random survey.

Campelen gear is more effective than Lofoten for all shrimp sizes but two factors must be taken into account: the difference in gear design and the difference in mesh size of the cod-end. The gear design might determine the catchability on the whole stock, but the mesh size determines the retention of small size shrimp.

Figure 4 shows shrimp length distribution obtained with both Lofoten and Campelen gears. Length distribution of each gear was calculated adding the observed length distribution of each haul, so, no quantitative conclusion can be derived from those distributions. Table 6 shows length frequencies by strata estimated in the 17 additional hauls made with the Campelen gear. As we can see, small size shrimp (9.5–12 mm CL) appear in strata 3 and 4, which doesn't appear with the Lofoten gear because of the different codend mesh size.

Catches were transformed to catch per mile, dividing catch by the towed distance. The catch ratio between both gears was 5.00, being the highest the catch of the Campelen gear, but this ratio is influenced by the two factors already cited (gears design and cod-end selectivity). The cod-end mesh size is 35 mm in Lofoten gear and 20 mm in the Campelen one. The 50% selectivity for the 35 mm mesh size would be around 18 mm CL shrimp. So, taking into account only the fully recruited portion of the distribution of both gears, that is, those shrimps bigger than 20 mm CL (roughly the female stock), the biomass ratio is only 2.5. This means that the Campelen gear is more than two times more efficient to catch shrimp.

For shrimp less than 20 mm CL, the Lofoten gear appears very inefficient due to its highest cod-end mesh size. The Campelen gear shows two modal groups but the Lofoten only one. The abundance ratio between both gears is huge, but its contribution to the catch ratio is low, due to the low weight at those small shrimp sizes. The contribution of the small shrimp to the catch ratio is also dependent on the year-class abundance. Without small shrimp, the catch ratio would be around the 2.5 factor already cited.

Size distribution and age structure. As it was explained, shrimp length distribution is very dependent on cod-end mesh size, particularly for small shrimp. The length distribution of shrimp obtained in the survey with the Lofoten gear did not record adequately the small size groups, and those 17 hauls made in the comparative trial of both Lofoten and Campelen gears can not be used for a quantitative analysis. Even so, a more clear image of the current year-classes in the fishery can be derived from a joint analysis of the survey results and those from the Campelen gear in the comparative trial and other surveys made on Flemish Cap: the Canadian survey in 1996 (Parsons *et al*., 1997) and the 1998 EU survey (del Río, 1998). The gears used in each survey were:

Survey	**Type of gear**	**Cod-end mesh size**	**Liner**
1996 Canadian survey	CAMPELEN	40 mm	13 mm
1999 comparative trial	CAMPELEN	20 mm	-
1998 EU survey	LOFOTEN	40 mm	25 mm
1999 EU survey	LOFOTEN	35 mm	-

Table 7 shows modal groups and age interpretation of shrimp from these three surveys made on Flemish Cap. In the Canadian survey and the 1998 EU survey size distributions were analyzed with the MYX program (Macdonald and Pitcher, 1979). Age groups from the 1999 EU survey were deduced from the modal group interpretation in those previous surveys. Figure 5 shows shrimp age and modal groups from 1998 and 1999 EU survey and the comparative trial. Shrimp size distribution has been divided into male and female size distribution.

Shrimp modal groups of the Canadian survey for ages 1, 2 and 3 are composed by shrimp with CL of 11.28 mm, 15.82 mm and 20.52 mm respectively, slightly longer than shrimps for this ages in the EU surveys: 10.5 mm, 14.5 mm and 18 mm respectively. The reason of this difference could be that the Canadian survey was conducted during September-October, that is, later in the year than EU surveys, conducted during July-August 1998 and July 1999.

A modal group about 10.5 mm CL is observed in surveys made with Campelen gear, both in 1996 Canadian survey and in the comparative trial. This modal group was interpreted as being age one (Parsons *et al*, 1997). The presence (although precariously) of this modal group in the 1998 EU survey, must be explained by the higher catchability with the 25 mm liner used that year in the Lofoten gear.

The youngest modal groups of shrimp are non-represented (age 1) or under-represented (ages 2 and 3) in length distributions of shrimp population caught with Lofoten gear. Campelen gear is more efficient for small size shrimp and all modal groups are represented. Consequently, length distributions from the Campelen gear samples are the best representation of the shrimp stock structure.

The age interpretation proposed in Figure 4 for 1999 is consistent with previous views in the 1998 EU surveys and the 1996 Canadian one.

Acknowledgements

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Table 1.- Total shrimp biomass estimated by swept area method and average catch per mile.

Year	Biomass (t)	Average catch per mile (Kg)
1988	2164	1.54 ± 0.28
1989	1923	1.37 ± 0.24
1990	2139	1.53 ± 0.21
1991	8211	5.83 ± 0.71
1992	16531	11.75 ± 1.86
1993	9256	6.57 ± 1.04
1994[1]	3337	2.37 ± 0.35
1995	5413	3.85 ± 0.44
1996	6502	4.62 ± 0.34
1997	5096	3.62 ± 0.25
1998[2]	16844	11.81 ± 0.80
1999	12430	8.83 ± 0.67

[1]codend mesh-size 40 mm

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

Table 2.- Total shrimp biomass estimated by strata (tons).

Stratum	Depth (Fathoms)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	70-80	0	0	0	0	0	0	0	0	0	0	0	0
2	81-100	0	0	0	0	0	0	0	162	0	0	16	0
3	101-140	0	0	0	5	0	1	0	2	86	21	184	161
4	101-140	0	0	0	0	0	0	0	0	0	0	29	155
5	101-140	0	0	0	4	8	0	0	6	12	57	299	851
6	101-140	0	0	2	19	3	3	0	11	94	111	805	542
7	141-200	18	20	212	713	2134	1404	93	299	684	637	1304	1438
8	141-200	9	51	46	158	1130	545	3	183	412	269	827	1158
9	141-200	57	47	24	150	88	109	0	506	324	287	1898	653
10	141-200	115	44	188	1499	2278	972	658	873	707	706	2910	1883
11	141-200	89	0	105	733	2714	794	358	452	699	669	2463	1477
12	201-300	786	582	313	1733	3329	1786	599	778	910	871	1033	1192
13	201-300	64	58	42	63	28	120	0	28	416	394	984	929
14	201-300	255	218	407	814	1640	1161	556	632	706	286	1778	995
15	201-300	404	328	558	1485	2522	2029	916	1021	922	332	1320	764
16	301-400	308	234	239	171	303	133	44	47	148	121	340	136
17	301-400	2	10	0	0	0	0	0	0	0	1	0	0
18	301-400	0	0	0	0	0	0	0	1	30	8	0	2
19	301-400	56	331	4	663	354	163	111	412	351	327	656	91
Total:		2164	1923	2139	8211	16531	9256	3337	5413	6502	5096	16844	12430

Table 3.- Shrimp length frequencies and percentages by sex in the 1999 EU survey.

Length (mm) CL	Males	Immature Females	Mature Females	Ovigerous Females
8.5	1			
9.0				
9.5				
10.0				
10.5				
11.0				
11.5				
12.0				
12.5	4			
13.0	34			
13.5	79	1		
14.0	138	2		
14.5	186	2		
15.0	200	2		
15.5	319	1		
16.0	398			
16.5	636	3		
17.0	985	2		
17.5	1155	10		
18.0	1271	28	1	
18.5	911	39	7	
19.0	778	71	5	
19.5	443	140	11	1
20.0	507	204	37	
20.5	472	473	70	
21.0	471	559	139	1
21.5	378	831	215	
22.0	218	838	376	4
22.5	157	915	511	4
23.0	87	697	528	2
23.5	38	576	610	3
24.0	25	455	525	5
24.5	5	366	422	8
25.0		233	412	2
25.5		134	356	3
26.0		75	323	2
26.5		23	244	2
27.0		8	222	
27.5		7	150	
28.0		3	70	
28.5			40	
29.0			23	
29.5			12	
30.0			8	
30.5		1	3	
31.0			2	
31.5				
32.0		1	1	
	45%	30.50%	24.20%	0.16%

Frequence x 10^5

Table 4.- Length frequencies by strata in the 1999 EU survey.

	STRATA															
Length (mm CL)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	19	Total
8.5			1													1
9.0																
9.5																
10.0																
10.5																
11.0																
11.5																
12.0																
12.5	1			2				2								4
13.0	4	3	3	12	2			6	2							34
13.5	13		13	16	16	2		11	8							80
14.0	22	6	12	11	41	4		29	11			4				140
14.5	19	19	10	23	50	19		35	11			1				188
15.0	18	36	21	18	31	23		39	13	3						202
15.5	13	40	31	8	74	33		76	22	8	3	12				320
16.0	13	54	53	20	59	32	14	104	33	10		5	1			398
16.5	18	41	91	29	92	46	28	162	66	33		29	4			639
17.0	17	77	113	34	141	83	49	225	131	68	3	33	13			987
17.5	16	84	98	36	186	181	38	225	125	98	12	36	30	1		1165
18.0	18	72	57	22	159	261	47	203	162	176	39	45	40			1300
18.5	15	36	23	19	129	202	26	122	96	129	51	56	50	1		957
19.0	11	28	34	28	71	166	40	94	119	128	61	42	30			854
19.5	11	8	63	21	57	108	21	80	79	65	30	28	21	2		595
20.0	16	6	68	37	59	66	34	150	113	46	56	69	27	1		748
20.5	21	6	153	61	96	56	44	200	174	43	36	93	25	3	2	1015
21.0	24	1	115	87	117	107	51	222	164	78	58	101	34	8	2	1170
21.5	22	9	185	76	200	132	57	215	246	60	83	71	53	8	3	1424
22.0	22	1	172	98	227	153	54	244	167	106	68	62	45	11	5	1436
22.5	23		121	75	250	169	88	267	247	102	85	101	43	9	6	1587
23.0	16	3	88	54	181	135	86	225	173	101	90	89	58	8	4	1314
23.5	17		79	45	174	99	80	203	161	108	98	88	68	4	3	1227
24.0	5		45	32	96	83	59	157	99	128	103	111	85	7	2	1010
24.5	4		24	37	66	45	43	86	89	98	120	87	90	10	3	801
25.0	4		28	39	48	25	35	69	54	91	96	68	73	9	5	647
25.5	3		13	26	42	10	40	53	44	55	53	79	64	6	5	493
26.0	1		15	9	30	13	21	43	34	52	60	63	42	10	6	400
26.5			8	11	21	1	21	21	24	33	22	47	43	8	10	269
27.0				4	12	11	12	17	18	40	35	36	23	13	10	230
27.5			4	6	4	2	13	5	18	18	19	28	21	10	9	157
28.0			4		2		6	2		8	8	15	14	7	7	73
28.5				3	2		1	7	4	2	2	6	6	6	2	40
29.0							4	8		1	1	3	1	2	3	23
29.5							1	5		1			2	1	1	12
30.0								2		3		1	1		1	8
30.5										1		2	1			4
31.0								2								2
31.5																
32.0										1			1			2

Frequence x 10^5

Table 5.- Mean weights by length-class in the years 1989-1999

CL (mm)	Mean weights (g)										
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
10.0	0.6	0.6	0.7	0.7	0.8	0.7	0.6	0.6	0.5	0.6	0.6
12.5	1.2	1.2	1.3	1.4	1.4	1.3	1.2	1.1	1.1	1.1	1.1
15.0	2.0	2.0	2.1	2.3	2.4	2.2	2.1	2.0	1.9	1.9	1.9
17.5	3.1	3.2	3.3	3.5	3.6	3.4	3.3	3.2	3.0	3.0	3.1
20.0	4.6	4.7	4.9	5.1	5.2	5.0	4.9	4.8	4.5	4.5	4.6
22.5	6.5	6.6	6.9	7.1	7.3	7.1	7.0	6.9	6.4	6.4	6.6
25.0	8.9	9.0	9.3	9.5	9.7	9.6	9.5	9.5	8.8	8.8	9
27.5	11.7	11.8	12.3	12.4	12.7	12.6	12.6	12.7	11.7	11.7	12
30.0	15.1	15.3	15.8	15.9	16.1	16.2	16.3	16.6	15.3	15.1	15.6
32.5	19.1	19.3	19.9	19.9	20.1	20.4	20.7	21.2	19.5	19.2	19.9
35.0	23.7	23.9	24.7	24.5	24.8	25.3	25.8	26.6	24.4	23.9	24.8

Table 6.- Length frequencies by strata, in the additional hauls made with Campelen gear in the 1999 EU survey.

	STRATA					
Length (mm CL)	3	4	8	12	13	Total
8.5						
9.0						
9.5		9				9
10.0	9	2				11
10.5	18	18				36
11.0	9	16				25
11.5		11				11
12.0		4				4
12.5	212	2				214
13.0	780					781
13.5	1631	7	569			2208
14.0	2232		1876	13		4124
14.5	2186		3294	29		5512
15.0	1189		3864	182		5237
15.5	478		2631	227		3337
16.0	67		2355	301	6	2731
16.5	58		2416	531	13	3020
17.0	18		3312	992	65	4389
17.5	9		3364	1625	145	5147
18.0	18		2109	1505	246	3879
18.5	51		1220	1275	271	2820
19.0	18		565	593	303	1480
19.5	33		187	444	144	808
20.0			382	276	108	768
20.5	9		777	164	66	1016
21.0			335	189	81	605
21.5			729	257	115	1102
22.0			939	294	136	1371
22.5			499	328	121	950
23.0			752	414	139	1306
23.5			468	539	123	1133
24.0			386	381	109	878
24.5			213	405	129	748
25.0			105	328	108	540
25.5			156	149	56	361
26.0				111	49	160
26.5				108	44	152
27.0			54	73	12	140
27.5				22	20	42
28.0				3	12	15
28.5				3	3	6
29.0				6	5	12
29.5					1	1
30.0					2	2
30.5					1	1
31.0					1	1
31.5					1	1
32.0					1	1

Frequence x 10^5

Table 7.- Shrimp modal groups and ages in the 1996 Canadian survey and in 1998 and 1999 EU surveys on Flemish Cap.

CAMPELEN GEAR

1996 CANADIAN SURVEY				**1999 EU COMPARATIVE TRIAL**			
MALES		FEMALES		MALES		FEMALES	
Age	Modal group	Age	Modal group	Age	Modal group	Age	Modal group
1	11.28	4 +	23.5	1	10.5	3-4 ?	22-23
2	15.82			2	14.5	5	24.5
3	20.52			3	18	6	26.5
				4	21.5	7	29

LOFOTEN GEAR

1998 EU SURVEY				**1999 EU SURVEY**			
MALES		FEMALES		MALES		FEMALES	
Age	Modal group	Age	Modal group	Age	Modal group	Age	Modal group
1	10.5	4	22	1	-	4	22.5
2	14.5	5	24.6	2	14.5	5	24
3	18.8	6	26.7	3	18	6	27
4	21.5	7	29	4	21		

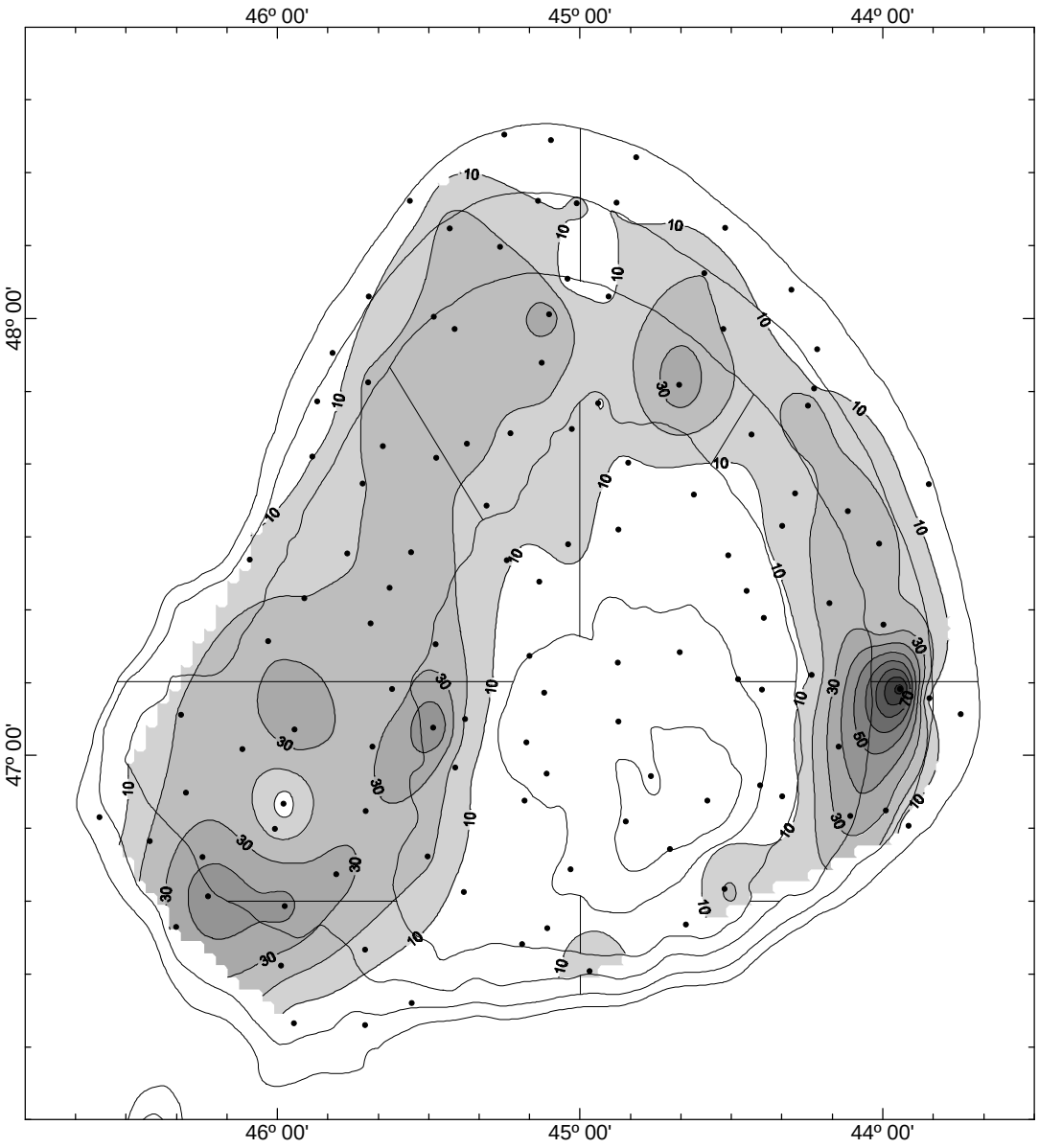

Figure 1.- Shrimp catches distribution (kg/tow) in July 1999 on Flemish Cap.

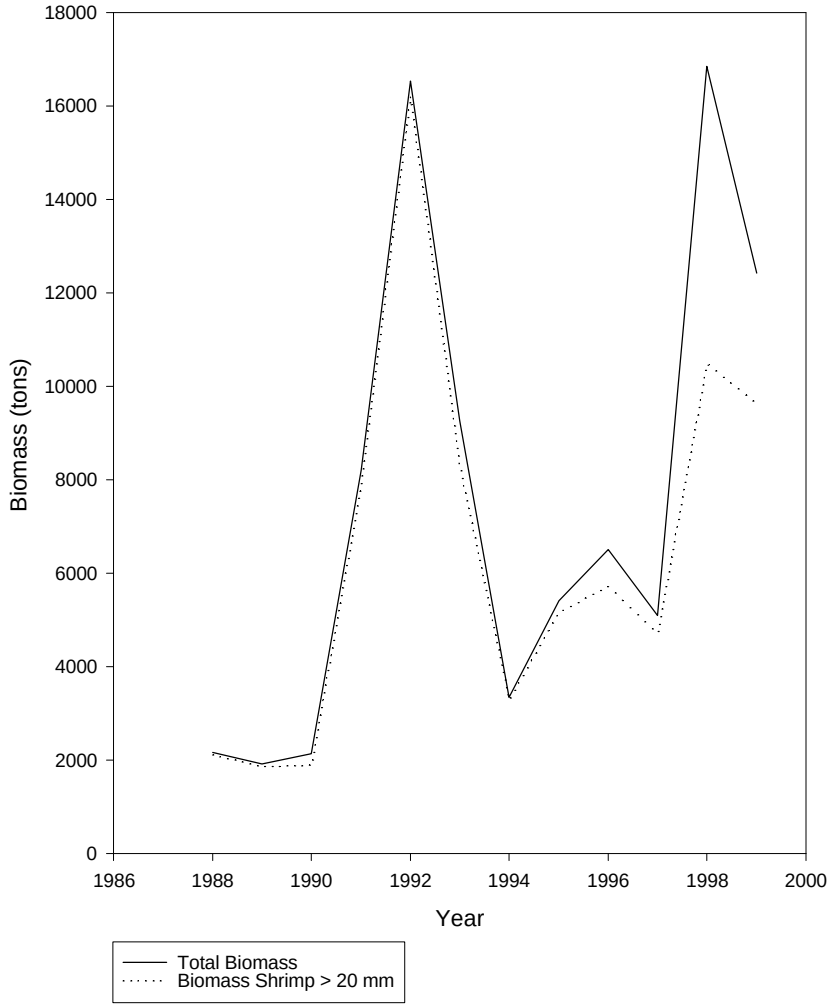

Figure 2.- Total biomass and biomass for shrimp bigger than 20 mm CL (adult stock) in the period 1988-1999.

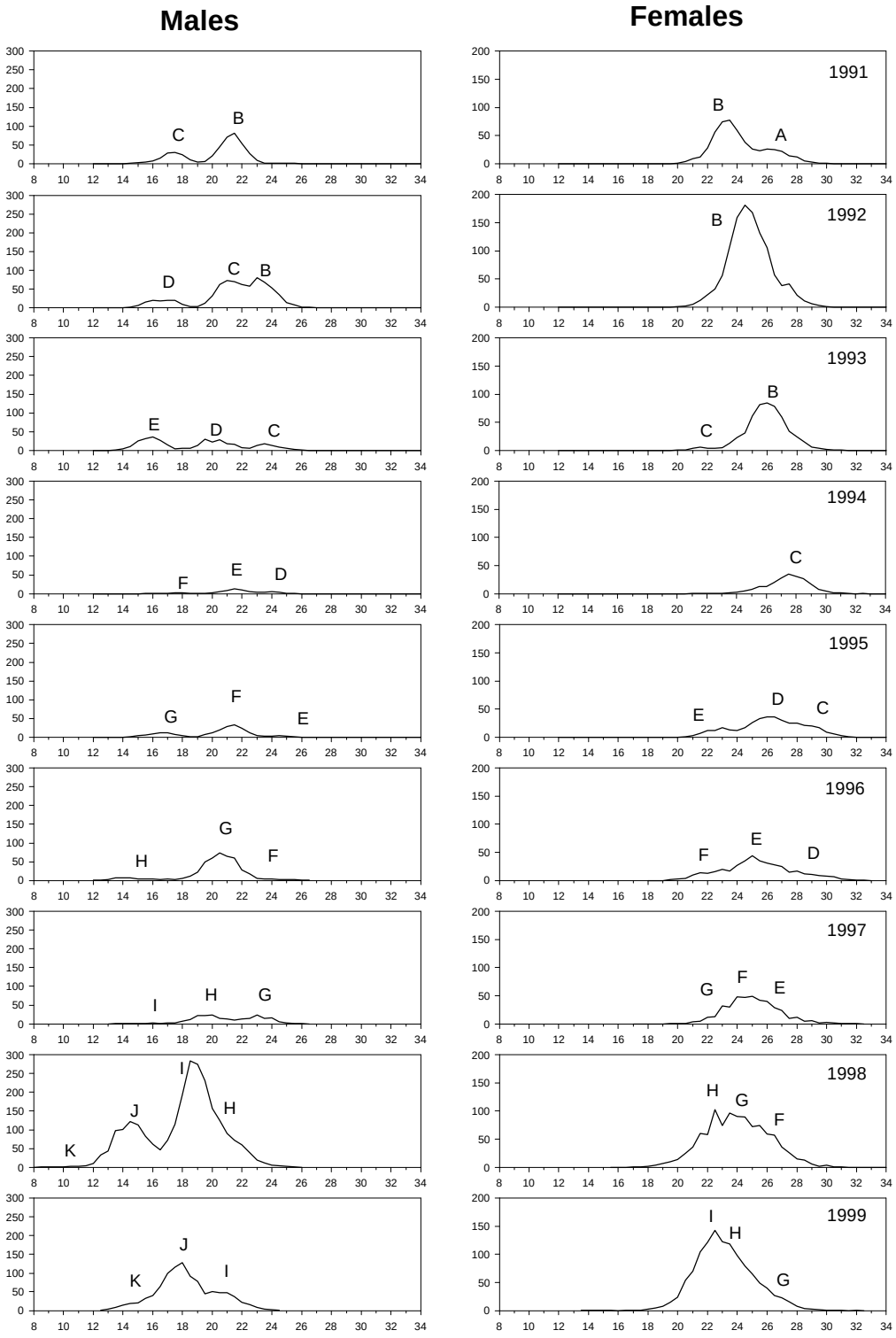

Figure 3.- Shrimp size distribution on Flemish Cap 1991-1999 surveys.
Y-axis = Frequence (10^6) X-axis = Carapace Length (mm).

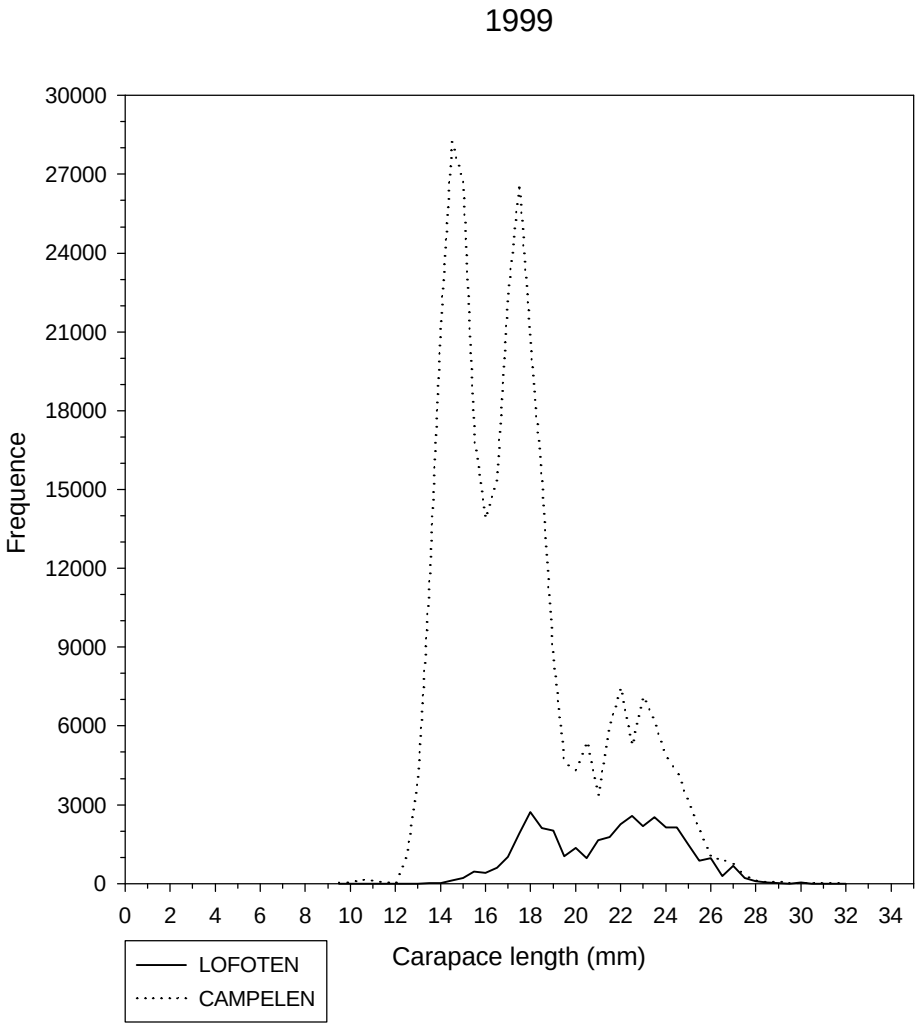

Figure 4.- Comparison of shrimp size distributions from Lofoten and Campelen gears, in the 1999 EU survey on Flemish Cap.

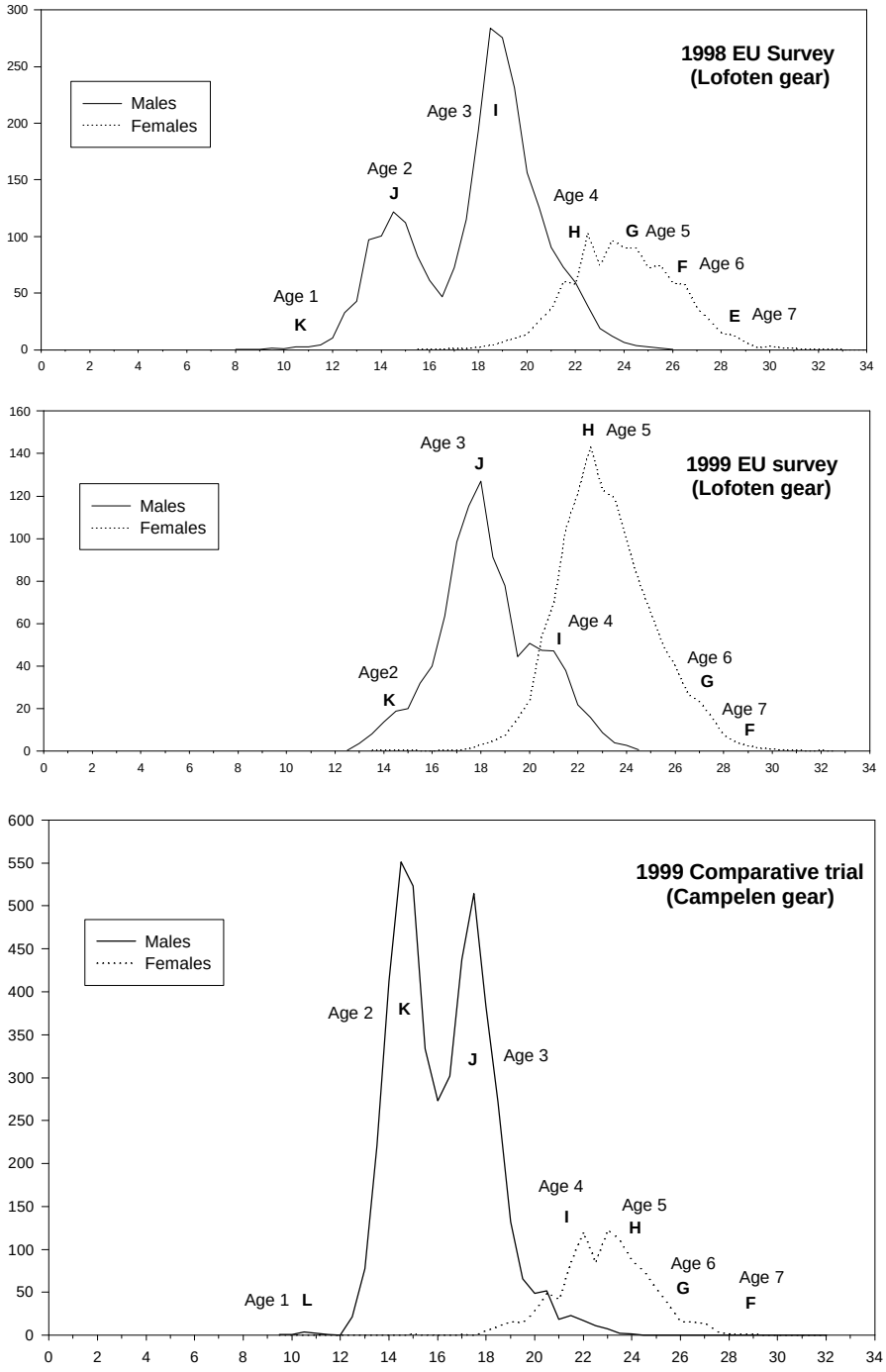

Figure 5.- Shrimp modal and age groups in 1998 and 1999 EU surveys on Flemish Cap.
Y – Axis = Frequence X – Axis = Carapace Length (mm)
(Same letters for each age group as in figure 3)