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Northern Shrimp (*Pandalus borealis*) on Flemish Cap in July-August 1998

by

J. L. del Rio

Instituto de Investigaciones Marinas, Eduardo Cabello 6
36208 Vigo, Spain

A stratified random bottom-trawl survey on Flemish Cap (NAFO Div. 3M) was carried out in July-August 1998 on board R/V Cornide de Saavedra. The survey was conducted from July 17 to August 2 following the same method used since 1988 and provided data on the distribution, abundance, biomass and demographic structure of shrimp in the area. Results of shrimp population (*Pandalus borealis*) are presented in this paper and compared with those previously observed.

Material and Methods

The survey was conducted following the same procedures as in previous years (Vázquez et al., 1998). The trawl used was the same that in previous surveys, a Lofoten type with a codend mesh size of 35 mm. One gear with the unique 35 mm codend available on board was lost in haul 14. The codend replacement has 40 mm mesh size, so a 25 mm liner was introduced.

Samples of approximately one kilogram shrimp were taken in each tow this specie was present. Samples were immediately frozen for further analysis at the laboratory. Shrimps was 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) were 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. 5157 individuals were weighed to the nearest 0.1 g after a little draining time to calculate the length-weight relationship.

Results

A total of 119 valid bottom trawls were completed in Flemish Cap. Shrimp occurred in 104 sets and catches per tow were highly variable (from 70 g to 118 kg). Total shrimp biomass estimated by swept area method and average catch per mile from 1988 to 1998 are presented in Table 1. The estimated biomass for 1998 is much higher (approximately threefold) than that of the last years. This increase is partially due to the codend effective mesh size being smaller than in previous years: 25 mm instead of 35 mm.

Failing a shrimp selectivity curve to calculate the effect of mesh size change, the effect of the mesh size can be envisaged by comparison of results from the Canadian survey on Flemish Cap in September-October 1996, made with a 13 mm liner (Parsons et al., 1997), with the EU-survey in July 1996, made with a 35 mm codend mesh size (del Rio, 1996). In the Canadian survey, length distribution of male shrimp shows two strong modal group in 15 and 20 mm CL, but the EU-survey only shows the largest one (Figure 1), so the 35 mm mesh size retention is low for shrimp less than 20 mm CL. In the Canadian survey, length distribution of females also shows two modal groups, with 22 and 24.5 mm CL modes, and roughly the same size. In the EU-survey, the abundance at 24.5 mm CL is higher than at 22 mm CL, indicating than the 22 mm CL group is not full recruited to the 35 mm mesh size.

The 50% selection for a 35 mm mesh size seems to be around 22 mm CL for shrimp. So, taking into account that 50% of the total catch of the current survey with the 25 mm liner was less than 22 mm CL, the total biomass index could be overestimated by a factor of two in the current survey in comparison with previous 35 mm mesh sizes surveys. The effect of the liner is particularly important on male catches where small size individuals are much more abundant than previously. Nevertheless, female abundance also increased from 1997 to 1998 surveys.

The effect of mesh size change was analyzed by comparison of hauls realised in this survey with a codend mesh size of 35 mm and those made with a 25 mm liner in the same strata. Ten hauls with a 35 mm codend and fourteen hauls with a 25 mm liner were made in strata 3, 8, 12 and 13. Common strata for these hauls were:

STRATUM	HAULS	
	35 mm	25 mm
3	8, 9, 10	15, 44, 46, 47
8	6, 7, 12, 13	117, 119, 121
12	5, 11	17, 18, 26, 29, 38
13	1	122, 123

Length frequencies distribution by strata and trawl configuration are compared and provided in Figure 2. Shrimp captures with a 25 mm liner were higher than that with a 35 mm codend both in weight and number. This increase was mainly observed in small size individuals. This rule is not so clear for large size individuals. In strata 8 and 13, the 35 mm mesh size retention is higher than the 25 mm liner, but 35 mm hauls were conducted at the beginning of the survey and the 25 mm hauls were made at the end. Differences could be considered accidental, as results of the timing variation. The effect of the liner is particularly important when survey results are compared with previous surveys, where 35 mm codend was used.

Table 2 shows the modal groups of the shrimp caught by the trawl with a 35 mm codend mesh size and with a 25 mm liner in the survey. Three length distribution modal groups are observed in each stratum, and there is a close correspondence between those of the 35 mm codend and the 25 mm liner. In strata 3, for example, length distribution with a 35 mm codend shows three strong modal group in 14, 19.5 and 22 mm CL, but 14, 18.5 and 22.5 mm CL with a 25 mm liner. We conclude that modal lengths were independent of the codend mesh size, so survey results can be compared with previous surveys in this sense.

It could be hypothesized that a small codend mesh size, changing the gear geometry, may modify their catchability for full recruited stocks. Such a change can't be denied but their effect could be no significant taking into account the high intrinsic variability of trawl catches. Changes in shrimp catchability due to small mesh sized codend, not attributed to gear selectivity, or due to codend fullness are considered similar phenomena. Both, a smaller codend mesh size or a heavy catch, increase the codend resistance, with a possible effect on gear geometry and catchability. So, a test on catchability associated to codend fullness will be interpreted as a test on changes in catchability produced by changes in mesh size codend. The relationship between shrimp catches and total catch in the codend were analyzed with the results of the 1988 to 1998 surveys. For each stratum at each survey, both shrimp catches and total catch in each haul were transformed to get a mean catch equal 1 and a mean total catch equal 1, so data from different survey and strata became comparable. Results from a regression analysis are presented in the table below. Determination coefficients are very low for shrimp, as well as most of species. Sebastes fasciatus is the species with the highest determination coefficient and this is the reason for their inclusion in the table. We conclude that there is no significant change in catchability by the use of the 25 mm liner, so changes in mesh selectivity are only expected.

Variable	reg.coef.	r^2	Log-transformed reg.coef.	Log-transformed r^2	n
Shrimp catch	0.024	0.000	0.089	0.003	905
Shrimp abundance	-0.038	0.000	0.016	0.000	725
Shrimp abundance (<25 mm CL)	0.040	0.000	0.107	0.003	718
Shrimp abundance (>25 mm CL)	0.012	0.000	0.105	0.003	711
S. fasciatus catch	0.624	0.134	0.549	0.125	803
S. fasciatus abundance	0.598	0.145	0.525	0.129	686

Length frequencies and percentages by sex from 1998 survey are shown in Table 3. These length frequencies are split into males and immature, mature and ovigerous females. The catches in 1998 contained higher proportions of males. Over 70% of individuals caught in this year were male. The 29.5% of individuals were female: 16.8% immature, 9.8% mature and 2.9% ovigerous. The spawning period in Flemish Cap begins between the end of July and the beginning of August (Mena, 1991). This year survey was carried in the same date that the 1997 survey, later in the season than in previous years. The percentages of ovigerous females in these two years are very much alike and were the highest observed since the surveys began. Males presented a CL between 8.0 and 26.0 mm. Females presented a CL between 15.5 and 32.5 mm comprising the groups: 15.5-28.5 mm immature, 19.5-32.5 mm mature and 19.5-29.5 mm ovigerous.

According to Unnur Skúladóttir (personal communication), a modal analysis of the length distribution to estimate age structure, using the MIX program (Macdonald and Pitcher, 1979), indicates the presence of three size groups of male shrimp in this year. The component at 18.89 mm CL (age 3), accounting for 38.7% of the total catch in numbers. Females were split into primiparous (age 4 and 5) and multiparous (age from 4 to 7). About 16% of the catch in number consisted of primiparous females and 12.7% were multiparous females.

Age	2	3	4	4	5	4	5	6	7
Sex	Male	Male	Male	Primi. fe.	Primi. fe.	Multi. fe.	Multi. fe.	Multi. fe.	Multi. fe.
CL (mm)	14.59	18.89	21.58	21.96	24.68	22.21	24.67	26.70	29.08
Per cent	18.83	38.78	12.92	7.98	8.79	1.72	5.36	5.11	0.50

Length frequencies by strata in previous years (Table 4) indicate that the presence of shrimp is scarce in depths lower than 257 m (140 fathoms) or higher than 554 m (301 fathoms). The presence of shrimp in shallowest water, depths less than 257 m, increased from 189 tons estimated in 1997 to 1333 tons in 1998 (Table 5). This increase was produced by few hauls on the stratum 6 with large catches, mainly of small shrimp. Shrimps do not appear in depths shallower than 146 m (80 fathoms). The results indicate that minimum shrimp size increases with depth:

minimum observed length (mm CL)	depth range m	depth range fathoms
8.0	146-183	81-100
8.5	183-257	101-140
9.0	257-360	141-200
12.5	360-545	201-300
14.0	545-725	301-400

Biomass distribution estimated in 1998 (Table 5) shows a similar pattern to that observed in the 1997 survey for most of strata, although in strata with depths lower than 257 m (strata 2 to 6) the biomass increased. It is to note that shrimp appeared in stratum 4 (183 – 257 m) for first time in this year. Shrimp length distributions on Flemish Cap 1990-1998 are provided in Figure 3. It is assumed that modal groups named with the same letter belong to the same year-class. The increase of biomass from 1997 to 1998 was mainly due to a increase of abundance of modal group named J (17 - 22 mm CL) in 1997 (del Rio, 1997) and also appeared a new modal group named K, comprised for males shrimp with modes at approximately 9.5-16.5 mm CL. This modal group does not appear significantly in previous surveys because these small size shrimp are inefficiently caught by the 35 mm mesh size codend used in previous years.

Mean weight by length class of shrimp for years 1989-1998 were compared in Table 6; it was observed that 1998 mean weights were similar to that observed in 1997 for sizes up to 30.0 mm CL, but they were smaller for sizes greater than 30.0 mm CL. The mean weights increased in all length-classes from 1989 to 1992, but they only increased for sizes greater than 27.5 in the period 1993-1996 and decreased for all small sizes. They smallest weight were observed in 1997 for all length-classes.

Catch distributions in kg/tow in the survey are provided in Figure 4. The results showed that shrimp occurred mainly in the northwestern and western areas of the bank. Catches do never exceeded 10 kg/tow in central and slope portions of the bank. Catches higher that 50 kg/tow occurred in the western sector and the southwestern area of the Flemish Cap.

Acknowledgements

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Table 1.- Total 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

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

Table 2.- Modal group by strata and trawl configuration (mm CL).

STRATUM	MODAL GROUP	
	35 mm	25 mm
3	14 - 19.5 - 22	14 - 18.5 - 22.5
8	16 - 19 - 22.5	15 - 18 - 22.5
12	20.5 -24.5 - 26.5	19.5 - 25 - 26.5
13	21 - 23 - 26.5	20.5 - 23 - 26

Table 3.- Length frequencies and percentages by sex

Length (mm)	Males	Immature Females	Mature Females	Ovigerous Females
8.0	1			
8.5	5			
9.0	5			
9.5	14			
10.0	11			
10.5	28			
11.0	24			
11.5	44			
12.0	103			
12.5	325			
13.0	428			
13.5	973			
14.0	1004			
14.5	1218			
15.0	1123			
15.5	827	1		
16.0	612			
16.5	466	1		
17.0	726	11		
17.5	1152	9		
18.0	1933	20		
18.5	2841	38		
19.0	2753	68		
19.5	2311	88	3	9
20.0	1561	121	4	11
20.5	1257	211	21	19
21.0	904	281	29	47
21.5	730	473	38	91
22.0	595	441	61	74
22.5	383	812	96	122
23.0	189	561	109	75
23.5	123	664	225	77
24.0	63	540	291	69
24.5	36	419	405	71
25.0	27	337	324	61
25.5	16	321	354	70
26.0	2	165	342	82
26.5		191	319	64
27.0		84	253	28
27.5		38	201	23
28.0		5	134	6
28.5		1	122	0
29.0			49	13
29.5			13	2
30.0			32	
30.5			12	
31.0			11	
31.5			1	
32.0			1	
32.5			1	
	70.5%	16.8%	9.8%	2.9%

frequency x 10^5

Table 4.- Lenght frequencies by strata

	STRATA																
Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	19	Total
8.0	1																1
8.5	1	1		3													5
9.0	2	1			2												5
9.5	3	1	2		6	2											14
10.0	4		1		4	2											11
10.5	4	1	1	1	9				9	3							28
11.0	3	1		1	14				4								24
11.5	8	2	2	7	7	9			3	6							44
12.0	13	5	3	18	46	15			3								103
12.5	26	15	12	34	140	31	5		25	34			3				325
13.0	22	30	15	60	123	67	9	11	42	45			5				428
13.5	18	29	30	77	262	165	70	28	135	133			27				973
14.0	9	44	32	71	129	209	114	68	157	151			10	9			1004
14.5	3	40	28	56	133	235	197	75	200	222	7		9	11			1218
15.0	1	29	21	37	60	216	208	112	222	178	9		13	17			1123
15.5		18	11	22	35	131	186	64	182	130	13	6	5	27			828
16.0		12	7	10	33	105	171	38	83	93	9	19	8	25			612
16.5		6	2	10	40	89	62	53	89	72	13		12	15	4		467
17.0		16		16	57	122	37	60	140	195	20	20	22	24	2	5	737
17.5		17	1	21	92	188	22	64	312	282	37	33	17	65	8	2	1161
18.0		25	1	51	101	259	41	129	472	473	153	19	81	138	4	4	1953
18.5		31		40	134	344	63	250	794	543	192	28	128	269	14	49	2879
19.0		30	1	48	91	260	112	387	628	478	184	59	202	288	26	29	2821
19.5		21	1	29	60	160	114	334	546	345	206	79	177	252	32	55	2411
20.0		20	1	25	50	55	73	246	359	189	118	103	250	162	22	25	1697
20.5		14		33	63	29	50	259	170	185	120	127	278	104	44	30	1508
21.0		16		43	62	39	18	151	169	240	82	130	179	97	14	23	1261
21.5		18		49	97	84	42	138	218	215	82	77	162	90	37	25	1332
22.0		17		58	78	80	51	132	149	112	53	101	189	96	33	24	1171
22.5		21		33	94	102	100	142	305	232	58	32	146	99	28	23	1413
23.0		15		13	69	96	79	51	176	149	49	65	74	48	18	31	934
23.5		17		14	72	116	89	137	192	134	82	16	100	85	10	24	1089
24.0		9		5	43	76	68	143	204	133	47	46	78	78	6	31	963
24.5		8		7	43	87	40	177	143	140	70	52	49	82	6	27	931
25.0		4		1	29	50	25	114	119	93	88	54	75	66	6	25	749
25.5				3	14	39	33	153	87	90	43	79	79	61	22	59	761
26.0		1			3	18	16	63	64	82	34	63	96	58	25	65	591
26.5		1			3	19	11	81	36	42	50	90	93	63	10	77	574
27.0					4	15	7	22	33	28	31	63	54	27	22	59	365
27.5					12	5			15	5	26	44	61	25	31	37	262
28.0						5			16	9	7	20	37	18	11	22	145
28.5							1		21	1	15	12	23	9	18	23	123
29.0							1		15		1		30		4	11	62
29.5											2	4	3		1	4	15
30.0									7	4	2	2	13		3	1	32
30.5											2	4		3	2	2	12
31.0									2	3	2	2			2		11
31.5															1		1
32.0											1						1
32.5																	1

frequency x 10^5

Table 5.- Total biomass estimated by strata (tons)

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

Table 6.- Mean weights and length class in the years 1989-1998

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

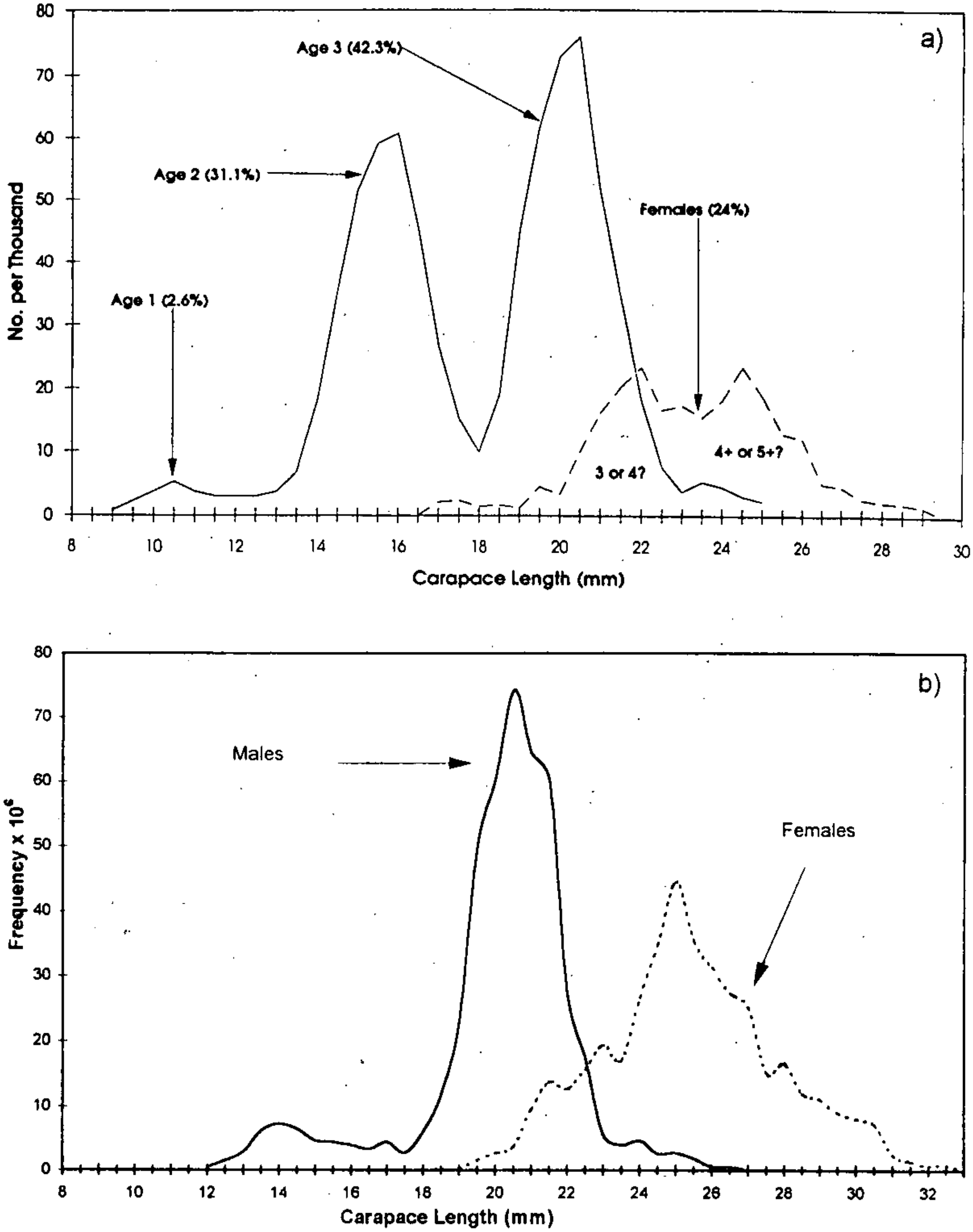

Figure 1.- Comparison of results from the Canadian and EU surveys:

a) Abundance of shrimp at length and age in Div 3M determined from the 1996 Canadian research trawl survey (Parsons et al, 1997)

b) Shrimp length distribution in the 1996 EU-survey

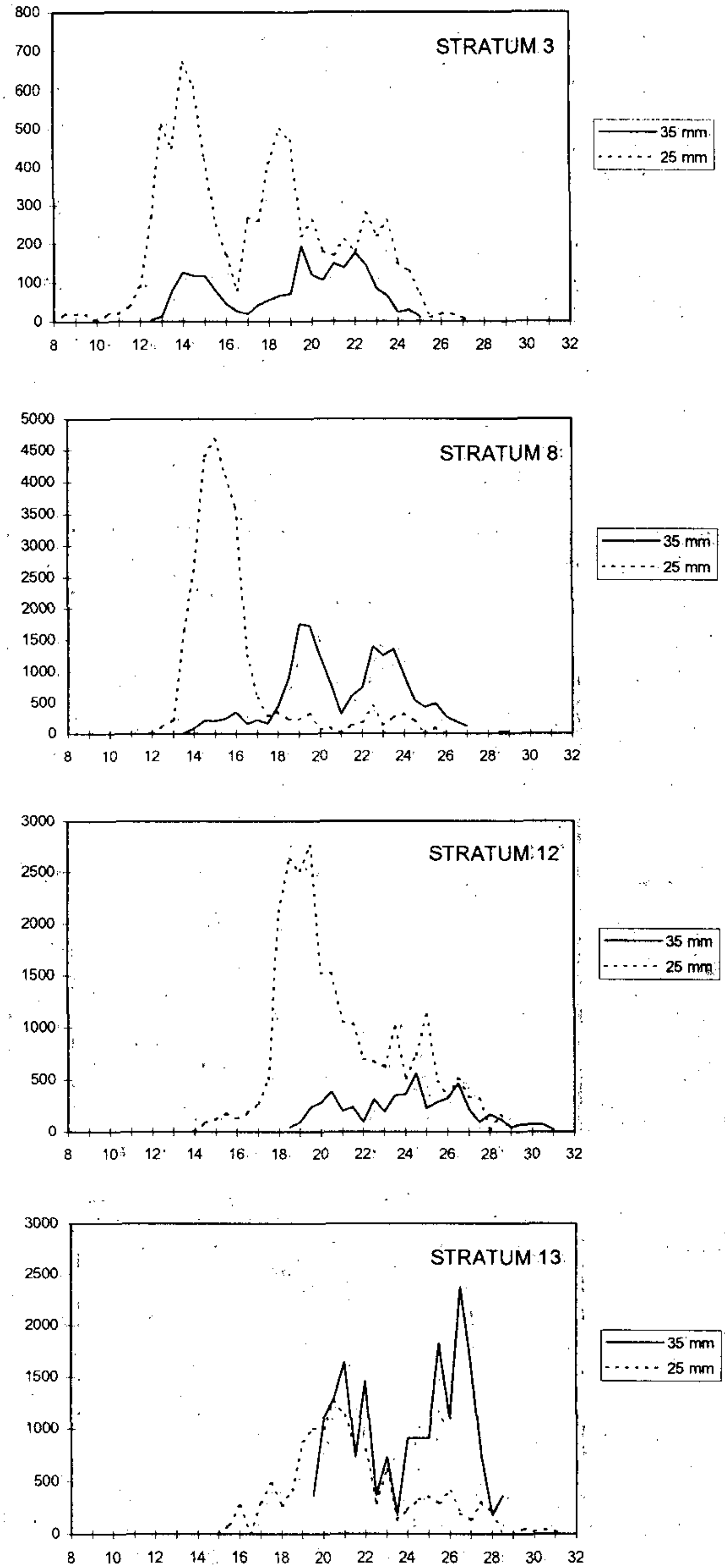

Figure 2.- Shrimp lenght distribution by strata and trawl configuration in 1998 survey
Y-Axis=Frequency(10^5) X-Axis=Carapace Length (mm)

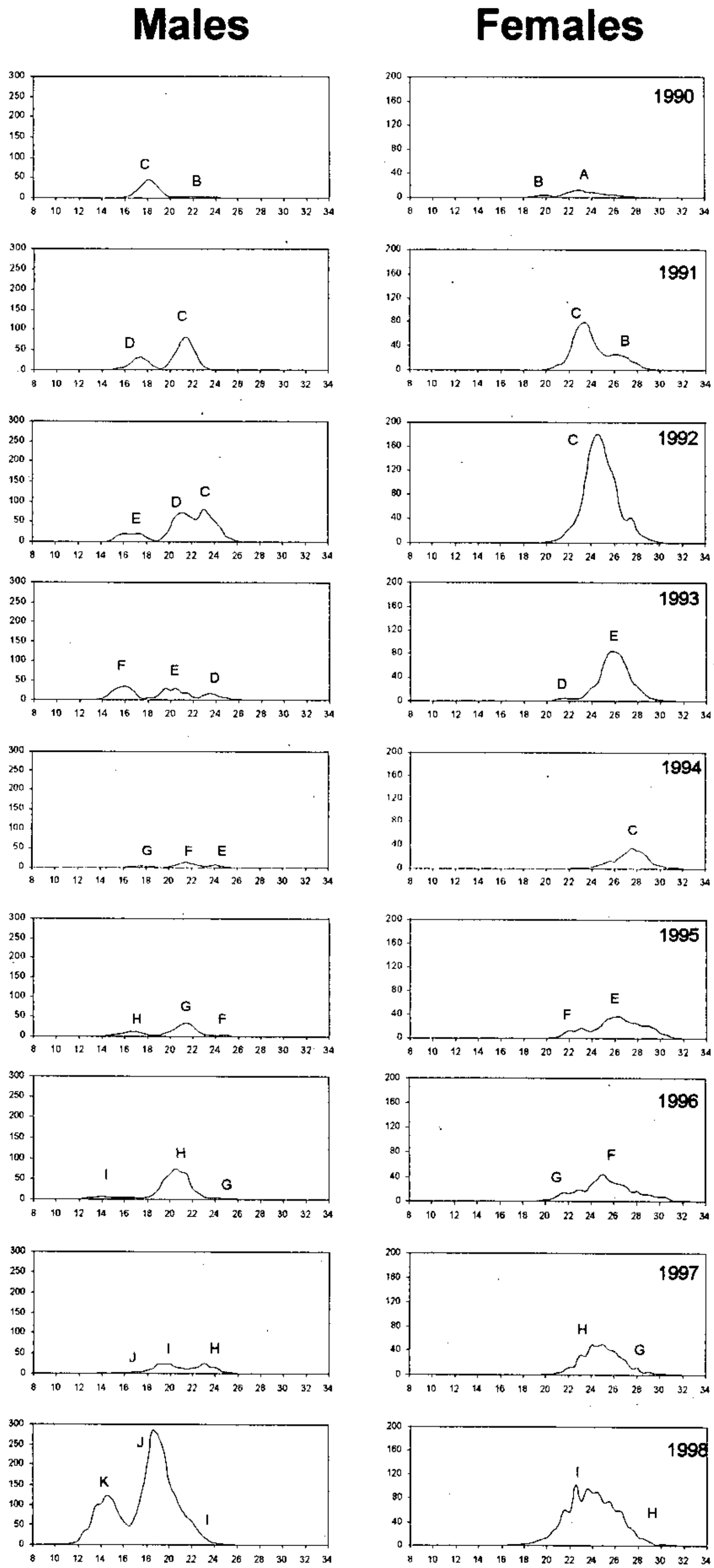

Figure 3.- Shrimp length distribution on Flemish Cap 1990-1998 surveys
Y-Axis=Frequency(10^6) X-Axis=Carapace Length (mm)

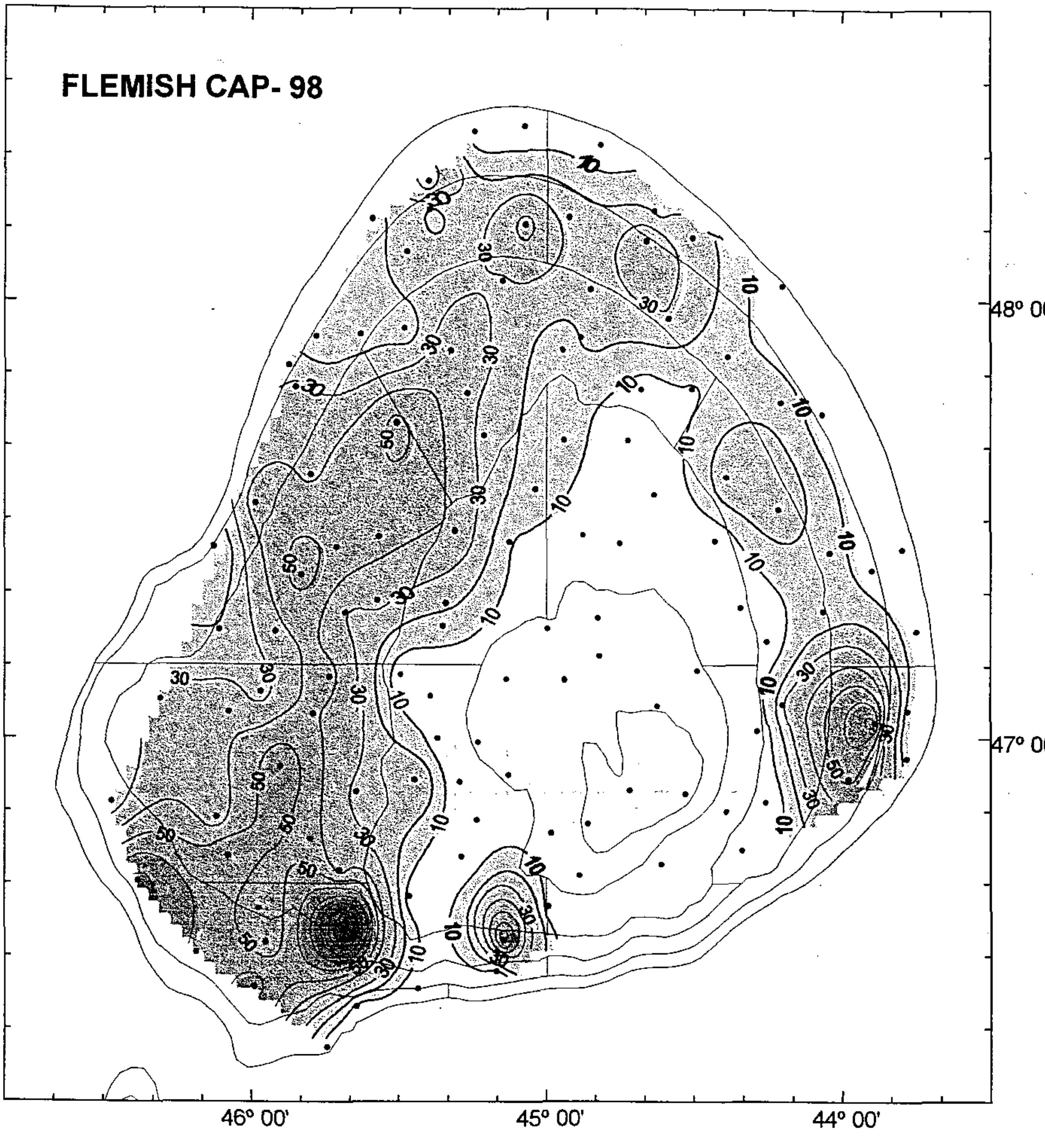

Figure 4.- Shrimp catch (Kg/tow) distribution in July 1998 on Flemish Cap..