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Mapping the distribution, abundance and biomass of shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Div. 3M) based on data obtained from a Canadian research trawl survey, September - October, 1996

by

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INTRODUCTION

A research trawl survey was conducted by Canada on Flemish Cap from September 24 to October 12, 1996. Although the stratified-random design was intended primarily for groundfish, the trawl used was a Campelen shrimp trawl and the depths sampled (to 732 m) included the known distribution of northern shrimp in the area. Data on numbers and weights of shrimp in the catches, as well as size distributions, were analyzed spatially in an attempt to determine whether or not the survey, if conducted annually, can provide a representative index of changes in stock over time, either in terms of size (i.e. abundance/biomass), demographic structure or both.

MATERIALS AND METHODS

The survey was conducted during two trips of the Canadian research vessel Wilfred Templeman in the fall of 1996. Fishing sets of 15 minutes duration and towing speed of 3 knots were randomly allocated to strata which covered the entire Cap to 732 m (Fig. 1). The trawl used was a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 13 mm liner. Mean wingspread was estimated by SCANMAR at 16.8 m. Details of the survey design and fishing protocols are given in (Brodie, 1996).

Numbers and weights of *Pandalus borealis* were obtained from each set in which they occurred. In addition, frozen samples were retained from most sets and subsequently analyzed at the Northwest Atlantic Fisheries Centre for length, sex and maturity. The distribution (catch weights and numbers) was mapped using the Spatial Analysis System (SPANS), which contoured shrimp density over 14 intervals (see Kulka et al., 1995 for analytical details). Shrimp biomass (weight) and abundance (numbers) were estimated by areal expansion using both Stratified Analysis Programs - STRAP (Smith and Somerton, 1981) and SPANS.

Oblique carapace lengths of shrimp were measured to 0.1 mm using Vernier calipers and grouped to 0.5 mm intervals for presentation. Females, when not ovigerous, were separated from males on the shape of the endopod of the first pleopod (Rasmussen, 1953). Length frequency distributions were grouped by similarity and displayed for different depths and areas of the Cap.

RESULTS

Distribution, biomass and abundance

A total of 68 successful survey sets was completed within the Flemish Cap stratified area. Location of fishing stations and details of set and catch are given in Fig. 2 and Table 1. Shrimp occurred in 53 sets and catches were highly variable, ranging from 0.02 kg (n=2) to 82.4 kg (n=16,078). Best catches occurred at depths between 280 and 350 m, primarily on the western slope of the Cap.

Shrimp catch weights and numbers were contoured over 14 density intervals using the SPANS software. The analyses showed that shrimp occurred mainly in the western and northwestern areas and were scarce in depths less than 200 m (Fig. 3 and 4). Generally, the eastern slope was sparsely populated but there were occasional good catches in the southeast.

Midpoints of the density intervals generated by SPANS were used to calculate biomass and abundance by areal expansion. For each of the 14 density areas, trawlable units were calculated and multiplied by the average weights and numbers. These were summed to produce estimates of approximately 24,000 tons and 4.4 billion shrimp for the total area (Tables 2 and 3).

Traditional STRAP areal expansion estimates were also calculated based on the groundfish stratification scheme and were very similar to the SPANS results. A comparison of the estimates from the two methods is given in Table 4. In the case of STRAP, lower and upper values are the 95% confidence intervals whereas, for SPANS, they are the values generated using the left and right bounds of the density intervals, respectively.

Demographic structure

A visual examination of the length distributions of shrimp sampled from Flemish Cap revealed 6 general types (Fig. 5):

1. Small shrimp with modes at approximately 10 and 15 mm (ages 1 and 2);
2. Predominance of the 15 mm mode (age 2);
3. Small and medium-sized shrimp with modes at 15 and 20 mm (ages 2 and 3);
4. Predominance of the 20 mm mode (age 3);
5. Medium and large shrimp with modes at 20 and 25 mm (ages 3 and 4+); and
6. Large shrimp with one or more modes greater than 24 mm (ages 4+).

The smallest sizes occurred in only a few sets on the western slope of the Cap (strata 505 and 506) in shallow water (about 220 m). Age 2 shrimp (15 mm mode) were more widespread in depths ranging from approximately 210 to 290 m. They occurred both west (strata 505, 506 and 511) and east (strata 503 and 508) but were slightly deeper in the east. The small and medium

sizes (ages 2 and 3) co-occurred in deeper water between 230 and 340 m in both western (505, 507 and 511) and eastern (508) strata. The 1993 year class (20 mm mode) dominated in several catches taken on the western slope in strata 505, 510 and 511 (240 - 320 m), areas fished heavily by the commercial fleet in 1996. This year class was not so prominent on the eastern slope. Larger, older shrimp occurred along with the 1993 year class over a wide range of depths (290 - 700 m) both west (strata 510 and 514) and east (512 and 516), somewhat deeper in the latter. Catches with shrimp larger than 24 mm (ages 4+) also occurred over a wide depth range (300 - 670 m). Most of these catches were small but were spread over several strata; 509, 514, 515 and 519 in the west and 512, 513 and 516 in the east.

A single length frequency representing the total catch of shrimp taken in all survey sets (Fig. 6) shows the dominance of the 1993 year class (20 mm mode) in the area. However, the 1994 year class (15 mm) is strongly represented and there is a sign of the 1995 year class at 10 mm. Larger shrimp (> 24 mm), representing ages 4+, were less abundant and occurred mainly in the deeper strata (> 366 m).

DISCUSSION

The Canadian fall survey on Flemish Cap in 1996 provided valuable data on the distribution, abundance, biomass and demographic structure of shrimp in the area. Most notable is the representation of age 2 animals which were not found in quantity in either the 1996 EU survey or the commercial fishery (NAFO, 1996). If the survey is conducted annually, distribution by size/age can be monitored over time, a biomass/abundance index can be produced and a recruitment index might be possible. The additional information would improve the basis for annual assessments of stock status.

REFERENCES

Table 1. Set details related to shrimp catches from the Canadian research trawl survey on Flemish Cap - fall, 1996.

Trip	Set	Latitude	Longitude	Wt. (kg)	Number	Stratum	Depth (m)	Temp. (C)
195	2	46.79	46.55	4.65	247	518	623	3.4
195	3	46.53	46.23	12.3	870	514	436	3.4
195	4	46.41	45.84	0	0	514	476	3.3
195	5	46.3	45.82	0	0	518	684	3.2
195	6	46.49	45.73	0.69	33	514	377	3.5
195	7	46.61	45.76	36.05	3272	509	305	3.5
195	8	46.57	45.47	8.15	1401	505	237	3.6
195	10	46.52	44.8	36.2	3212	509	297	88.8
195	11	46.71	44.98	0	0	502	161	3.1
195	12	46.78	45.26	3.2	1655	505	214	3.4
195	13	46.85	45.42	5.35	1163	505	232	3.5
195	14	46.86	45.53	15	2616	505	247	3.5
195	15	46.87	45.67	29	4860	510	259	3.5
195	16	46.98	45.64	0	0	510	258	3.5
195	17	46.91	45.87	5.65	630	510	289	3.5
195	18	46.9	46.03	48.85	9217	510	282	3.6
195	19	47.08	46.28	33.85	6347	510	318	3.5
195	20	47.15	46.39	31.4	3992	514	367	3.4
195	21	47.11	45.84	29.75	5758	510	290	3.5
195	22	47.19	45.65	16.43	2171	511	272	88.8
195	23	47.14	45.36	1.3	830	505	213	3.2
195	24	47.26	45.32	2.48	1283	506	218	3.2
195	25	47.36	45.15	3.35	1827	506	211	3.3
195	26	47.27	44.95	0	0	502	175	3.1
195	27	47.22	44.89	0	0	502	158	3.1
195	28	47.12	44.63	0	0	502	150	3
195	29	47.1	44.5	0	0	502	153	3
195	30	47	44.41	0	0	502	157	3
195	31	46.94	44.66	0	0	501	126	3.2
195	32	46.94	44.82	0	0	501	134	3.2
195	33	46.59	44.35	0	0	517	619	3.2
195	34	46.75	44.13	0.32	19	513	450	3.3
195	35	46.77	43.99	0.02	2	517	612	3.2
195	36	46.85	44.2	37.25	7760	508	289	3.4
195	38	46.97	43.9	3.55	280	513	522	3.2
195	39	47.06	44.31	0	0	504	227	3.4
195	40	47.14	44.36	0	0	504	213	3.4
195	41	47.15	44.16	12.8	4892	508	291	3.4
195	42	47.3	43.84	0.33	20	516	563	3.3
195	43	47.4	43.95	1.76	120	512	474	3.4
195	44	47.57	44.27	1.22	224	508	309	3.5
195	45	47.36	44.41	0.07	21	503	229	3.4
195	46	47.39	44.6	0	0	503	187	3.2
195	47	47.55	44.64	4.4	2276	503	227	3.4
195	48	47.66	44.61	9.45	3500	503	242	3.5
195	49	47.73	44.48	21.6	4947	508	286	3.4
195	50	47.9	44.31	23.94	2741	512	490	3.4
196	7	47.65	45.89	3.79	250	515	389	4
196	8	47.82	45.86	2.64	149	515	492	88.8
196	9	48.15	45.6	1.34	90	519	577	3.4
196	10	48.26	45.39	21	1710	519	561	3.5
196	11	48.22	45.31	13.4	1235	515	470	88.8
196	12	48.32	44.95	1.67	132	516	597	3.3
196	13	48.07	45.22	55.6	10296	507	342	88.8
196	14	47.99	45.15	72.8	13236	507	300	4
196	15	48.08	44.55	25.5	2300	512	521	3.4
196	16	47.97	44.45	27.2	3490	512	458	3.5
196	17	47.99	44.15	1.64	207	516	709	3.1
196	18	47.92	44.12	1.82	118	516	669	88.8
196	19	47.87	44.99	24.3	7147	507	263	3.5
196	20	47.88	45.17	25.1	4954	507	271	3.5
196	21	47.74	45.29	24	4286	507	261	88.8
196	22	47.74	45.54	79.8	15152	511	283	3.5
196	23	47.6	45.67	82.4	16078	511	284	3.5
196	24	47.55	45.05	10.4	4100	506	233	3.5
196	25	47.49	45.44	14.1	3721	511	259	3.5
196	26	47.41	45.67	34.5	9220	511	277	3.5
196	27	47.45	46.17	1.73	440	519	581	3.4

Table 2. Shrimp biomass on Flemish Cap, fall 1996, estimated by SPANS.

SINGLE MAP ANALYSIS										
	Density interval									
Class	Lower	Upper	% Area	Cum. %	km^2	Units	Av. wt (kg)	Biomass (kg)	Low	High
11	0	0.5983	11.84	11.84	4434	189892.9	0.29915	56806.46104	0	113612.92
12	0.5983	1.4599	6.87	18.71	2572.6	110175.6	1.0291	113381.71	65918.061	160845.36
13	1.4599	1.8012	5.93	24.64	2218.6	95014.99	1.63055	154926.6919	138712.38	171141
14	1.8012	3.2214	6.42	31.06	2405.5	103019.3	2.5113	258712.3681	185558.36	331866.37
15	3.2214	4.65	4.76	35.83	1783.3	76372.59	3.9357	300579.6025	246026.66	355132.54
16	4.65	7.4503	9.09	44.92	3404.6	145807.3	6.05015	882156.0361	678003.95	1086308.1
17	7.4503	10.1084	7.1	52.02	2658.2	113841.5	8.77935	999454.373	848153.33	1150755.4
18	10.1084	12.4944	6.26	58.29	2345.6	100454	11.3014	1135270.836	1015429.2	1255112.5
19	12.4944	16.8482	6.93	65.22	2596.1	111182	14.6713	1631184.477	1389152.4	1873216.6
20	16.8482	22.0015	7.24	72.46	2711.6	116128.5	19.42485	2255778.693	1956556.2	2555001.2
21	22.0015	26.1653	7.35	79.81	2751	117815.8	24.0834	2837405.038	2592124.3	3082685.8
22	26.1653	32.6653	7.21	87.02	2700.7	115661.7	29.4153	3402223.604	3026323.1	3778124.1
23	32.6653	42.0705	6.57	93.6	2460.5	105374.7	37.3679	3937631.252	3442096.2	4433166.3
24	42.0705	84.4	6.4	100	2397.7	102685.2	63.23525	6493324.293	4320017.7	8666630.9
					37439.9	**1603422**		**24458835.44**	**19904072**	**29013599**
Total of 14 classes										
Wingspread = 16.8 m										
Distance = 1390 m										
Unit of effort = 0.02335 km^2										

Table 3. Shrimp abundance on Flemish Cap, fall 1996, estimated by SPANS.

SINGLE MAP ANALYSIS										
	Density interval									
Class	Lower	Upper	% Area	Cum. %	Area	Units	Mean n	Abundance	Low	High
11	0	81.31	11.46	11.46	4292.6	183837.3	40.655	7473903.769	0	14947807.54
12	81.31	151.63	6.99	18.45	2615.7	112021.4	116.47	13047134	9108461.113	16985806.9
13	151.63	280	6.01	24.46	2250.7	96389.72	215.815	20802347.77	14615573.49	26989122.06
14	280	569.58	6.35	30.81	2377.4	101815.8	424.79	43250353.15	28508436.83	57992269.46
15	569.58	870	4.41	35.22	1651.9	70745.18	719.79	50921674.56	40295040.77	61548308.35
16	870	1301.37	8.75	43.97	3274	140214.1	1085.685	152228380.7	121986295.5	182470466
17	1301.37	1693.61	7.9	51.87	2957.4	126655.2	1497.49	189664964.7	164825337.8	214504591.6
18	1693.61	2194.59	5.65	57.52	2115.6	90603.85	1944.1	176142953.3	153447593.8	198838312.8
19	2194.59	2764.01	7.43	64.95	2783	119186.3	2479.3	295498582.4	261565052.2	329432112.6
20	2764.01	3433.55	7.52	72.47	2817.2	120651	3098.78	373870793	333480469.9	414261116.1
21	3433.55	4294	6.7	79.17	2506.9	107361.9	3863.775	414822164.8	368632398.1	461011931.5
22	4294	5744.89	6.81	85.98	2550.1	109212	5019.445	548183584.3	468956291.2	627410877.5
23	5744.89	8323.55	7.42	93.4	2777.1	118933.6	7034.22	836605240.3	683260557.6	989949923.1
24	8323.55	16078	6.6	100	2472.8	105901.5	12200.78	1292080361	881476421.4	1702684300
			100		**37442.4**	**1603529**		**4414592437**	**3530157930**	**5299026945**
Total of 14 classes										
Wingspread = 16.8 m										
Distance = 1390 m										
Unit of effort = 0.02335 km^2										

Table 4. Comparison of estimates of abundance and biomass - SPANS vs STRAP					
Shrimp survey - Flemish Cap, 1996					
Modei	**Variable**	**Mean**	**Lower**	**Upper**	**+/- %**
SPANS	number	4414592437	3530157930	5299026945	20.03
STRAP	number	4399550597	3282787319	5516313875	25.38
SPANS	weight (kg)	24458835	19904072	29013599	18.62
STRAP	weight (kg)	24067267	17931197	30203337	25.50

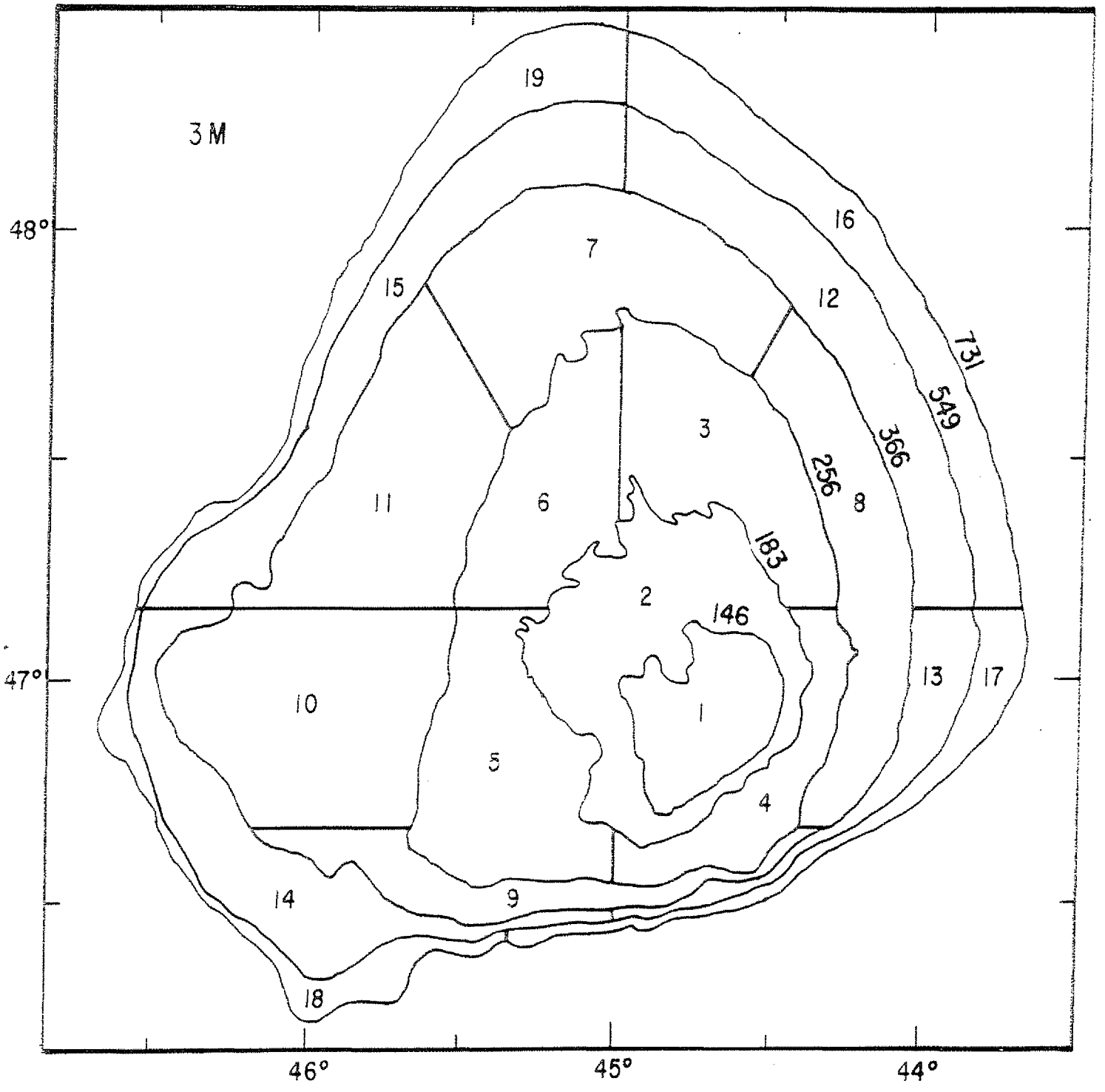
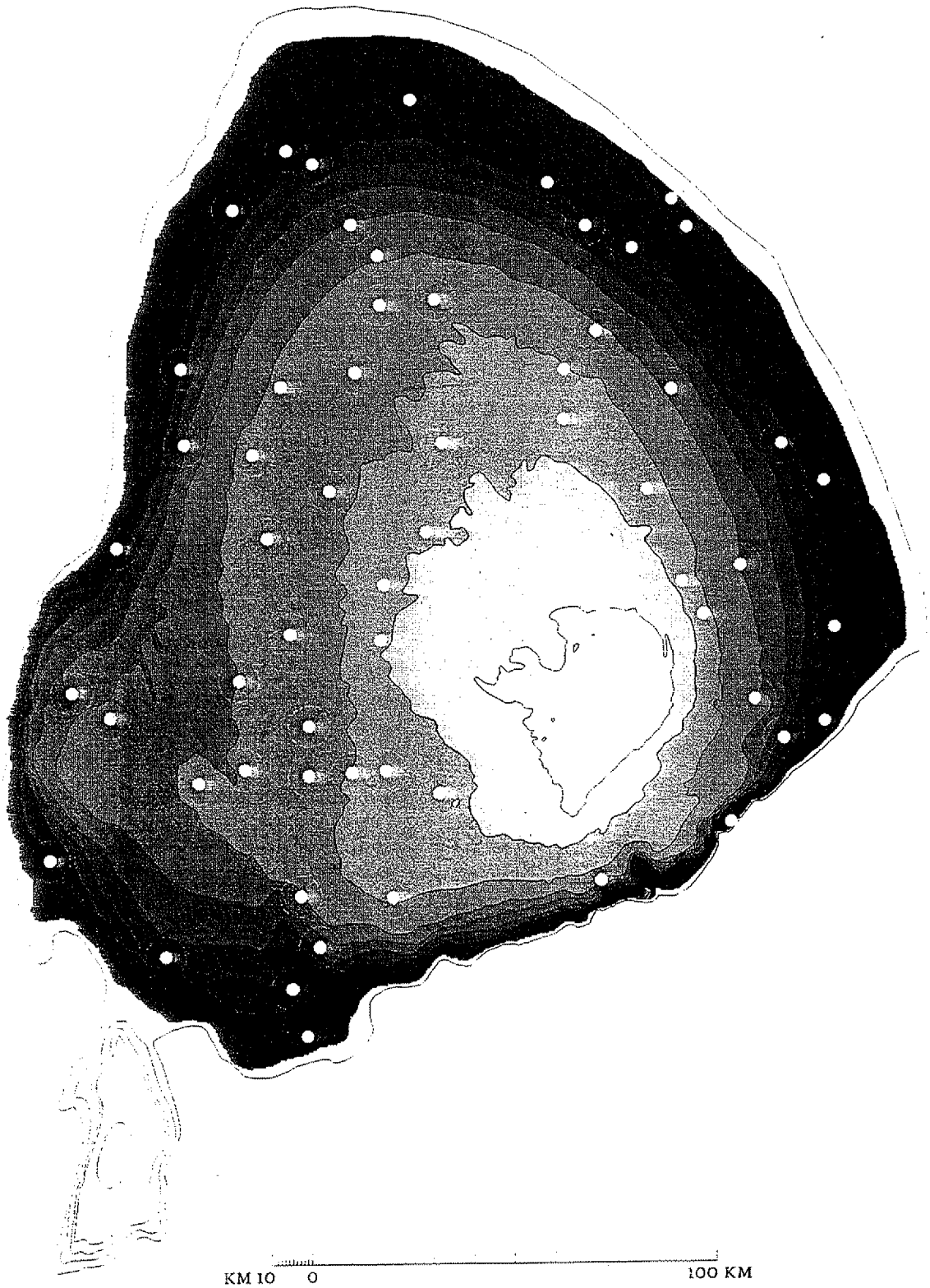


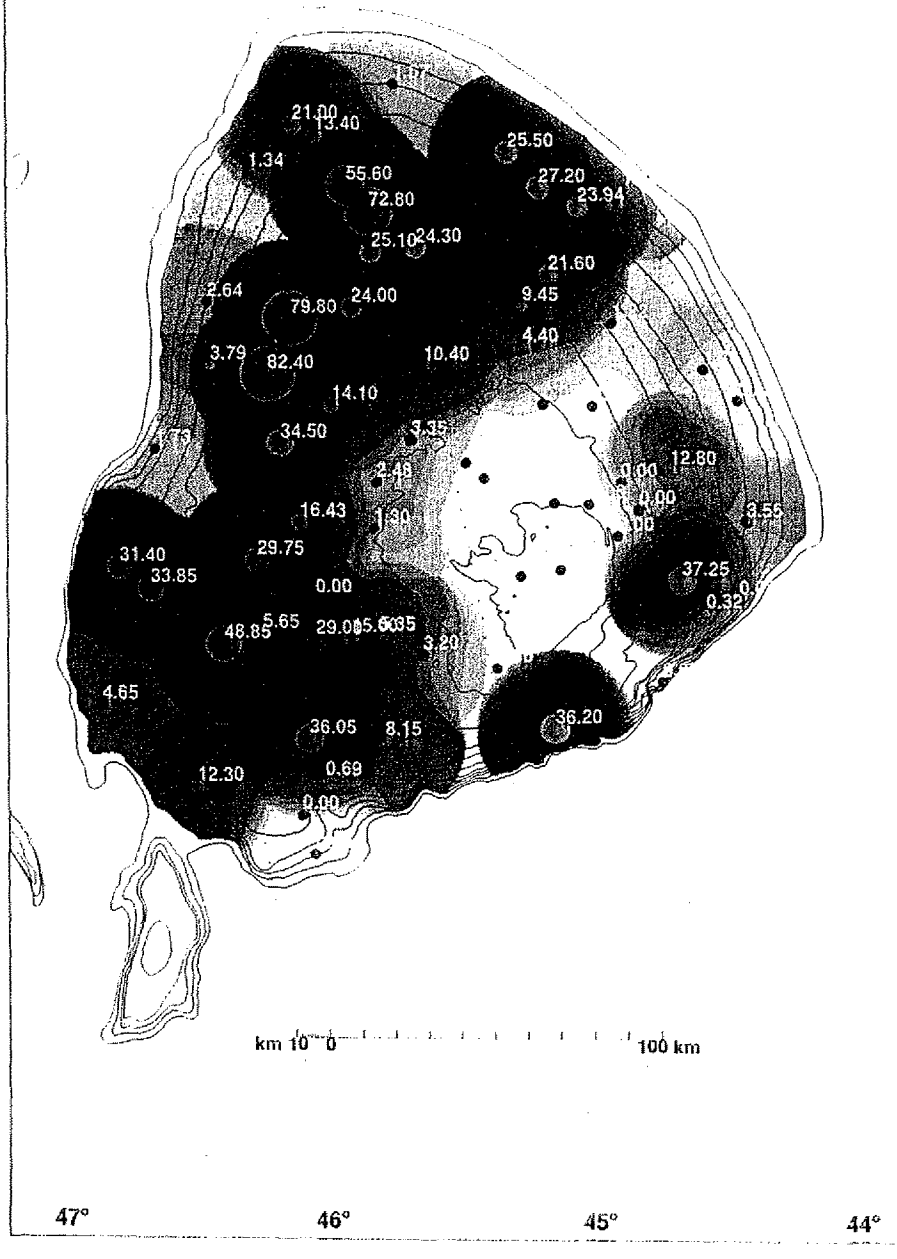
Figure 1. Stratification scheme for Canadian research trawl surveys on Flemish Cap.
(Strata numbered consecutively from 1 to 19 correspond to strata 501 to 519 in Table 1.)

Figure 2.



Bathymetry and set Locations

46° 45° 44°


21.00
13.40
1.34
25.50
55.60
27.20
72.80
23.94
25.10
24.30
21.60
2.64
79.80
24.00
9.45
4.40
3.79
82.40
10.40
14.10
34.50
3.35
2.49
12.80
0.00
0.00
3.55
16.43
1.30
31.40
29.75
33.85
37.25
0.00
0.32
48.85
5.65
29.08
3.20
4.65
36.05
8.15
36.20
12.30
0.69
0.00
km 10 0
100 km
47°
46°
45°
44°

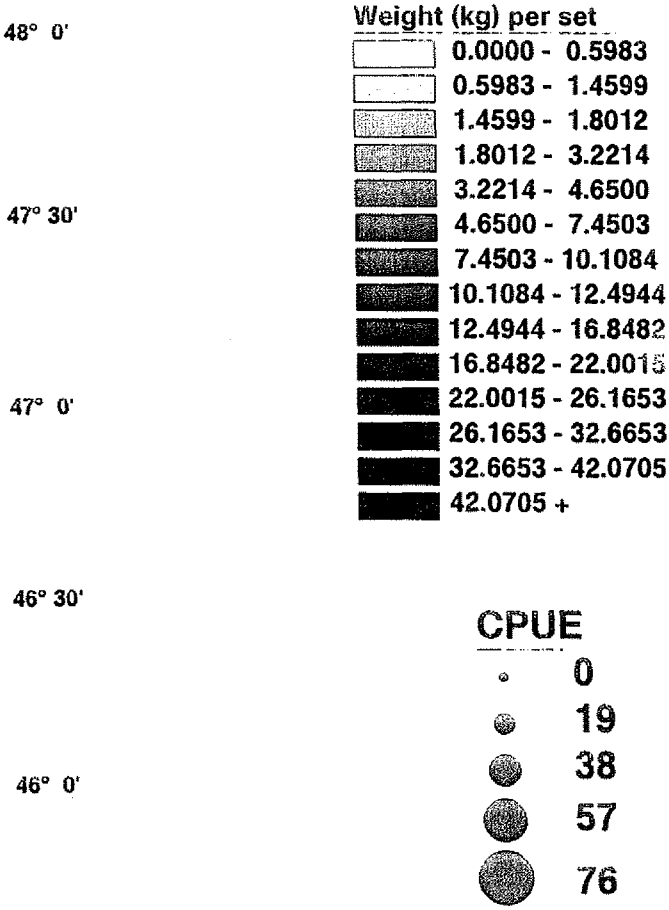
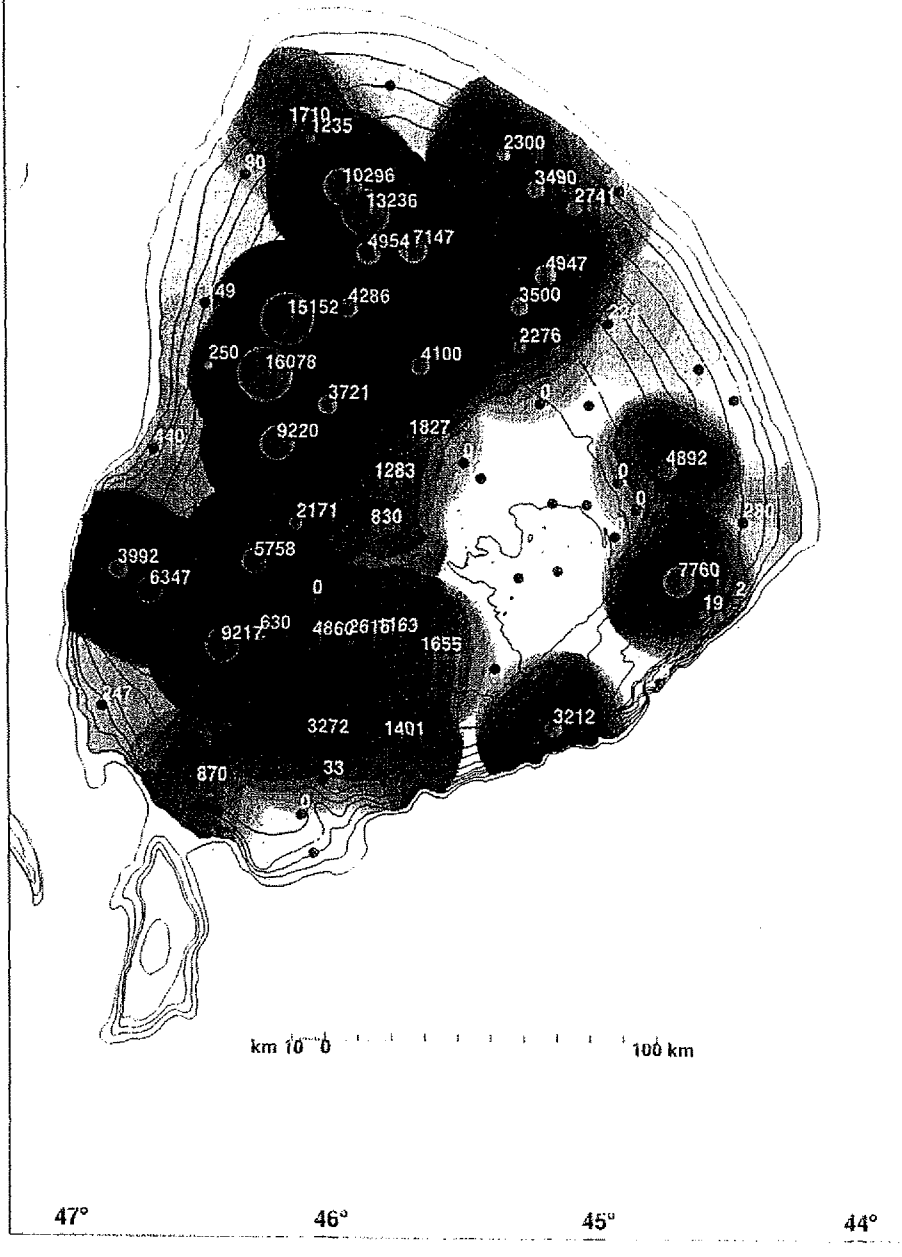


Figure 3.

Shrimp catch (kg) per tow, 1996


1710
1235
2300
80
10296
3490
13236
2741
4954
7147
4947
149
15152
4286
3500
2276
250
16078
4100
3721
0
440
9220
1827
0
4892
1283
0
0
2171
830
3992
5758
6347
7760
0
19
2
9217
630
4862
6163
1655
347
3272
1401
3212
870
33
0
km 10 0
100 km
47°
46°
45°
44°

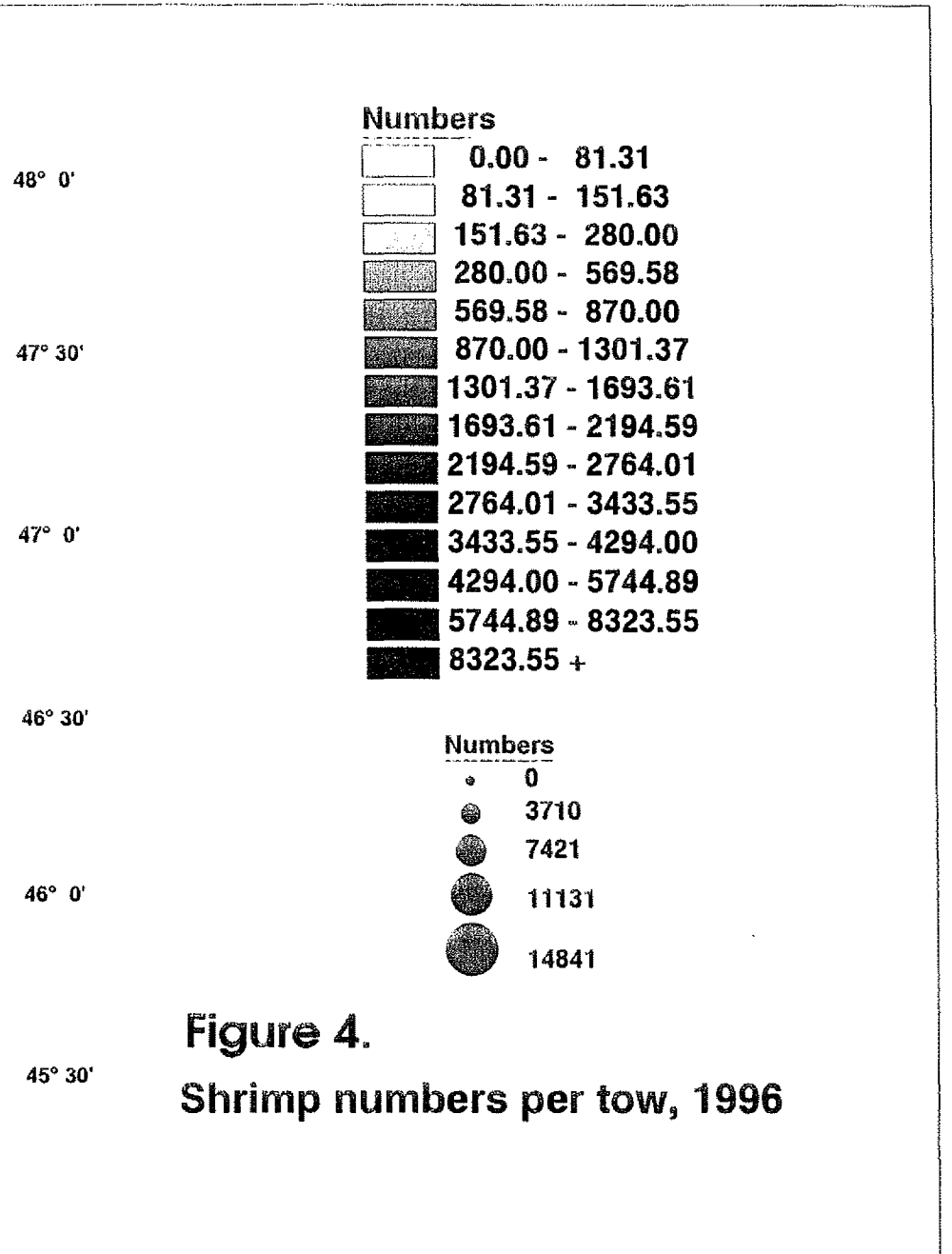


Figure 4.

Shrimp numbers per tow, 1996

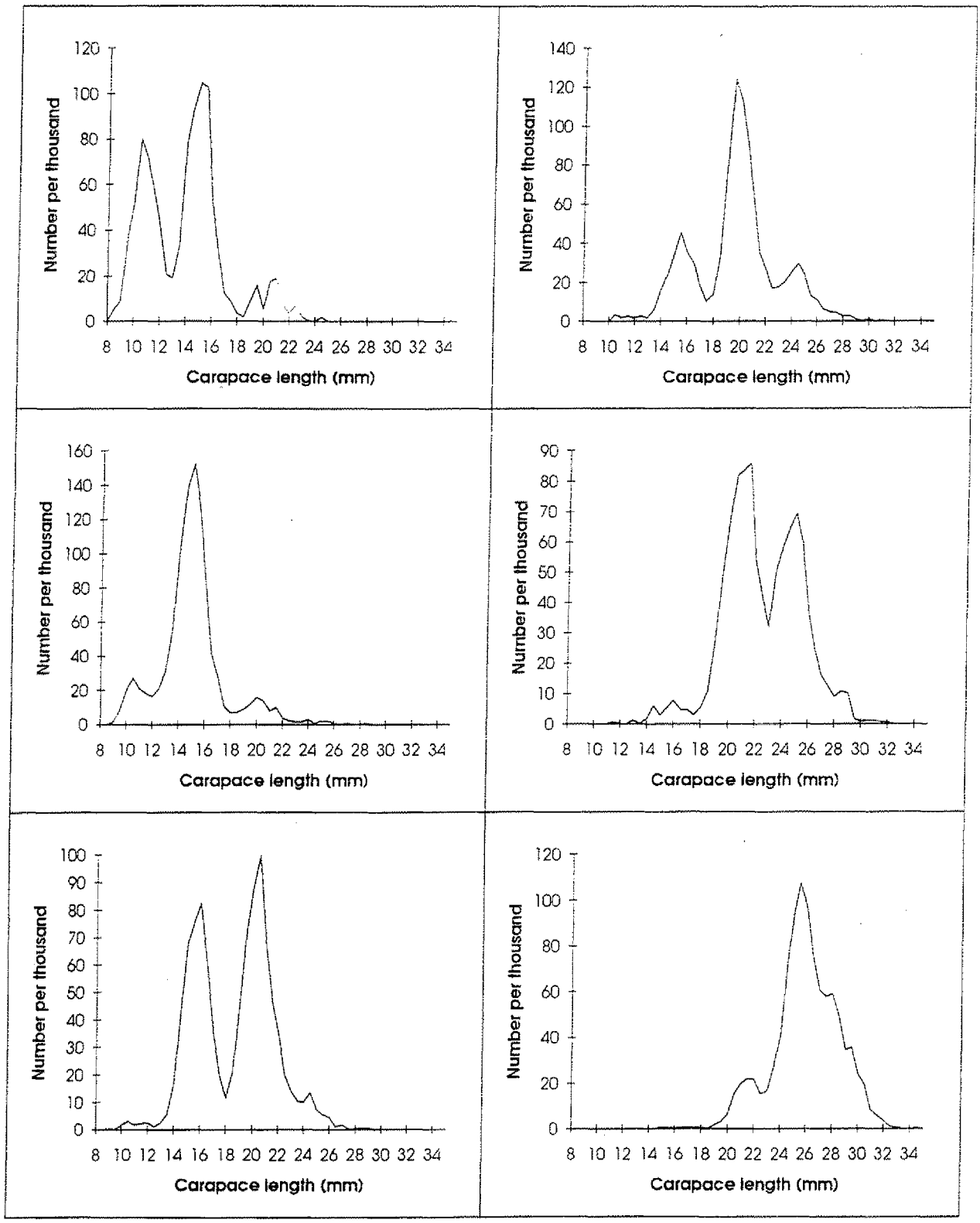


Figure 5. Research survey length distributions of shrimp on Flemish Cap, fall 1996.

Figure 6. Number of shrimp caught at length during the fall 1996 research survey on Flemish Cap.

