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Distribution, biomass, abundance and demography of shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Div. 3M) based on data obtained during 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 (NAFO Div. 3M) from September 24 to October 12, 1996. Although a stratified-random design was employed to determine distribution and stock size for various groundfish species, a shrimp trawl was used as the sampling device and the depths sampled (to 731 m) included the known distribution of northern shrimp (*Pandalus borealis*) in the area. Data on numbers and weights of shrimp in the catches, as well as size distributions, were analyzed in an attempt to determine whether or not such surveys, if conducted annually, can provide useful information on temporal and spatial changes in stock size (i.e. abundance/biomass), distribution and demographic structure.

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 at towing speed of 3 knots were randomly allocated to strata which covered the entire Cap to 731 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 SPANS (over 6 density intervals) and Stratified Analysis Programs - STRAP (Smith and Somerton, 1981).

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 (median size and modal structure) and displayed to illustrate the various size/age components in the stock. A composite size distribution describing the estimated abundance of males and females at length was constructed and analyzed by MIX (Macdonald and Pitcher, 1979) for age structure.

RESULTS

Distribution, biomass and abundance

A total of 68 successful survey sets was completed within the Flemish Cap stratified area (Fig. 1). Location of fishing stations and details of set and catch are given in Fig. 2 and Table 1. Shrimp occurred in 56 sets and catches per standard tow were highly variable, ranging from 0.02 kg (n=2) to 70.42 kg (n=13,121). Best catches (> 30 kg) occurred primarily at depths between 280 and 350 m on the western slope of the Cap. Bottom temperatures ranged between 3.1 and 4.0° C in depths where shrimp were present and were 3.5° C or greater in areas of highest shrimp density.

Shrimp catch weights and numbers were mapped over 14 density intervals using the SPANS software. The results showed that shrimp occurred mainly in the northwestern and western 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 high catches in the southeast.

Six density intervals generated by SPANS were considered appropriate for the calculation of biomass and abundance by areal expansion. For each of the density areas (km^2), trawlable units were calculated and multiplied by the average weights and numbers of shrimp caught at all stations within the area. The products were summed to produce estimates of approximately 21,800 tons and 3.7 billion shrimp^{2}for the total area (Tables 2 and 3) using this model-based technique.

Traditional, design-based, areal expansion estimates (STRAP) were also calculated using the groundfish stratification scheme and these were very similar to the SPANS results. Biomass was estimated at roughly 21,100 tons and abundance at 3.9 billion (Tables 4 and 5). The 95% confidence intervals for both numbers and weights were within 25% of the mean estimate.

The precision of the two methods was compared by calculating the variance of the stratified mean weight for each. For STRAP, the stratified mean was 13.6 kg and the variance 2.29 and for SPANS the mean was 13.5 kg and the variance 2.04.

Demographic structure

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

1. Small, male shrimp with modes at approximately 11 and 15 mm (ages 1 and 2). These occurred in only a few sets on the western slope (strata 505 and 506) in shallow water (≈220 m).

2. Predominance of the 15 mm mode (age 2). Shrimp of this size 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.

3. Small and medium-sized male shrimp with modes at 15 and 20 mm (ages 2 and 3). These co-occurred in depths between 230 and 340 m in both western (505, 507 and 511) and eastern (508) strata.

4. Predominance of the 20 mm mode of mostly males (age 3). This mode (the 1993 year class) 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. However, it was not so prominent on the eastern slope.

5. Medium (mostly male) and large (female) shrimp with modes at 20 and 25 mm (ages 3+). 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.

6. Large (mostly female) shrimp with mean size about 25 - 26 mm. Catches with only large shrimp 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.

The male component of the single length frequency representing abundance-at-length for both sexes (Fig. 6) was analyzed by MIX for age composition. Females, although distinctly bimodal at 22 and 24.5 mm, were treated as a composite age group (NAFO SCS Doc. 96/19). Results showed the dominance (42%) of the 1993 year class (mean length = 20.5 mm) in the area. However, the 1994 year class (15.8 mm) also was strongly represented (31%) and there was some indication of the 1995 year class (2.6% at 11.3 mm).The majority of females was ovigerous at the time of the survey and could not be separated into primiparous and multiparous groups. Females, comprising 24% of the estimated abundance, were assigned a composite age of 4+ years. As noted by Skuladottir (1996) and Safronov and Anikeev (1997), some of the smaller primiparous females can be interpreted as age 3, in which case the strength of the 1993 year class is underestimated in this analysis.

Age	1	2	3	4+
Sex	Male	Male	Male	Female
CL (mm)	11.28	15.82	20.52	23.5
Per cent	2.62	31.06	42.25	24.06

DISCUSSION

The Canadian fall survey on Flemish Cap in 1996 provided useful data on the distribution, abundance, biomass and demographic structure of shrimp in the area. Most notable is the representation of age 2 males which were not found in quantity in either the 1996 EU survey or the commercial fishery (NAFO, 1997). If similar surveys can be 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.

Biomass and abundance can be estimated by either model-based (SPANS) or design-based (STRAP) methods, provided that the range of shrimp distribution is well sampled. The 1996 survey data also were analyzed by kriging (J. Lambert, IML, Mont-Joli, Quebec, pers. comm.), another model-based method, which produced similar results. Irrespective of analytical method, the estimates, as currently calculated, can only be viewed as an index, given the discrepancy between estimates of stock size and actual catch from the fishery.

REFERENCES

BRODIE, W.B. 1996. A description of the 1995 fall groundfish survey in Divisions 2J3KLNO. *NAFO SCR. Doc.* 96/27, Serial No. N2700: 7 p.

KULKA, D. W., WROBLEWSKI, J.S., and NARYANAN, S. 1995. Inter-annual patterns in the winter distribution and recent changes and movements of northern Atlantic cod (*Gadus morhua* Linnaeus, 1758) on the Newfoundland-Labrador shelf. *ICES J. Mar. Sci.*, **52**: 889-902.

MACDONALD, P.D.M., and T.J. PITCHER, 1979. Age-groups from size-frequency data: a versatile and efficient method of analyzing distribution mixtures. *J. Fish. Res. Board Can.*, **36**: 987-1001.

NAFO. 1997. Scientific Council Reports. 163 - 167.

RASMUSSEN, B. 1953. On the geographical variation on growth and sexual development of the deep sea prawn (*Pandalus borealis*, Kroyer). Fiskeridir. Skr. Havunders., **10** (3): 1 - 160.

SAFRONOV, A.M., and V.J. ANIKEEV. 1997. Northern shrimp in Russian catches from Flemish Cap bank (NAFO Division 3M) in 1995 - 1996. *NAFO SCR. Doc.* 97/2, Serial No. N2827, 11p.

SKULADOTTIR, U. 1996. Length and weight at age of northern shrimp (*Pandalus borealis* Kr.) at the Flemish Cap in 1996 from Icelandic samples. *NAFO SCR. Doc.* 96/100, Serial No. N2783, 7p.

SMITH, S.J., and G.D. SOMERTON. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. *Can. Tech. Rep. Fish. Aquat. Sci.* 1030: iv+66p.

Table 1. Set details for shrimp catches from the Canadian research survey in Div. 3M, Sep - Oct, 1996.

Trip	Set	Latitude	Longitude	Wt. (kg)	Number	Stratum	Depth	Temp. (C)
195	2	46.79	46.55	3.33	188	518	624	3.4
195	3	46.53	46.23	9.71	707	514	436	3.4
195	4	46.41	45.84	0.92	59	514	476	3.3
195	5	46.3	45.82	0	0	518	677	3.2
195	6	46.49	45.73	0.69	34	514	377	3.5
195	7	46.61	45.76	36.05	3318	509	306	3.5
195	8	46.57	45.47	8.15	1393	505	237	3.6
195	10	46.52	44.8	33.94	3085	509	302	3.5
195	11	46.71	44.98	0	0	502	162	3.1
195	12	46.78	45.26	2.82	1402	505	215	3.4
195	13	46.85	45.42	5.36	1162	505	233	3.5
195	14	46.86	45.53	14.06	2464	505	247	3.5
195	15	46.87	45.67	27.19	4617	510	259	3.5
195	16	46.98	45.64	17.12	3044	510	259	3.5
195	17	46.91	45.87	5.65	656	510	290	3.5
195	18	46.9	46.03	45.8	8667	510	283	3.6
195	19	47.08	46.28	33.85	6176	510	319	3.5
195	20	47.15	46.39	29.35	3649	514	367	3.4
195	21	47.11	45.84	26.25	5016	510	290	3.5
195	22	47.19	45.65	16.31	2143	511	270	3.5
195	23	47.14	45.36	1.3	869	505	214	3.2
195	24	47.26	45.32	2.33	1204	506	218	3.2
195	25	47.36	45.15	3.14	1808	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	159	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	127	3.2
195	32	46.94	44.82	0	0	501	134	3.2
195	33	46.59	44.35	0	0	517	604	3.2
195	34	46.75	44.13	0.27	18	513	450	3.3
195	35	46.77	43.99	0.02	2	517	610	3.2
195	36	46.85	44.2	37.25	7865	508	289	3.4
195	38	46.97	43.9	3.33	267	513	517	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	11.29	4223	508	291	3.4
195	42	47.3	43.84	0.3	19	516	563	3.3
195	43	47.4	43.95	1.76	123	512	474	3.4
195	44	47.57	44.27	1.21	246	508	310	3.5
195	45	47.36	44.41	0.07	24	503	229	3.4
195	46	47.39	44.6	0.01	13	503	188	3.2
195	47	47.55	44.64	3.88	2059	503	227	3.4
195	48	47.66	44.61	8.35	3250	503	242	3.5
195	49	47.73	44.48	21.61	5021	508	287	3.4
195	50	47.9	44.31	21.12	2432	512	490	3.4
196	7	47.65	45.89	3.55	255	515	390	3.7
196	8	47.82	45.86	2.48	145	515	492	3.3
196	9	48.15	45.6	1.26	84	519	575	3.4
196	10	48.26	45.39	18.53	1587	519	559	3.5
196	11	48.22	45.31	13.4	1241	515	470	3.8
196	12	48.32	44.95	1.32	106	516	597	3.3
196	13	48.07	45.22	49.06	9613	507	342	
196	14	47.99	45.15	64.24	12743	507	301	4
196	15	48.08	44.55	22.5	1990	512	519	3.4
196	16	47.97	44.45	22.67	3019	512	459	3.5
196	17	47.99	44.15	1.23	146	516	707	3.1
196	18	47.92	44.12	1.82	126	516	669	
196	19	47.87	44.99	21.44	6013	507	264	3.5
196	20	47.88	45.17	20.91	3868	507	271	3.5
196	21	47.74	45.29	20	4926	507	261	
196	22	47.74	45.54	70.42	13121	511	283	3.5
196	23	47.6	45.67	68.66	13979	511	285	3.5
196	24	47.55	45.05	9.19	3954	506	234	3.5
196	25	47.49	45.44	12.44	3488	511	259	3.5
196	26	47.41	45.67	32.35	9509	511	278	3.5
196	27	47.45	46.17	1.63	414	519	581	3.4

TABLE 2. SHRIMP BIOMASS ON FLEMISH CAP ESTIMATED BY SPANS - SINGLE MAP ANALYSIS - 6 INTERVALS.

	Density interval (kg)										
Class	Lower	Upper	% Area	km^2	Units	No. Sets	Av. wt (kg)	VAR	Str. mean	Biomass (kg)	% Biomass
1	0	6.995	33.63	12685.7	541892.4	26	1.36	5.6169	0.46	736973.60	3.39
2	6.995	13.99	24.91	9395.8	401358.4	16	8.88	106.2961	2.21	3564062.54	16.38
3	13.99	20.985	15.54	5862.7	250435.7	8	20.2	99.6004	3.14	5058801.37	23.24
4	20.985	27.98	12.35	4659.9	199056	6	21.25	289.3401	2.62	4229939.13	19.44
5	27.98	34.975	8.24	3108.8	132797.9	8	25.25	197.9649	2.08	3353148.23	15.41
6	34.975		5.34	2012.8	85980.35	4	56.06	556.0164	2.99	4820058.44	22.15
			100.00	37725.7	1611521	68			**13.50**	**21762983.30**	100.00
Total of 6 classes											
Wingspread = 16.845 m											
Distance = 1390.24 m											
Unit of effort = 0.02341 km^2											

TABLE 3. SHRIMP ABUNDANCE ON FLEMISH CAP ESTIMATED BY SPANS - SINGLE MAP ANALYSIS - 6 INTERVALS.

	Density interval (n)										
Class	Lower	Upper	% Area	km^2	Units	No. Sets	Av. wt (kg)	VAR	Str. mean	Abundance (n)	% Abundance
1	0	1424.59	39.93	15065.2	643537	25	292	734449	116.61	187912789.41	5.06
2	1424.59	2849.18	26.41	9964.5	425651.4	19	1835	3283344	484.68	781070375.91	21.05
3	2849.18	4273.77	12.37	4665.4	199290.9	9	3216	2579236	397.71	640919538.66	17.27
4	4273.77	5698.36	10.61	4001.8	170944	5	3778	13823524	400.76	645826586.93	17.40
5	5698.36	7122.95	5.20	1962.3	83823.15	4	6884	9903609	358.07	57703858l.80	15.55
6	7122.95		5.48	2066.5	88274.24	6	9945	21641104	544.76	877887334.47	23.66
			100.00	37725.7	1611521	68			**2302.58**	**3710655207.18**	100.00
Total of 6 classes											
Wingspread = 16.845 m											
Distance = 1390.24 m											
Unit of effort = 0.02341 km^2											

TABLE 4. STRATIFIED-RANDOM ANALYSIS FOR SHRIMP IN DIV. 3M, 1996 - WEIGHT (KG).

STRATUM	NO. SETS	TOTAL	AV./SET	UNITS	TOTAL WGT.	VARIANCE
501	2	0.000	0.0000	50182.28	0.00	0.000
502	6	0.000	0.0000	122961.27	0.00	0.000
503	4	12.308	3.0771	92147.59	283543.54	15.626
504	2	0.000	0.0000	51062.68	0.00	0.000
505	5	31.696	6.3392	103152.47	653904.76	25.410
506	3	14.651	4.8836	72778.99	355426.34	14.044
507	5	175.644	35.1287	120613.56	4237000.65	414.922
508	4	71.364	17.8410	94788.76	1691129.04	236.789
509	2	69.988	34.9938	46073.79	1612294.80	2.231
510	6	155.852	25.9753	139541.97	3624649.58	189.605
511	5	200.183	40.0366	118265.85	4734967.84	781.471
512	4	68.050	17.0125	98310.32	1672509.19	103.874
513	2	3.595	1.7974	36536.22	65670.06	4.686
514	4	40.670	10.1676	88332.56	898128.31	181.233
515	3	19.428	6.4760	97723.40	632860.78	36.246
516	4	4.668	1.1671	93027.98	108573.44	0.402
517	2	0.016	0.0079	31694.07	250.22	0.000
518	2	3.329	1.6643	30813.68	51282.77	5.540
519	3	21.418	7.1393	60746.98	433693.21	97.336

95 % CONFIDENCE INTERVALS FOR TOTAL AND MEAN WEIGHTS

TOTAL	UPPER	LOWER	MEAN
21,055,884.53	26,028,141.17	16,083,627.88	13.5954

TOTAL	UPPER	LOWER	EFFECTIVE DEGREES OF FREEDOM	STUDENTS T-VALUE
21,055,884.53	16.8059	10.3849	16	2.12

TABLE 5. STRATIFIED-RANDOM ANALYSIS FOR SHRIMP IN DIV. 3M, 1996 - NUMBERS

STRATUM	NO. SETS	TOTAL	AV./SET	UNITS	TOTAL NO.	VARIANCE
501	2	0.00	0.00	50182.28	0.00	0.00
502	6	0.00	0.00	122961.27	0.00	0.00
503	4	5345.47	1336.37	92147.59	123143052.85	2551789.63
504	2	0.00	0.00	51062.68	0.00	0.00
505	5	7289.81	1457.96	103152.47	150392361.57	363356.12
506	3	6966.01	2322.00	72778.99	168993071.25	2088538.77
507	5	37163.58	7432.72	120613.56	896486300.73	13489341.45
508	4	17354.94	4338.74	94788.76	411263334.05	9887972.79
509	2	6403.31	3201.66	46073.79	147512447.52	27071.74
510	6	28176.67	4696.11	139541.97	655304632.17	7423953.96
511	5	42240.64	8448.13	118265.85	999125069.14	29479048.53
512	4	7563.64	1890.91	98310.32	185895904.97	1566917.77
513	2	284.69	142.34	36536.22	5200703.20	31171.92
514	4	4448.50	1112.12	88332.56	98236749.96	2956669.59
515	3	1641.31	547.10	97723.40	53464876.85	364126.41
516	4	396.79	99.20	93027.98	9228130.52	3149.19
517	2	1.58	0.79	31694.07	25021.64	1.25
518	2	187.86	93.93	30813.68	2894285.25	17645.15
519	3	2085.55	695.18	60746.98	42230314.74	624108.38

95 % CONFIDENCE INTERVALS FOR TOTAL AND MEAN NUMBERS

TOTAL	UPPER	LOWER	MEAN
3949396256.40	4882975763.81	3015816748.99	2550.05

TOTAL	UPPER	LOWER	EFFECTIVE DEGREES OF FREEDOM	STUDENTS T-VALUE
3949396256.40	3152.84	1947.25	14	2.145

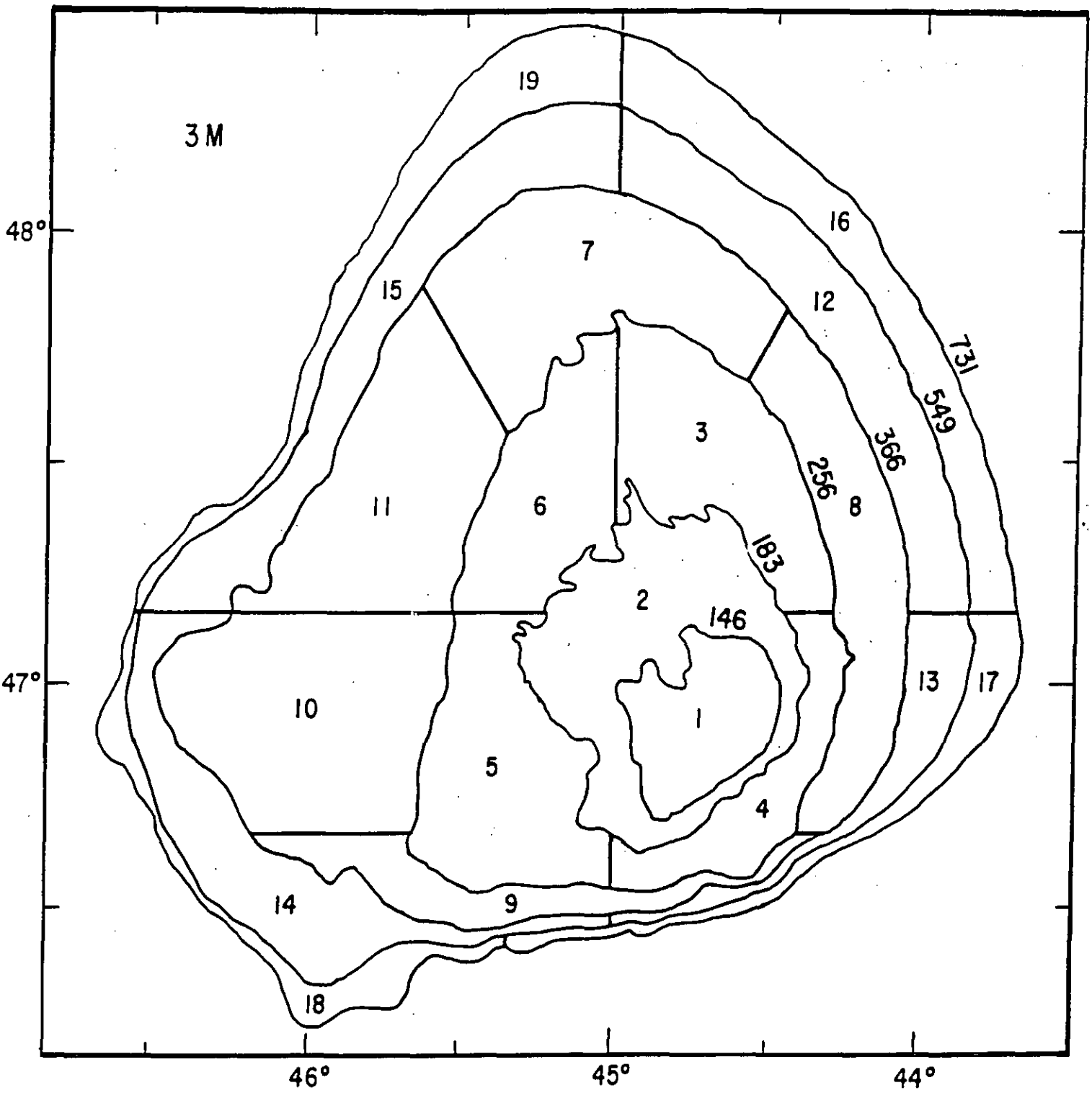

Figure 1. Stratification scheme for Canadian research trawl surveys on Flemish Cap.
(Strata numbered consecutively from 1 to 19 correspond to strata 501 to 519 in Table 1.)

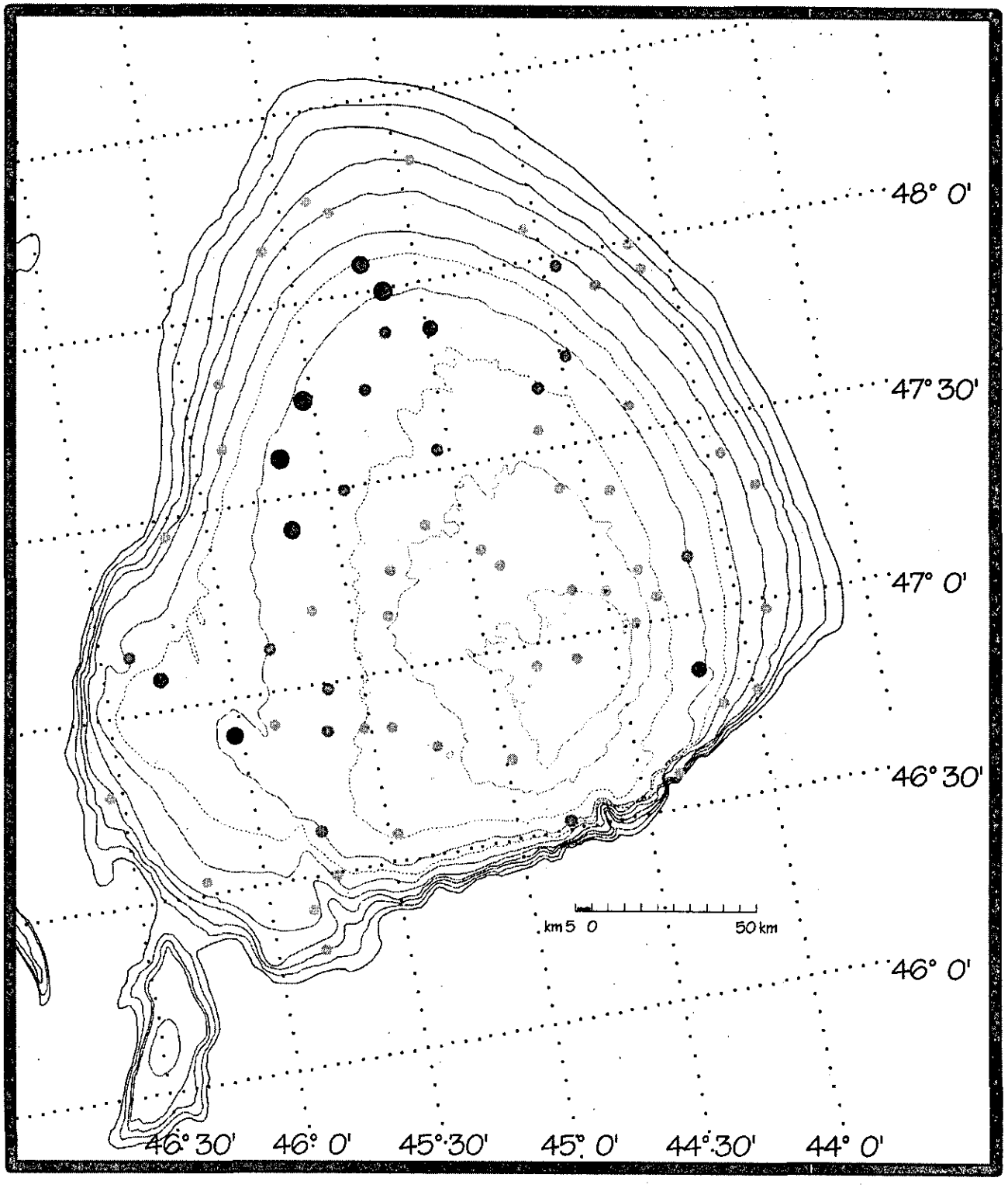

Figure 2. Bathymetry of Flemish Cap and set locations for the 1996 research trawl survey.

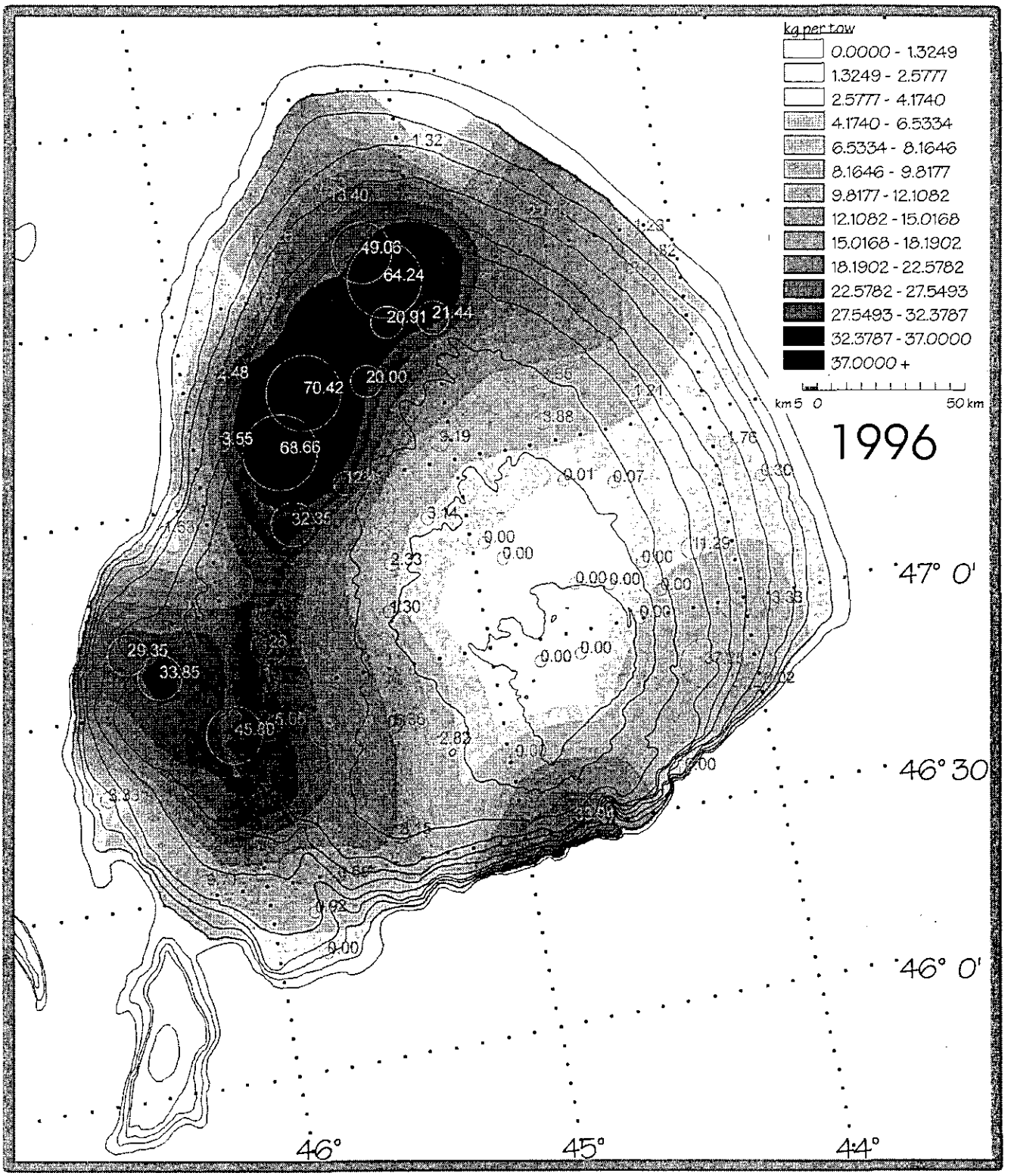

Figure 3. Shrimp catch (kg) per tow from the 1996 research survey, modelled by SPANS.

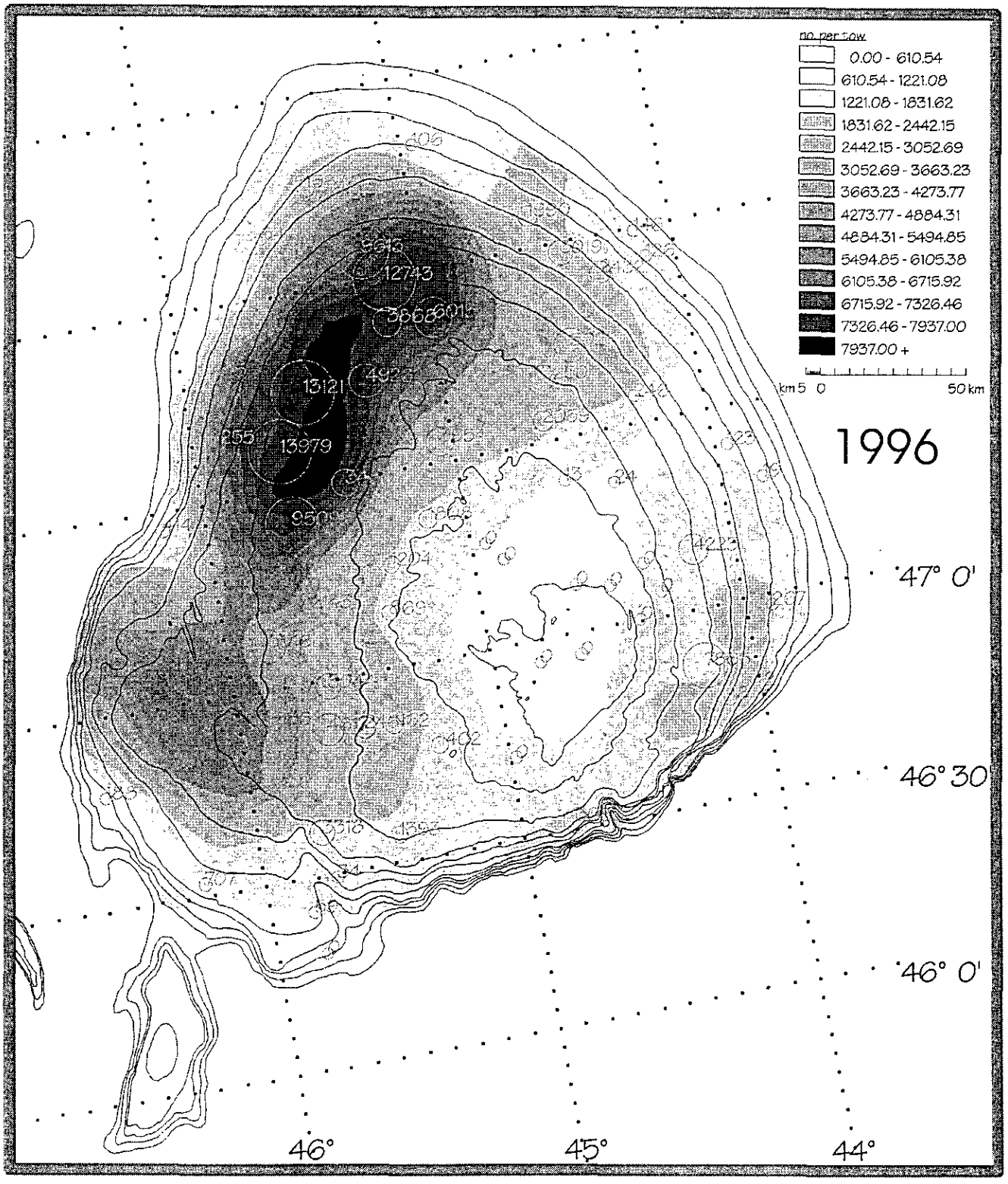

Figure 4. Shrimp catch (#) per tow from the 1996 research survey, modelled by SPANS.

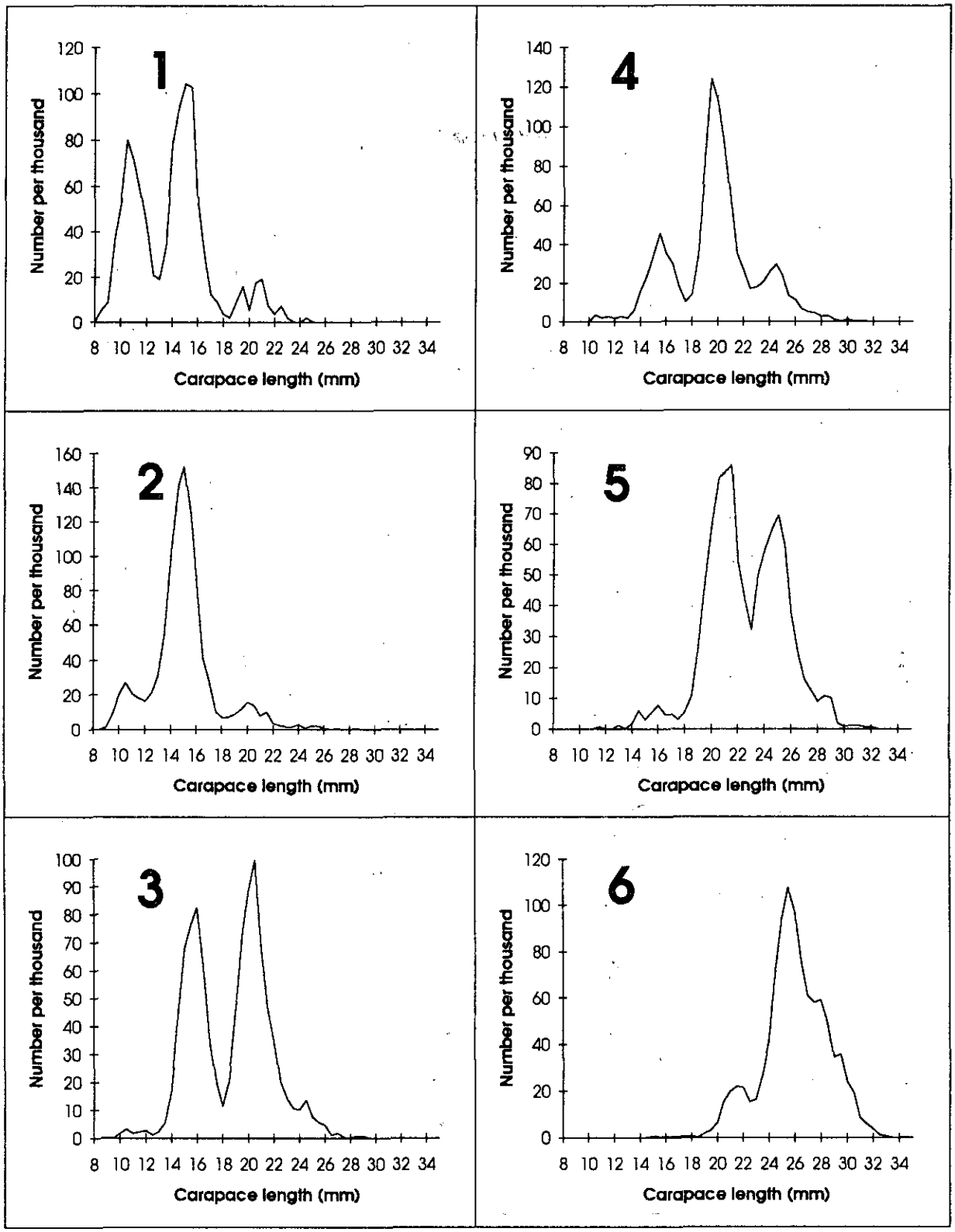

Figure 5. Research survey length distributions of shrimp on Flemish Cap, fall 1996.

Fig. 6. Abundance of shrimp at length and age in Div. 3M determined from 1996 research trawl survey.