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Report on a Stratified-Random Trawl Survey for Shrimp (Pandalus borealis) in NAFO Subareas 0+1 in July-September 1991, and a Comparison with Earlier Surveys.

by

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INTRODUCTION

In July-September 1991 a random-stratified trawl survey was carried out in the main part of shrimp distribution area in NAFO Divisions 1A-1E and a part of Subarea 0.

The survey was carried out in almost the same area as similar surveys in 1988-90 with the scope of assessing the trawlable biomass of the offshore SA0+1 shrimp stock, and to collect biological samples to estimate the size composition of this stock.

Surveying conditions were favorable without ice problems or bad weather.

MATERIALS AND METHODS

The survey was carried out in the offshore area between 61°52'5N and 72°30'N in Davis Strait from the 3-mile limit off the Greenland coast in depths between 150 m and 600 m including that part of Subarea 0 which is adjacent to the shrimp areas in Subarea 1.

The survey was conducted with the 722 GRT stern trawler M/T PAAMIUT which is of the same size as the trawlers used since 1988 in the trawl surveys. Also, the same trawling gear as earlier was used (Skjervoy 3000/20 with bobbin gear and a double-bag with 44 mm mesh size in the codend). The trawl doors used were of the type 'PERFECT GREENLAND', size 370*250 cm, weight 2420 kg. The wing spread was estimated by use of SCANMAR equipment to an average of 27.7 m. The mean trawling distance was 4.59 km, giving a mean swept area of 0.127 km² per haul.

The duration of the hauls was held as close as possible to 60 minutes. In order to minimize the influence of vertical migration of shrimp the trawl operations were carried out only in the daytime (0900-1900 UTC).

In the area between 61°52'5N and 69°30'N the stratification was made on basis of depth contours. As in the stratification scheme for the earlier surveys this area was divided into subareas (Fig. 1). Each of these subareas was further divided into four depth strata (150-200 m, 200-300 m, 300-400 m and 400-600 m).

Due to scarce information on bottom topography the area between 69°30'N and 71°00'N was divided into separate shrimp grounds as defined by the distribution of the fishery. However, some reduction of one stratum in this area (N5) was made compared to earlier years, based on better knowledge of the shrimp distribution from recent years.

It was estimated from the time available for the survey that about 110-120 hauls could be taken with trawling operations in the day-time only. In most of the survey area the coverage would then be about 750 km² per haul. In some of the strata in the northern area a lower coverage was accepted, being areas with known very low shrimp densities. The average coverage in the northern area was thus about 1400 km² per haul.

Hauls were allocated to a stratum proportionally to its size. However, a minimum of two hauls per stratum was always scheduled, so additional hauls were placed in some of the smaller strata. Within the strata the trawling sites were chosen at random according to the NAFO 'Manual of Groundfish Surveys in the Northwest Atlantic' (Doubleday, 1981). The sites of the trawl hauls are shown in Fig. 2a-d.

The mean biomass with standard deviation by stratum was calculated by means of the swept area method and assuming a catchability coefficient of 1. Sums of the calculated biomasses were made by region (North of 69°30'N, South of 69°30'N in the Greenland zone, and the Canadian zone), and further, a pooled standard deviation by region was derived to indicate the level of confidence for the final biomass estimate.

Biological samples were taken from all catches, if the catch was not too small or damaged to give a proper sample. Shrimp were sorted by sexual characteristics and obligue carapace length was measured to the nearest 0.1 mm and afterwards pooled in 0.5 mm groups. Samples were weighted by catch and stratum area, to obtain estimates of total number of shrimp by sex and length group for each stratum and for the total survey area. These estimates were compared to results from earlier surveys to yield indications of changes in abundance of size groups.

A new method has been introduced for describing the distribution of shrimp biomass in the area south of 69°30'N. Shrimp densities in the depth range 150-600 meters were estimated on basis of the survey stations by the computer programme 'Spline Survey Designer Software System' (Stolyarenko, 1987), and maps with isolines for different levels of density were produced for presentation.

RESULTS AND DISCUSSION

Shrimp catches from the trawl hauls were used to estimate the trawlable biomass for all strata. Table 1a-c gives a list of all catches taken. The biomass estimates for all strata in the three regions are shown in Table 2a-c.

When comparing the size of the estimated total biomass from the recent survey with the results from corresponding surveys in 1988-90 (Carlsson & Kanneworff, 1989; 1990; 1991), a decline through the years is indicated (Table 3, Fig. 3). However, some uncertainty remains concerning the high figure for 1989 due to the possible influence of a significantly smaller trawl wing spread used that year than in the three other years. The calculated absolute biomass levels through all four years can therefore only be compared with caution. However, some information may be obtained on a.o. displacement of the stock from year to year by analysing figures for the proportion of biomass in different strata relative to the yearly totals (Table 4).

In relation to 1988 and 1990 a larger part of the stock was found in the southern strata (W3-W5/W6) than in 1989 and 1991. A steady decline in biomass is seen through the four years in the northernmost areas, N1-N7 (Tables 3-4).

In 1989 the stock was concentrated in strata with depths between 200 and 300 meters, while in 1990 shrimp were more concentrated in depths between 300 and 400 meters. Through all four years a displacement of the stock to deeper waters is indicated, the stock being nearly absent in depths between 150 and 200 meters in 1990 and 1991 (Table 5). In 1991 20% of the biomass was estimated in the depth stratum 400-600 meters, the highest figure on record.

When examining the geographical distribution of the shrimp biomass as estimated by the 'spline'-method (Stolyarenko, 1987) it is obvious that large fluctuations in the distribution occur (Fig. 4-7) and that high concentrations of shrimp may be found at different locations from year to year. This phenomenon hampers an optimal stratification for a traditional stratified-random survey. This sampling problem might be solved by carrying out a two-stage survey or a two vessel survey, in which the second part of the survey or the second vessel could make a more intense sampling in areas with high shrimp densities to obtain a better description of the distribution.

The 'Spline Survey Designer Software System' (loc. cit.) also offers a possibility of designing a sampling scheme on basis of previously obtained information on shrimp distribution (or other factors influencing stock density, e.g. bottom temperature). The sampling might be optimized by this method, especially in connection with a two-stage survey, but in the lack of a series of parallel surveys applying both methods a direct comparison of the results is difficult. However, biomass calculations from both methods based on the stratified-random samplings during 1988-91 are in good agreement.

Length-frequency distributions of shrimp for the total survey area in 1988-91 are given in Fig. 8 and for 1991 in Table 6. A direct comparison of total numbers of shrimp by sex from year to year is complicated not only by differences in trawl design and minor changes in the area surveyed between years. Furthermore, samples could not be obtained from all strata in all years, however most strata without samples contain very small biomass estimates.

The text table below shows an increase in number of males from 1988 to 1989, and a decrease through 1989 to 1991. Numbers of primiparous females decrease from 1988 to 1989, increase in 1990 almost to the level of 1988, and decreased in 1991, indicating a poor recruitment in 1991 to the female group. Multiparous females decreased from 1988 to 1989, but remained stable in the following years. The stable number of multiparous females between 1990 and 1991 may be explained by a good recruitment to the female group in 1990 as evidenced by the relatively high number of primiparous females this year.

No. of shrimp (billions)	1988	1989	1990	1991
males	19.8	34.0	19.4	12.5
prim.fem.	3.5	2.6	3.3	1.3
mult.fem.	4.6	3.7	3.4	3.4
Total	27.9	40.3	26.1	17.2

Savard et al. (1989) used modal analysis on shrimp samples collected during Greenland trawl surveys in Davis Strait in 1983 to 1987 and summarized age and growth data as shown in Table 7. Using these data as a length-at-age key on the total length-frequency distributions from the surveys in 1988 to 1991 (Fig. 8), consistency is found from year to year. In 1988 a dominant mode is found around 20 mm CL and another mode at 22.5 mm CL, representing 5 and 6 years old males. In 1989 these modes have moved to 22 mm and 24.5-25 mm CL, respectively, now representing 6 years old males and 7 years old primiparous females. A new mode of males is indicated around 20 mm CL (5 years old), but the distribution is characterized by a dominant mode at 17.5 mm CL, showing a significant recruitment to the fishery of probably 4 years old males. In 1990 this 'year-class' is still significant, now at 19.5 mm CL, while there are no indications of a significant new recruitment to the fishery of smaller shrimp. The 22 mm group from 1989 is present as primary females in 1990. As would be expected, the 1985 'year-class' is found in 1991 at 21.5 mm, naturally with a lower abundance. Also a new mode is found around 17.5 mm (the 1987 'year-class'). This mode is, however, significantly lower than was indicated for the 1985 'year-class' in the 1989 material.

Figures 9a-e show length-frequencies of the total number of shrimp by stratum and years. All depth strata are combined, the strata north of 69°30'N are combined in two main strata (stratum NW = stratum N1-N4, NS = N5-N7) and all strata on the Canadian side of the midline combined in one stratum (C) (refer to Fig. 1). Both main strata north of 69°30'N (Fig. 9b) show a significant decrease in abundance of shrimp for all sizes over the four years, except for some recruitment of the 1985 'year-class' in stratum NS in 1991. In stratum C (Fig. 9a) all size groups decrease from 1988 to 1989, while in 1990 numbers of females increase and a dominant male group around 20 mm CL is evident. In 1991 the female component has been drastically reduced and the distribution is now totally dominated by the 1985 'year-class' around 22 m CL. In strata W1, W2 and W3 the female component has decreased in abundance from 1990 to 1991 (Figures 9c-d), and the distributions are in 1991 totally dominated by the 1985 'year-class'. On the other hand, in strata W4, W5 and W6 there is an increasing number of females. In stratum W6 some recruitment of the 1987 'year-class' (around 18 mm CL) is indicated. Figures 10a-e show the numbers of shrimp by stratum (stratum W1 - W6) and depth from 1988 to 1991 for males, primiparous females, multiparous females and for all sex groups combined. From 1988 to 1990 an axis is indicated from shallow water in southern areas with smaller shrimp to deeper water to the north with larger shrimp. In 1991 the distribution over the area is more even, however, still with smaller shrimp being more abundant in shallower water and larger shrimp more abundant in deeper water. In 1990 and 1991 practically no shrimp were found in the shallow water area (150-200 m).

CONCLUSIONS

The total biomass estimate from the stratified trawl surveys indicate a general decline when comparing the results of the surveys through the years 1988-91. While the figures for 1989 were about 30% higher than in 1988, the 1990-biomass was at the level of 1988, and the 1991-biomass was reduced to 70% compared to the year before. In 1989 and 1991 a southward displacement of the stock was indicated. In 1990 a displacement in the opposite direction was found in the areas south of 69°30'N. The biomass in the areas north of 69°30'N exhibit a significant decrease through the period.

A migration towards deeper water through the years is indicated, the stock being nearly absent in shallow water in 1991, and with 20% of the stock in the depth stratum 400-600 meters.

Doubts whether the estimates of absolute biomass from the four trawl surveys are comparable have been expressed. The arguments are based on the differences in gear design between years. When looking at the total biomasses in terms of length-frequency distributions the recruitment of a significant group of males in 1989 may, however, explain at least in parts the high biomass estimate obtained in 1989.

Also, there is some consistency with regard to the progression of identifiable size groups of shrimp between the years. In 1989 a significant recruitment to the fishery of small shrimp around 19.5 mm CL is obvious. L50 is at the mesh size used in the surveys (about 43 mm stretched mesh) around 16.5 mm CL (Lehmann & Degel, 1991). The same 'year-class' can be identified not only in 1990 but also in 1991.

The primary females found in 1990 contributed to the multiparous females in 1991. In 1991 the recruitment to the primiparous females was relatively small, and in 1992 it may be expected that the number of multiparous females will decrease. On the other hand the dominant 1985 'year-class' will contribute to the group of primiparous females in 1992, but the significance of this will depend heavily on the impact of the fishing pressure before this happens. There are no indications of a good recruitment of new male groups in 1991.

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Table 1a. List of trawl stations in strata west of the midline in the Davis Strait survey 1991. Catches are given in kg.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
STRATUM C1-3									
91PA0070026 026	KX436	322.0	60	508	0	4	11	0	523
91PA0070027 027	LA436	341.5	61	165	0	5	37	0	207
STRATUM C1-4									
91PA0070025 025	KX434	537.5	61	0	0	14	27	0	41
STRATUM C3-2									
91PA0070024 024	KV436	295.0	58	61	0	1	14	0	77
STRATUM C3-3									
91PA0070021 021	KP438	370.0	60	98	0	7	25	0	130
91PA0070020 020	KP439	303.0	63	459	0	1	10	0	471
91PA0070022 022	KR439	332.5	60	185	0	11	221	0	418
STRATUM C3-4									
91PA0070023 023	KS435	543.0	63	3	0	18	46	0	67

Table 1b. List of trawl stations in strata north of 69°30'N in the Davis Strait survey 1991. Catches are given in kg.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
STRATUM N1									
91PA0080014 080	ML002	266.0	65	2	0	.	0	2	4
91PA0080013 081	MM003	304.0	62	56	0	.	0	30	86
91PA0080009 082	MM005	272.0	64	4	0	.	.	11	15
91PA0080012 078	MM439	324.5	61	200	0	.	0	47	247
91PA0080010 079	MN001	239.0	61	1	0	.	.	2	2
STRATUM N2									
91PA0080016 114	MD437	315.5	62	0	0	0	0	0	0
91PA0080015 115	ME438	307.5	62	0	0	0	0	0	0
91PA0080008 116	MK005	168.0	61	0	0	0	0	0	0
STRATUM N3									
91PA0080006 084	MF007	296.5	60	422	0	1	0	37	460
91PA0080007 083	MG008	189.5	61	10	0	0	0	.	10
STRATUM N4									
91PA0080019 086	MA005	460.0	62	32	0	11	0	8	51
91PA0080017 085	MB004	329.0	60	39	0	.	0	3	42
91PA0080003 112	MB009	465.5	60	45	0	30	7	23	104
91PA0080004 087	MD010	345.0	62	278	0	0	0	.	278
91PA0080005 113	MD010	172.5	61	23	0	0	0	.	23
STRATUM N5									
91PA0080028 070	LM439	337.5	60	0	0	0	0	7	7
91PA0080026 072	LN438	303.5	61	1	0	1	0	7	9
91PA0080027 071	LN438	295.0	61	0	0	0	0	2	2
91PA0080025 073	LP439	347.5	60	5	0	1	1	19	25
91PA0080023 075	LR437	327.5	61	2	0	0	2	5	9
91PA0080024 074	LR438	341.0	61	7	0	0	0	4	11
91PA0080022 076	LT437	485.5	66	0	0	3	4	14	20
91PA0080021 077	LV438	587.5	61	1	0	0	0	.	1
STRATUM N6									
91PA0080031 107	LM008	137.5	64	0	0	0	0	1	1
91PA0080029 108	LP005	237.5	61	0	0	0	0	0	0
91PA0080030 109	LP006	168.5	60	0	0	0	0	1	1
91PA0080020 110	LX003	514.5	63	7	0	30	0	18	54
91PA0080018 111	MA004	424.5	61	58	0	.	.	32	89
STRATUM N7									
91PA0080001 089	LT011	208.0	60	0	0	2	0	1	3
91PA0080002 088	LV011	227.0	60	7	0	0	0	13	21

Table 1c. List of trawl stations in strata south of 69°30'N east of the midline in the Davis Strait survey 1991. Catches are given in kg.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
STRATUM W1-1									
91PA0070058 051	LF007	185.0	62	0	0	0	0	0	0
91PA0070057 050	LG008	162.5	60	0	0	0	0	0	0
91PA0070063 063	LG015	169.5	60	21	0	0	0	0	21
91PA0070056 049	*LH010*	179.5	*61*	*0*	*0*	*0*	0	0	0
STRATUM W1-2									
91PA0070060 053	LD005	284.0	62	17	0	0	0	0	17
91PA0070061 052	LE005	265.5	57	2	0	0	0	0	2
91PA0080040 063	LF003	230.5	40	1	0	0	0	0	1
91PA0080041 064	LF004	223.0	61	0	0	.	0	1	1
91PA0070062 065	LH003	234.5	63	0	0	0	0	0	0
91PA0080032 106	LJ003	227.0	61	0	0	0	0	0	0
STRATUM W1-3									
91PA0070031 058	KZ003	381.0	60	127	0	24	33	0	184
91PA0070033 057	KZ005	361.5	61	356	0	54	148	0	558
91PA0070029 059	LA001	305.5	63	110	0	6	5	0	121
91PA0070028 028	LA438	321.0	59	40	0	0	2	0	42
91PA0070030 060	LB002	314.0	62	311	0	8	16	0	335
91PA0070059 054	LB006	333.5	61	1475	0	0	0	1	1476
91PA0080039 062	LF440	309.0	62	28	0	1	1	23	53
91PA0080035 067	LH439	331.5	62	199	0	7	12	45	262
91PA0080037 066	LH439	359.0	63	234	0	23	21	23	302
91PA0080033 068	LJ439	353.0	60	8	0	0	0	5	13
STRATUM W1-4									
91PA0080038 061	LF437	536.5	68	3	0	5	10	3	21
91PA0080034 068	LJ438	443.0	63	4	0	3	1	2	10
STRATUM W2-1									
91PA0070055 045	LE011	153.5	60	0	0	0	0	0	0
91PA0070064 047	LF015	158.5	63	9	0	0	0	0	9
STRATUM W2-2									
91PA0070052 043	LB014	221.0	59	13	0	11	11	0	35
91PA0070053 099	LD012	250.0	63	0	0	0	2	0	2
91PA0070054 046	LE012	210.0	60	0	0	0	0	0	0
STRATUM W2-3									
91PA0070034 055	LA009	396.0	60	723	0	60	24	0	807
91PA0070035 039	LA011	372.0	60	1352	0	30	34	0	1415
91PA0070050 041	LA013	358.5	60	851	0	30	34	0	916
STRATUM W2-4									
91PA0070051 042	LB016	542.5	60	806	0	97	32	0	935
STRATUM W3-1									
91PA0070016 093	KM006	184.0	59	0	0	0	1	0	1
91PA0070042 034	KS005	164.0	60	0	0	0	0	0	0
91PA0070041 035	KS007	154.5	63	0	0	0	0	0	0
STRATUM W3-2									
91PA0070018 091	KL003	277.5	62	104	0	0	1996	0	2100
91PA0070017 092	KL005	234.0	60	0	0	0	0	0	0
91PA0070019 090	KM002	269.0	60	142	0	0	416	0	558
91PA0070043 033	KR004	269.0	61	256	0	0	1	0	257
91PA0070040 036	KV006	235.0	59	3	0	0	0	0	4
91PA0070047 037	KV010	248.5	60	10	0	3	84	0	97
STRATUM W3-3									
91PA0070038 031	KS001	325.0	63	574	0	12	45	0	630
91PA0070039 030	KS440	327.0	61	242	0	2	18	0	261
91PA0070037 032	KT002	342.5	60	662	0	4	21	0	686
STRATUM W3-4									
91PA0070044 094	KJ006	504.0	62	3	0	17	70	0	90
91PA0070036 029	KV440	418.0	62	398	0	11	20	0	429
91PA0070032 056	KX005	440.0	61	217	0	38	27	0	283
91PA0070048 038	KX011	479.0	65	769	0	79	60	0	907
91PA0070049 040	KZ012	445.0	63	761	0	120	100	0	982
STRATUM W4-1									
91PA0070011 103	KA008	185.5	60	0	0	0	0	0	0
91PA0070014 098	KD009	177.0	60	0	0	0	1	0	1
91PA0070015 102	KD011	191.0	60	0	0	0	0	0	0
91PA0070010 099	KD013	191.0	60	0	0	0	0	0	0

Table 1c continued.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
91PA0070046 096	KG007	188.5	59	19	0	1	15	0	34
STRATUM W4-2									
91PA0070012 104	KB007	298.5	64	0	0	0	8	0	9
91PA0070008 100	KB013	289.5	60	775	0	9	57	0	842
STRATUM W4-3									
91PA0070009 101	KD013	312.0	60	1759	0	14	142	0	1915
91PA0070045 095	KH007	362.5	62	391	0	2	72	0	465
STRATUM W4-4									
91PA0070007 105	KA006	568.5	62	0	0	6	26	0	33
91PA0070013 097	KD006	503.5	60	3	1	11	30	0	45
STRATUM W5-1									
91PA0070001 014	JH019	173.0	60	0	0	0	0	0	0
91PA0070004 017	JL014	175.0	60	0	0	1	8	0	10
STRATUM W5-2									
91PA0060011 009	JB019	241.5	60	60	0	1	75	6	141
91PA0060009 011	JE018	295.0	60	489	0	0	95	4	588
91PA0060010 010	JF017	241.5	60	195	0	0	4	1	200
91PA0070006 019	JT011	278.5	62	360	0	0	24	0	384
STRATUM W5-3									
91PA0060008 012	JF019	341.5	61	545	12	4	48	8	618
91PA0070002 015	JK013	378.5	60	0	0	4	6	0	9
STRATUM W5-4									
91PA0060007 013	JF020	454.0	60	430	6	6	15	11	466
91PA0070003 016	JL013	497.0	60	0	1	3	5	0	8
91PA0070005 018	JR011	558.0	60	0	0	3	10	0	13
STRATUM W6-1									
91PA0060002 003	HS026	172.0	60	7	0	0	0	10	17
91PA0060004 005	HT023	190.5	60	10	0	0	2	2	13
STRATUM W6-2									
91PA0060012 008	JB023	236.0	60	526	0	4	40	35	604
STRATUM W6-3									
91PA0060006 007	HZ024	358.5	54	61	2	0	22	11	96
STRATUM W6-4									
91PA0060001 002	HP026	456.0	60	378	41	2	5	12	439
91PA0060003 004	HS023	520.5	58	0	0	1	66	32	99
91PA0060005 006	HV025	406.0	60	749	9	7	60	39	863

Table 2a. Estimated trawlable biomass in strata west of the midline in the Davis Strait survey 1991.

STRATUM	SQKM	BIOMASS IN STRATA					
		TONS	HAULS	STD	STDERR	MIN	MAX
AREA C1 300-400 M	655	1643.7	2	1069.8	756.5	887	2400
AREA C1 400-600 M	312	0.5	1	.	.	0	0
AREA C3 200-300 M	660	311.8	1	.	.	312	312
AREA C3 300-400 M	1192	2210.3	3	1441.9	832.5	850	3722
AREA C3 400-600 M	623	13.5	1	.	.	14	14

Table 2b. Estimated trawlable biomass in strata north of 69°30'N in the Davis Strait survey 1991.

STRATUM	SQKM	BIOMASS IN STRATA					
		TONS	HAULS	STD	STDERR	MIN	MAX
AREA N1	3649	1517.5	5	2586.9	1156.9	13	6023
AREA N2	11789	0.0	3	0.0	0.0	0	0
AREA N3	367	586.4	2	785.2	555.2	31	1142
AREA N4	2249	1551.5	5	2155.0	963.8	408	5398
AREA N5	5990	85.3	8	100.3	35.5	4	272
AREA N6	15926	1625.4	5	3199.4	1430.8	0	7314
AREA N7	1159	34.3	2	44.3	31.3	3	66

Table 2c. Estimated trawlable biomass in strata south of 69°30'N east of the midline in the Davis Strait survey 1991.

STRATUM	SQKM	BIOMASS IN STRATA					
		TONS	HAULS	STD	STDERR	MIN	MAX
AREA W1 150-200 M	2363	98.3	4	196.6	98.3	0	393
AREA W1 200-300 M	5213	121.0	6	244.4	99.8	0	617
AREA W1 300-400 M	9239	19864.4	10	27756.4	8777.3	664	94945
AREA W1 400-600 M	752	24.6	2	6.9	4.9	20	29
AREA W2 150-200 M	1499	49.7	2	70.3	49.7	0	99
AREA W2 200-300 M	2477	86.1	3	149.2	86.1	0	258
AREA W2 300-400 M	1453	10538.0	3	2469.5	1425.8	8881	13376
AREA W2 400-600 M	559	3910.5	1	.	.	3910	3910
AREA W3 150-200 M	2215	0.0	3	0.0	0.0	0	0
AREA W3 200-300 M	4810	3082.8	6	3697.4	1509.4	4	9239
AREA W3 300-400 M	2714	10339.4	3	5155.3	2976.4	4739	14887
AREA W3 400-600 M	3361	10442.7	5	8119.3	3631.1	75	19408
AREA W4 150-200 M	4204	159.5	5	356.5	159.5	0	797
AREA W4 200-300 M	1736	6347.0	2	8968.4	6341.6	5	12689
AREA W4 300-400 M	745	6403.9	2	5630.2	3981.2	2423	10385
AREA W4 400-600 M	1915	27.4	2	35.1	24.8	3	52
AREA W5 150-200 M	1995	1.5	2	2.1	1.5	0	3
AREA W5 200-300 M	3454	6863.7	4	3934.0	1967.0	2236	11414
AREA W5 300-400 M	1797	3808.1	2	5385.4	3808.1	0	7616
AREA W5 400-600 M	2806	3174.7	3	5498.8	3174.7	0	9524
AREA W6 150-200 M	1095	73.3	2	24.8	17.5	56	91
AREA W6 200-300 M	1491	6592.1	1	.	.	6592	6592
AREA W6 300-400 M	1300	773.8	1	.	.	774	774
AREA W6 400-600 M	884	2629.2	3	2630.9	1518.9	2	5264

Table 3. Sums of estimated biomasses in main regions 1988-91.

AREA	BIOMASS IN YEAR 1988	1989	1990	1991
WEST	122323	184032	131977	95411
CANADA	8111	3992	9959	4180
NORTHWEST	25177	11805	10228	5400
TOTAL	155611	199829	152164	104991

Table 4. Stratum areas in % of total survey area in 1991, and calculated biomass estimates in % of total yearly biomass from surveys 1988-91 in the area 61°52'5N - 72°30'N.

	DEPTH STRATUM 150-200 M	200-300 M	300-400 M	400-600 M	TOTAL
W1 AREA	2.3	5.0	8.8	0.7	16.8
1988-BIOM	0.0	0.8	18.8	0.0	19.5
1989-BIOM	0.1	5.2	6.7	0.0	12.0
1990-BIOM	0.1	1.5	18.2	0.0	19.9
1991-BIOM	0.1	0.1	19.0	0.0	19.2
W2 AREA	1.4	2.4	1.4	0.5	5.7
1988-BIOM	0.0	4.4	7.3	1.0	12.8
1989-BIOM	0.0	6.0	10.6	0.9	17.5
1990-BIOM	0.0	3.4	17.2	5.0	25.7
1991-BIOM	0.0	0.1	10.1	3.7	13.9
W3 AREA	2.1	4.6	2.6	3.2	12.5
1988-BIOM	0.0	11.8	7.7	4.4	23.9
1989-BIOM	0.1	17.2	5.9	3.8	27.0
1990-BIOM	0.0	7.1	9.9	4.7	21.7
1991-BIOM	0.0	3.0	9.9	10.0	22.9
W4 AREA	4.0	1.7	0.7	1.8	8.2
1988-BIOM	7.4	3.1	0.2	2.2	13.0
1989-BIOM	1.4	14.0	0.0	0.1	15.5
1990-BIOM	0.0	5.5	0.7	0.0	6.3
1991-BIOM	0.2	6.1	6.1	0.0	12.4
W5 AREA	1.9	3.4	1.9	2.7	9.6
1988-BIOM	0.0	3.3	2.6	3.5	9.4
1989-BIOM	3.4	9.8	5.4	1.5	20.2
1990-BIOM	0.0	2.3	4.2	2.4	9.0
1991-BIOM	0.0	6.6	3.2	3.0	12.8
W6 AREA	1.0	1.4	1.2	0.8	4.6
1988-BIOM	-	-	-	-	-
1989-BIOM	-	-	-	-	-
1990-BIOM	0.1	3.5	0.1	1.3	5.0
1991-BIOM	0.1	6.3	0.7	2.5	9.6
C1 AREA	-	-	0.6	0.3	0.9
1988-BIOM	-	-	1.1	0.0	1.1
1989-BIOM	-	-	0.5	0.0	0.6
1990-BIOM	-	-	2.2	0.0	2.2
1991-BIOM	-	-	2.4	0.0	2.4
C3 AREA	-	0.6	1.1	0.6	2.4
1988-BIOM	-	-	4.1	-	4.1
1989-BIOM	-	-	1.1	0.3	1.4
1990-BIOM	-	1.6	2.3	0.3	4.2
1991-BIOM	-	0.5	1.8	0.0	2.2

	TOTAL
N1 AREA	3.5
1988-BIOM	1.5
1989-BIOM	2.2
1990-BIOM	1.6
1991-BIOM	1.5
N2 AREA	11.3
1988-BIOM	7.0
1989-BIOM	0.6
1990-BIOM	1.1
1991-BIOM	0.0
N3 AREA	0.4
1988-BIOM	0.0
1989-BIOM	0.1
1990-BIOM	0.2
1991-BIOM	0.6
N4 AREA	2.1
1988-BIOM	2.6
1989-BIOM	1.4
1990-BIOM	1.7
1991-BIOM	1.5

	TOTAL
N5 AREA	5.7
1988-BIOM	1.4
1989-BIOM	1.7
1990-BIOM	0.6
1991-BIOM	0.1
N6 AREA	15.2
1988-BIOM	1.5
1989-BIOM	-
1990-BIOM	0.4
1991-BIOM	1.6
N7 AREA	1.1
1988-BIOM	2.1
1989-BIOM	0.0
1990-BIOM	0.6
1991-BIOM	0.0

Table 5. Relative distribution (%) of estimated biomasses 1988-91 in depth strata south of 69°30'N.

YEAR	DEPTH STRATUM 150-200	200-300	300-400	400-600
1988	8.9	28.2	49.9	13.2
1989	5.7	57.3	30.7	6.3
1990	0.3	25.8	58.8	15.1
1991	0.4	23.5	55.8	20.3

Table 6. Numbers of shrimp per length group (carapace length) in total biomass estimate in 1991, based on pooling of individual samples weighted by catch and stratum area.

LENGTH, CPL	MALES	PRIM.FEM	MULTI.FEM	TOTAL
7.5	841280	0	0	841280
8.5	224329	0	0	224329
10	979552	0	0	979552
10.5	498008	0	0	498008
11	5261927	0	0	5261927
11.5	9954480	0	0	9954480
12	22117098	0	0	22117098
12.5	30803574	0	0	30803574
13	42794618	0	0	42794618
13.5	39527621	0	0	39527621
14	22000107	0	0	22000107
14.5	40133673	0	0	40133673
15	67268924	0	0	67268924
15.5	149587933	0	0	149587933
16	245251501	0	0	245251501
16.5	327685338	0	0	327685338
17	391986985	0	0	391986985
17.5	434309524	0	0	434309524
18	433710305	0	224329	433934634
18.5	389336269	0	0	389336269
19	440335488	0	410287	440745775
19.5	568683259	0	243255	568926514
20	829260190	224329	3000693	832485212
20.5	1168841444	3202664	2885108	1174929216
21	1425487790	2239040	8463291	1436190121
21.5	1489669273	9610402	11430858	1510710533
22	1348679403	34814770	28187304	1411681477
22.5	1131540289	74856991	64891000	1271288280
23	707898429	150921979	123789274	982609682
23.5	394675417	237746978	216262157	848684552
24	192668919	274084345	250711101	717464365
24.5	82679632	216308810	358349354	657337796
25	31451394	158852916	367941788	558246098
25.5	23960649	91811889	361382125	477154663
26	10394109	47631057	325681338	383706504
26.5	1903739	17958656	284068150	303930545
27	2421098	9086873	265527291	277035262
27.5	1418819	4140380	240492029	246051228
28	1523337	5187970	158846962	165558269
28.5	6088	2890701	122086805	124983594
29	274609	369361	65014244	65658214
29.5	102708	0	46680435	46783143
30	0	255335	27076429	27331764
30.5	0	0	12962306	12962306
31	0	0	13212380	13212380
31.5	0	139800	1677831	1817631
32	0	0	1190177	1190177
33.5	0	0	1904822	1904822
TOTAL	12508149129	1342335246	3364593123	17215077498

Table 7. Summary of age and growth data for samples of northern shrimp from Davis Strait, 1983-87, combined (from Savard et al., 1989).

Age	Min - max lengths (mm)	Range	Mean length (mm)	Increment (mm)
1	7.4 - 9.8	2.4	8.4	> 3.9
2	10.9 - 13.1	2.2	12.3	> 3.4
3	14.5 - 16.6	2.1	15.7	> 2.8
4	17.6 - 19.4	1.8	18.5	> 2.1
5	19.1 - 22.1	3.0	20.6	> 2.1
6	21.3 - 23.8	2.5	22.7	> 2.2
7	23.0 - 26.6	3.6	24.9	> 1.4
8	24.4 - 28.0	3.6	26.3	

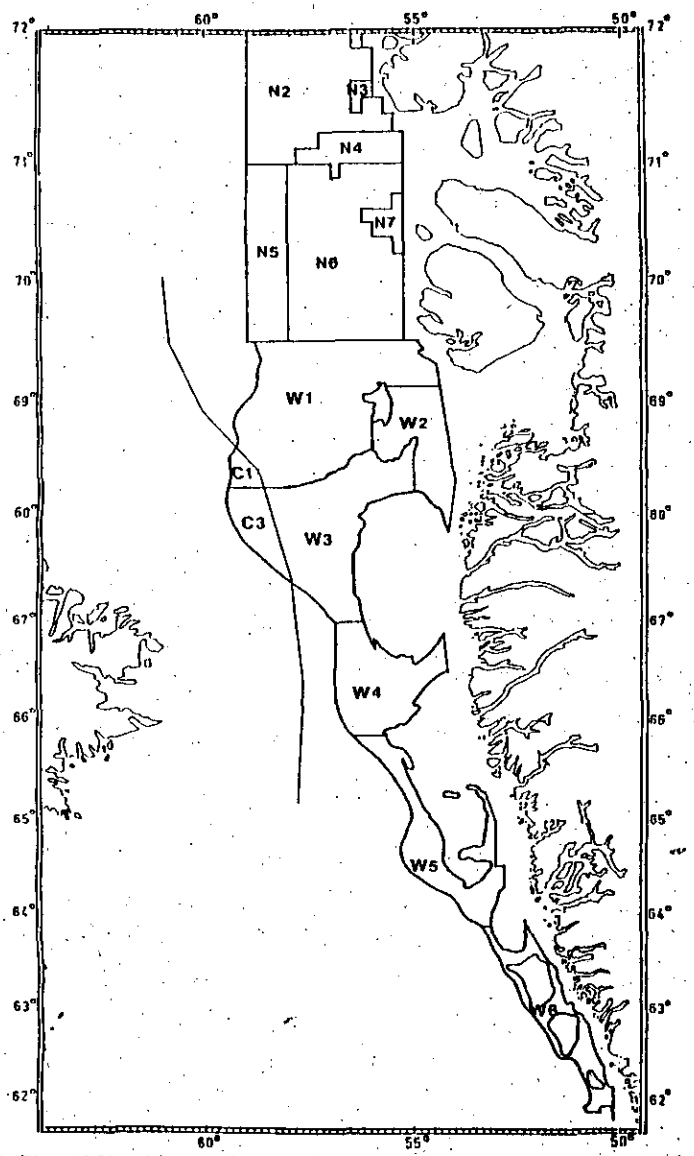

Figure 1. Stratification scheme for the West Greenland trawl survey in 1991, showing strata in the main areas in the Davis Strait. Stratum N1 is outside the map.

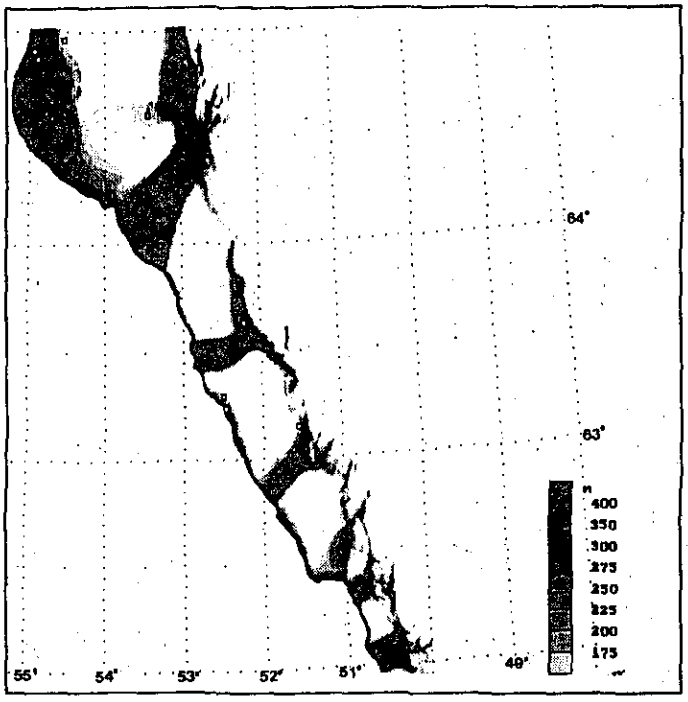

Figure 2a. Topographic map for the area 62°N-65°N with trawl stations in the shrimp survey in 1991.

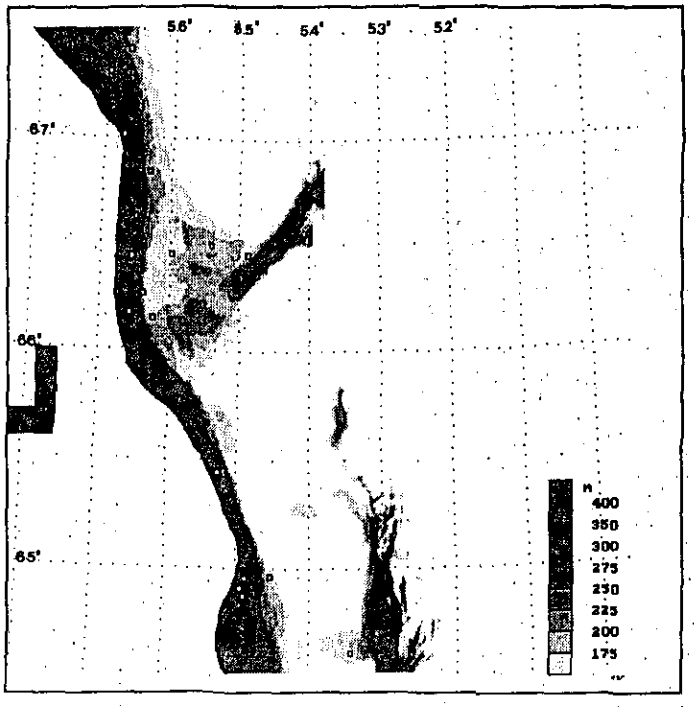

Figure 2b. Topographic map for the area 64°30'N-67°30'N with trawl stations in the shrimp survey in 1991.

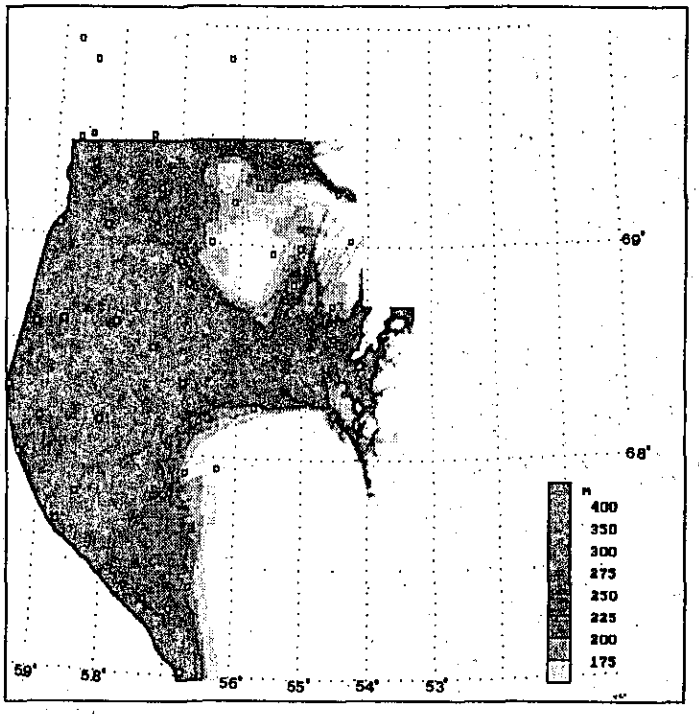

Figure 2c. Topographic map for the area 67°N-70°N with trawl stations in the shrimp survey in 1991.

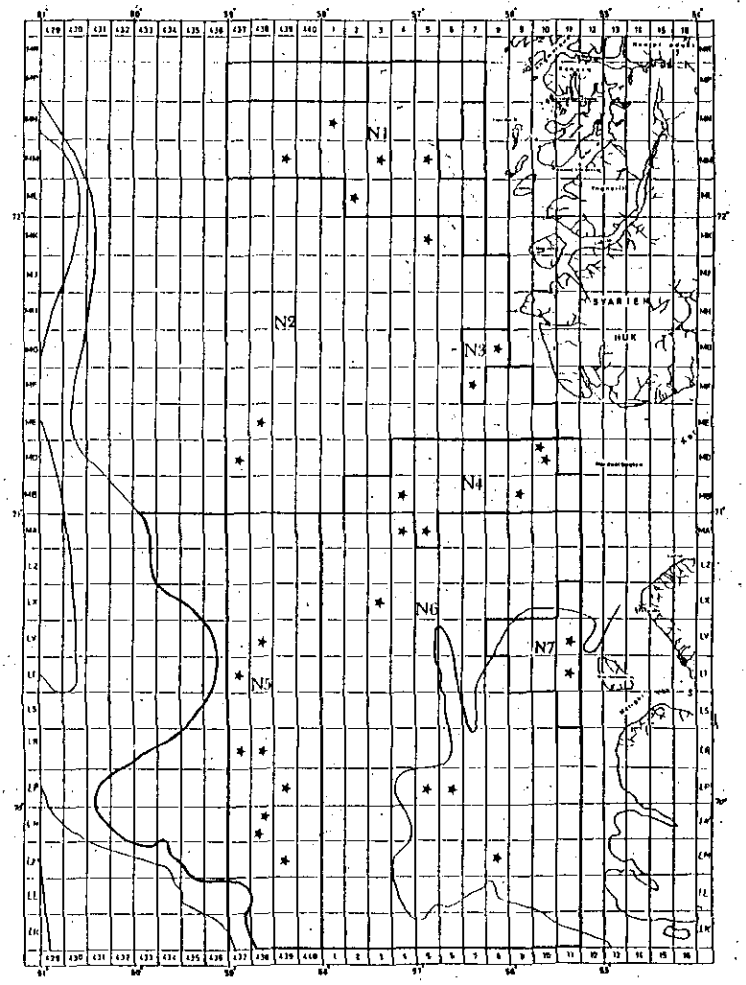

Figure 2d. Map of the area 69°30'N-72°30'N with stratum numbering and trawl stations in the shrimp survey 1991.

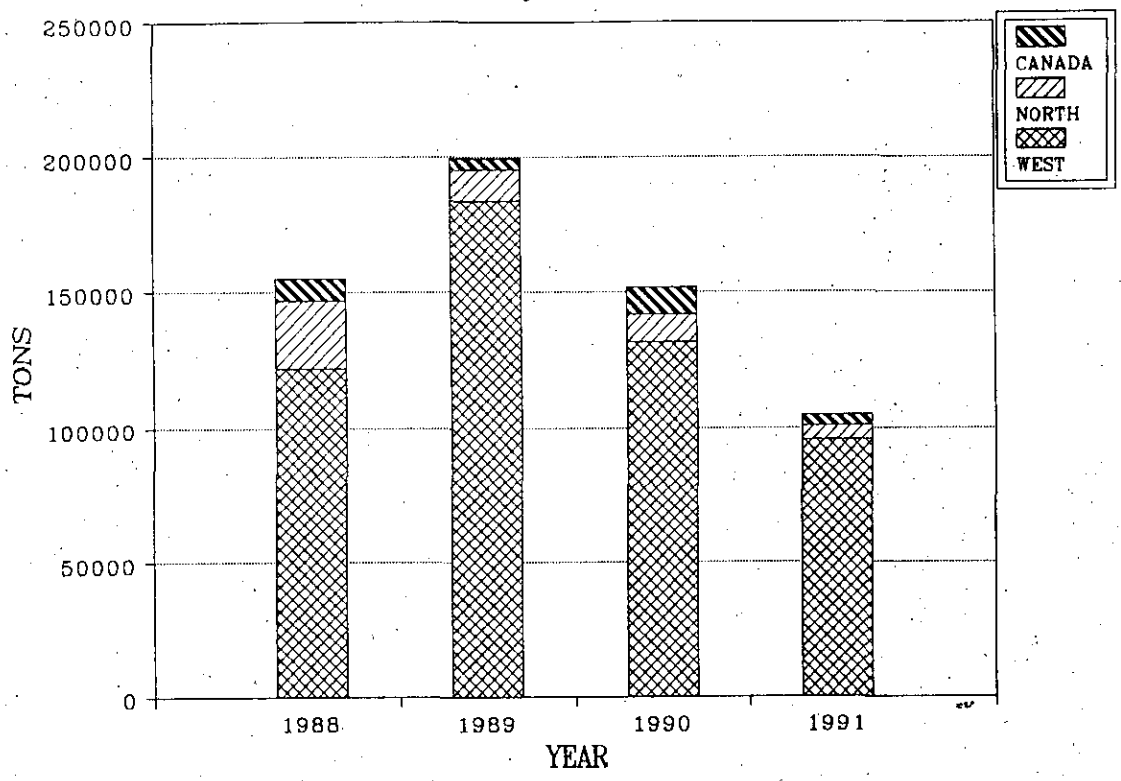

Figure 3. Estimated total biomass 1988-91 for the three main regions in the Davis Strait from trawl surveys.

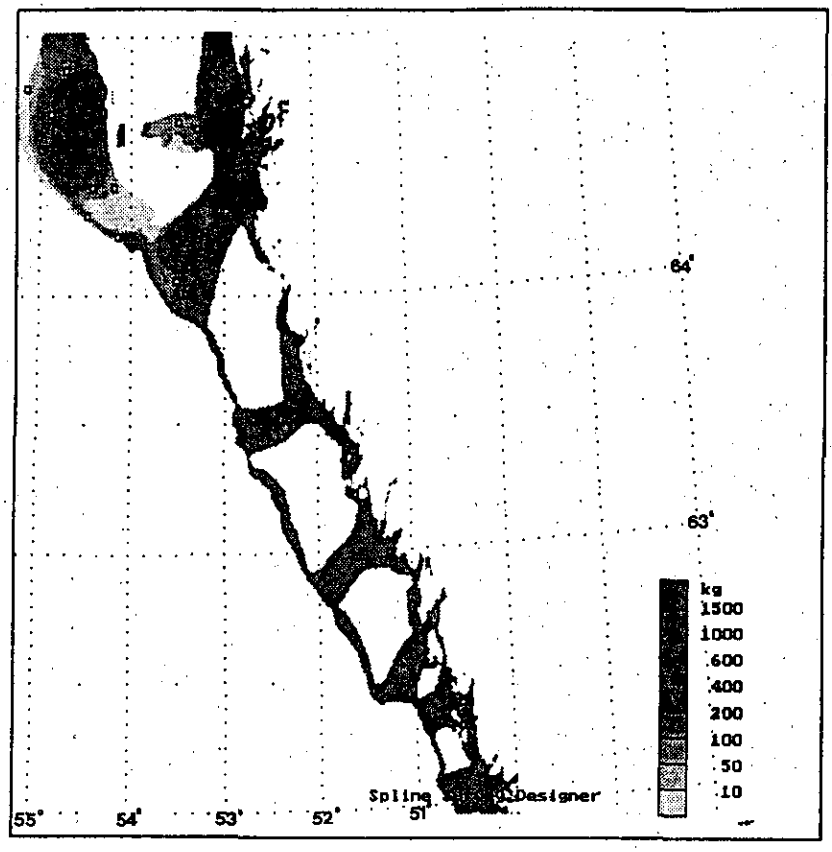

Figure 4a. Contour map with estimated shrimp densities 1988 for the area 62°N-65°N as calculated with the 'spline' method, based on trawl survey data from 1988. Sampling sites are also given.

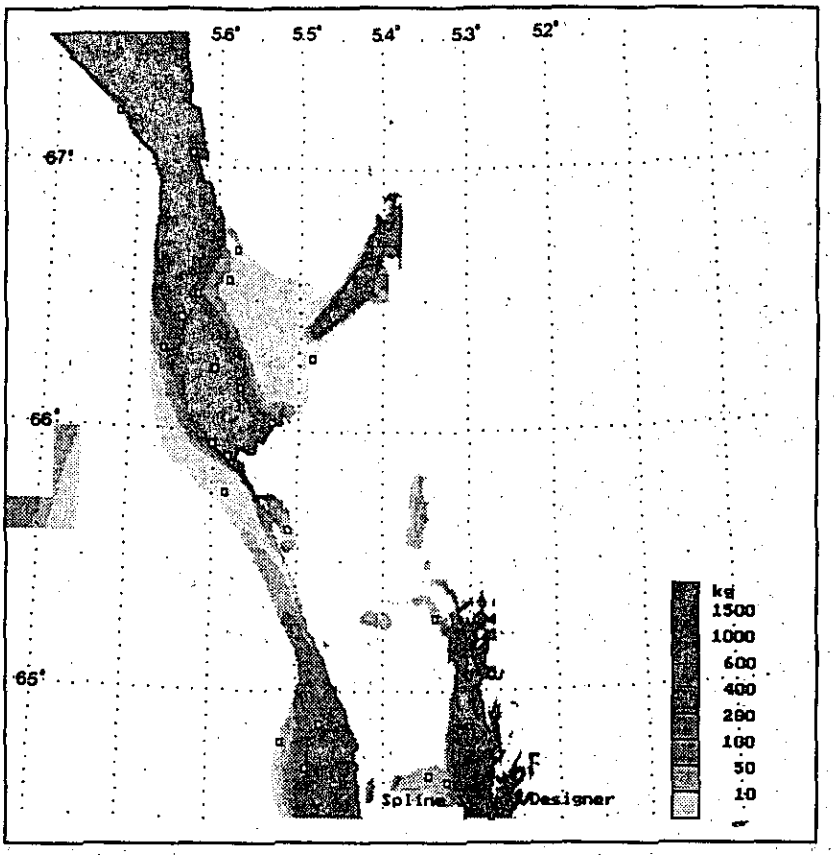

Figure 4b. Contour map with estimated shrimp densities 1988 for the area 64°30'N-67°30'N as calculated with the 'spline' method, based on trawl survey data from 1988. Sampling sites are also given.

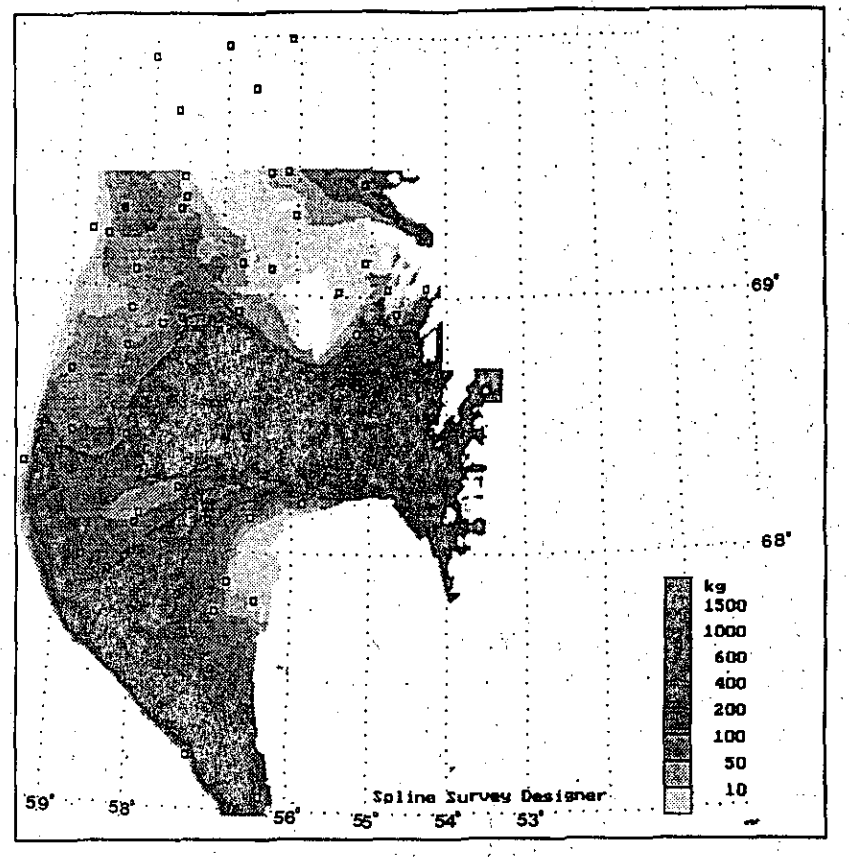

Figure 4c. Contour map with estimated shrimp densities 1988 for the area 67°N-70°N as calculated with the 'spline' method, based on trawl survey data from 1988. Sampling sites are also given.

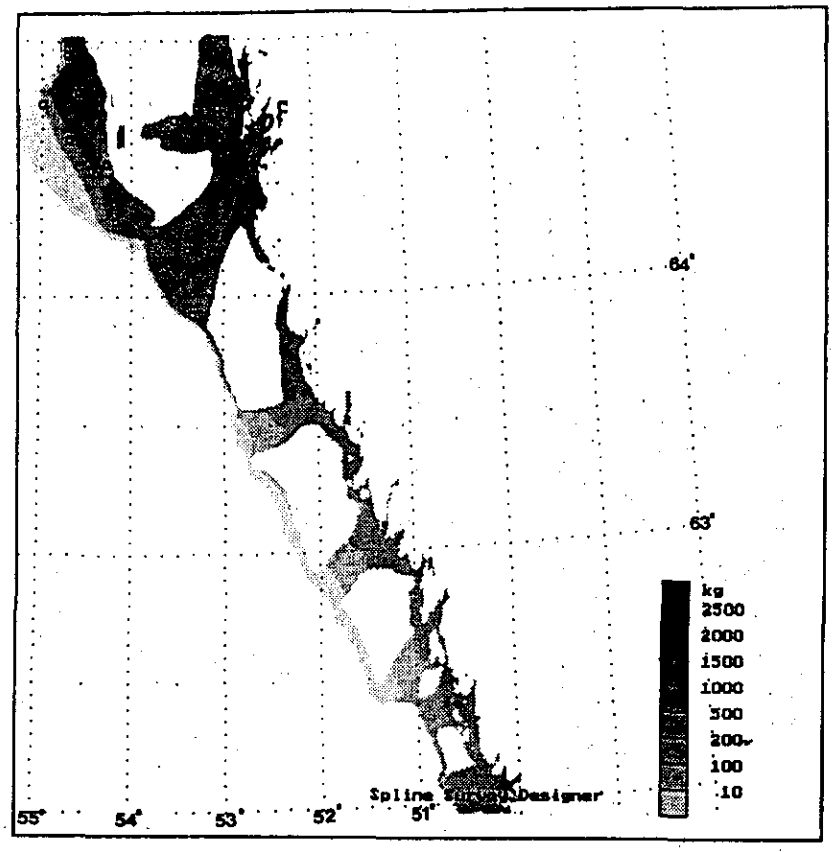

Figure 5a. Contour map with estimated shrimp densities 1989 for the area 62°N-65°N as calculated with the '*spline*' method, based on trawl survey data from 1989. Sampling sites are also given.

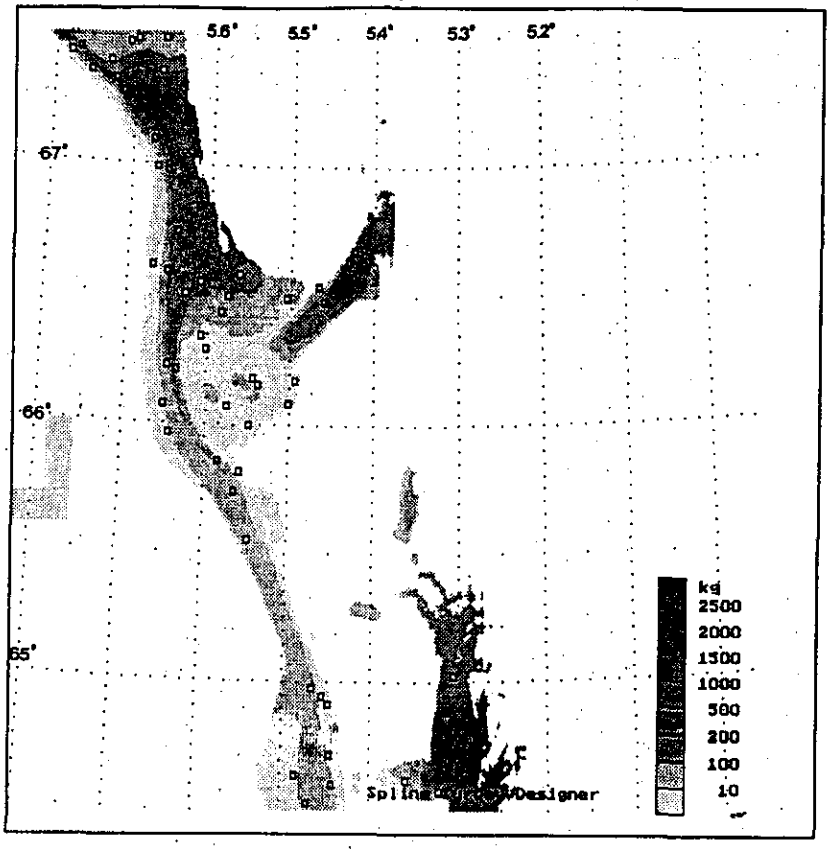

Figure 5b. Contour map with estimated shrimp densities 1989 for the area 64°30'N-67°30'N as calculated with the 'spline' method, based on trawl survey data from 1989. Sampling sites are also given.

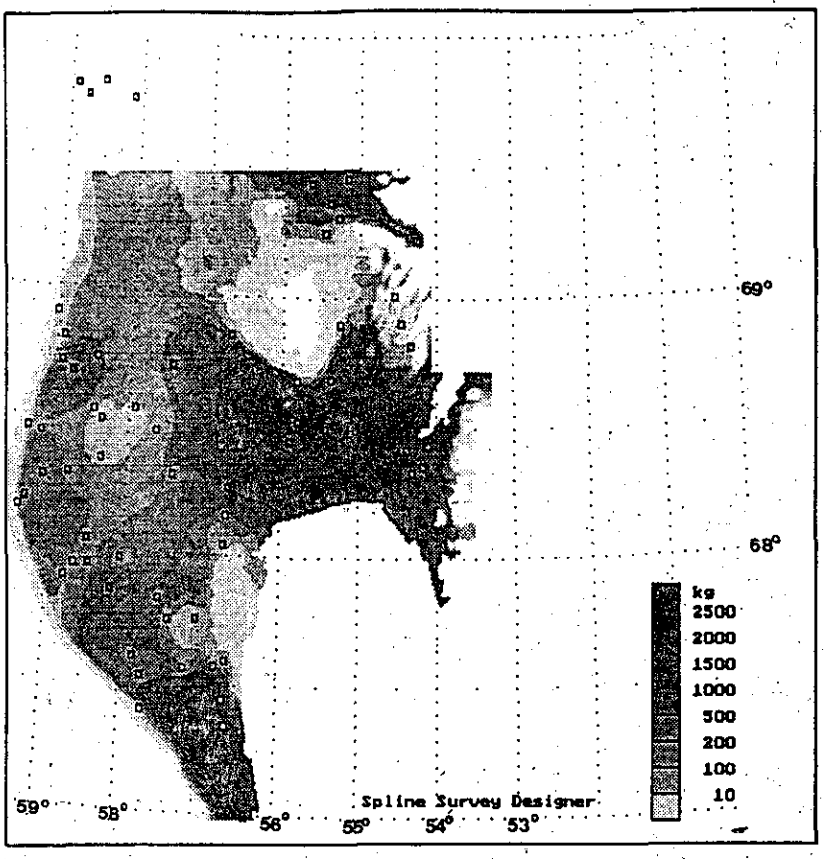

Figure 5c. Contour map with estimated shrimp densities 1989 for the area 67°N-70°N as calculated with the 'spline' method, based on trawl survey data from 1989. Sampling sites are also given.

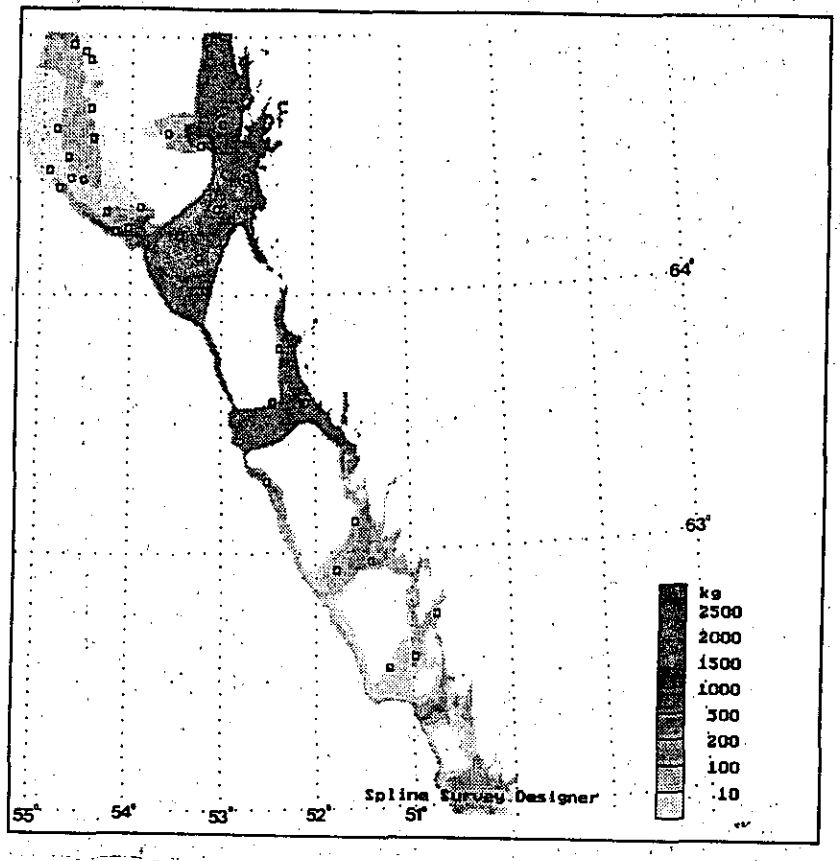

Figure 6a. Contour map with estimated shrimp densities 1990 for the area 62°N-65°N as calculated with the 'spline' method, based on trawl survey data from 1990. Sampling sites are also given.

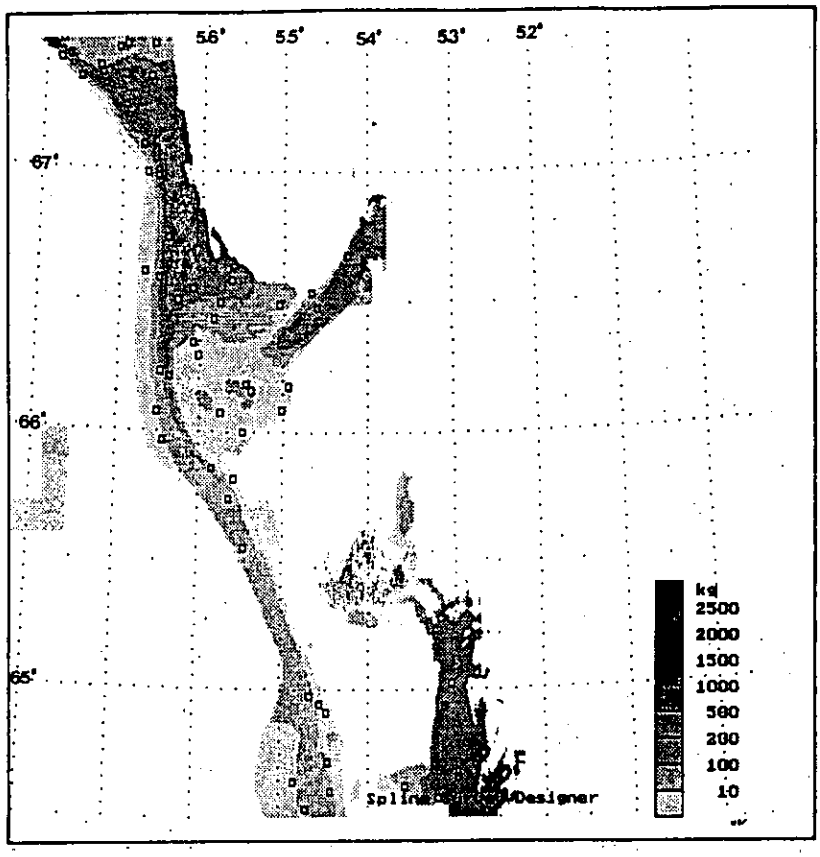

Figure 6b. Contour map with estimated shrimp densities 1990 for the area 64°30'N-67°30'N as calculated with the 'spline' method, based on trawl survey data from 1990. Sampling sites are also given.

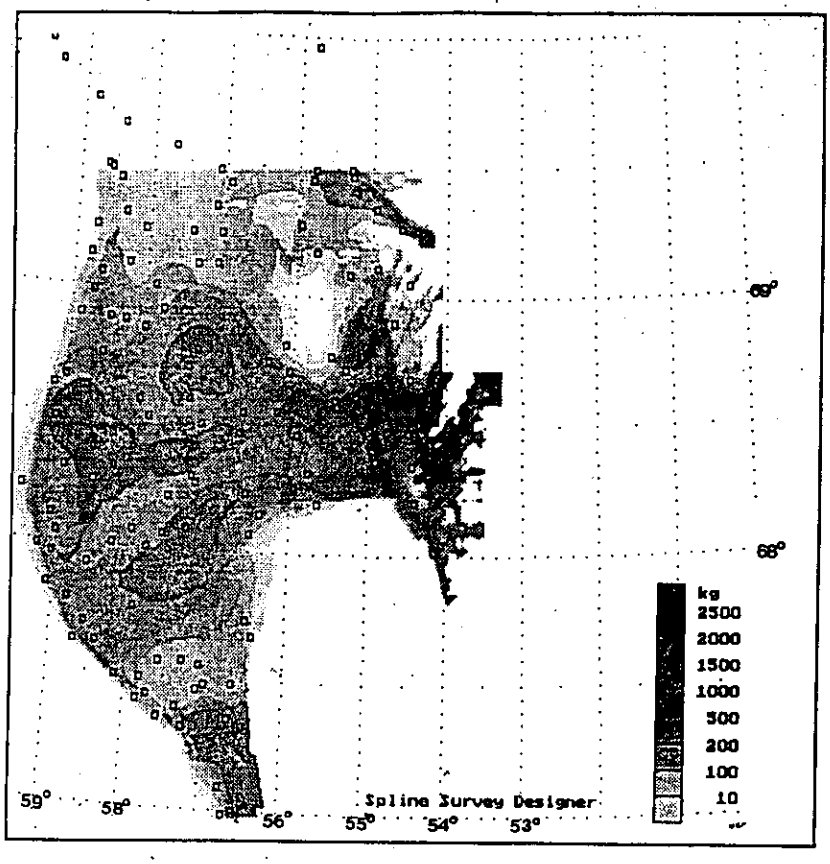

Figure 6c. Contour map with estimated shrimp densities 1990 for the area 67°N-70°N as calculated with the 'spline' method, based on trawl survey data from 1990. Sampling sites are also given.

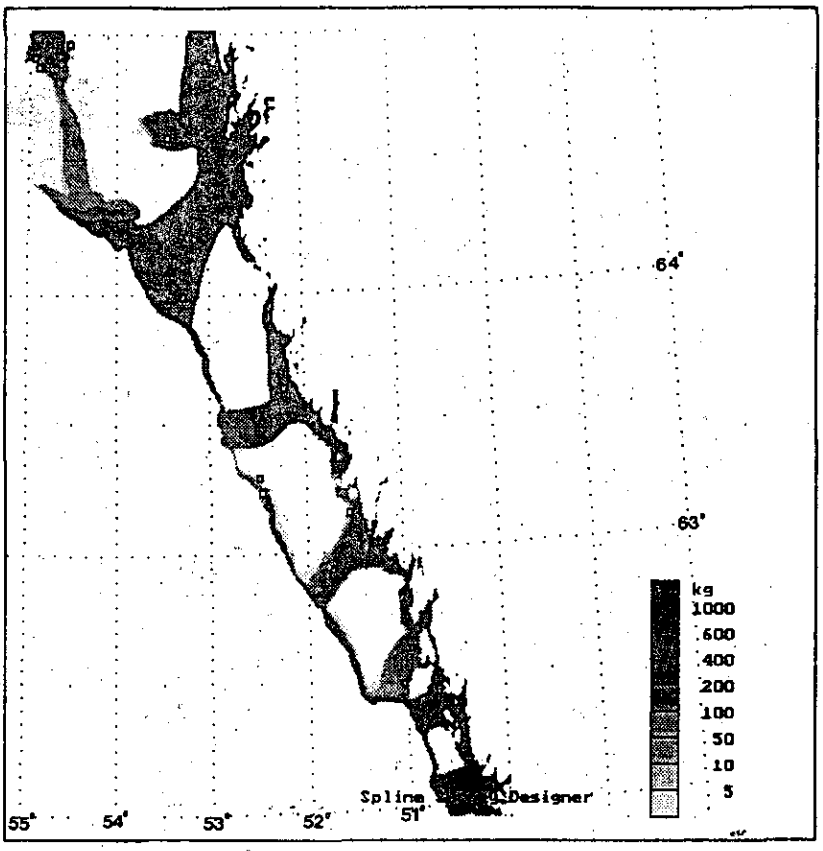

Figure 7a. Contour map with estimated shrimp densities 1991 for the area 62°N-65°N as calculated with the 'spline' method, based on trawl survey data from 1991. Sampling sites are also given.

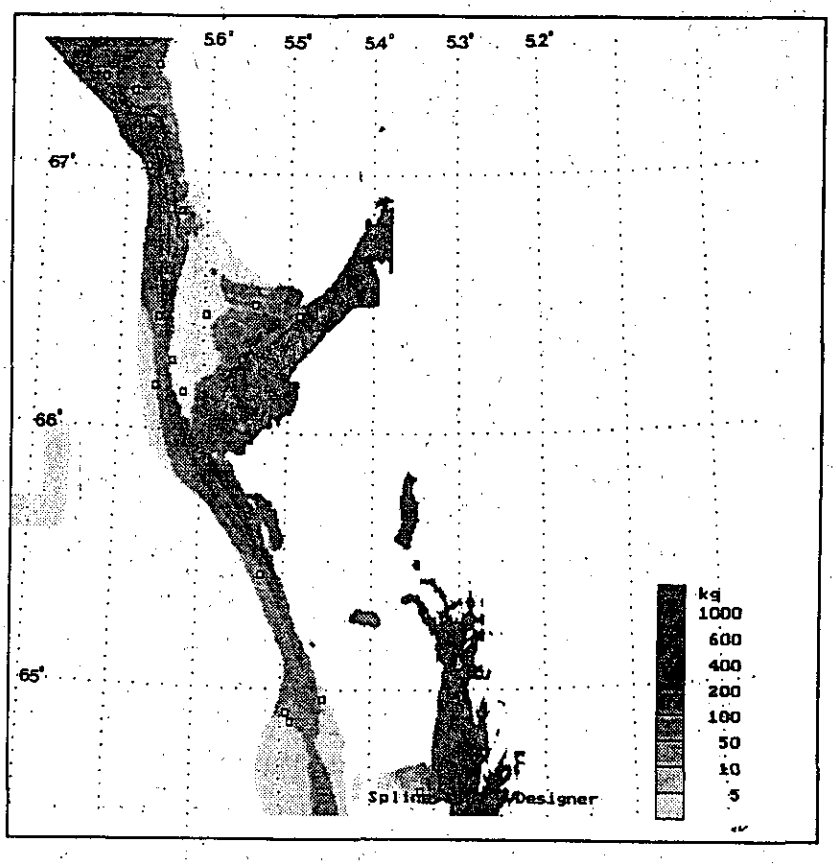

Figure 7b. Contour map with estimated shrimp densities 1991 for the area 64°30'N-67°30'N as calculated with the 'spline' method, based on trawl survey data from 1991. Sampling sites are also given.

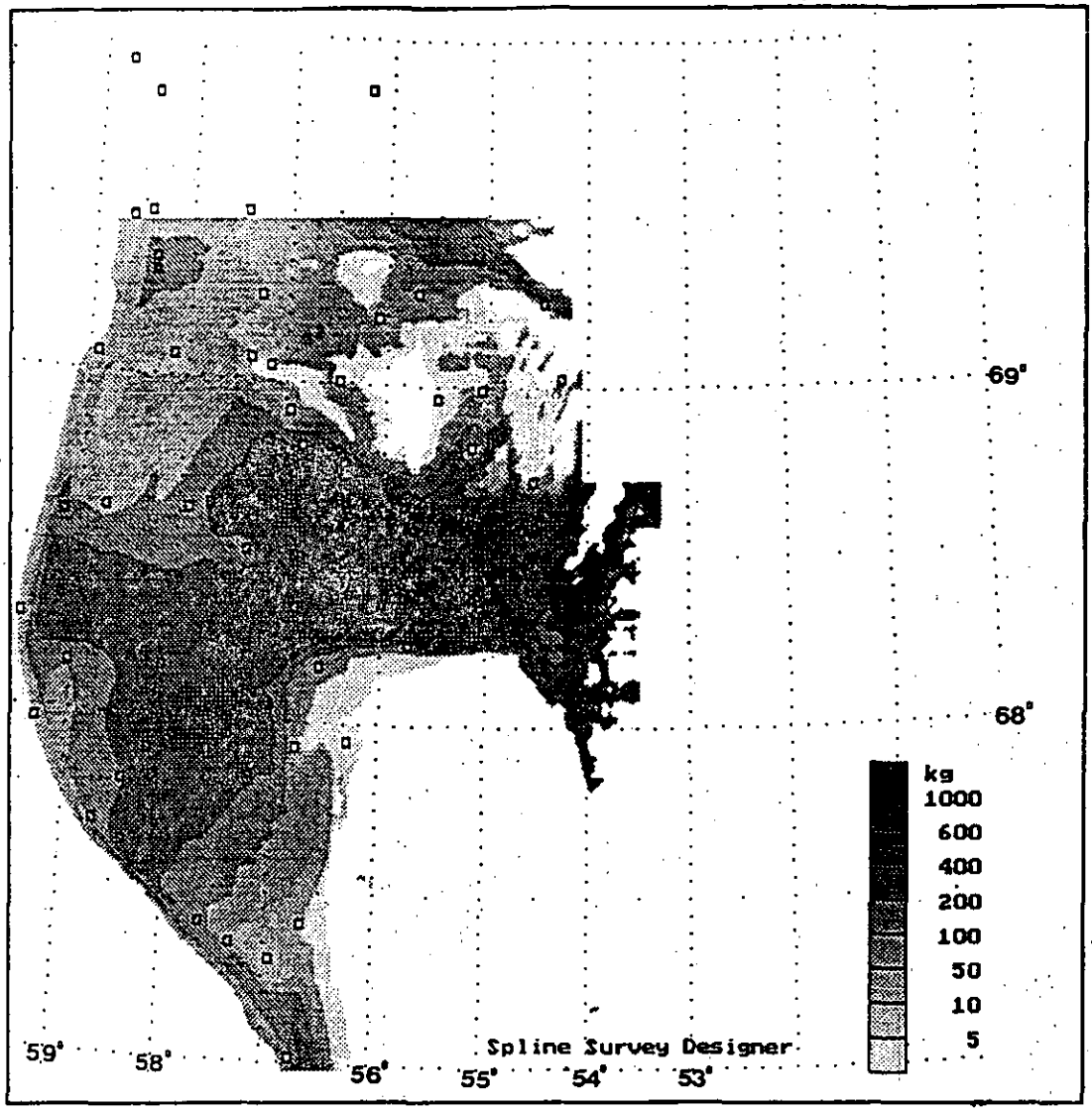

Figure 7c. Contour map with estimated shrimp densities 1991 for the area 67°N-70°N as calculated with the 'spline' method, based on trawl survey data from 1991. Sampling sites are also given.

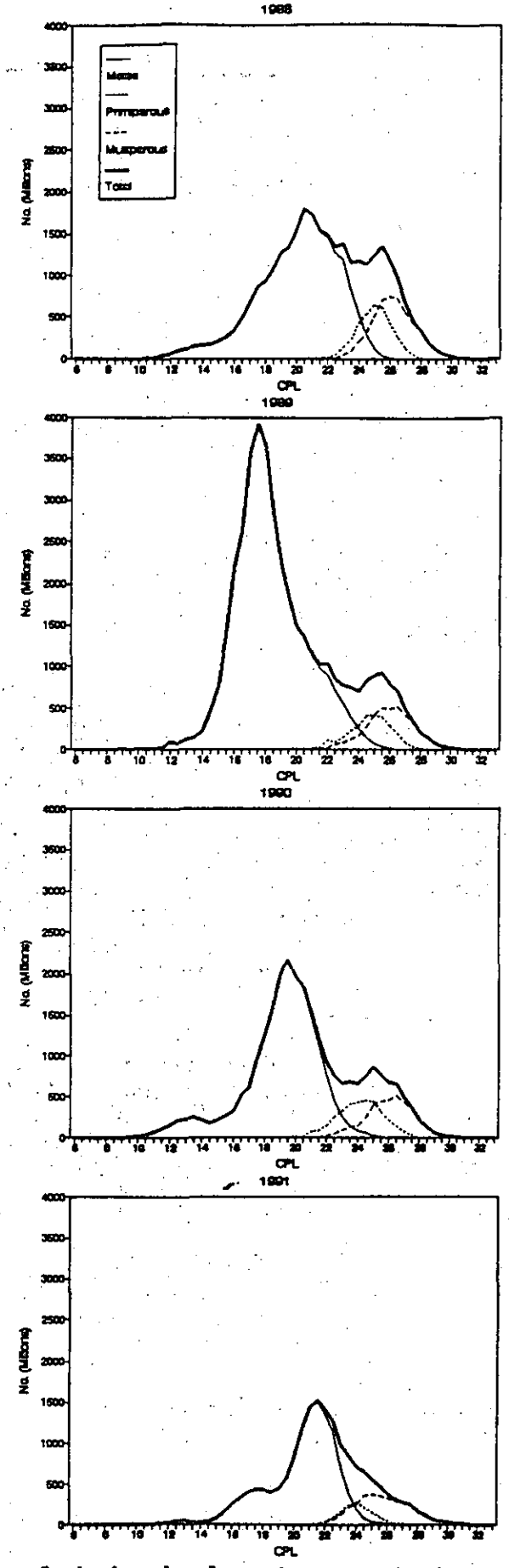

Figure 8. Numbers of shrimp by length group (CL) in the total survey area in 1988-91, based on pooling of samples weighted by catch and stratum areas.

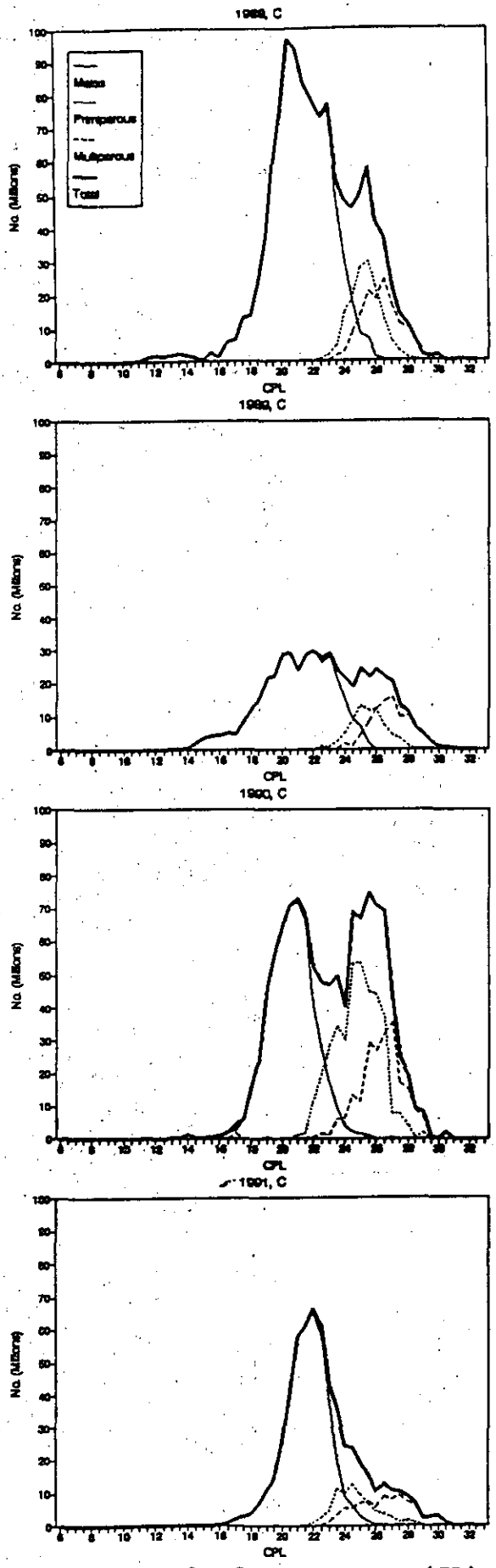

Figure 9a. Numbers of shrimp by length group (CL) in strata C1+C3 (see Fig. 1) in 1988-91, based on pooling of samples weighted by catch and stratum area.

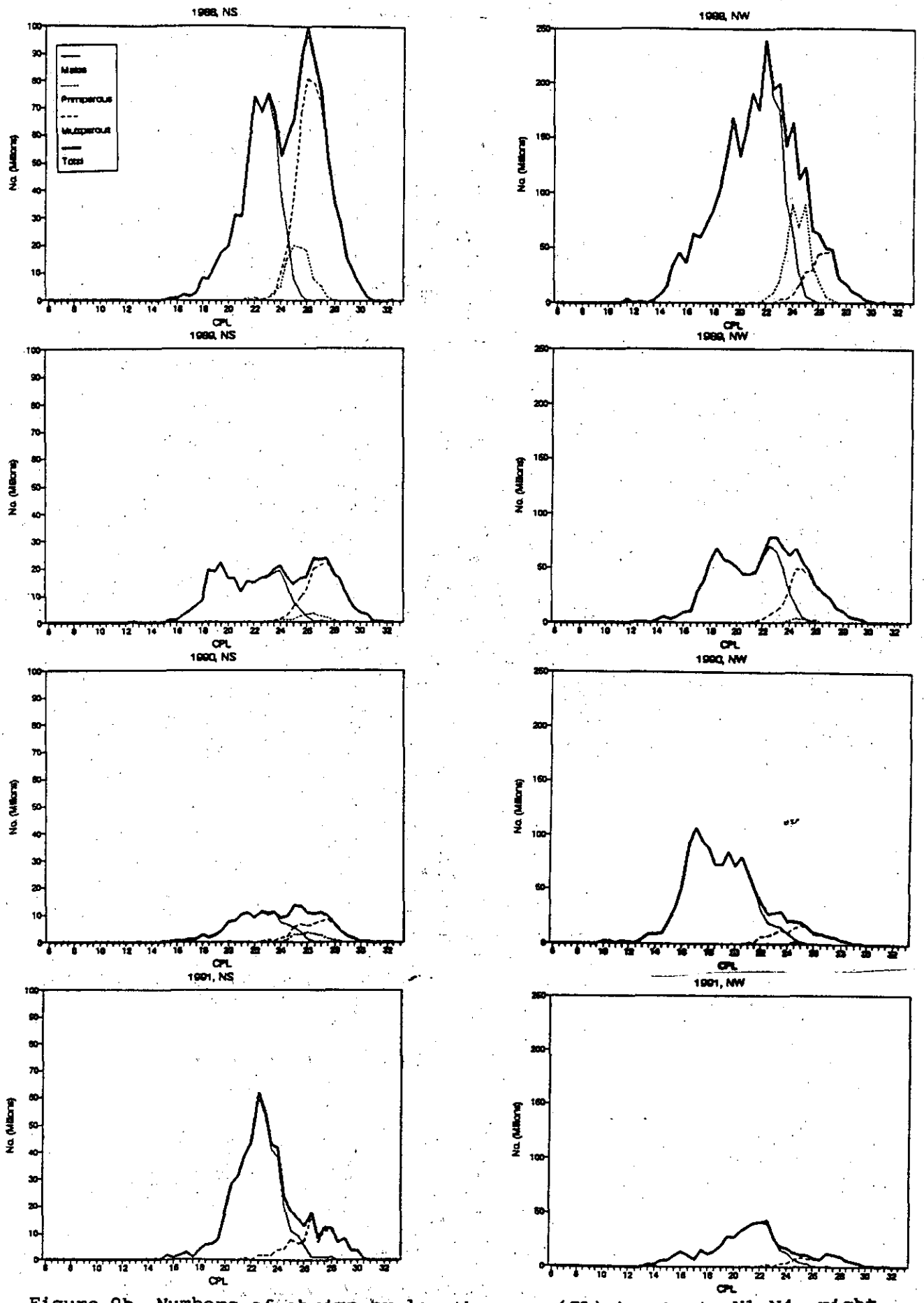

Figure 9b. Numbers of shrimp by length group (CL) in strata N1-N4, right column, and N5-N7, left column (see Fig. 1) in 1988-91, based on pooling of samples weighted by catch and stratum area.

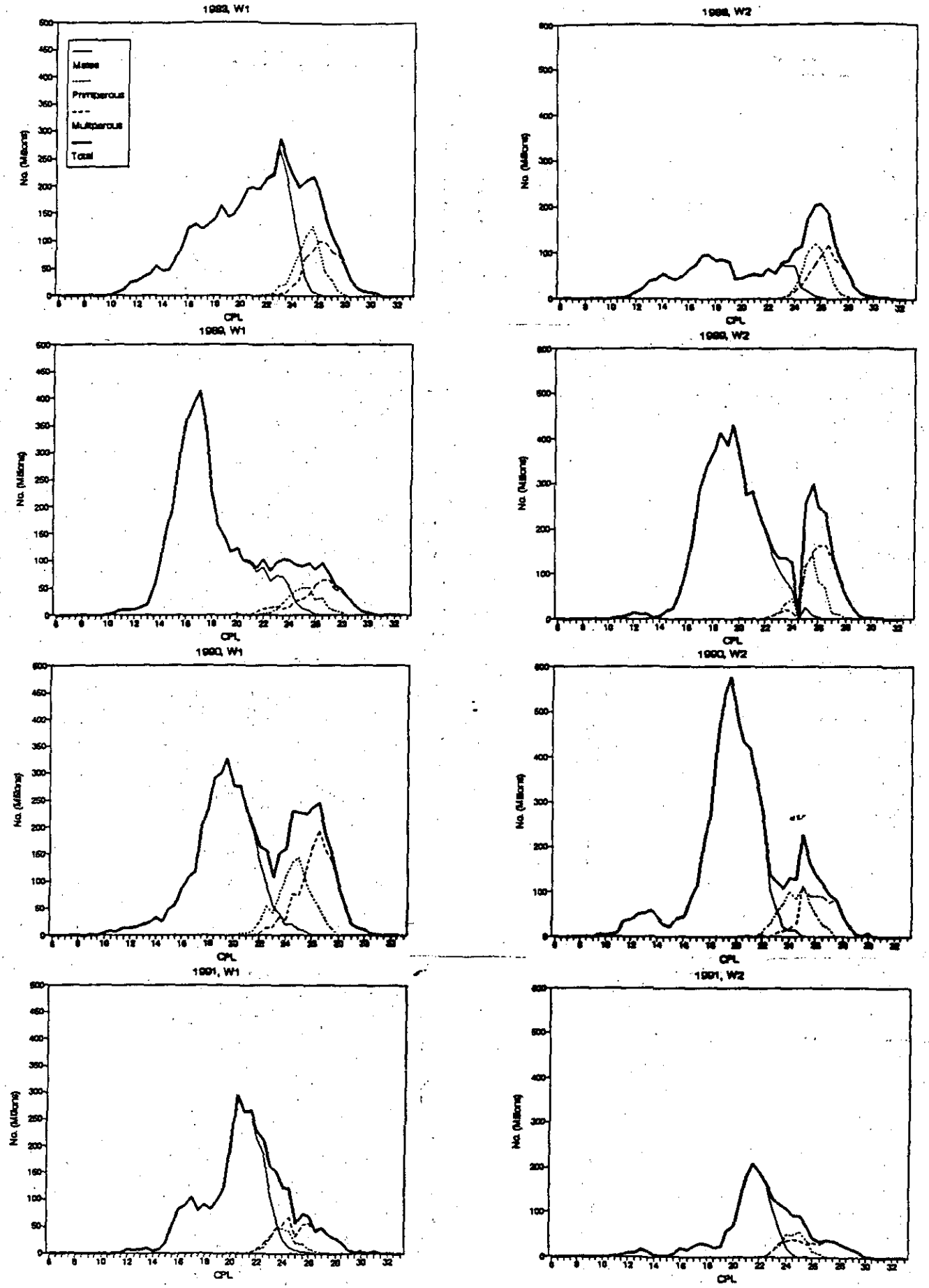

Figure 9c. Numbers of shrimp by length group (CL) in stratum W1, right column, and W2, left column (see Fig. 1) in 1988-91, based on pooling of samples weighted by catch and stratum area.

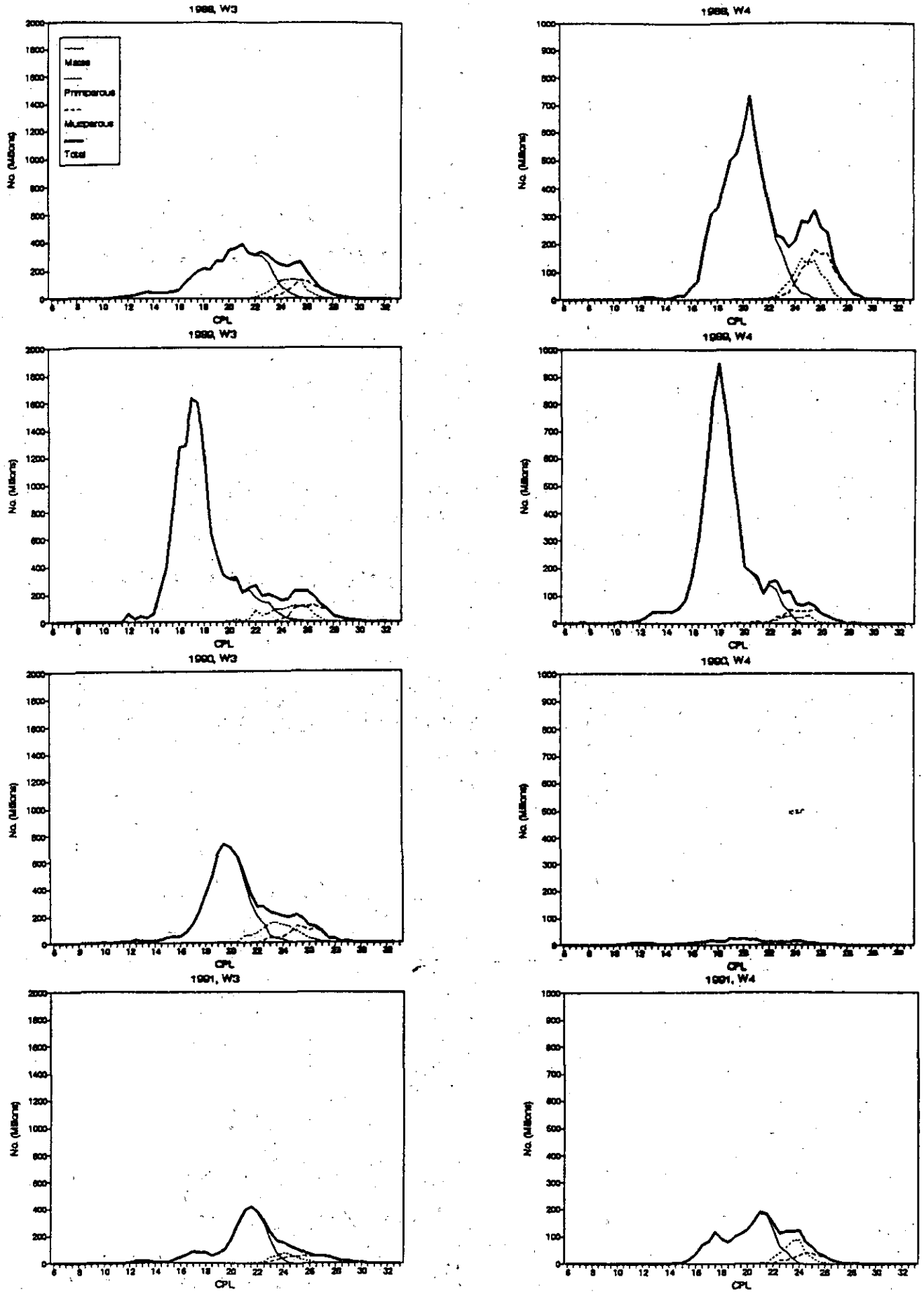

Figure 9d. Numbers of shrimp by length group (CL) in stratum W3, right column, and W4, left column (see Fig. 1) in 1988-91, based on pooling of samples weighted by catch and stratum area.

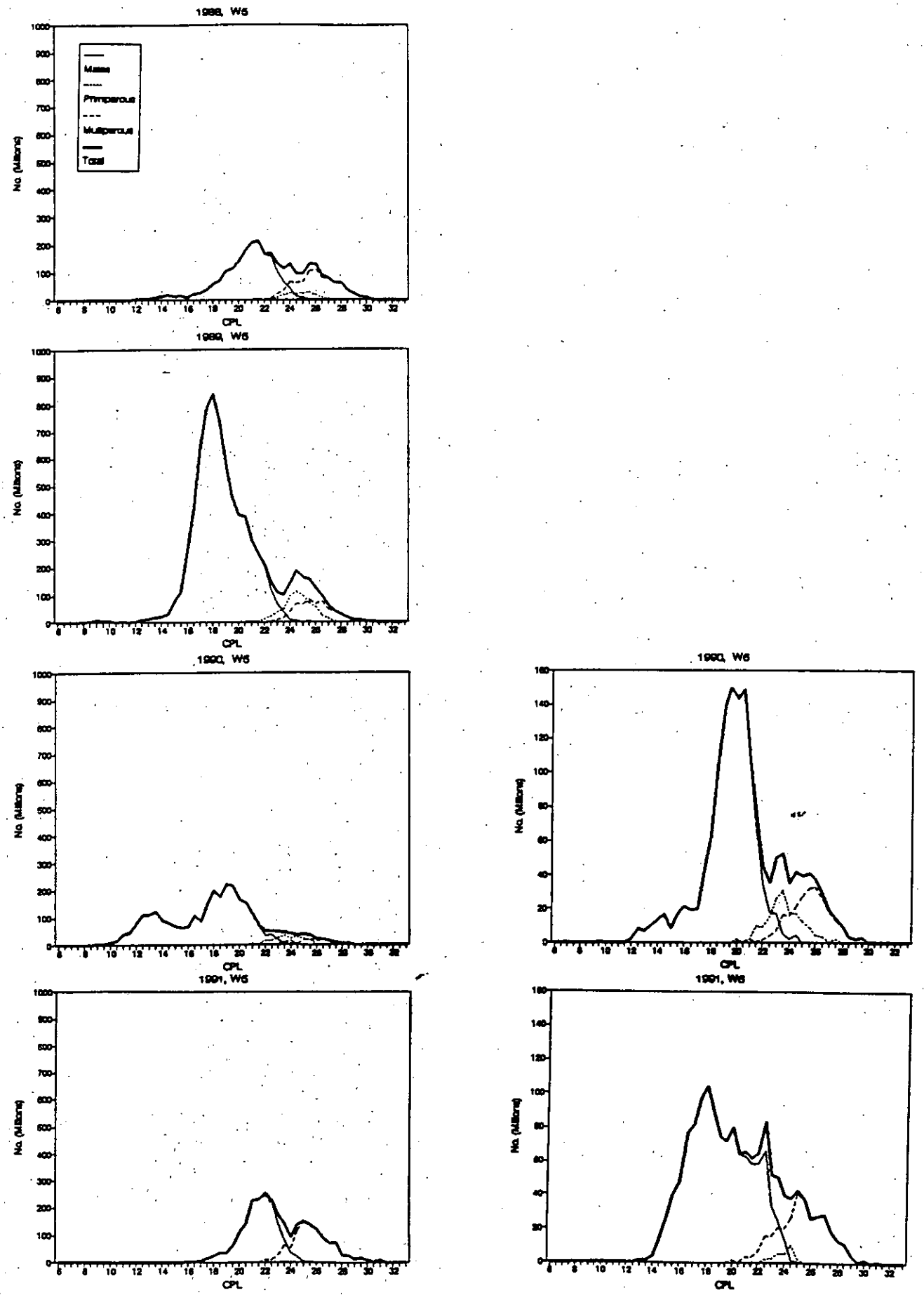

Figure 9e. Numbers of shrimp by length group (CL) in stratum W5, right column, and W6, left column (see Fig. 1) in 1988-91, based on pooling of samples weighted by catch and stratum area.

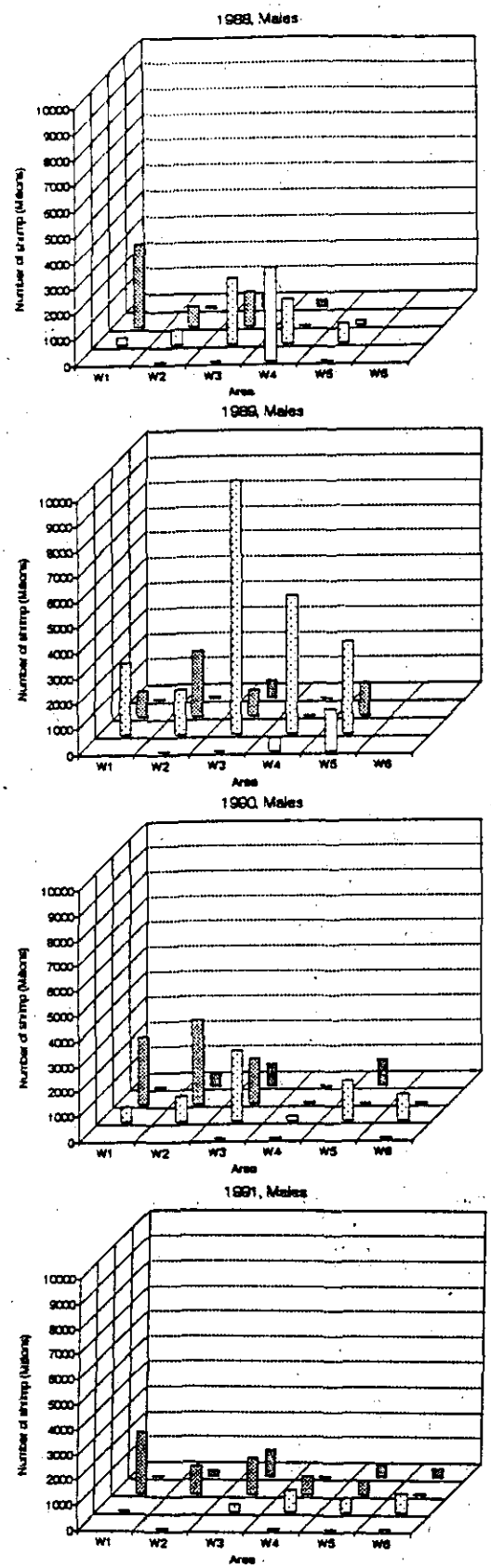

Figure 10a. Numbers of males by stratum and depth in 1988-91, based on pooling of samples (see text).

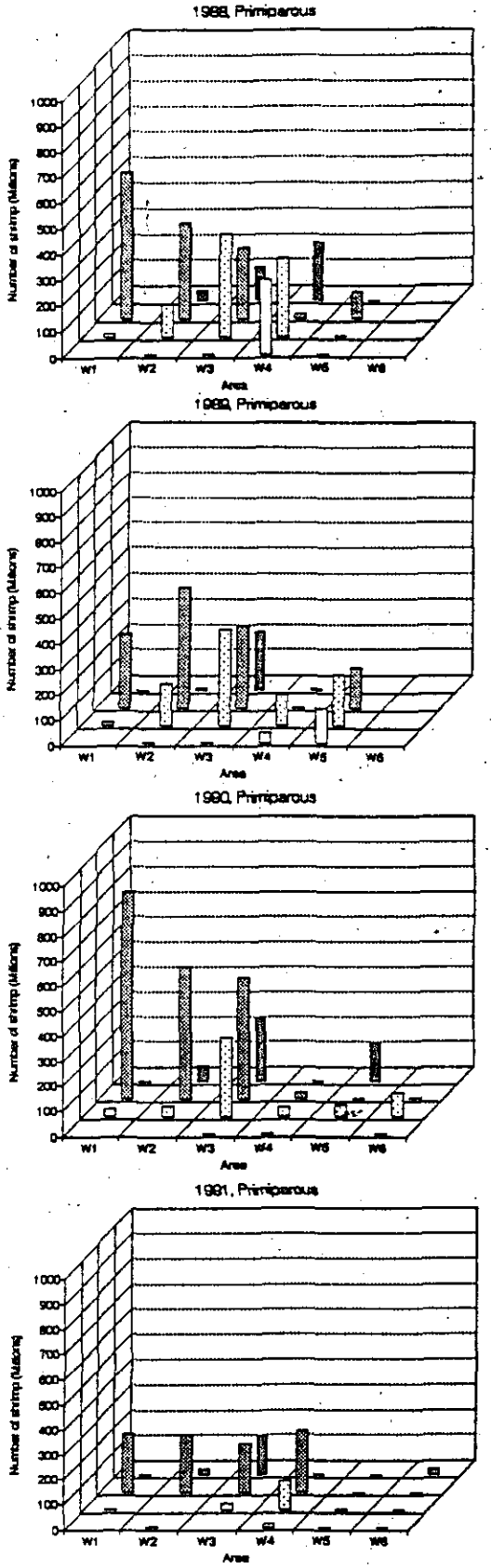

Figure 10b. Numbers of primiparous females by stratum and depth in 1988-91, based on pooling of samples (see text).

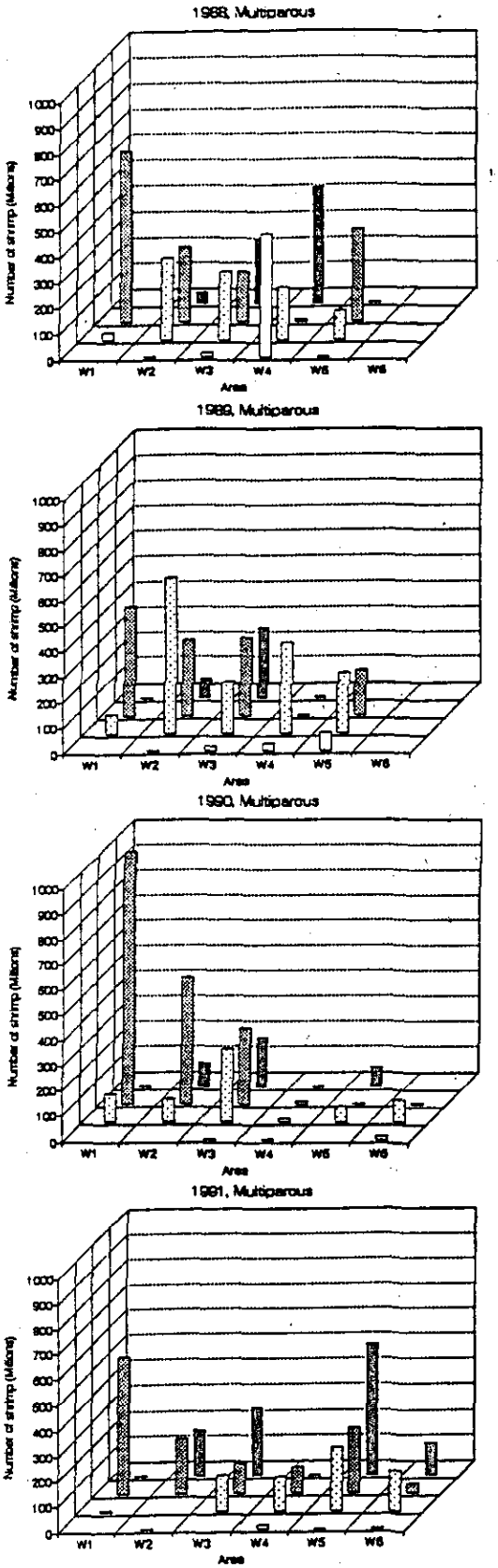

Figure 10c. Numbers of multiparous females by stratum and depth in 1988-91, based on pooling of samples (see text).

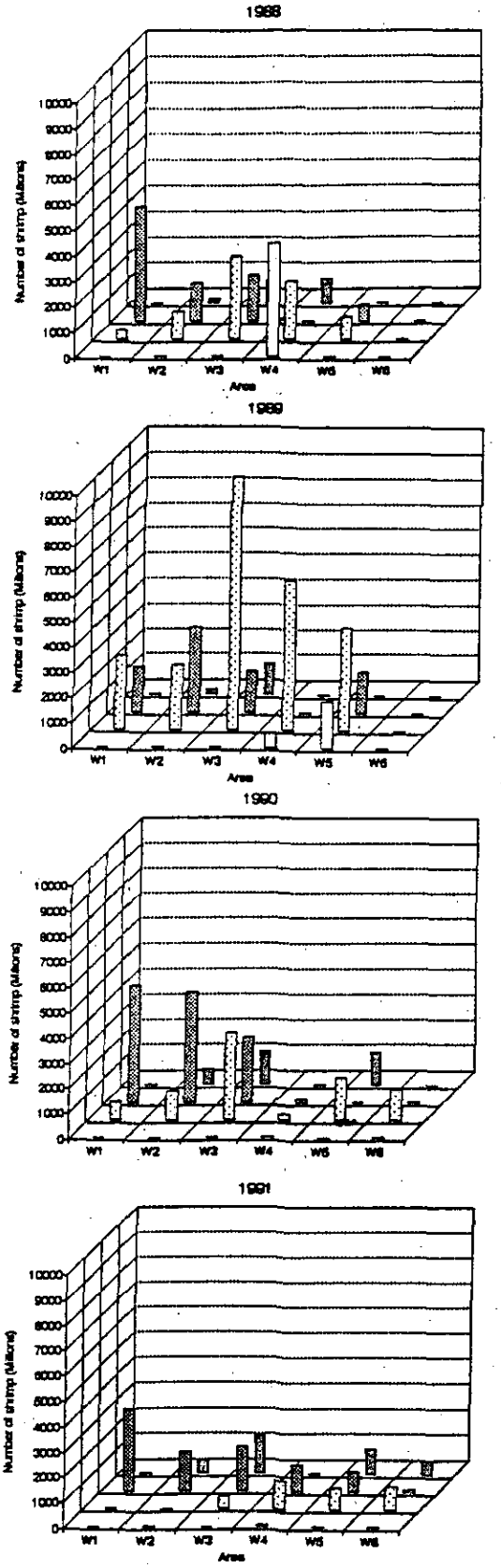

Figure 10d. Total numbers of shrimp by stratum and depth in 1988-91, based on pooling of samples (see text).