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Trawl Survey for Shrimp (*Pandalus borealis*) in Denmark Strait, 1995

by

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INTRODUCTION

Annual trawl surveys for estimating the shrimp stock biomass in Denmark Strait have been carried out since 1989 (except for 1991 and 1993). While the survey in 1989 covered the commercial fishery area only, later surveys were aimed to cover the total stock distribution area (Kanneworff & Lehmann, 1991).

All surveys were carried out in the September-October period because this period normally is the best to avoid severe problems with bad weather and ice cover. Although it is known that shrimp densities are lower at this time of the year - compared to the December-May period, where most of the commercial catches are taken - it is hoped that a time series of survey results will show that biomass estimates may be useful as indices of the status of the stock.

In 1989, 1990, and 1992 the surveys were based on the stratified-random technique. From 1994 a new sampling technique based on the Spline Survey Designer Software System (Stolyarenko, 1987; 1993) was introduced (Andersen *et al.*, 1994).

The Icelandic authorities kindly granted permission to carry out research in the Icelandic economic zone.

MATERIAL AND METHODS

The survey was performed with the 722 GRT trawler *Paamiut*, using a 3000/20 meshes *Skjervøy* shrimp trawl with bobbins gear and a 20 mm double-bag in the codend. Trawl doors were *Greenland Perfect*, size 370*270 cm. Trawl geometry was measured with *Scanmar* acoustic sensors mounted on the trawl doors, and a *Furuno* trawleye on the headrope.

Standard towing time was 60 minutes. Trawling was carried out in day-time (0800-1800 UTC) only, to minimize the influence of vertical migrations. Distance between the trawl doors was measured continuously during trawling, and the mean wing spread was calculated for each haul. Together with calculated trawling distance (using GPS positions at beginning and end of the haul) the mean wing spread was used to estimate a swept area for each haul.

The survey area (Fig. 1) covered the supposed main distribution area of the shrimp stock, i.e. the offshore area between 65°N and 68°N, bordered to the east by the 600 m depth contour.

Based on information from the earlier surveys a sampling scheme was constructed by means of the Spline Survey Designer Software System (Stolyarenko, loc. cit.). The number of sampling sites (50) was chosen as about 2/3 of the

expected total number of stations that could be visited during the allocated survey period. After completing the primary sampling program (in which two stations were omitted due to extreme bottom conditions), the rest of the stations were selected haul by haul based on information from all the hauls taken during the survey (including 25 hauls from the area south of 65°N, taken during a trawl survey immediately before the present).

The total catch was sorted and weighed by species. From each haul a sample of shrimp was taken from the cod-end. Shrimps were sorted by sexual characteristics, and oblique carapace length was measured to the nearest 0.1 mm.

The shrimp catch per standard trawling area (0.11 km^2, roughly corresponding to a haul duration of 60 minutes) was calculated as input value for the Spline computer programme.

RESULTS AND DISCUSSION

Biomass

In total 72 stations were fished, of which 48 belonged to the primary sampling scheme. Fig. 2 shows the distribution of the shrimp biomass as calculated from the basic sampling scheme. The total biomass estimate from the **first phase** was 7215 tons. It is obvious that further sampling is needed to delineate the observed concentrations around 65°45'N 32°W and 66°30'N 28°30'W. Further information on the large areas in the west is also desirable but less important due to assumed low shrimp density. In the southwestern corner of the survey area higher densities of shrimp - produced by the model as the result of catches in trawl stations to the south of the survey area - should also be investigated.

In the **second phase** of the survey one station was placed in the southwestern corner of the survey area, reducing shrimp densities here somewhat (Fig. 3). Further sampling in this area might have been appropriate, but time did not allow.

Four stations were selected around the concentration at 65°45'N 32°W (based on one haul in the first phase) and resulted in a better definition of this concentration (Fig. 3).

It was decided to concentrate the sampling during the rest of the survey time in the area between 66°15'N and 67°N and 28°W and 31°15'W. During the first phase of the survey the commercial fishery took place in the area around the concentration found at 66°30'N 28°30'W. When returning to the area in the second phase, the commercial fishery had moved northwest to around 66°45'N 29°30'W. In agreement with this the sampling of the second phase resulted in a reduction of the first concentration and the occurrence of a new high density area where the commercial fishery now took place. This raises the question of the stability of shrimp concentrations over the time (about two weeks) between the first phase and the second phase survey in this area: The high density area found in the first phase is - although based on only one station and thus poorly defined - hardly an artifact, as the commercial fishery took place here at that time. Whether the significant reduction of this concentration observed in the second phase is a result of the commercial fishery, due to a dispersion of shrimp, or a combination of both is difficult to decide. On the other hand, the new concentration found in the second phase in the area to where the commercial fishery had moved, may have existed already during the first phase. It may not have been observed by neither the fishery nor the survey. Or it may be the result of a new concentration or movement of already existing concentrations. Under all circumstances this change in abundance may cause a reevaluation of the survey design, e.g. with an immediate delimitation of observed high density areas during the first phase.

After completion of the second phase of the survey a biomass estimate of **4558 tons** was calculated for the total area. This estimate is of the same order of magnitude as the estimate from 1989, and higher than the estimates from 1990, 1992, and 1994:

Year	Biomass estimate
1989	4879
1990	1860
1992	1044
1994	3800
1995	4558

The spline method was discussed in detail in Andersen *et al.* (1994).

Stock composition

Overall length frequency distributions for the surveys prior to 1994 were constructed by pooling of samples after weighting with catch and stratum area (Carlsson and Kanneworff, 1993). Although the spline method was used in 1994 and 1995, overall length frequency distributions were constructed based on the stratum areas used in the earlier surveys (Fig. 4 and Table 2 - strata used in earlier surveys are shown in Fig. 6), and the total number of shrimp estimated over the years in the traditional survey area was calculated (in millions):

	males	females	total
1989	231.0	135.4	366.3
1990	142.6	85.7	228.3
1992	163.6	45.3	209.0
1994	264.4	90.4	354.8
1995	315.7	109.9	425.6

The higher biomass estimate found in 1995 compared to 1990, 1992, and 1994 is the result of an increasing number of both male and female shrimp. The 1995 biomass estimate is at the same order of magnitude as the 1989 estimate, but the stock composition is different with a significantly higher total number of shrimp based on a major increase in number of males, while the number of females decreased slightly.

The male component in 1989 consisted of a broad range of year classes ranging from 18 to 32 mm CL (Fig. 4). Since then the male distribution has been dominated by fewer year classes, and the right side of the distribution has been cut off, indicating that sex change is taking place at a smaller size (Fig. 4 and 5). In 1995 the male component is largely dominated by two groups, one around 24 mm CL and another one - which is responsible for the increase in total number of males compared to 1994 - around 21.5 mm CL.

The female component is reduced continously over the first three years. Inside the female group there is a change towards smaller size, very large females (32 - 36 mm CL) are almost absent since 1992, while females smaller than 28 mm CL are becoming more numerous, confirming the earlier sex change as indicated by the change in largest male size. In 1989 the female component was dominated by a peak at 30.5 mm CL. In 1995 the dominating peak is at 28.5 mm CL, but several groups of smaller females are indicated.

In 1994 there were only minor indications of recruitment of the large groups of males occurring in 1995 at 21.5 and 24 mm CL. Migrations into the survey area may therefore be assumed, and it is still not known where the smaller shrimp of the Denmark Strait stock should be found.

Overall length frequency distributions from the fishing areas (strata Q2, Q3, Q4, and Q5) south of the traditional fishing area are shown in Fig. 5. A wide range of size groups of both males and females occur, but shrimp smaller than 20 mm CL are almost absent also in these areas.

Fig. 6 shows the calculated numbers of shrimp per stratum in 1995, and Fig.s 7 and 8 show the density in numbers of male and female shrimp as calculated by the Spline Survey Designer program, based on shrimp samples from north of 65°N. Both male and female shrimp are most abundant in the central area west of the midline to Icelandic waters (males in strata 14, 15, 16, 22 and 23) and females in strata 15, 16 and 23). Compared to earlier years shrimp are much more concentrated in 1995.

CONCLUSION

The biomass of shrimp in Denmark Strait is estimated to be close to the level of 1989 and higher than the estimates in 1990, 1992, and 1994.

A new sampling design, based on the Spline Survey Designer Software System, was used in 1994 and again in 1995, dividing the survey into two phases with a primary sampling scheme in phase one and additional stations in phase two, selected to improve the delimitation of shrimp concentrations. Due to possible changes in shrimp abundance caused by the commercial fishery and/or movement of shrimp during the survey period, the survey design should be redefined in the future, so that high abundance areas can be explored and delimitated immediately after they are found.

Overall length frequency distributions show that the increase in biomass in 1995 is based primarily on dominant groups of males at 21.5 and 24 mm CL and females at 28.5 mm CL. The shift in the female group towards smaller sizes and the absence of the largest male group as found in all succesive surveys when compared to 1989 is still obvious, indicating that a change in size at sex change took place between 1989 and 1990.

Absence of the smaller male and juvenile shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown. Smaller shrimp were also absent in samples from the fishing areas south of 65°N.

Highest abundance of both male and female shrimp were found in the central area west of the midline to Icelandic waters. Shrimp were more concentrated than in earlier years.

REFERENCES

Andersen, M., D.M. Carlsson, and P. Kanneworff, 1994. Trawl survey for shrimp (*Pandalus borealis*) in Denmark Strait, 1994. *NAFO SCR Doc.* 94/90. Ser.No. N2477.

Carlsson, D.M. and P. Kanneworff, 1993. Stratified-random trawl survey for Shrimp (*Pandalus borealis*) in Denmark Strait in 1992. *NAFO SCR Doc.* 93/66. Ser.No. N2250.

Kanneworff, P. and K. M. Lehmann, 1991. Report on a stratified-random trawl survey for shrimp (*Pandalus borealis*) in ICES division XIVb in 1990. *NAFO SCR Doc.* 91/52. Ser.No. N1935.

Stolyarenko, D.A., 1987. The spline approximation method and survey design using interaction with a microcomputer: Spline Survey Designer Software System. *ICES C.M.* K:29.

Stolyarenko, D.A., 1993. Spline Survey Designer Software System. The geographic information system for fisheries surveys (for the IBM PC and compatibles). D.A. Stolyarenko.

Table 1. List of stations in the shrimp survey north of 65°N in Denmark Strait, 1995. Catches are given in kg.

Station ID	Area code	Depth	Tr-time	SHR	COD	GHL	RED	MIX	TOTAL
95PA0080001	707 JX118	453.0	67	0	2	0	4	18	25
95PA0080002	712 JZ116	311.0	61	1	0	0	1	772	774
95PA0080003	714 KA119	423.0	60	0	0	0	0	32	33
95PA0080004	721 KE119	318.5	60	140	3	0	1	111	254
95PA0080005	725 KF120	321.0	60	8	0	0	0	230	238
95PA0080006	724 KF123	352.5	60	6	0	1	0	881	888
95PA0080007	727 KF125	482.5	62	0	0	1	0	20	22
95PA0080008	732 KH126	550.5	61	0	0	2	0	6	8
95PA0080009	733 KH124	380.5	60	0	0	2	0	28	31
95PA0080010	735 KJ121	363.5	60	2	0	1	0	42	45
95PA0080011	738 KL122	345.0	60	0	0	0	0	34	35
95PA0080012	743 KN123	256.5	60	0	0	0	0	18	18
95PA0080013	742 KN120	267.5	60	0	0	0	0	155	155
95PA0080014	744 KN118	296.5	60	0	0	0	0	70	70
95PA0080015	748 KP116	274.0	60	0	0	0	0	16	16
95PA0080016	749 KS113	245.5	60	0	0	0	0	9	9
95PA0080017	750 KS106	379.5	61	0	0	3	1	44	48
95PA0080018	746 KP107	436.0	60	7	0	2	1	4	15
95PA0080019	745 KN110	392.5	60	0	0	0	0	0	1
95PA0080020	747 KP112	294.5	60	0	0	0	0	0	0
95PA0080021	737 KL110	440.5	60	2	0	1	0	1	4
95PA0080022	741 KM109	444.0	60	2	0	0	0	1	3
95PA0080023	739 KL106	580.5	60	1	0	1	0	1	3
95PA0080024	736 KJ109	541.5	60	0	0	0	0	2	2
95PA0080025	734 KH111	395.5	60	7	0	5	0	2	15
95PA0080026	728 KG110	492.0	48	4	0	1	0	3	9
95PA0080027	726 KF111	408.0	60	11	0	13	0	3	27
95PA0080028	731 KH118	323.0	53	3	0	0	0	18	20
95PA0080029	730 KG115	347.0	60	14	0	7	0	8	29
95PA0080030	719 KD114	307.5	60	20	0	0	0	57	77
95PA0080031	718 KD116	289.5	60	37	0	1	0	70	108
95PA0080032	720 KD111	472.5	61	26	0	9	0	20	55
95PA0080033	716 KB109	504.5	60	6	0	3	0	5	15
95PA0080034	713 KA113	301.5	60	0	0	0	0	3652	3652
95PA0080035	708 JX111	468.5	60	4	0	8	0	32	45
95PA0080036	703 JS106	337.5	60	0	10	0	3	8	21
95PA0080037	706 JV105	271.5	60	23	0	0	3	1271	1297
95PA0080038	709 JX106	346.5	60	1	0	0	0	130	131
95PA0080039	717 KB104	320.5	60	0	0	4	0	1	5
95PA0080040	723 KF102	336.0	60	0	0	0	0	1	1
95PA0080041	729 KG099	235.0	49	0	0	0	0	1	1
95PA0080042	722 KE098	354.5	60	0	0	0	0	1	1
95PA0080043	711 JZ097	278.5	60	0	0	0	0	4	4
95PA0080044	704 JS101	290.0	60	0	0	3	13	255	271
95PA0080045	702 JR098	315.5	60	0	0	1	3	29	33
95PA0080046	705 JS096	243.5	60	0	0	0	1	1238	1240
95PA0080047	701 JP095	248.5	60	0	0	1	362	629	993
95PA0080048	751 JN090	212.5	60	0	0	0	8	60	68
95PA0080049	710 JX100	326.0	60	0	0	2	1	3	7
95PA0080050	752 JZ103	266.5	60	2	0	0	3	1248	1253
95PA0080051	753 JT103	264.5	60	0	0	0	1	216	216
95PA0080052	754 JV106	315.0	30	1	0	1	1	336	340
95PA0080053	755 JV107	369.0	60	0	0	0	1	27	27
95PA0080054	756 KB111	426.0	60	10	0	6	0	5	20
95PA0080055	757 KE112	367.5	60	8	0	2	0	3	13
95PA0080056	758 KE110	492.0	60	35	0	8	0	5	48
95PA0080057	759 KE107	432.0	60	0	0	2	0	1	3
95PA0080058	760 KH114	265.0	60	0	0	0	0	102	103
95PA0080059	761 KG113	322.0	60	84	0	0	1	32	117
95PA0080060	762 KF115	307.5	60	36	0	0	0	14	50
95PA0080061	763 KE116	318.0	60	31	0	0	0	4	35
95PA0080062	764 KE118	330.0	60	15	0	0	0	5	19
95PA0080063	765 KG113	326.0	60	56	0	1	0	17	74
95PA0080064	766 KF113	284.5	60	18	0	1	1	16	36
95PA0080065	767 KG116	352.0	60	41	0	7	0	53	101
95PA0080066	768 KF115	331.0	60	44	1	4	8	51	108
95PA0080067	769 KF114	325.0	60	302	1	1	1	27	331
95PA0080068	770 KE120	313.0	61	23	0	0	0	49	72
95PA0080069	771 KD120	348.0	60	3	0	0	0	331	334
95PA0080070	772 KD119	318.0	60	2	0	0	0	35	38
95PA0080071	773 KB118	293.0	60	2	0	0	0	989	991
95PA0080072	774 KE119	329.5	60	1	0	2	0	37	40

Table 2. Number of shrimp (thousands) per length group (CL) in total biomass estimate north of 65°N, based on pooling of samples weighted by catch and stratum area.

CL	Males	Prim.fem.	Mul.fem.	Total
10.0	21	0	0	21
10.5	41	0	0	41
11.0	13	0	0	13
11.5	66	0	0	66
12.0	101	0	0	101
12.5	279	0	0	279
13.0	258	0	0	258
13.5	288	0	0	288
14.0	358	0	0	358
14.5	337	0	0	337
15.0	890	0	0	890
15.5	996	0	0	996
16.0	1119	0	0	1119
16.5	2102	0	54	2155
17.0	2165	0	8	2173
17.5	2409	0	0	2409
18.0	2827	0	0	2827
18.5	5358	102	126	5586
19.0	7986	0	17	8003
19.5	9069	34	21	9123
20.0	13109	31	34	13174
20.5	15243	14	45	15302
21.0	15914	102	220	16236
21.5	18346	33	214	18593
22.0	18140	11	181	18333
22.5	17185	37	652	17873
23.0	18708	44	1315	20067
23.5	22623	50	1391	24064
24.0	22157	61	2236	24454
24.5	21886	0	2181	24066
25.0	23410	4	3105	26519
25.5	19249	45	2841	22136
26.0	18456	4	4148	22608
26.5	14749	4	5315	20068
27.0	8578	4	7694	16276
27.5	5802	33	8439	14274
28.0	2580	0	9131	11711
28.5	1840	0	12002	13842
29.0	557	0	10557	11115
29.5	296	0	8576	8872
30.0	45	37	8326	8409
30.5	21	0	6418	6439
31.0	0	0	4894	4894
31.5	33	0	3472	3505
32.0	30	0	2145	2175
32.5	0	102	1912	2015
33.0	16	0	727	743
33.5	0	0	450	450
34.0	0	0	174	174
34.5	0	0	131	131
35.0	0	0	43	43
35.5	0	0	0	0
36.0	0	0	0	0
36.5	0	0	0	0
Total	315657	753	109196	425606

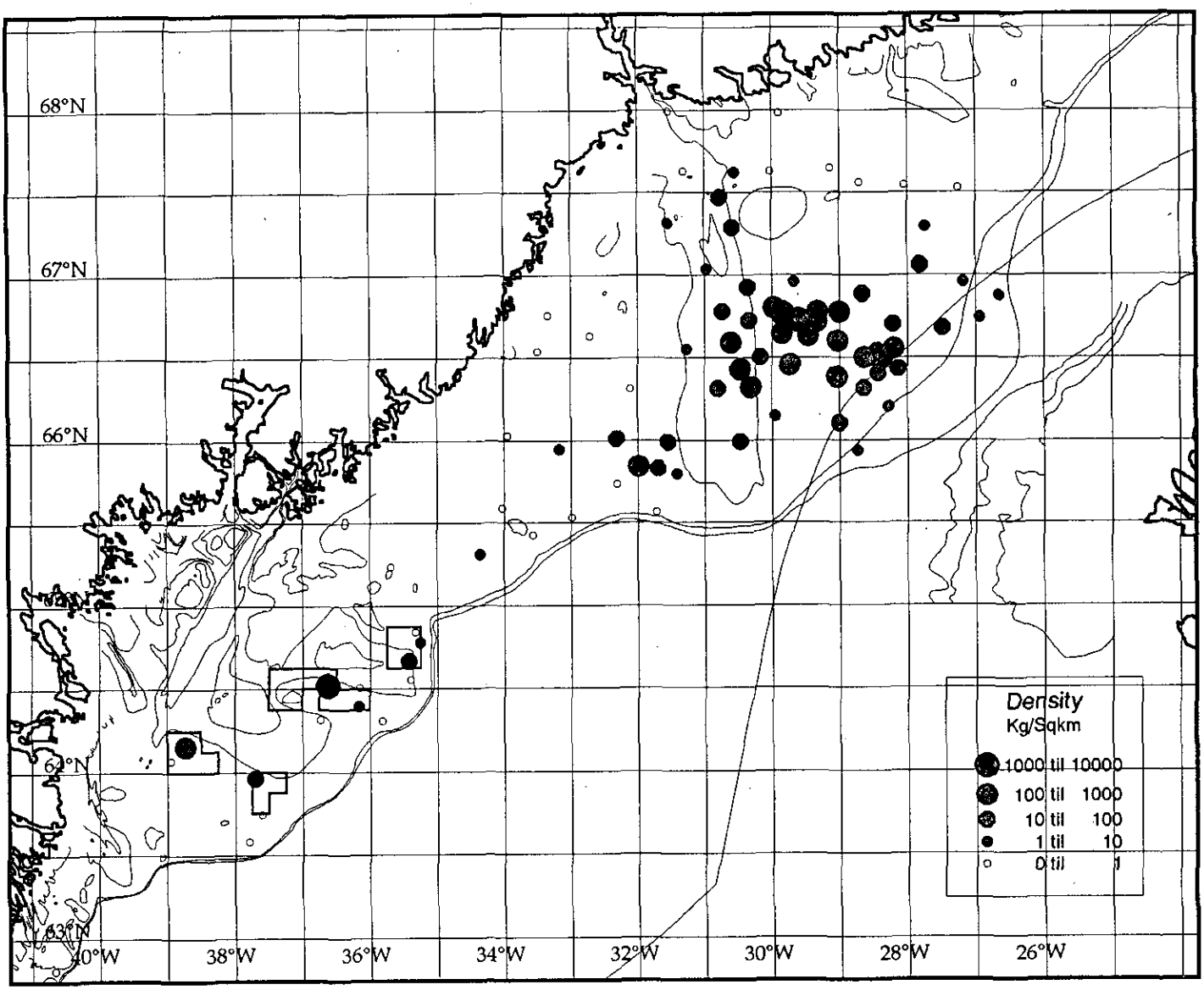

Figure 1. Map of the survey area (north of 65°N) and the area of the preceeding survey (south of 65°N) in Denmark Strait, with sampling sites and catch of shrimp (per km^2). Strata with commercial fishery south of 65°N are indicated.

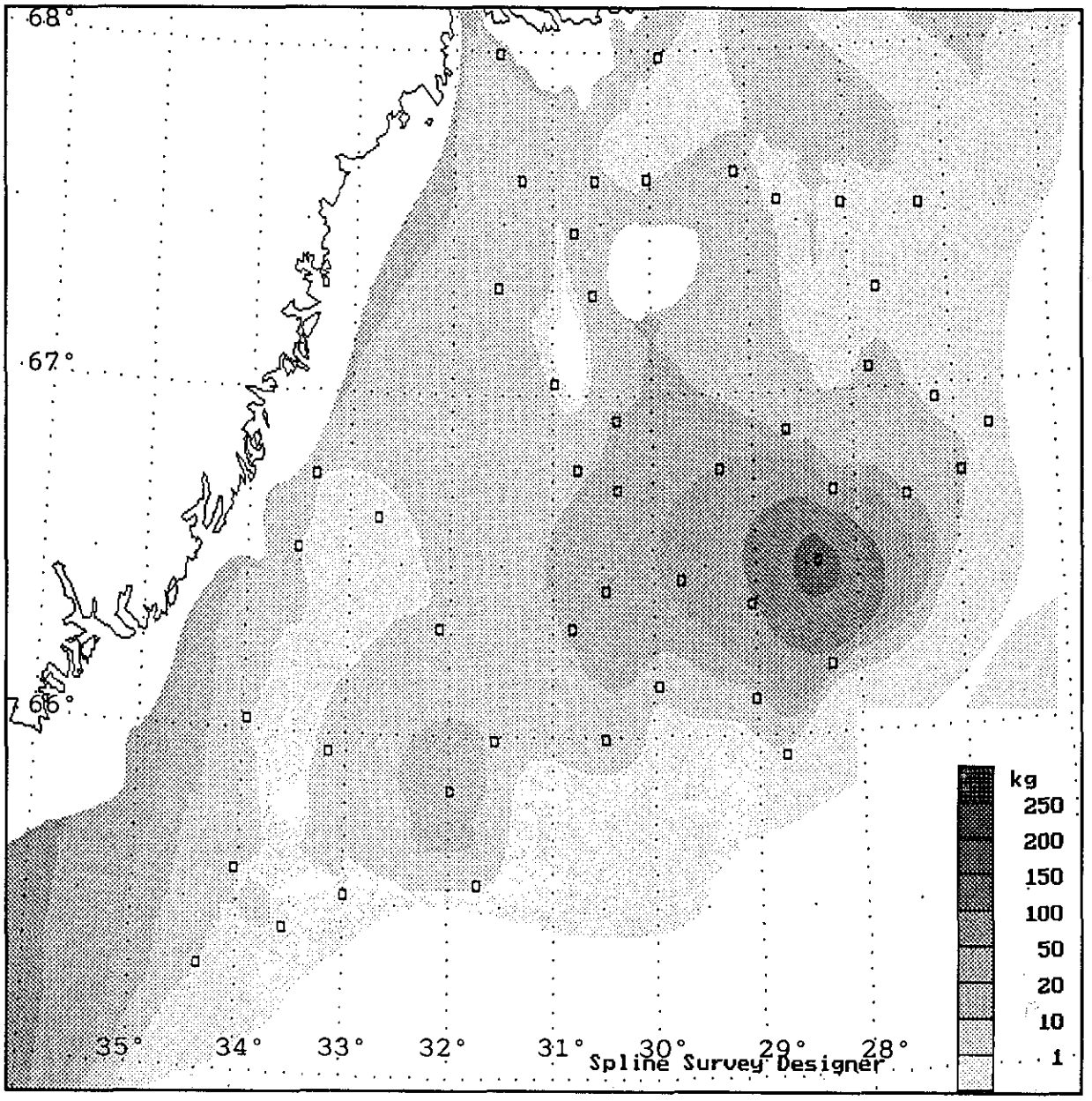

Figure 2. Sampling sites and calculated shrimp densities from the first phase of the survey.

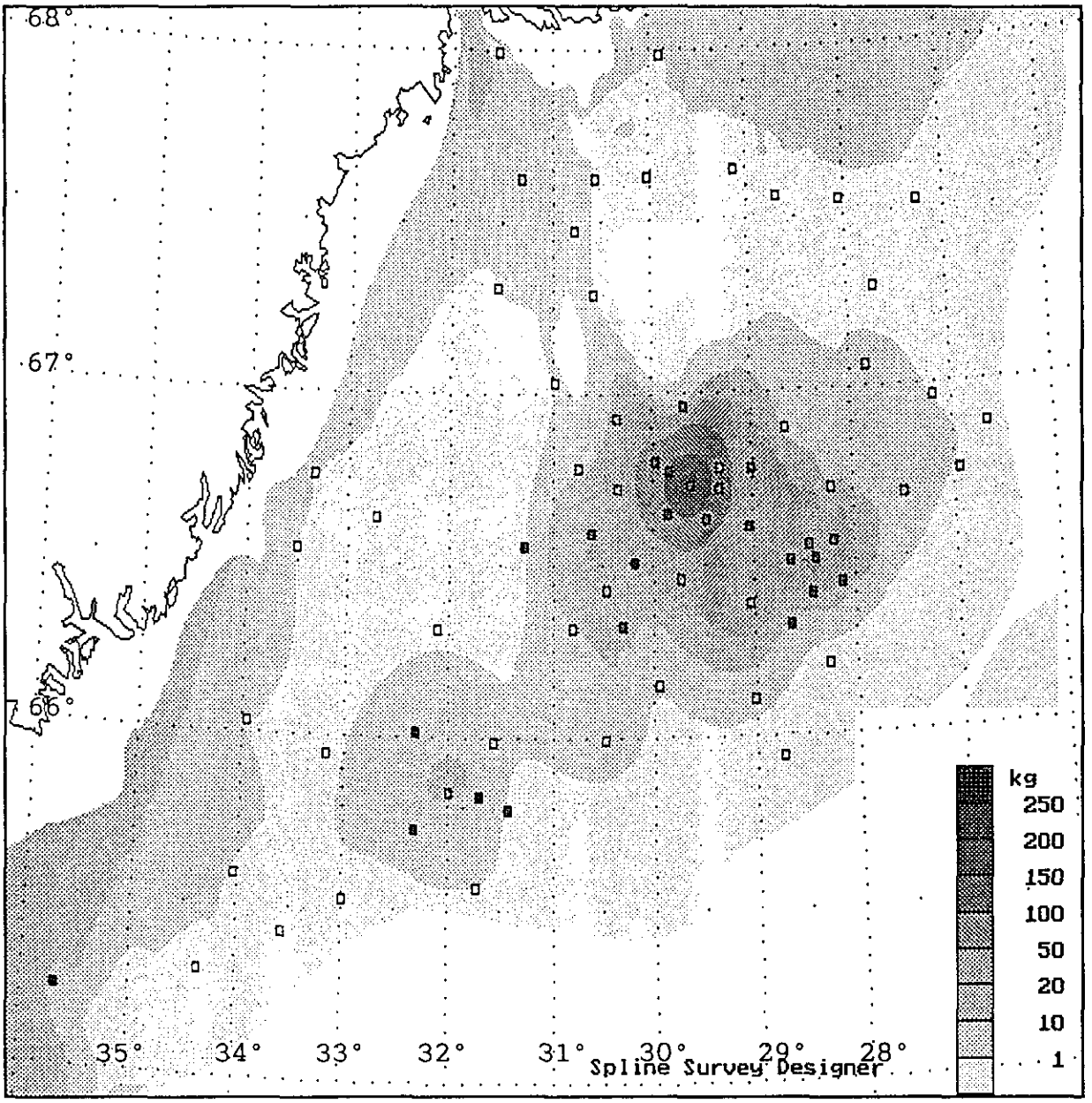

Figure 3. Calculated shrimp densities from the total survey. Sampling sites of the second phase are shown as filled rectangles.

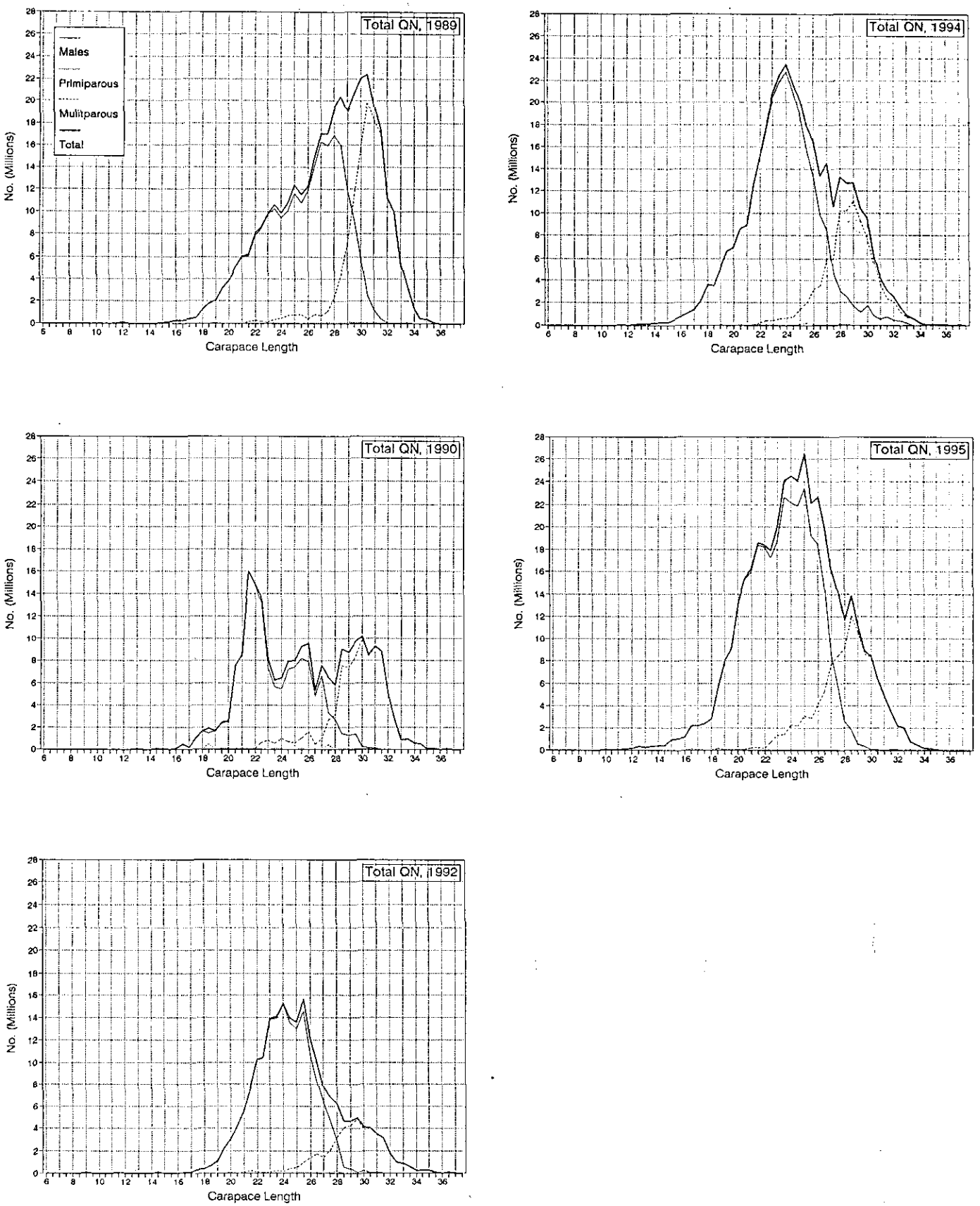

Figure 4. Numbers of shrimp by length group (CL) in the traditional survey area (north of 65°N) by year, based on pooling af samples weighted by catch and stratum area.

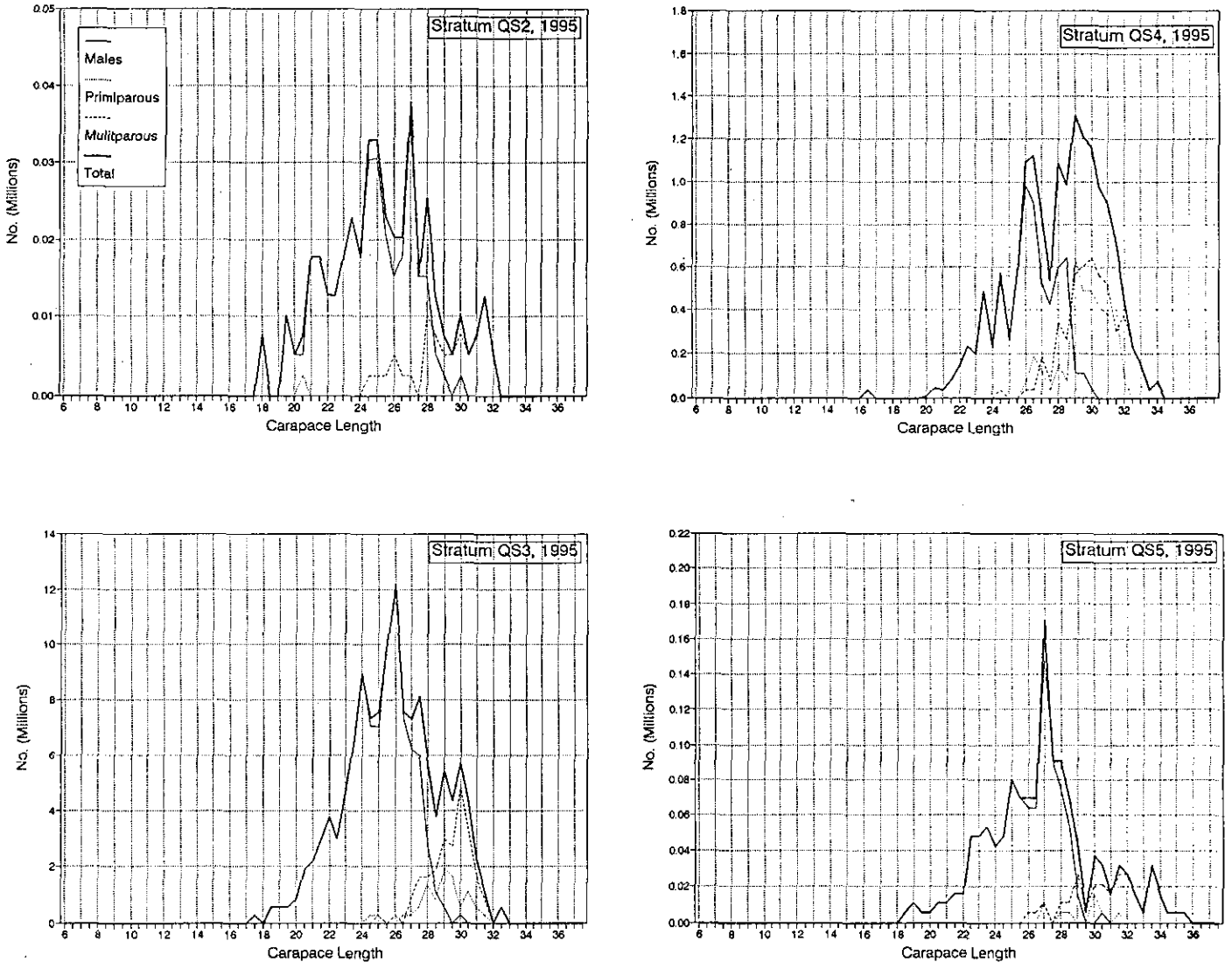

Figure 5. Numbers of shrimp by length group (CL) in strata south of 65°N in 1995, based on pooling of samples weighted by catch and stratum area (note different scales on Y-axes).

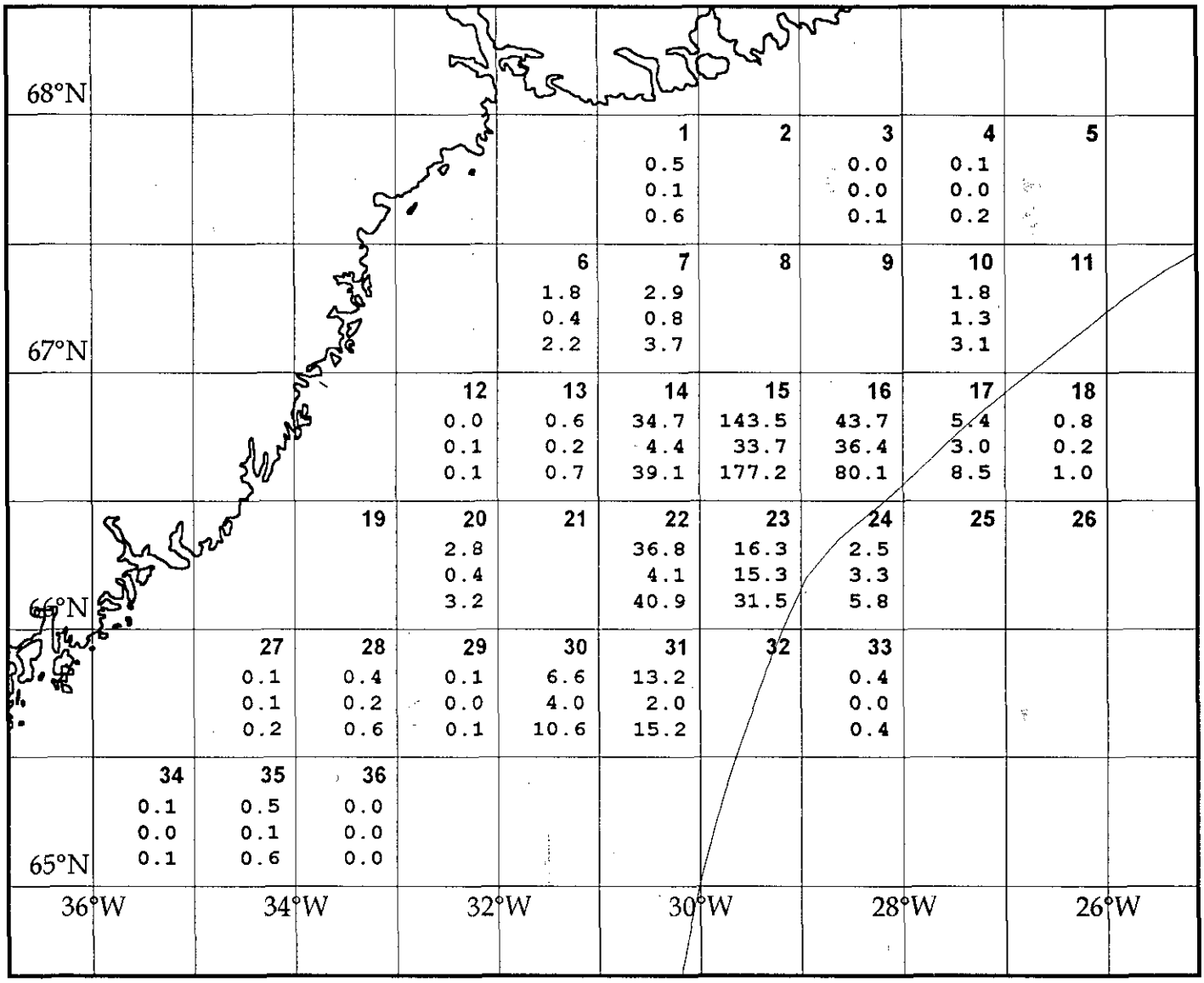

Figure 6. Calculated numbers of shrimp (males, females and total, in millions) per stratum north of 65°N in 1995.

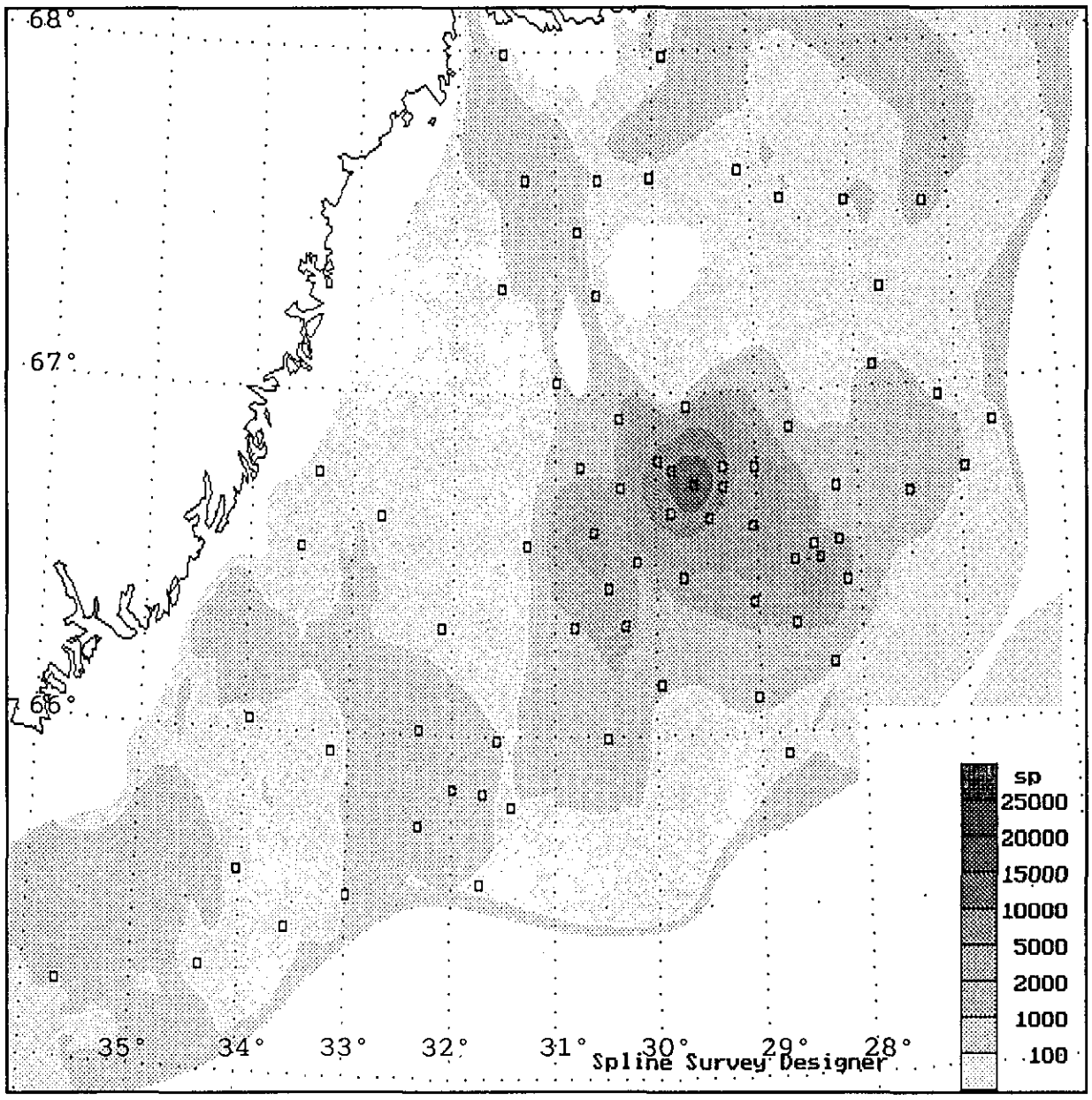

Figure 7. Density (in numbers) of male shrimp north of 65°N, calculated by the Spline Survey Designer based on shrimp samples from this area.

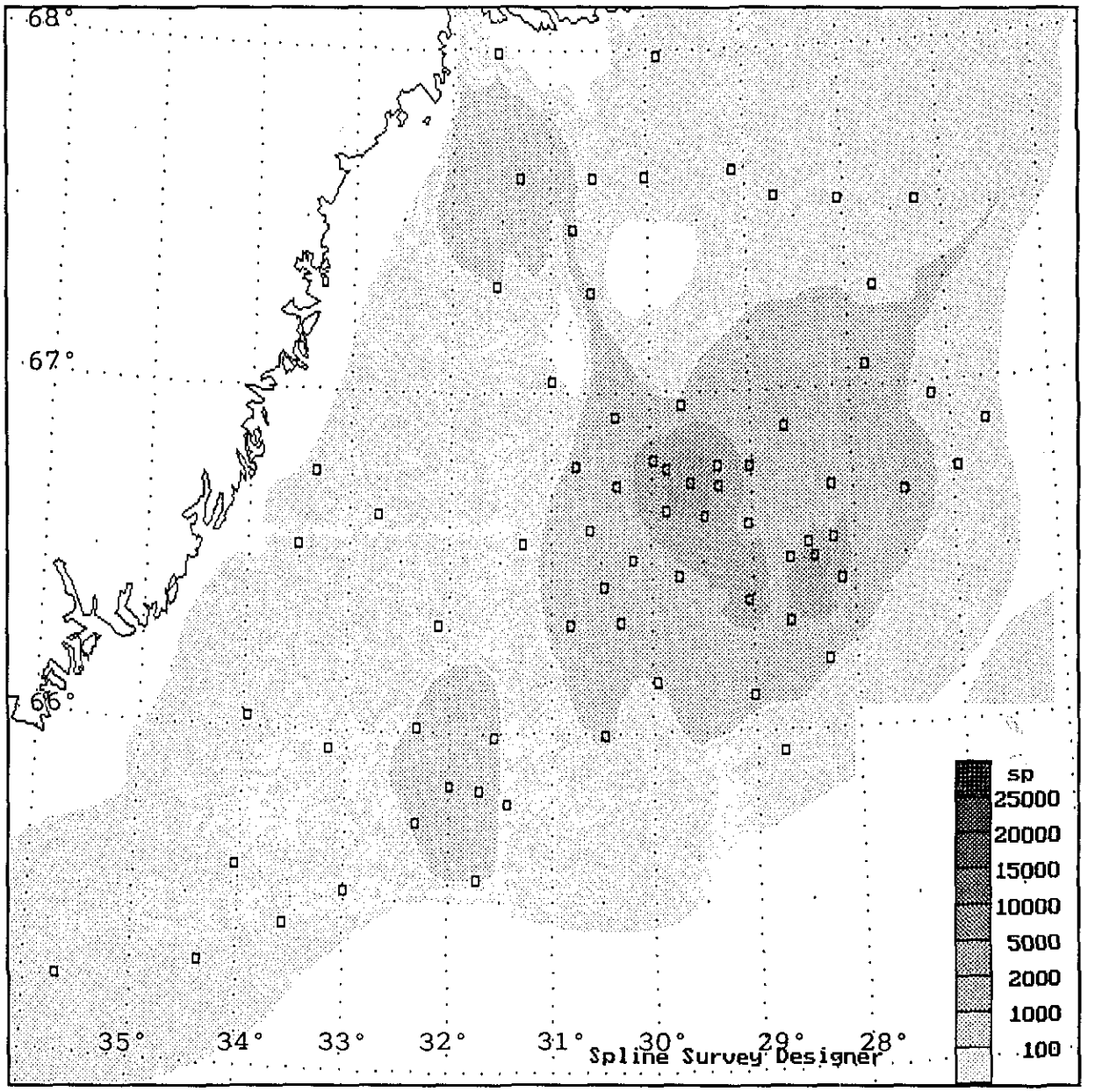

Figure 8. Density (in numbers) of female shrimp north of 65°N, calculated by the Spline Survey Designer based on shrimp samples from this area.