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Trawl Survey for Shrimp (*Pandalus borealis*) in Denmark Strait, 1994

by

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INTRODUCTION

Trawl surveys for estimating the shrimp stock in Denmark Strait have been carried out in autumn of the years 1989, 1990, 1992 and 1994. In the first three years the surveys were based on random stratified technique. The survey in 1989 covered the commercial fishery area only (i.e. expected distribution area for the female stock component; Lehmann & Kanneworff, 1990), while the surveys in the later years all were aimed to cover the main stock distribution area (Kanneworff & Lehmann, 1991; Carlsson & Kanneworff, 1993), i.e. areas north of 65°N. The survey in 1992 also included a special study to demonstrate the possible influence of sampling strategy (random stations versus fixed stations) on the estimated level of biomass.

Stratified random sampling is generally regarded to be an adequate sampling technique for the West Greenland shrimp grounds. However, due to the special characteristics of the Denmark Strait (in terms of bottom conditions, strong currents, ice cover and the stock structure) is can be disputed whether this is the case for the Denmark Strait shrimp grounds. In the present survey a new sampling technique for this area was therefore introduced, based on the Spline Survey Designer Software System (Stolyarenko, 1987; 1993).

As in earlier years the survey was carried out in the autumn because this period normally is the best to avoid severe problems with bad weather and ice cover. On the other hand it is known that low shrimp densities can be expected at that time of the year.

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

MATERIAL AND METHODS

The survey area (Fig. 1) covered the expected 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.

The trawling gear used was a 3000/20 meshes *SKJERVOY* shrimp trawl with bobbins gear and a 20 mm double-bag in the codend. Trawl doors were '3.7 *GREENLAND PERFECT*', size 370*270 cm.

Based on information from the three earlier surveys a sampling scheme was constructed by means of the Spline Survey Designer Software System (Stolyarenko, loc. cit.). The number of sampling sites (59) was chosen as about 2/3 of the expected total number of stations that could be visited during the allocated survey period. After completing this primary sampling programme (in which six stations were omitted due to extreme bottom conditions or obvious oversampling of areas with very low shrimp density), the rest of the stations were selected haul by haul based on information from all the hauls taken during the survey (including 19 hauls from the area between 63°N and 65°N, taken during a trawl survey immediately before the present).

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

Biological samples were taken from all catches, provided that the catch was not too small or damaged (e.g. mixed with large amounts of sponges). Shrimps were sorted by sexual characteristics, and oblique carapace length was measured to the nearest 0.1 mm.

RESULTS AND DISCUSSION

Biomass

In total, 69 stations were fished, of which 53 belonged to the primary sampling scheme. Fig. 2 shows the distribution of the shrimp biomass as calculated from the basic sampling scheme. A total biomass estimate of 4500 tons was derived. It is obvious, that further sampling sites are needed to delineate the observed concentrations, especially those in the area around the 'Storfjord Deep' between 30°W and 31°W. A better information on the large areas in the west is, however, also desirable but less important due to expected low shrimp density.

Due to rough bottom it was not possible to access large parts of the western side of the 'Storfjord Deep' (Fig. 3), so the densities in a part of this area is without doubt somewhat overestimated. In the second phase of the survey it was decided to concentrate further sampling in the areas east of 31°W regardless that large areas with no shrimp or with very low densities might be badly defined. The biomass in this large area is probably also overestimated due to the scarce sampling, so a major part of the about 800 tons calculated for this area is most likely an artifact. The observed concentration of shrimps around 66°45'N 28°30'W is presumably also slightly overestimated, but bad weather on the last day of the survey caused a cut-off of extra stations around this concentration. Figure 2 and 3 show that the main concentration of the shrimp (around 66°20'N 29°10'W) became better defined by the second phase of the survey, and that a small new concentration (NW of the former) was identified.

After completion of the survey a biomass estimate of **3800 tons** was calculated for the total area.

The estimated biomass for this year is of the same order of magnitude as the estimate from 1989, and higher than the estimates from 1990 and 1992:

Year	Biomass estimate
1989	4879
1990	1860
1992	1044
1994	3800

Biomass estimates at the observed level are rather low in relation to a total commercial catch of 6-8000 tons per year. However, as the commercial catch rates during the September-October period consistently have been low, it must be assumed either that the shrimp stock is not available to the fishing gear at that time of the year or that it has migrated out of the area. In the latter case the total stock area is unknown not only to the surveyors but also to the commercial fishery.

The level of the biomass estimates in relation to estimates from Norwegian surveys 1985-89 has been discussed earlier (Carlsson & Kanneworff, 1993).

The spline method

For the first time in the East Greenland area a survey based on the Spline methodology was carried out. Is has been discussed earlier (Kanneworff & Lehmann, 1991; Carlsson & Kanneworff, 1993) whether the method of stratified-random sampling is optimal or even adequate for the Denmark Strait area. The Spline method was introduced this year as an experiment especially because of its flexibility during the survey. A flexible sampling procedure is important when working in large areas with only a few spots with shrimp concentrations in order to avoid oversampling of areas with low shrimp densities.

The experience from the present survey includes the following:

1. All two-phase surveys have the drawback of going through the survey area more than once, but the Spline method reduces the repetition to areas with the highest concentrations.
2. Even when fairly large variations in stock distribution from year to year exist, it is possible to establish a primary sampling scheme based on earlier survey material which describes the presence of shrimp concentrations reasonably.
3. During the survey it is possible to decide a low station coverage in areas with observed low shrimp densities, and thus reserve more sampling time for the higher density areas.
4. The Spline computer program offers no estimation of biomass confidence in contrast to the stratified-random method. But as a greater sampling effort is cast on limited areas with higher shrimp densities it is conceivable that the variance of the total biomass estimate is lower by this method.
5. As the sampling sites in the second phase of the survey are chosen 'by hand' during the survey, the quality of this operation is dependent on personal skill and experience.
6. The Spline computer programme is an excellent tool for presentation of observed stock distribution.

Stock composition

Overall length frequency distributions for the surveys in 1989, 1990 and 1992 were constructed by pooling of samples after weighting with catch and stratum area (Carlsson and Kanneworff, 1993). Although the 1994 survey was conducted using the spline method, an overall length frequency distribution was

constructed based on the stratum areas used in earlier surveys (Fig. 4 and Table 2 - strata used in earlier surveys are shown in Fig. 6), and the total number of shrimp found over the years in the traditional survey area were calculated:

	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

In accordance with the higher biomass estimate found in 1994 compared to 1990 and 1992, an increase in number of shrimp is evident, based on an increase in number of females to the level of 1990, and an increase in number of males to over the 1989 level. The 1994 biomass estimate is still well below the 1989 estimate, as the number of females is only 2/3 of the 1989 number, and the increase in number of males is based on the 24 mm carapace length (CL) group, while the 28 mm CL group dominated in 1989.

The male component in 1989 consisted of a broad range of year classes ranging from 18 to 32 mm CL. In 1990 and 1992 the size of the male component depends on 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. This is also the case in 1994, where the male component is largely dominated by the 24 mm CL group.

The female component is reduced continuously 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 in 1992 and 1994, while the group of females smaller than 28 mm CL is getting relatively more numerous, confirming the earlier sex change as indicated by the change in largest male size. In 1994 the female group is dominated by a peak around 29 mm CL.

In the 1992 length distribution there were no indications of coming recruitment of the relatively large group of males occurring in 1994 at 24 mm CL. Massive migrations into the survey area may therefore be assumed, and it is still a mystery where the younger shrimp of the Denmark Strait stock should be found.

Overall length frequency distributions from the new fishing areas (strata Q2, 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 1994. Similar to 1992 (Carlsson and Kanneworff, loc. cit.) largest numbers of shrimp are found in the central area (strata 7, 14, 15, 16, 23, and 24) and in the southwestern area (strata 19, 20 and 27), but the concentrations are more widespread than in 1992. Both male and female shrimp are most numerous in strata close to the midline to Iceland waters (males in strata 15 and 16 and females in strata 16 and 23).

CONCLUSION

The biomass of shrimp in Denmark Strait is estimated to be close to the level of 1989 and higher than both the 1990 and 1992 estimates. The observed distribution of biomass has been fairly stable through the four years of survey.

A new sampling method for this area, based on the Spline Survey Designer Software System, was introduced and tested for its practical use. In the Denmark Strait, where shrimp concentrations are distributed in few spots over a large area, the Spline sampling method is considered to be superior to stratified-random sampling, because of the ability of this method to avoid oversampling of areas with low shrimp densities.

Overall length frequency distributions from the 1994 survey show that the increase in biomass this year is based primarily on dominant groups of males at 24 mm CL and females at 29 mm CL. The shift in the female group towards smaller sizes and the absence of the largest male group as found in the 1990 and 1992 surveys when compared to 1989 results 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 new fishing areas south of 65°N.

Largest number of male and female shrimp were found in the same areas as in 1992, but concentrations were more widespread.

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Table 1. List of trawl hauls in the shrimp survey in Denmark Strait, 1994. Catches are given in kg.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
94PA0090001 551	KM126	298.5	60	0	0	0	0	11	11
94PA0090002 556	KP121	265.5	60	0	0	0	0	400	400
94PA0090003 559	KS115	328.5	48	0	0	0	0	0	0
94PA0090004 558	KR109	366.0	60	0	0	0	0	0	0
94PA0090005 555	KN111	313.5	46	0	0	0	0	0	0
94PA0090006 553	KN113	233.0	60	0	0	0	0	542	542
94PA0090007 545	KK114	234.0	60	0	0	0	0	198	198
94PA0090008 547	KK111	312.0	60	0	0	0	0	0	1
94PA0090009 546	KK110	425.5	60	41	0	3	0	10	53
94PA0090010 548	KL111	233.5	60	6	0	0	0	6	12
94PA0090011 549	KL106	580.0	47	0	0	0	0	0	0
94PA0090012 550	KJ106	326.5	60	0	0	0	0	0	1
94PA0090013 542	KJ107	346.5	60	0	0	0	0	0	0
94PA0090014 541	KJ106	275.0	41	0	0	0	0	0	0
94PA0090015 538	KH104	292.0	60	0	0	0	0	0	0
94PA0090016 524	KE104	331.0	39	0	0	0	0	0	0
94PA0090017 514	KA100	338.0	60	10	0	2	0	7	19
94PA0090018 506	JX094	258.5	31	0	0	0	0	0	0
94PA0090019 000	JT095	317.0	60	4	0	2	0	3	8
94PA0090020 511	JZ101	305.0	60	5	0	1	0	34	40
94PA0090021 507	JX106	340.5	60	0	0	0	0	1	1
94PA0090022 502	JS106	289.5	60	0	0	0	0	1	1
94PA0090023 505	JV108	412.0	53	4	0	0	0	5	9
94PA0090024 504	JT109	408.5	60	1	0	0	0	5	6
94PA0090025 520	KD111	464.0	60	15	0	8	0	8	31
94PA0090026 518	KB108	453.5	34	2	0	0	0	7	9
94PA0090027 519	KB107	317.5	51	0	0	0	0	1	2
94PA0090028 525	KE109	478.0	60	0	0	0	0	2	2
94PA0090029 532	KF110	483.0	60	14	0	8	0	7	29
94PA0090030 535	KG112	363.0	60	5	0	2	0	3	10
94PA0090031 540	KH114	261.5	60	0	0	0	0	138	138
94PA0090032 539	KH115	292.0	60	0	0	0	0	68	68
94PA0090033 530	KF115	324.5	60	24	0	1	0	6	32
94PA0090034 528	KE112	305.0	60	2	0	0	0	38	41
94PA0090035 521	KD113	324.0	60	0	0	0	0	3	3
94PA0090036 517	KB115	314.0	61	98	0	10	0	80	188
94PA0090037 523	KE117	324.0	60	70	0	5	0	25	99
94PA0090038 528	KE119	324.5	60	7	0	3	0	5	14
94PA0090039 533	KG120	333.0	60	29	0	4	0	296	329
94PA0090040 534	KG117	342.0	60	15	0	5	0	8	28
94PA0090041 544	KJ119	333.0	60	1	0	0	0	27	28
94PA0090042 543	KJ122	379.5	60	3	0	11	0	26	40
94PA0090043 536	KH122	376.5	60	3	0	2	0	31	36
94PA0090044 537	KH123	371.5	60	0	0	0	0	4	4
94PA0090045 531	KF124	447.0	60	1	0	4	0	12	16
94PA0090046 529	KF123	380.5	60	1	0	0	0	11	11
94PA0090047 527	KE121	333.0	55	0	0	0	0	5	5
94PA0090048 522	KD123	414.5	61	0	0	0	0	32	32
94PA0090049 512	KA121	465.5	60	2	0	2	0	19	23
94PA0090050 516	KB120	345.5	60	1	0	0	0	1202	1203
94PA0090051 515	KB117	271.0	60	34	1	1	0	304	340
94PA0090052 513	KA117	301.0	60	13	0	0	0	1159	1172
94PA0090053 000	JX118	512.5	47	0	0	0	0	8	9
94PA0090054 509	JX116	299.0	60	0	0	0	0	1	1
94PA0090055 000	KA115	301.5	60	5	0	1	0	334	340
94PA0090056 000	KB113	322.5	60	8	0	7	0	37	52
94PA0090057 000	JZ113	292.0	60	1	0	0	0	969	970
94PA0090058 000	KA110	510.0	50	3	0	0	0	39	43
94PA0090059 000	KA111	455.5	60	4	0	10	0	5	20
94PA0090060 000	KD110	477.0	60	4	0	6	0	6	15
94PA0090061 000	KL110	517.0	45	1	0	0	0	1	1
94PA0090062 000	KK110	457.5	60	22	0	3	0	14	38
94PA0090063 000	KH110	455.5	60	6	0	7	0	7	21
94PA0090064 000	KF113	320.5	60	46	0	3	0	13	61
94PA0090065 000	KF114	289.5	60	33	0	0	0	14	46
94PA0090066 000	KE115	315.5	60	16	0	0	0	6	22
94PA0090067 000	KF117	323.5	60	19	0	1	0	10	29
94PA0090068 000	KG116	356.0	60	3	0	0	0	13	16
94PA0090069 000	KH117	306.0	55	21	0	0	0	120	141

Table 2. Number of shrimp (thousands) per length group (CL) in total biomass estimate north of 65°N, based on pooling of samples from the catch.

CL	Males	Prim.fem.	Mul.fem.	Total
11.5	12.9	0.0	0.0	12.9
12.0	0.0	0.0	0.0	0.0
12.5	12.9	0.0	0.0	12.9
13.0	121.5	0.0	0.0	121.5
13.5	120.2	0.0	0.0	120.2
14.0	163.2	0.0	0.0	163.2
14.5	212.4	0.0	0.0	212.4
15.0	219.9	0.0	0.0	219.9
15.5	460.2	0.0	0.0	460.2
16.0	750.2	0.0	0.0	750.2
16.5	1048.0	0.0	0.0	1048.0
17.0	1352.8	0.0	0.0	1352.8
17.5	2180.6	0.0	0.0	2180.6
18.0	3606.5	0.0	0.0	3606.5
18.5	3533.7	0.0	0.0	3533.7
19.0	5133.3	0.0	12.9	5146.2
19.5	6591.7	0.0	0.0	6591.7
20.0	6933.5	0.0	0.0	6933.5
20.5	8552.1	0.0	13.8	8565.9
21.0	8844.8	0.0	0.0	8844.8
21.5	12551.4	11.9	38.0	12601.2
22.0	14992.2	11.9	222.1	15226.1
22.5	17362.5	11.9	385.6	17759.9
23.0	20351.3	11.9	403.4	20766.5
23.5	21840.1	0.0	591.2	22431.3
24.0	22804.6	0.0	648.4	23453.0
24.5	21046.1	33.2	718.1	21797.3
25.0	18856.4	79.9	1373.7	20310.0
25.5	15726.6	154.2	1981.7	17862.5
26.0	13224.4	61.6	3177.5	16463.5
26.5	9824.7	37.8	3512.5	13375.1
27.0	8518.4	4.3	6019.2	14541.9
27.5	4603.2	4.3	5952.5	10559.9
28.0	3002.5	69.0	10140.6	13212.1
28.5	2446.3	66.4	10176.2	12688.8
29.0	1598.8	0.0	11068.6	12667.4
29.5	1128.3	0.0	9287.3	10415.6
30.0	1732.7	0.0	7756.4	9489.1
30.5	803.3	0.0	5599.0	6402.3
31.0	553.0	0.0	3627.8	4180.8
31.5	723.3	0.0	2315.6	3038.9
32.0	390.0	0.0	2094.4	2484.4
32.5	338.3	0.0	1203.3	1541.6
33.0	155.0	0.0	688.5	843.5
33.5	0.0	0.0	575.6	575.6
34.0	0.0	0.0	140.8	140.8
34.5	0.0	0.0	37.4	37.4
35.0	0.0	0.0	44.3	44.3
35.5	0.0	0.0	7.3	7.3
36.0	0.0	0.0	6.6	6.6
36.5	0.0	0.0	0.0	0.0
37.0	0.0	0.0	6.4	6.4
Total	264423.9	558.1	89826.4	354808.3

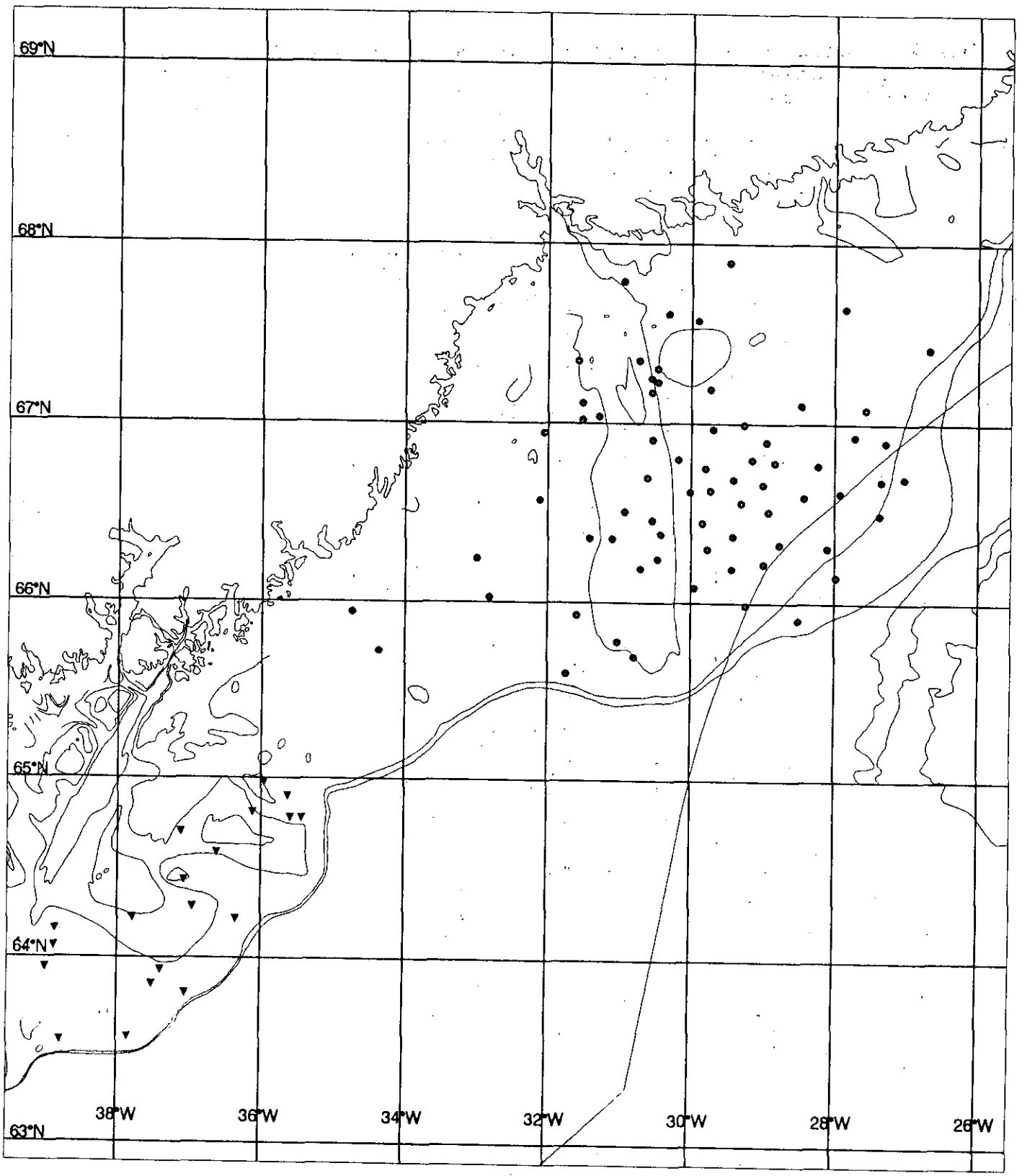

Figure 1. Map of the survey area in Denmark Strait. Sampling sites for the survey, designed with the Spline method (circles) and for the preceding trawl survey (triangles).

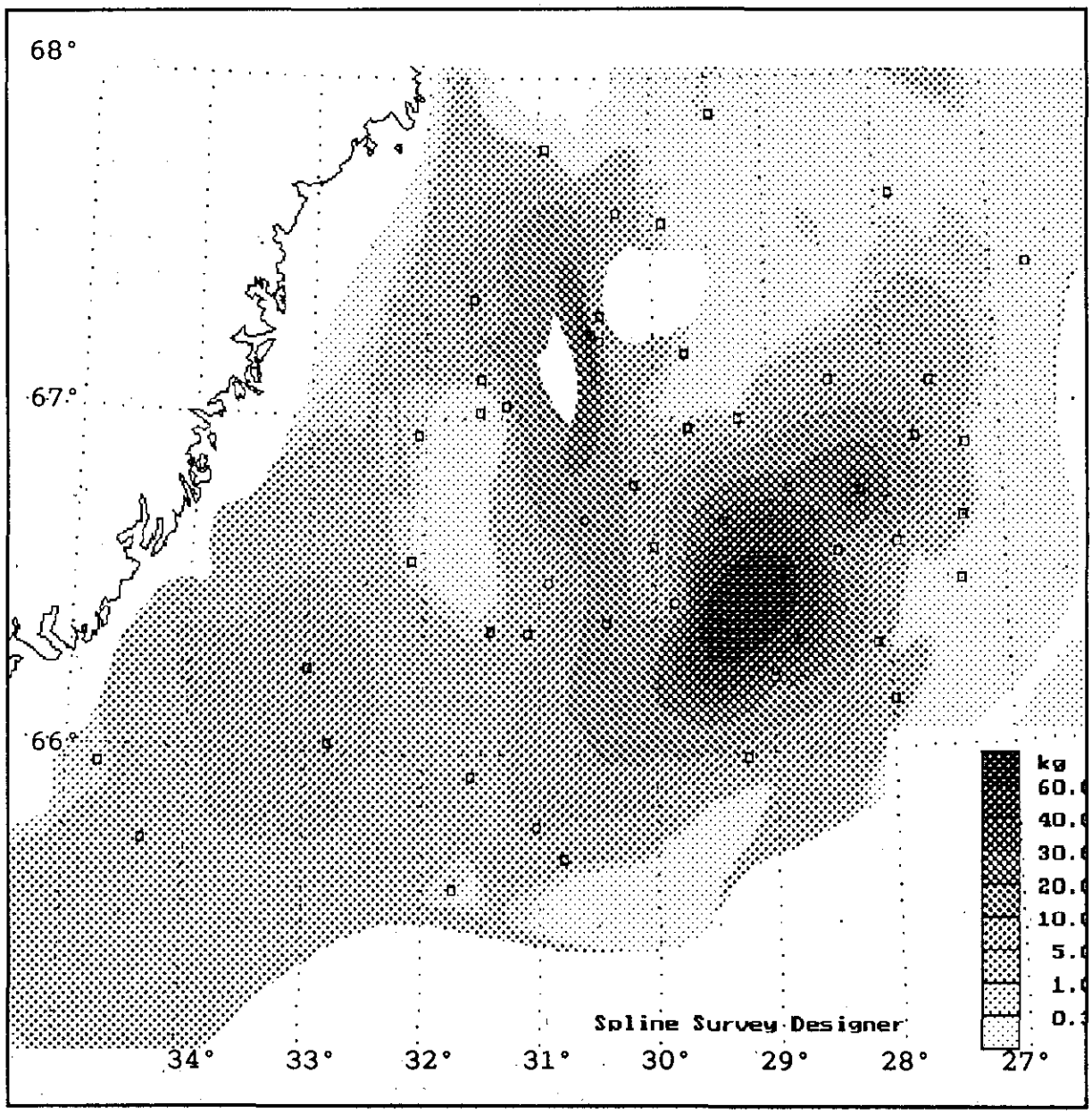

Figure 2. Shrimp densities as calculated from the primary sampling scheme before additional stations were taken. Sampling sites are also given.

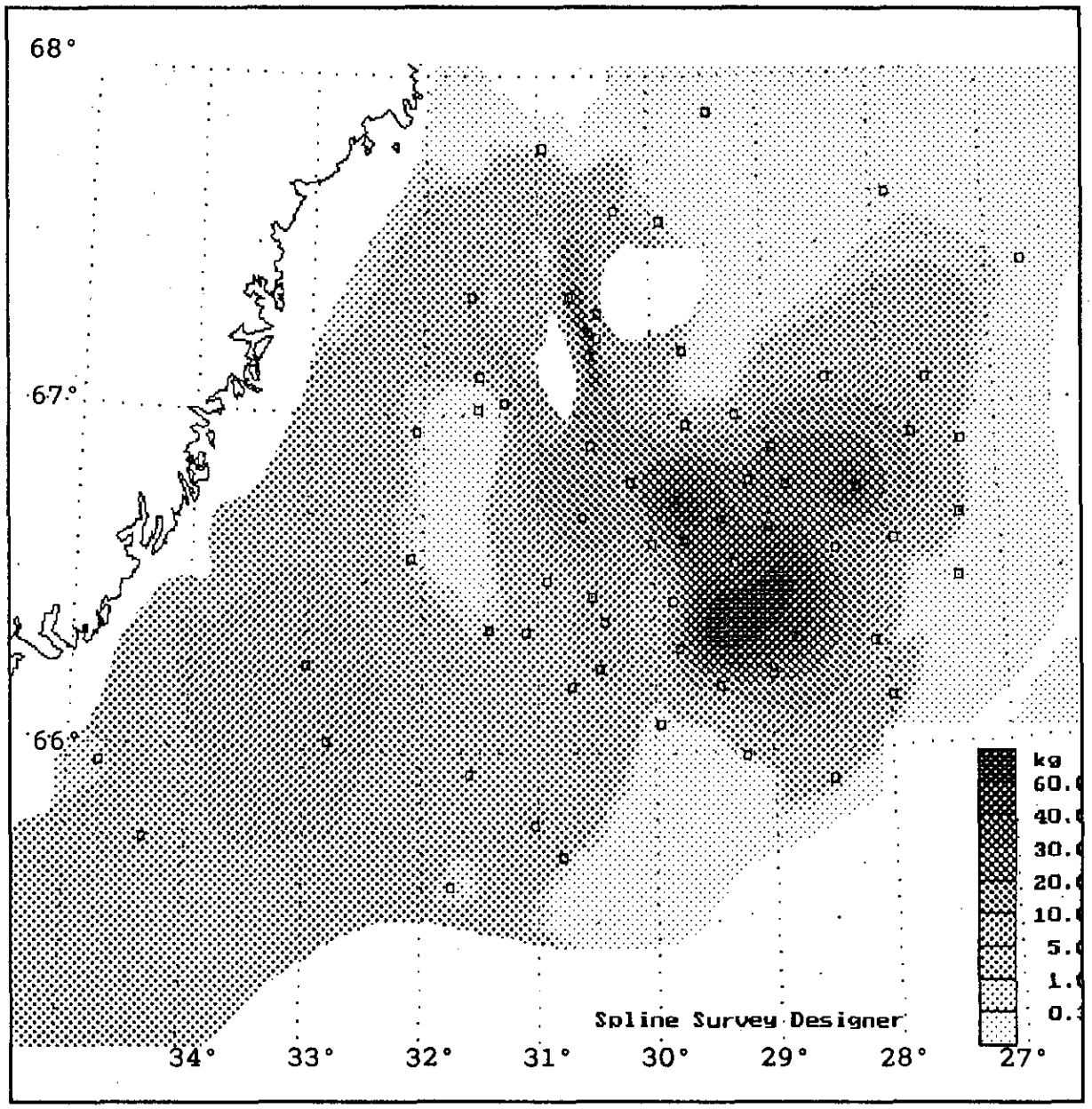

Figure 3. Shrimp densities as calculated from the completed survey after additional stations were taken. Sampling sites are also given.

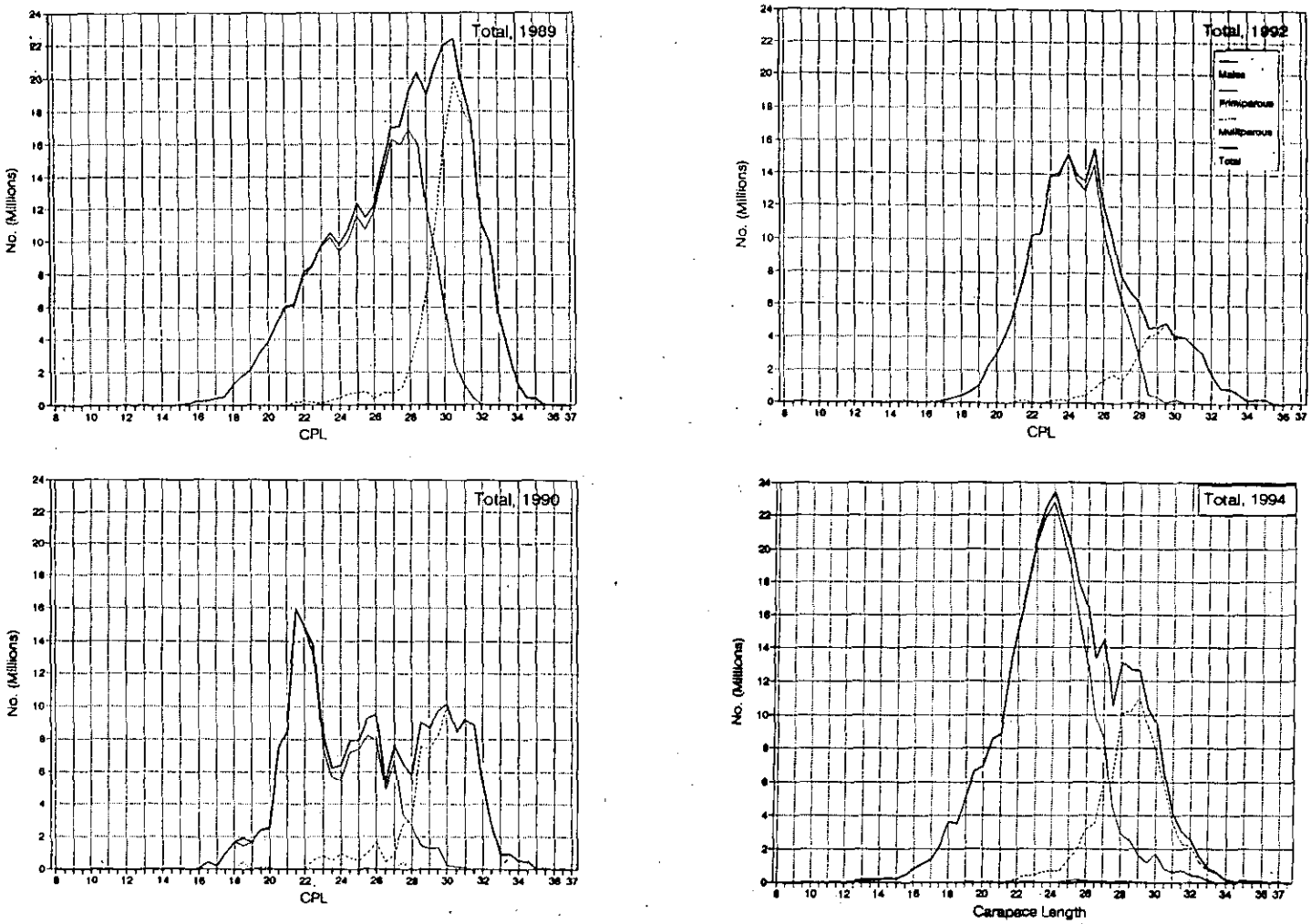

Figure 4. Numbers of shrimp by length group (CL) in the survey area (north of 65°N) in 1989, 1990, 1992 and 1994, based on pooling af samples weighted by catch and stratum area.

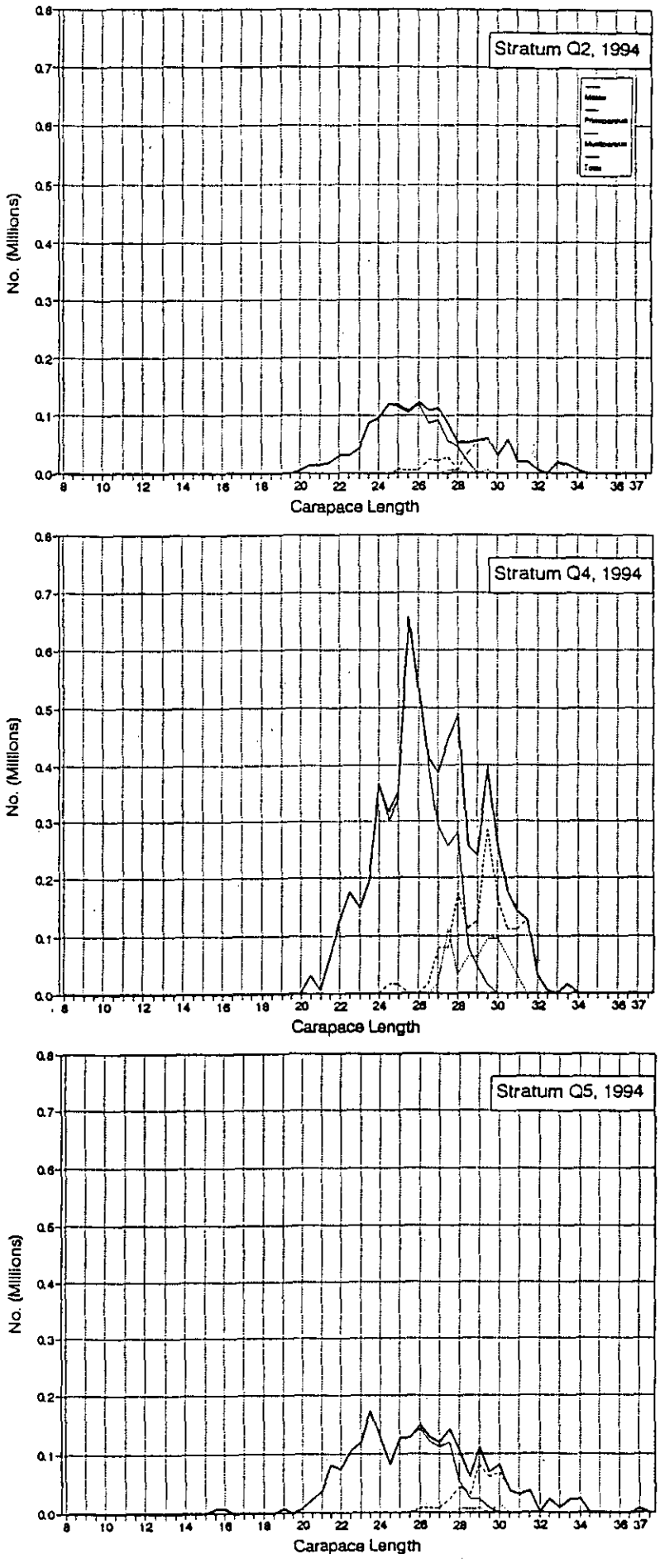

Figure 5. Numbers of shrimp by length group (CL) in strata south of 65°N, based on pooling of survey samples weighted by catch and stratum area.

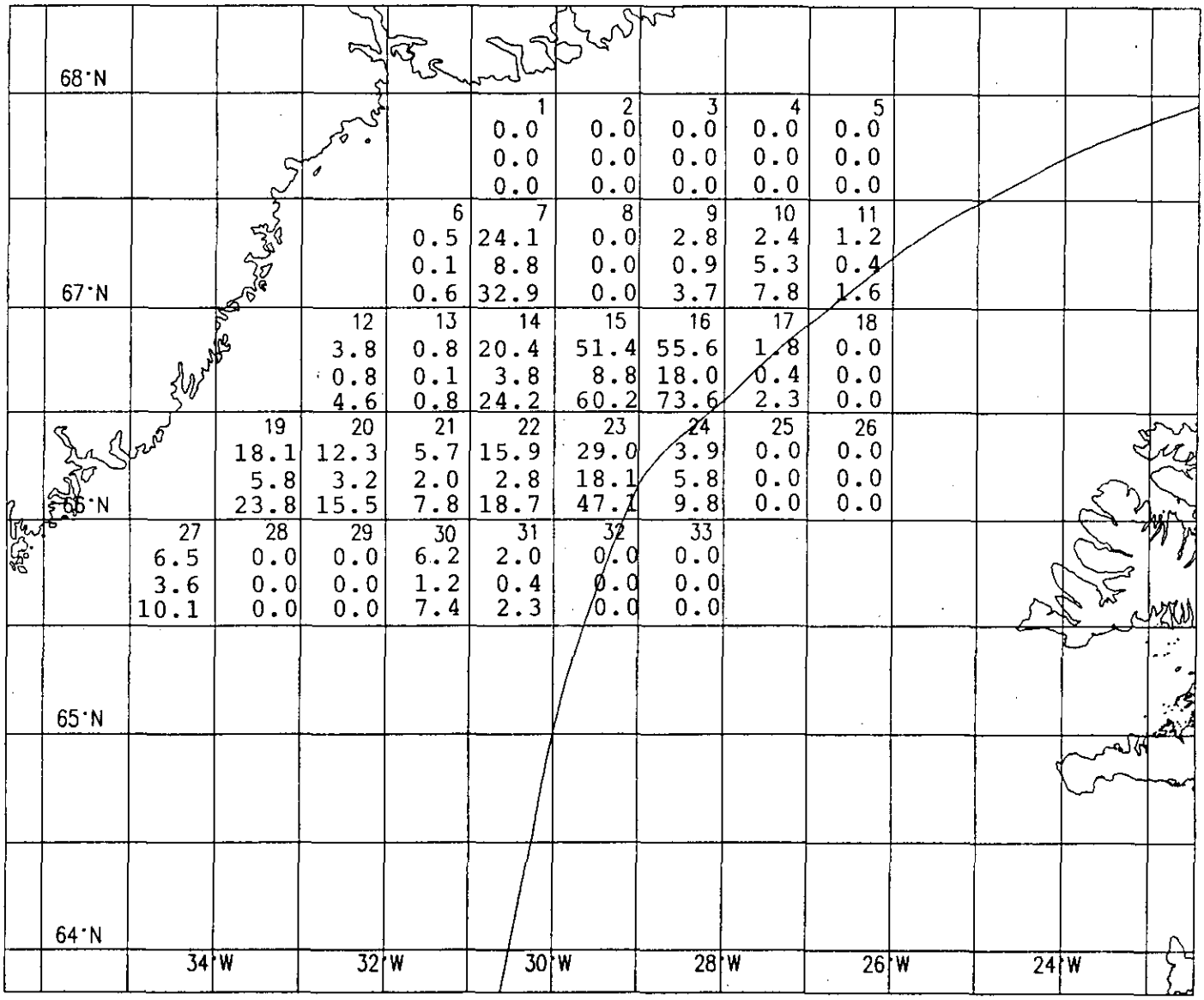

Figure 6. Calculated numbers of shrimp (females, males and total, in millions) per stratum in 1994.