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Stratified-Random Trawl Survey for Shrimp (Pandalus *borealis*) in Denmark Strait in 1992.

by

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INTRODUCTION

Stratified-random trawl surveys have earlier been carried out in Denmark Strait in 1989 and 1990 (Lehmann & Kanneworff, 1990; Kanneworff & Lehmann, 1991). In 1992 the survey was planned - as in 1990 - to cover the supposed total distribution area for the stock. The survey in 1989 was concentrated on the female stock component only. The 1992 survey was carried out somewhat later in the year (October 8-26) compared to the former surveys. Due to bad weather and ice cover only 55 out of 81 planned stations were visited.

A special study in a selected area was undertaken to compare biomass estimates from earlier Norwegian surveys (Smedstad, 1990) with the present survey.

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 offshore part of Denmark Strait between 65°N and 68°N, bordered to the east by the 600 m contour line. Due to scarce information on bottom topography it was not possible to stratify after depth, and hence a stratification by 30*60 minutes geographical areas (Fig. 1) was used.

As in earlier surveys the trawling gear used was a 'SKJERVOY' shrimp trawl, size 3000/20 meshes, equipped with bobbin gear and a double-bag with 44 mm mesh size in the codend. Trawl doors were of the type 'PERFECT GREENLAND, size 370*270 cm.

Distance between trawl doors was measured continuously, and after the survey the wing-spread of the trawl was calculated to 23.1 meters at average. Based on wing-spread, trawling distance, catch of shrimp, and stratum area, an estimate of stratum biomass was calculated for each haul. Based on all hauls in a stratum a mean biomass estimate was calculated.

Four strata (No. 15, 16, 23 and 24) were selected for a special study to investigate the possible reasons for the large differences in the levels of biomass estimates obtained by the Norwegian surveys 1985-89 and the surveys conducted by the Greenland Fisheries Research Institute respectively. In the selected strata all Norwegian fixed trawling sites were visited in addition to a corresponding number of randomly selected stations.

A few trawl hauls were taken at the Icelandic shelf (outside the stratification scheme) in order to compare the shrimps from this area with shrimps from the Dohrn Bank area.

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.

CTD-casts were made at all trawling sites (Rønnow, 1993).

RESULTS AND DISCUSSION

In total, 59 trawl stations were fished (Table 1, Fig. 2), of which 37 belonged to the stratified-random survey. 22 planned stations, mostly in the northern and the western part of the survey area, were not visited due to ice problems and bad weather. The strata in these areas were thus badly covered, but a very low biomass was indicated by the neighbouring stations.

The calculated total biomass from the stratified-random survey stations was only 1044 tons of shrimp, being the lowest recorded in surveys in this area. The major part of the biomass was found in the central strata (Table 2). The survey in 1990 indicated a total biomass of 1860 tons for the same strata, while the Norwegian surveys in 1985-89 indicated a range from 25 to 50 thousand tons.

The present survey is obviously underestimating the biomass of the Denmark Strait shrimp stock. In November-December after the survey period total catches in the commercial fishery were more than 1500 tons. In the survey period, however, catch rates and catches in the commercial fishery were very small (Carlsson and Kanneworff, 1993). During the survey period - which is the only period where ice conditions allow access to all (or most of) the survey area, shrimp are obviously not fully available to the gear, either because they have moved elsewhere - i.e. the survey area is not covering the total stock area - or for other reasons.

The Norwegian surveys during 1985-89 estimated consistently larger biomass levels (Smedstad, 1989) than the Greenland surveys. Possible reasons for the discrepancies have been discussed earlier (Kanneworff & Lehmann, 1991). E.g. may the use of fixed stations, with possible higher shrimp abundance, in the Norwegian surveys have led to overestimation of stock size. During the present survey Norwegian trawling sites from the earlier surveys were visited in the central area (strata no. 15, 16, 23 and 24) in order to test this possibility. Biomass calculations for the four strata based on the Norwegian stations and those from the stratified-random survey are presented in Table 3. The Norwegian stations yielded a biomass estimate three times larger than the random stations. It is therefore conceivable that at least part of the large differences in biomass estimates could be explained by this phenomenon.

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 (Fig. 3). Even though the survey area in 1989 was smaller than in the following years, total numbers (millions) of shrimp decrease over the years:

	males	females	total
1989	231.0	135.4	366.3
1990	142.6	85.7	228.3
1992	163.6	45.3	209.0

Some significant changes are evident from the total distributions. The male component in 1989 consisted of a broad range of year-classes ranging from 18 to 32 mm carapace length (CL). In 1990 and 1992 the size of the male component seems to depend more 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. The female component is reduced continuously over the 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, 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.

Figures 4, 5, and 6 show the calculated numbers of shrimp per stratum in 1989, 1990 and 1992 respectively. Figure 6 shows an increase in total numbers in the western part of the survey area (strata 12, 20, 21, 28, and 29) in 1992, when compared to Fig. 5 (1991), largely due to the occurrence of a substantial amount of males in stratum 20. In stratum 7, the stratum with the highest numbers in 1990, numbers of both males and females have decreased by a factor 10, while abundance has increased in the central strata at the midline to Icelandic waters (stratum 15, 16, 17, 23 and 24). The concentration of shrimp in these strata resembles the distribution encountered in 1989 (Fig. 4), although numbers of males and especially females are much lower in 1992.

By-catches of fish were small in most of the strata (Table 1). Only in stratum 23 any noticeable amount of fish was taken, the main species being capelin, wolffish and polar cod. Large amounts of sponges were caught in many of the strata (especially in no. 5, 7, 9, 15, 20, 23 and 24).

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Table 1a. List of trawl hauls in the stratified-random survey in the Denmark Strait 1992. Stratum numbers with the extension 'G' and 'I' denote Greenland and Iceland part of a stratum, respectively.

STATION-IDENTIFICATION	AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
			STRATUM 5						
92PA0160002 074	KN126	300.0	60	0	0	0	0	1	1
92PA0160001 075	KP127	323.0	57	0	0	1	0	3	4
			STRATUM 6						
92PA0160049 056	KJ106	295.0	60	0	0	0	0	0	0
92PA0160048 072	KL106	582.0	21	0	0	0	0	0	1
			STRATUM 7						
92PA0160046 068	KK111	225.5	60	0	0	0	1	0	1
92PA0160047 073	KL110	480.0	60	7	0	3	1	2	12
			STRATUM 8						
92PA0160045 065	KJ114	236.5	49	0	0	0	0	1	1
			STRATUM 9						
92PA0160033 066	KJ118	330.5	60	0	0	0	0	0	0
92PA0160034 069	KK117	315.5	60	0	0	0	0	0	0
			STRATUM 10						
92PA0160005 067	KJ124	371.0	60	2	0	0	0	2	4
92PA0160004 070	KK124	342.5	60	0	0	0	0	0	0
			STRATUM 11						
92PA0160003 071	KL126	558.5	61	0	0	0	0	1	1
			STRATUM 12						
92PA0160050 053	KF103	366.5	60	1	0	1	0	0	2
			STRATUM 15						
92PA0160039 051	KE116	317.0	60	6	0	0	0	1	8
92PA0160043 057	KG114	289.5	45	0	0	0	0	0	0
92PA0160036 058	KG116	360.0	60	0	0	1	0	1	2
92PA0160044 061	KH113	287.5	60	0	0	0	0	0	0
			STRATUM 16						
92PA0160038 055	KF117	333.0	61	10	0	2	0	1	13
92PA0160031 063	KH120	339.0	46	2	0	0	1	0	3
			STRATUM 17						
92PA0160029 059	KG121	365.0	60	5	.	.	.	.	5
92PA0160030 064	KH122	369.5	60	42	0	1	2	3	47
			STRATUM 18 I						
92PA0160006 060	KG126	567.5	60	0	0	2	0	1	3
			STRATUM 20						
92PA0160052 036	JZ102	293.5	29	3	0	0	1	1	5
92PA0160051 040	KB101	350.5	60	0	0	0	0	0	1
			STRATUM 21						
92PA0160055 044	KD106	337.0	60	0	0	1	0	2	4
			STRATUM 23						
92PA0160015 035	JZ115	294.0	60	0	0	0	1	90	92
92PA0160019 046	KD115	312.0	60	6	0	0	0	42	48
92PA0160021 041	KD116	299.0	60	22	0	0	0	6	28
92PA0160022 047	KD116	325.0	60	17	0	2	0	20	39
			STRATUM 24 G						
92PS0160024 042	KB117	286.5	60	6	0	1	0	0	8
			STRATUM 24 I						
92PA0160010 037	JZ119	413.5	60	0	0	0	0	2	3
92PA0160009 038	JZ120	472.0	60	0	0	0	0	1	1
92PA0160012 039	KB119	320.5	60	7	0	0	0	36	43
			STRATUM 25 I						
92PA0160007 048	KD123	459.0	59	0	0	0	0	0	0
			STRATUM 28						
92PA0160054 025	JT098	321.5	60	0	0	0	0	3	3
			STRATUM 29						
92PA0160053 029	JV102	320.0	44	0	0	0	11	8	19
			STRATUM 33 I						
92PA0160008 033	JX119	482.5	60	0	0	2	1	2	4

Table 1b. List of trawl hauls of the Norwegian fixed stations in four selected strata.

STATION-IDENTIFICATION		AREA-CODE	DEPTH	TR-TIME	SHR	COD	GHL	RED	MIX	TOTAL
				STRATUM	15					
92PA0160040	010	KE115	307.5	60	47	0	0	2	5	54
92PA0160041	014	KF114	299.0	60	9	0	1	1	2	13
92PA0160042	013	KG113	321.5	60	0	0	0	0	0	0
92PA0160035	017	KH116	294.5	60	0	0	0	0	2	2
				STRATUM	16					
92PA0160023	011	KE117	329.0	60	134	1	2	5	7	148
92PA0160027	012	KE119	330.0	60	57	0	6	0	3	67
92PA0160037	015	KF117	346.5	60	5	0	3	0	1	8
92PA0160028	016	KF119	314.0	60	4	0	1	0	8	13
92PA0160032	018	KH119	339.0	60	0	0	0	0	0	0
				STRATUM	23					
92PA0160016	002	JZ113	295.5	60	1	0	0	0	180	181
92PA0160013	001	JZ116	306.5	60	2	0	1	1	35	38
92PA0160017	003	KA113	305.0	60	2	0	0	0	68	70
92PA0160014	004	KA116	306.0	60	1	0	0	0	39	40
92PA0160020	007	KB115	300.5	60	7	0	0	0	56	62
92PA0160018	006	KD113	329.5	60	13	0	0	1	2	15
				STRATUM	24 G					
92PA0160025	008	KD117	312.0	60	8	0	0	0	3	11
92PA0160026	009	KD118	327.0	60	30	0	0	0	1	31
				STRATUM	24 I					
92PA0160011	005	KA118	338.5	60	10	0	0	0	33	43

Table 2. Biomass of shrimp in Denmark Strait based on stratified-random stations only. Stratum numbers with the extension 'G' and 'I' denote Greenland and Iceland part of a stratum, respectively.

STRATUM	SQKM	BIOMASS IN STRATA				
		TONS	HAULS	STD	MIN	MAX
5	2338	3.0	2	1.8	2	4
6	2387	3.1	2	4.4	0	6
7	2387	77.6	2	109.8	0	155
8	2387	0.0	1	.	0	0
9	2387	0.0	2	0.0	0	0
10	2387	23.9	2	33.8	0	48
11	1262	0.0	1	.	0	0
12	2437	13.3	1	.	13	13
15	2437	35.8	4	67.0	0	136
16	2402	145.2	2	136.9	48	242
17	1201	291.8	2	337.3	53	530
18 I	1358	0.0	1	.	0	0
20	2487	112.2	2	154.9	3	222
21	2487	7.5	1	.	7	7
23	2379	230.8	4	189.2	10	389
24 G	512	30.4	1	.	30	30
24 I	1975	52.0	3	88.0	0	154
25 I	2273	0.0	1	.	0	0
28	2536	2.9	1	.	3	3
29	2536	12.4	1	.	12	12
33 I	884	1.8	1	.	2	2
TOTAL	43439	1044				

Table 3a. Biomass estimates in four selected strata based on Norwegian fixed stations.

STRATUM	SQKM	BIOMASS IN STRATA				
		TONS	HAULS	STD	MIN	MAX
15	2437	305.0	4	492.0	4	1033
16	2402	826.7	5	1136.8	3	2629
23	2379	129.7	6	183.4	18	486
24 G	512	80.9	2	65.5	35	127
24 I	1975	206.4	1	.	206	206
TOTAL	9705	1549				

Table 3b. Biomass estimates in four selected strata based on stratified-random stations.

STRATUM	SQKM	BIOMASS IN STRATA				
		TONS	HAULS	STD	MIN	MAX
15	2437	35.8	4	67.0	0	136
16	2402	145.2	2	136.9	48	242
23	2379	230.8	4	189.2	10	389
24 G	512	30.4	1	.	30	30
24 I	1975	52.0	3	88.0	0	154
TOTAL	9705	494				

Table 4. Numbers of shrimp (thousands) per length group (carapace length) in total biomass estimate in 1989, based on pooling of individual samples weighted by catch and stratum area.

CPL	Males	Prim. fem.	Mult. fem.	Total
12.0	54	0	0	54
12.5	0	0	0	0
13.0	0	0	0	0
13.5	0	0	0	0
14.0	0	0	0	0
14.5	0	0	0	0
15.0	4	0	0	4
15.5	110	0	0	110
16.0	233	0	0	233
16.5	274	0	0	274
17.0	369	0	0	369
17.5	502	0	0	502
18.0	1246	0	0	1246
18.5	1786	0	0	1786
19.0	2071	6	8	2086
19.5	3179	0	0	3179
20.0	3867	0	0	3867
20.5	5081	0	0	5081
21.0	6027	0	0	6027
21.5	6064	0	159	6223
22.0	7834	0	242	8076
22.5	8432	0	145	8578
23.0	9692	4	111	9807
23.5	10277	8	313	10599
24.0	9412	0	435	9847
24.5	10041	11	685	10736
25.0	11586	11	739	12336
25.5	10731	0	774	11505
26.0	11865	4	377	12247
26.5	14039	20	785	14844
27.0	16317	35	673	17026
27.5	15949	65	1043	17057
28.0	16876	30	2355	19260
28.5	15955	38	4393	20385
29.0	11832	56	7134	19022
29.5	9174	34	11419	20627
30.0	5884	44	16076	22005
30.5	2511	44	19842	22938
31.0	1208	68	18283	19560
31.5	393	19	16988	17401
32.0	19	19	11178	11217
32.5	0	14	9924	9939
33.0	36	10	5381	5427
33.5	36	0	3258	3294
34.0	0	0	1258	1258
34.5	0	0	406	406
35.0	0	0	361	361
35.5	0	10	9	18
Total	230970	550	134755	366275

Table 5. Numbers of shrimp (thousands) per length group (carapace length) in total biomass estimate in 1990, based on pooling of individual samples weighted by catch and stratum area.

CPL	Males	Prim. fem.	Mult. fem.	Total
13.0	8	0	0	8
13.5	0	0	0	0
14.0	0	0	0	0
14.5	41	0	0	41
15.0	41	0	0	41
15.5	0	0	0	0
16.0	41	0	0	41
16.5	421	0	0	421
17.0	180	0	0	180
17.5	986	0	0	986
18.0	1666	0	0	1666
18.5	1448	452	0	1900
19.0	1673	0	0	1673
19.5	2344	82	0	2426
20.0	2471	82	0	2553
20.5	7524	0	15	7540
21.0	8508	17	5	8530
21.5	15918	0	41	15959
22.0	14770	5	41	14817
22.5	13206	5	574	13786
23.0	7326	0	825	8151
23.5	5669	50	519	6238
24.0	5458	5	973	6435
24.5	7222	0	689	7911
25.0	7396	0	574	7970
25.5	8228	47	1003	9278
26.0	7906	0	1624	9530
26.5	4877	41	423	5341
27.0	6665	0	919	7584
27.5	3347	416	2718	6482
28.0	2740	0	3046	5788
28.5	1434	54	7576	9064
29.0	1290	27	7386	8703
29.5	1373	5	8302	9680
30.0	226	0	9922	10149
30.5	125	13	8404	8542
31.0	92	0	9184	9276
31.5	0	0	8806	8806
32.0	0	0	5155	5155
32.5	0	0	2733	2733
33.0	0	0	873	873
33.5	0	0	915	918
34.0	0	0	523	523
34.5	0	0	508	508
35.0	0	0	5	5
35.5	0	0	62	62
36.0	0	0	0	0
36.5	0	0	10	10
37.0	0	0	0	0
37.5	0	0	0	0
Total	142624	1302	84352	228279

Table 6. Numbers of shrimp (thousands) per length group (carapace length) in total biomass estimate in 1992, based on pooling of individual samples weighted by catch and stratum area.

CPL	Males	Prim. fem.	Mult. fem.	Total
9.0	0	0	5	5
9.5	0	0	0	0
10.0	0	0	0	0
10.5	0	0	0	0
11.0	0	0	0	0
11.5	24	0	0	24
12.0	0	0	0	0
12.5	0	0	0	0
13.0	0	0	0	0
13.5	0	0	0	0
14.0	0	0	0	0
14.5	74	0	0	74
15.0	0	0	0	0
15.5	0	0	0	0
16.0	0	0	0	0
16.5	24	0	0	24
17.0	81	0	0	81
17.5	280	0	0	280
18.0	357	0	0	357
18.5	632	0	0	632
19.0	1085	0	0	1085
19.5	2243	0	0	2243
20.0	3019	0	6	3025
20.5	4206	0	0	4206
21.0	5596	0	9	5605
21.5	7539	0	187	7726
22.0	10213	0	72	10286
22.5	10366	0	27	10393
23.0	13794	0	90	13833
23.5	13877	2	206	14085
24.0	15100	0	129	15229
24.5	13515	4	389	13908
25.0	12984	74	484	13542
25.5	14556	92	937	15585
26.0	10672	21	1400	12094
26.5	8321	33	1737	10090
27.0	6326	0	1414	7741
27.5	4682	74	2061	6817
28.0	2865	149	3177	6191
28.5	541	0	4093	4633
29.0	365	0	4272	4637
29.5	54	0	4876	4930
30.0	217	0	3900	4117
30.5	34	0	3996	4031
31.0	2	0	3519	3522
31.5	0	0	3097	3097
32.0	0	0	1758	1758
32.5	0	0	939	939
33.0	0	0	876	876
33.5	0	0	561	561
34.0	0	0	192	192
34.5	0	0	258	258
35.0	0	0	256	256
35.5	0	0	14	14
36.0	0	0	0	0
36.5	0	0	2	2
Total	163644	450	44940	209034

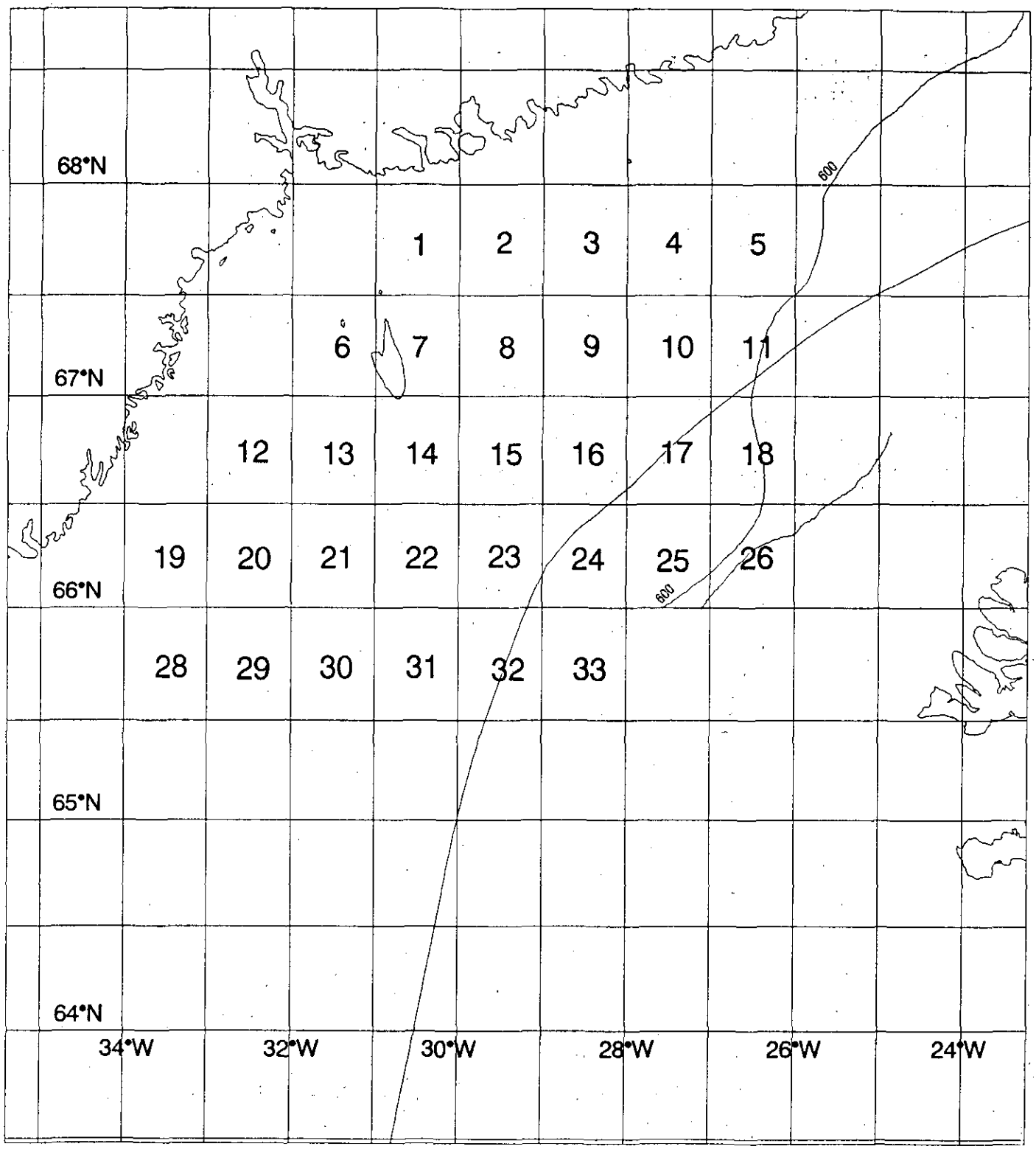


Figure 1. Stratification scheme for the Denmark Strait shrimp survey in 1992. Stratum numbering, the 600 meter depth contour, and the midline are shown.

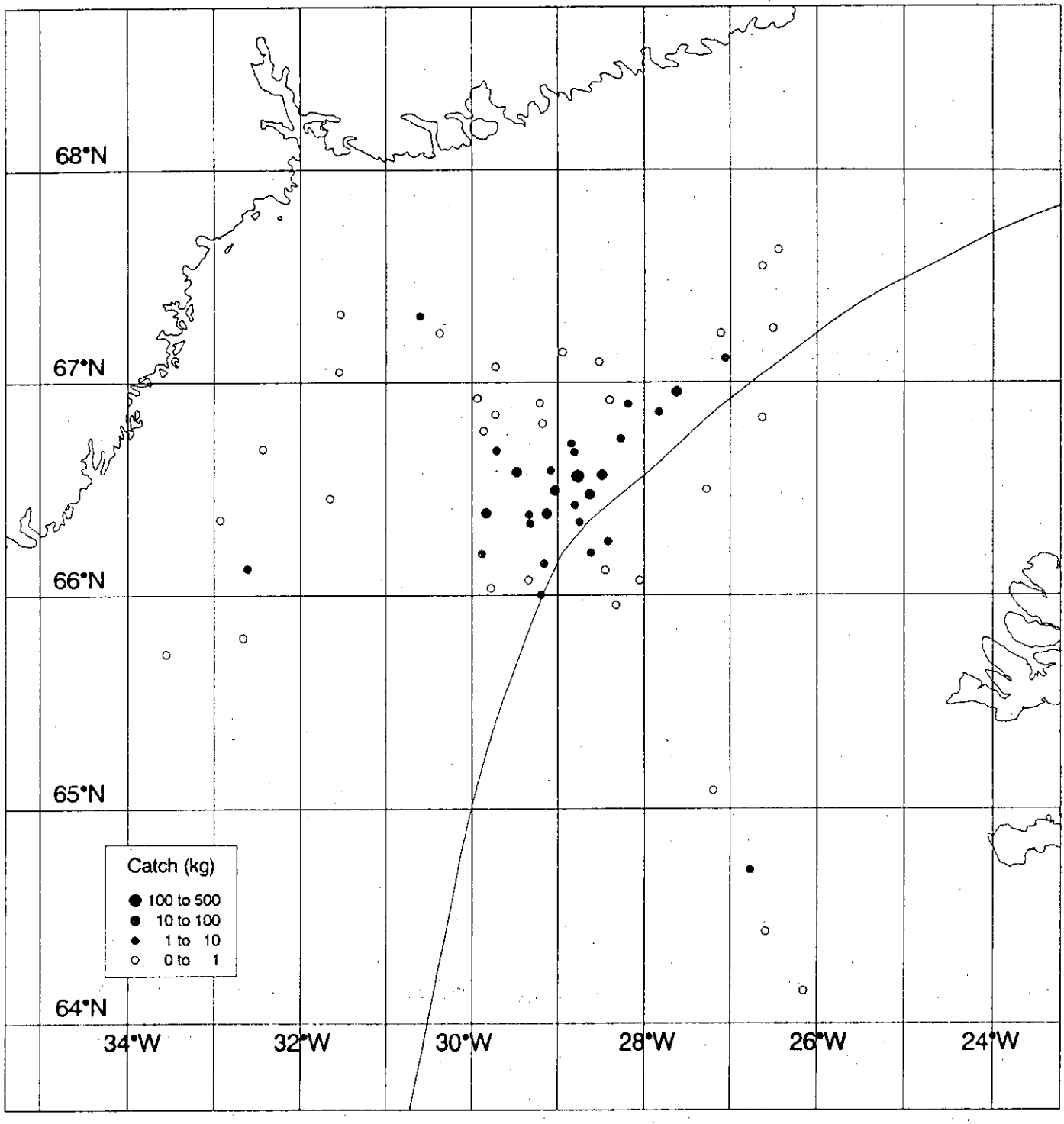
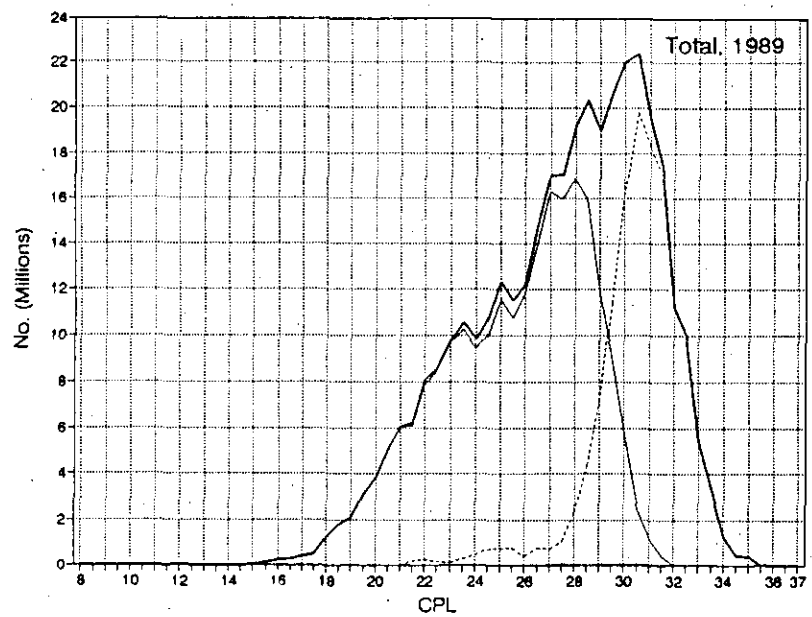
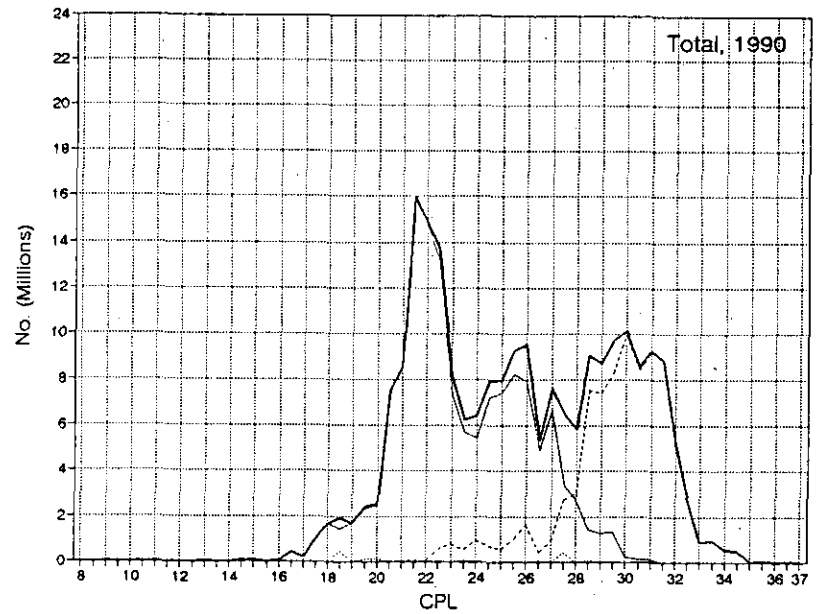


Figure 2. Sampling sites and trawl catches in the Denmark Strait shrimp survey, 1992.





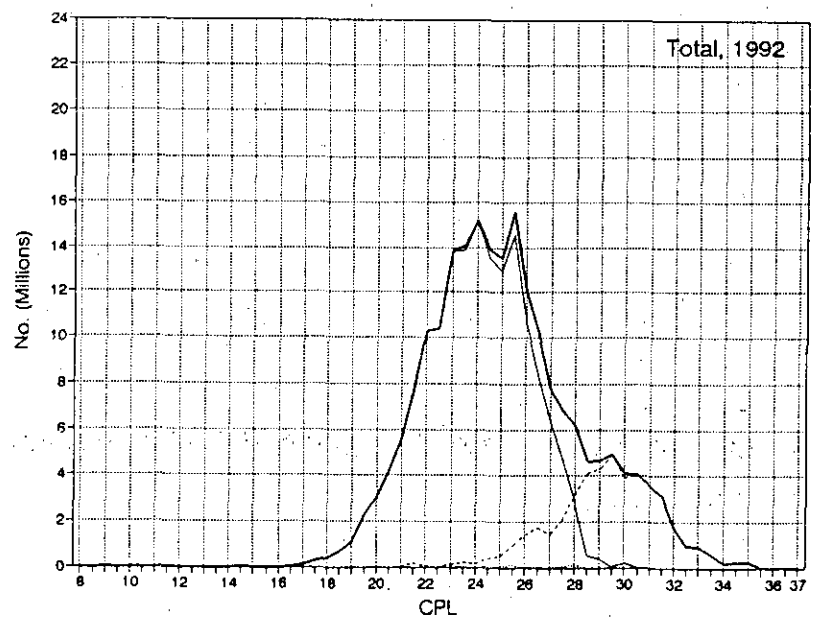


Figure 3. Numbers of shrimp by length group (CL) in the total survey area in 1989, 1990 and 1992, based on pooling of samples weighted by catch and stratum area.

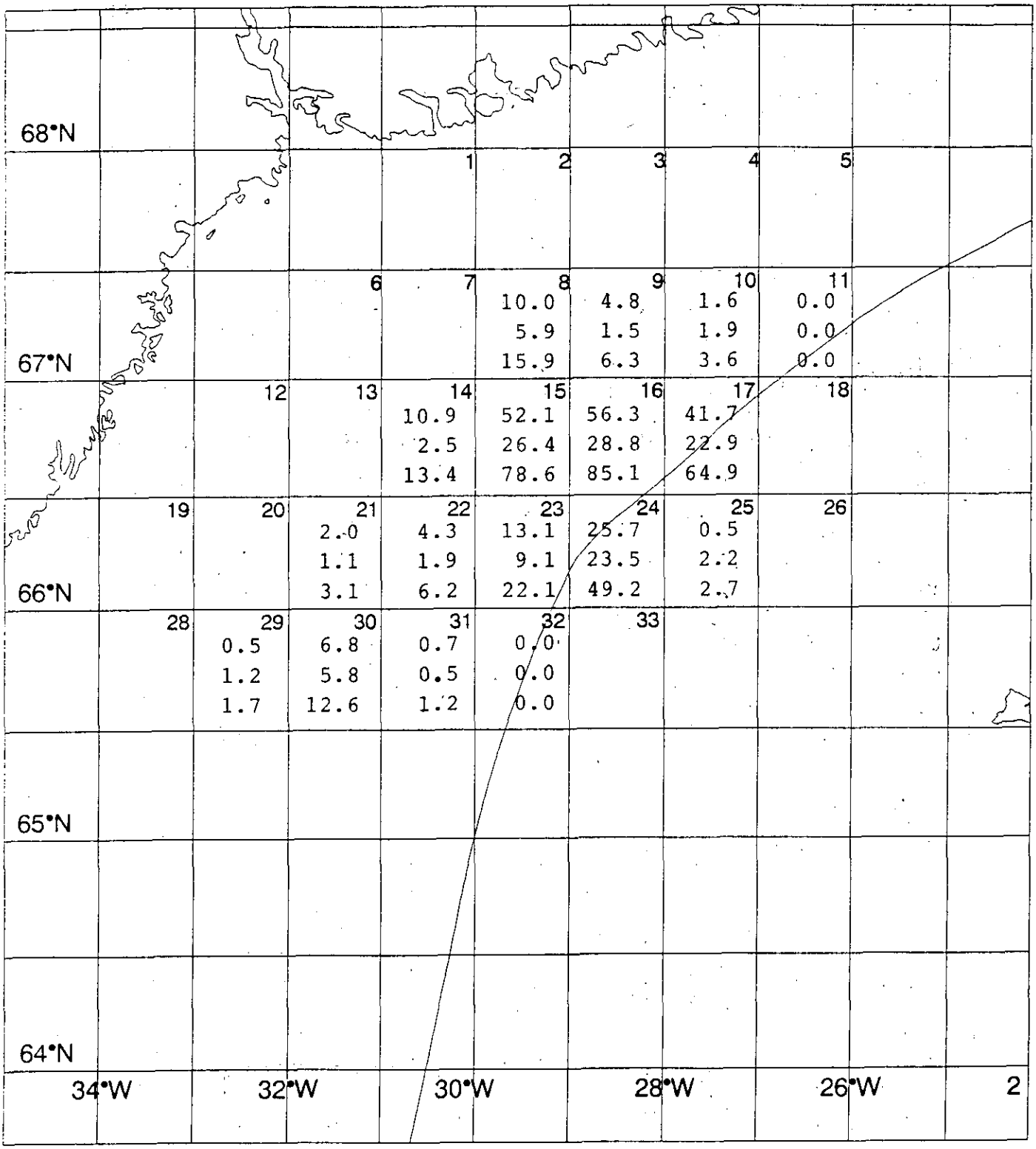


Figure 4. Calculated numbers of shrimp (males, females and total, in millions) per stratum in 1989.

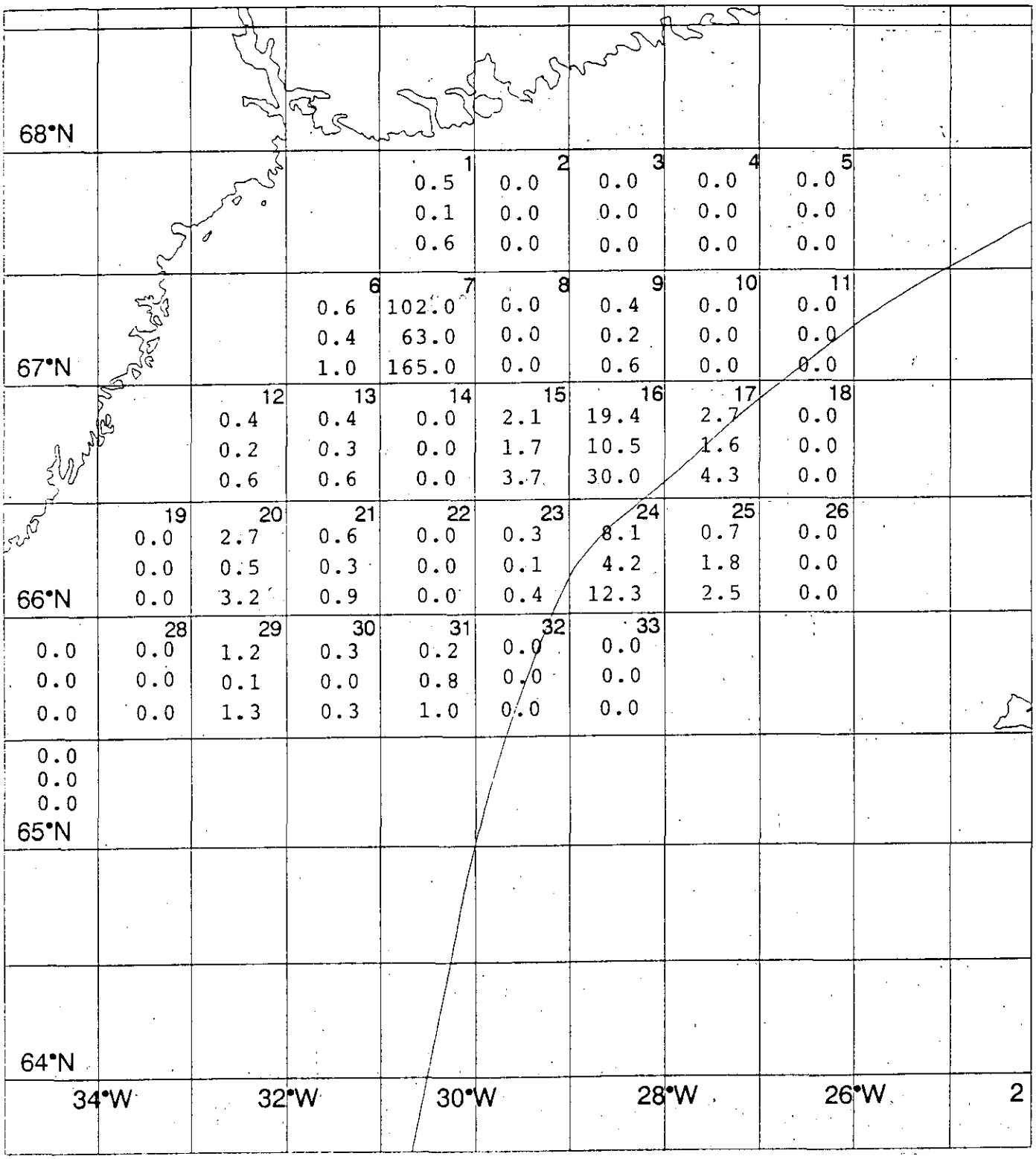


Figure 5. Calculated numbers of shrimp (males, females and total, in *millions*) per stratum in 1990.

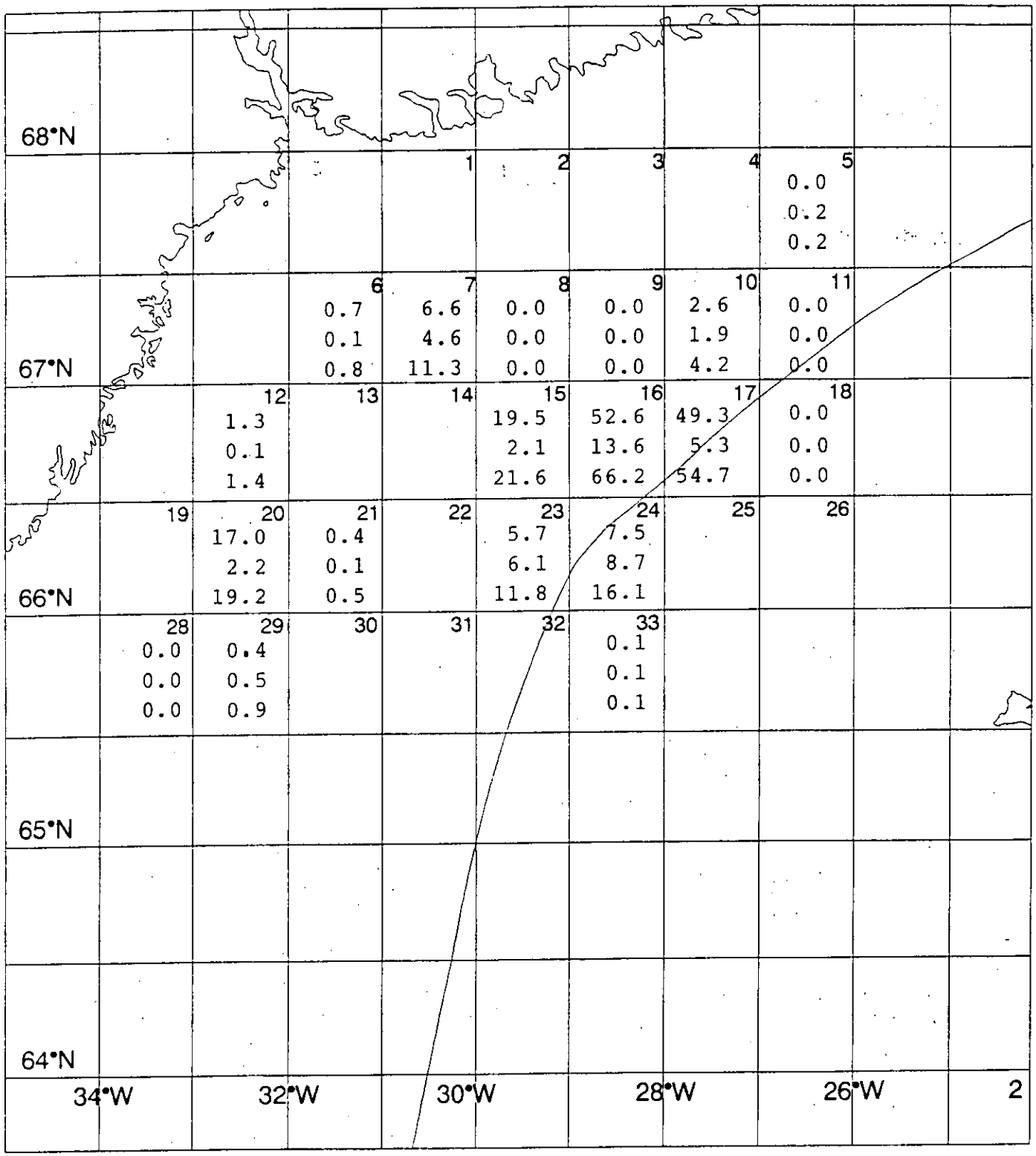


Figure 6. Calculated numbers of shrimp (males, females and total, in millions) per stratum in 1992.