Northwest Atlantic Fisheries Organization

Serial No. N4024 **NAFO SCR Doc. 98/115**

SCIENTIFIC COUNCIL MEETING - NOVEMBER 1998

Stratified-random Trawl Survey for Shrimp (*Pandalus borealis*) in Disko Bay and Vaigat, Inshore West Greenland, 1998

by

D. M. Carlsson and P. Kanneworff

Greenland Institute of Natural Resources
Box 2151, DK-1016 Copenhagen K., Denmark

Introduction

Since 1991, Greenland Institute of Natural Resources has annually conducted stratified-random trawl surveys in part of the inshore areas of West Greenland (Disko Bay and Vaigat) to assess the trawlable biomass and to obtain information on the biology of this component of the *Pandalus borealis* stock (Carlsson and Kanneworff, 1997). The present paper reports on a survey carried out in 1998 in connection with a corresponding survey in the offshore areas (Carlsson and Kanneworff, 1998).

Material and Methods

The survey area covers the inshore West Greenland area between 68°42'N and 70°37'5N (Fig. 1) in the depth interval 150-600 m, a total of 9,364 km². 36 hauls were taken in the period August 26 – September 2, 1998. One haul thus represents 260 km² on average. Depth contours are not mapped in detail, so a stratification based on depth as used in the offshore areas is not possible, but done by separating the region into nine geographical areas, based on information from the commercial fishery.

In the preceding years (1995-97) the surveys were carried out as two-stage surveys which additional hauls during the second stage allocated to strata with highest biomass estimates (and thus highest variation) in order to reduce the variance of the overall estimate. In connection with attempts to improve the sampling scheme for all the shrimp survey areas (see also Carlsson and Kanneworff, 1998) the series of two-stage sampling has been disconnected in 1998, but the same overall coverage as earlier years has been applied.

The survey was performed with the 722 GRT trawler Paamiut, using a 3000/20 meshes *Skjervøy* bottom trawl with a twin cod-end. Mesh size in the cod-end was 20 mm (stretched mesh). Trawl doors were *Greenland Perfect*, measuring 370*250 cm and weighing 2420 kg. Trawl geometry was measured with *Scanmar* acoustic sensors mounted on the trawl doors and *Furuno* trawleye on the headrope.

Standard towing time was 30 minutes. Trawling was carried out only in the daytime (0900-1900 UTC), to minimise the influence of vertical migrations of shrimp. The mean wingspread was calculated for each haul, based on information on distance between doors.

Swept area was calculated as the distance between starting and ending positions (GPS) multiplied by the mean wingspread.

From each haul a sample of approx. 4 kg of shrimp was taken from the cod-end of the trawl before the catch was sorted and weighed by species. Shrimps were sorted by sexual development, and oblique carapax length was measured by slide calliper to the nearest 0.1 mm. Measurements were later pooled in 0.5 mm groups, and 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 area.

Overall length distributions of male shrimp were separated in age groups by modal analysis (Macdonald and Pitcher, 1979) after identification of modes by visual inspection of combined and individual length frequencies from survey strata. Results were compared to results from modal analysis of length distributions from earlier years.

The total catch was sorted, counted and weighed by species.

Results and Discussion

Biomass estimates

In connection with re-evaluation of the design and efficiency of the trawl surveys a study group (Carlsson et al., 1998) has pointed out that a two-stage sampling in this type of survey may introduce a negative bias: 'Since the distribution of the shrimp catches is highly skewed to the right, the bias is caused by a tendency for the additional catches to be smaller than the first stage catches'. Table 1 shows that this effect may be observed in the 1996 and 1997 surveys. At the same time no substantial improvement in the confidence limits seems to be obtained. The survey in 1998 was carried out as a single-stage survey with the same number of stations as the final numbers in the other years. This accomplished the sampling programme 1-2 days shorter than in the other years.

For the nine strata in the area the trawlable biomass has been estimated based on the average catch per swept area. Table 2 shows the details from this calculation. In total, 64,168 tons is estimated for this region with approximate 95 % confidence limits of ±23,470 tons.

The estimated biomass for 1998 is the largest in the time series (Table 3, Fig. 2). A fairly steady increase is indicated since the low value in 1993. Some minor changes from year to year are observed for the various parts of the area, but on average a high degree of stability is seen despite the large commercial catches taken in this area in recent years (Hvingel et al., 1998). The apparent stability in the biomass is also seen in the commercial catch rates. As also observed for the offshore biomass estimate (Carlsson and Kanneworff, 1998) a relatively high variation around the estimated mean values is seen for 1998. Higher variation than normal with the same (or higher) number of sampling stations could indicate a more uneven distribution of the shrimp than earlier observed.

Stock composition

In accordance with the estimated biomass for 1998 being the largest in the time series of surveys, the estimated total numbers of both male and female shrimp are the highest on record (numbers in billions):

Year	males	females	total	males, %	females, %
1991	5.46	1.97	7.43	73.5	26.5
1992	5.55	1.55	7.10	78.2	21.8
1993	3.20	1.45	4.65	68.8	31.2
1994	4.94	1.63	6.57	75.2	24.8
1995	3.99	2.08	6.06	65.8	34.3
1996	5.97	2.21	8.18	73.0	27.0
1997	8.23	1.44	9.67	85.1	14.9
1998	8.87	2.30	11.17	79.4	20.6

The estimated biomass of shrimp was relatively stable from 1995 to 1997, while the estimated number of shrimp increased over the same years, due to an increase in number of males. Number of females increased slightly from 1995 to 1996, but decreased by about 30% from 1996 to 1997. In 1998 it increased again, but in relation to total number of shrimp it is still below average.

Table 4 and Fig. 3 show the number of shrimp (males and females) by stratum and year in 1995-98. Some changes in the relative occurrence of males and females are seen over the years. Compared to 1997 number of males increased in 1998 in western and central Disko Bay (areas D3 and D4) and in central Vaigat (D7 and D8). Number of females increased in southwestern and central Disko Bay (D1, D3, D4, and D5) and in southern Vaigat (D7). In all other areas except northern Vaigat (D9), where a steady decrease over the four year period is seen, number of females occur stable between 1997 and 1998.

Overall length distributions of shrimp from 1991 to 1998 are shown in Fig. 4. Because of similarity between length distributions of shrimp from the offshore areas and from the Disko and Vaigat area in terms of occurrence of length modes the age-at-length structure in the two regions has been considered similar. Age-at-length analysis of samples from the Disko and Vaigat areas has therefore been based on the theoretical size at age as interpreted in shrimp samples from the Davis Strait (Savard et al. 1994). Based on the progression of year classes in samples from 1995 to 1997 the age-at-length structure was reanalysed. The new interpretation by Carlsson (1997) indicated occurrence of only five modes of males between 8 and 23 mm CL, one mode less than the former. This new interpretation seems fit for the 1998-samples also and has been used here. Results are shown in Table 5 and compared to results from 1995-97 in Table 6.

Under the new interpretation male modes of age 1 to 5 can be identified at 9, 13, 16.5, 19.5, and 22.5 mm CL in most years, and the progression of modes can be followed through the years. In 1996 the group of two years old males is significant at 12.5 mm CL, and this year class (1994) dominates the male group in 1997 at 17 mm CL and in 1998 at 19.2 mm CL (Table 6).

Figures 4a and 4b show the overall length-frequency distributions by stratum in 1998, and Table 5 shows the breakdown in cohorts by modal analysis of combined area length distributions and the total area distribution. Results indicate good agreement in the determination of mean length by age for all areas. Furthermore, there is a fair agreement between the sum of abundances calculated for separate areas and for the total area (Fig. 5).

There are significant differences in the abundance of age groups between areas. Smaller male shrimp (age 2 and 3) are most abundant in the Vaigat area (D6, D7, and D8), age group 3 also in southeastern and western Disko Bay area (D2 and D3). Age group 4 dominates in southern and central Disko Bay (D1, D3, D4, and D5), while larger males are most abundant in central Disko Bay (D4). Recruitment of the 1997 year class is indicated in most areas, in highest abundance in southern and northern Disko Bay (D1, D2, and D6). Female shrimp are most abundant in southwestern and central Disko Bay (D1 and D4).

Table 6 shows mean carapace length and percents-at-age for males, and abundance-at-age for all shrimp in the survey area from 1995 to 1998. In 1998, the numbers of older males (age 4) and females (age 6+) are below averages for the three years, while the number of males at age 2 and - especially – age 3 are above. This indicates that the prospects for the fishery in 1999 are good in terms of shrimp size (large males and females), and good recruitment to the female group in year 2000, depending on the size of the 1994 year class at that time.

Conclusions

The estimated biomass in the Disko Bay – Vaigat area seems to be in a steady state, and an increase in total biomass is indicated for the period 1993-98 despite large commercial catches in recent years.

Stock composition data indicate occurrence of five age groups of male shrimp, with the 1994 year class dominating size distributions in both 1997 and 1998. The female component is larger than in 1997 and of the same magnitude as in 1995 and 1996. Prospects of recruitment to the female group are fair in 1999 and good in year 2000, where significant recruitment from the 1994 year class can be expected.

References

Carlsson, D.M., 1997. A new interpretation of the age-at-length key for shrimp (*Pandalus borealis*) in the Disko area (Disko Bay and Vaigat) in West Greenland (NAFO Subarea 1). NAFO SCR Doc. 97/104. Serial No. N2961.

Carlsson, D.M. and P. Kanneworff, 1997. Stratified-random trawl survey for shrimp (*Pandalus borealis*) in Disko Bay and Vaigat, inshore West Greenland, 1997. NAFO SCR Doc. 97/99. Serial No. N2956.

Carlsson, D.M. and P. Kanneworff, 1998. Offshore stratified-random trawl survey for shrimp (*Pandalus borealis*) in NAFO Subarea 0+1, in 1998. NAFO SCR Doc. 98/118. Serial No. N4027.

Carlsson, D.M., O. Folmer, C. Hvingel, P. Kanneworff, M. Pennington and H. Siegstad, 1998. A review of the trawl survey of the shrimp stock off West Greenland. NAFO SCR Doc. 98/114. Serial No. N4023.

Hvingel, C., O. Folmer and H. Siegstad, 1998. The Greenlandic fishery for northern shrimp (*Pandalus borealis*) off West Greenland, 1970 - 1998. NAFO SCR Doc. 98/111. Serial No. N4020.

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

Savard, L., D.G. Parsons, and D.M. Carlsson, 1994. Estimation of age and growth of northern shrimp (*Pandalus borealis*) in Davis Strait (NAFO Subareas 0+1) using cluster analysis and modal analysis. J. Northw. Atl. Fish.Sci., Vol. 16:64-74.

Table 1. Biomass estimates and their confidence in two-stage surveys 1995-97 and in the 1998-survey in Disko area.

Year	Stage	No. of Stations	Biomass	CL (95 %)	Pct.
1995	first	28	46453	17095	37
	both	37	47060	12643	27
1996	first	31	57494	11952	21
	both	36	55706	10279	19
1997	first	31	54117	15268	28
	both	37	48880	11174	23
1998	-	36	64168	23470	37

Table 2. Estimated trawlable biomass and sampling statistics in strata in Disko Bay – Vaigat area, 1998.

STRATUM	SQKM	TONS	HAULS	STD	CV
AREA D1	819	10361	3	16648	161
AREA D2	566	2980	2	948	32
AREA D3	1124	8069	4	6861	85
AREA D4	1834	15292	7	9276	61
AREA D5	612	5170	2	563	11
AREA D6	1014	3663	4	3681	101
AREA D7	1447	10852	6	6440	59
AREA D8	652	4840	3	3952	82
AREA D9	1296	2940	5	5077	173

Table 3. Biomass estimates (tons) 1991-98 in strata in Disko Bay – Vaigat.

Stratum	Sqkm	Biomass							
		1991	1992	1993	1994	1995	1996	1997	1998
D1	819	9390	3238	2595	10474	5229	3688	9410	10361
D2	566	5869	1510	1765	654	2339	1470	3793	2980
D3	1124	5667	5700	1719	7459	6572	2824	3162	8069
D4	1834	7928	13676	7686	7318	10534	18853	9131	15292
D5	612	892	3416	2890	2558	4722	3862	4233	5170
D6	1014	4006	5552	4717	2884	2008	3177	5910	3663
D7	1447	5298	6077	3643	3995	7799	16095	6165	10852
D8	652	3264	1046	2084	2573	1389	794	2922	4840
D9	1296	5264	4953	5072	3391	6467	3802	4154	2940
Total	9364	47578	45167	32169	41306	47058	54565	48880	64168

Table 4. Estimated no. of shrimp (males, females and total) by stratum in 1995-98.

No. of males, millions

Year/stratum	D1	D2	D3	D4	D5	D6	D7	D8	D9	Total
1995	429	370	855	795	441	194	414	50	438	3985
1996	1245	188	604	1264	618	687	1033	63	271	5971
1997	1897	829	257	1150	951	1757	777	132	485	8235
1998	1133	877	1166	1704	589	1215	1298	610	284	8875
Mean	1190	463	572	1070	670	879	741	81	398	6064

No. of females, millions

Year/stratum	D1	D2	D3	D4	D5	D6	D7	D8	D9	Total
1995	264	68	217	506	217	96	403	19	288	2076
1996	10	56	63	1028	113	35	670	29	204	2207
1997	208	96	145	368	104	69	153	140	155	1438
1998	533	52	284	591	226	37	313	142	120	2298
Mean	161	73	142	634	145	67	408	63	216	1907

Total No. of shrimp, millions

Year/stratum	D1	D2	D3	D4	D5	D6	D7	D8	D9	Total
1995	692	438	1072	1301	658	290	817	69	725	6062
1996	1255	244	667	2291	730	721	1703	92	475	8178
1997	2105	925	401	1518	1055	1827	930	272	641	9673
1998	1666	929	1451	2294	815	1252	1611	752	403	11172
Mean	1351	536	713	1703	815	946	1150	144	614	7971

Table 5. Carapace length, proportions-at-age, and abundance-at-age (millions) of male shrimp in the Disko Bay in 1998, based on modal analysis of length-frequency distributions from strata and total area.

CL, mm	AGE						C.V.	Standard
STRATUM	1	2	3	4	5	6		error
D1	9.1	12.6	15.4	18.9	22.0		0.06	.04-.17
D2	9.2	12.8	16.3	19.2			0.06	.04-.12
D3	9.4	13.5	16.4	19.4	22.7		0.06	.06-.14
D4	9.3	13.5	16.6	19.3	22.5		0.06	.06-.11
D5	9.3	12.9	16.3	19.3	22.1		0.06	.11-.21
D6	9.1	12.8	16.3	19.6			0.06	.03-.51
D7	9.8	13.4	17.4	20.2	23.8		0.06	.05-.19
D8		13.9	17.4	20.1	24.0		0.06	.07-.31
D9	9.2	13.9	18.0	20.2	23.5		0.06	.08-.35
mean	9.3	13.3	16.7	19.6	22.9			
TOTAL	9.3	13.2	16.4	19.2	22.9		0.07	.03-.07

Proportions	AGE						Standard	TOTAL
STRATUM	1	2	3	4	5	6	error	MALES
D1	0.13	0.05	0.12	0.55	0.15		.007-.020	1133.0
D2	0.19	0.22	0.37	0.22			.013-.021	876.7
D3	0.08	0.14	0.29	0.28	0.20		.007-.018	1166.3
D4	0.05	0.08	0.22	0.39	0.27		.005-.018	1703.6
D5	0.05	0.07	0.19	0.48	0.22		.009-.033	588.6
D6	0.10	0.35	0.44	0.11			.009-.017	1215.0
D7	0.05	0.28	0.23	0.20	0.24		.006-.017	1297.7
D8		0.32	0.31	0.18	0.20		.021-.030	610.0
D9	0.17	0.17	0.09	0.25	0.33		.022-.041	283.6
mean	0.10	0.19	0.25	0.30	0.23			8874.5
TOTAL	0.09	0.17	0.23	0.33	0.18		.003-.009	8874.5

Abundance	AGE						SUM	TOTAL
STRATUM	1	2	3	4	5	6		MALES
D1	147.3	56.7	136.0	623.2	170.0		1133.0	1133.0
D2	166.6	192.9	324.4	192.9	0.0		876.7	876.7
D3	93.3	163.3	338.2	326.6	233.3		1154.6	1166.3
D4	85.2	136.3	374.8	664.4	460.0		1720.6	1703.6
D5	29.4	41.2	111.8	282.5	129.5		594.5	588.6
D6	121.5	425.3	534.6	133.7	0.0		1215.0	1215.0
D7	64.9	363.4	298.5	259.5	311.4		1297.7	1297.7
D8	0.0	195.2	189.1	109.8	122.0		616.1	610.0
D9	48.2	48.2	25.5	70.9	93.6		286.4	283.6
SUM	756.4	1622.3	2332.9	2663.4	1519.7		8894.7	8874.5
TOTAL	798.7	1508.7	2041.1	2928.6	1597.4		8874.5	

Table 6. Carapace length and percents-at-age for males, and abundance at age for all shrimp in Disko Bay in 1995-98, based on modal analysis of total length-frequencies for the survey area.

CL, mm	AGE				
Year	1	2	3	4	5
1995		12.6	16.2	19.5	22.4
1996		12.6	16.4	19.3	22.2
1997	8.3	12.5	16.7	19.7	22.5
1998	9.3	13.2	16.4	19.2	22.9

Proportion	AGE					TOTAL
Year	1	2	3	4	5	MALES
1995		0.03	0.10	0.39	0.48	3985.5
1996		0.25	0.19	0.20	0.36	5970.5
1997	0.02	0.21	0.44	0.13	0.20	8234.7
1998	0.09	0.17	0.23	0.33	0.18	8874.5

Abundance	AGE						TOTAL
Year	1	2	3	4	5	6+	
1995	0.0	119.6	398.6	1554.3	1913.0	2076.1	6061.6
1996	0.0	1492.6	1134.4	1194.1	2149.4	2207.3	8177.8
1997	164.7	1729.3	3623.3	1070.5	1646.9	1438.2	9672.9
1998	798.7	1508.7	2041.1	2928.6	1597.4	2297.7	11172.2

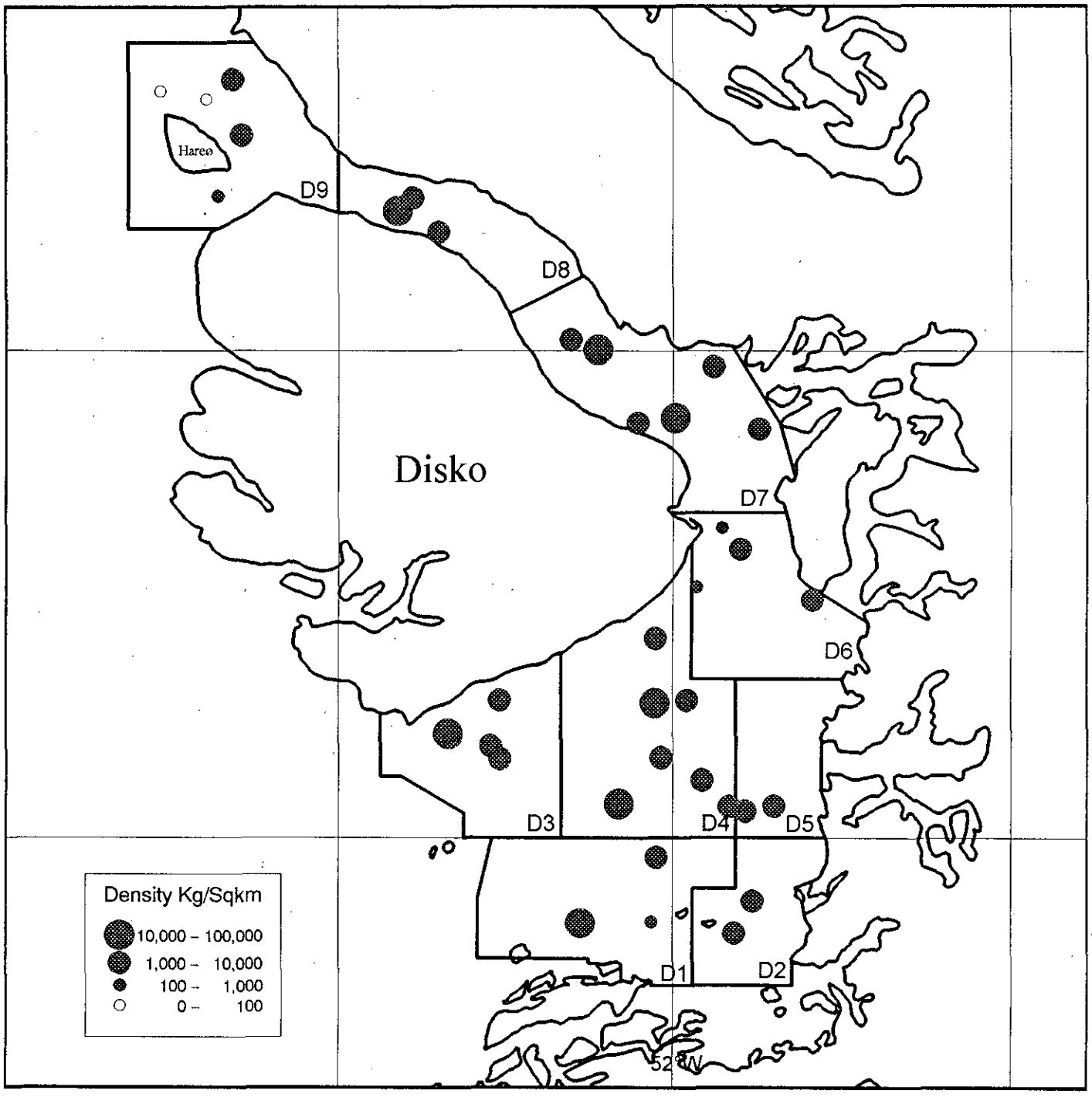

Fig. 1. Sampling sites and shrimp densities (kg per km² swept area) in the 1998 trawl survey in Disko Bay – Vaigat area.

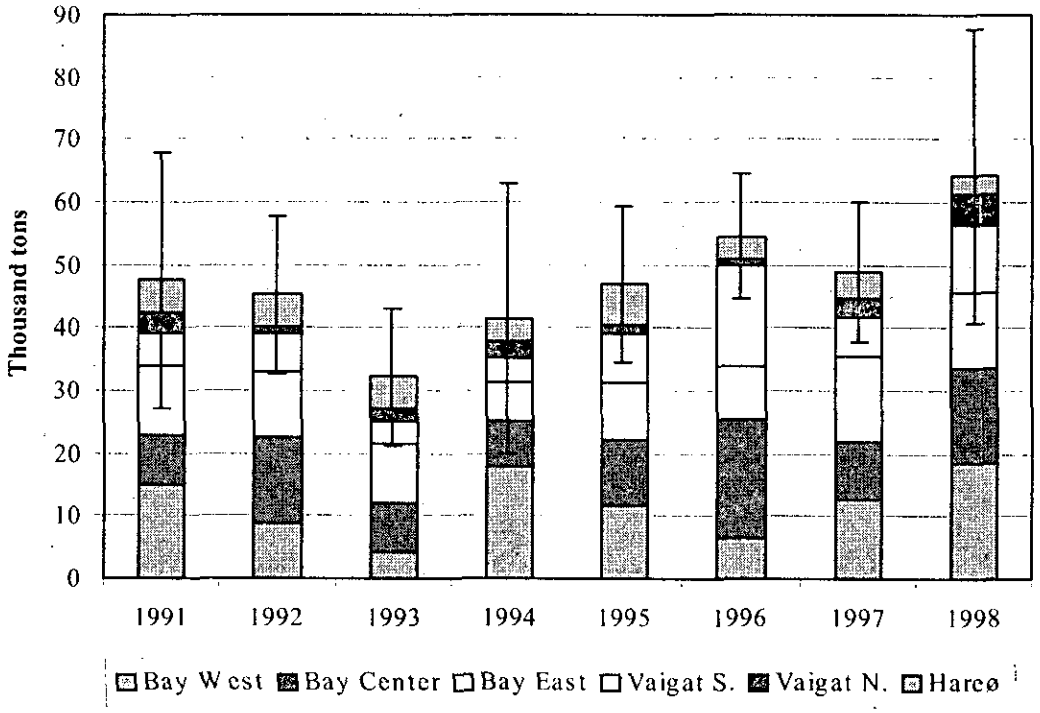

Fig. 2. Estimated biomass 1991-98 in different parts of the Disko Bay – Vaigat area. Approximate confidence limits (95 %) for the total biomass estimates are also indicated.

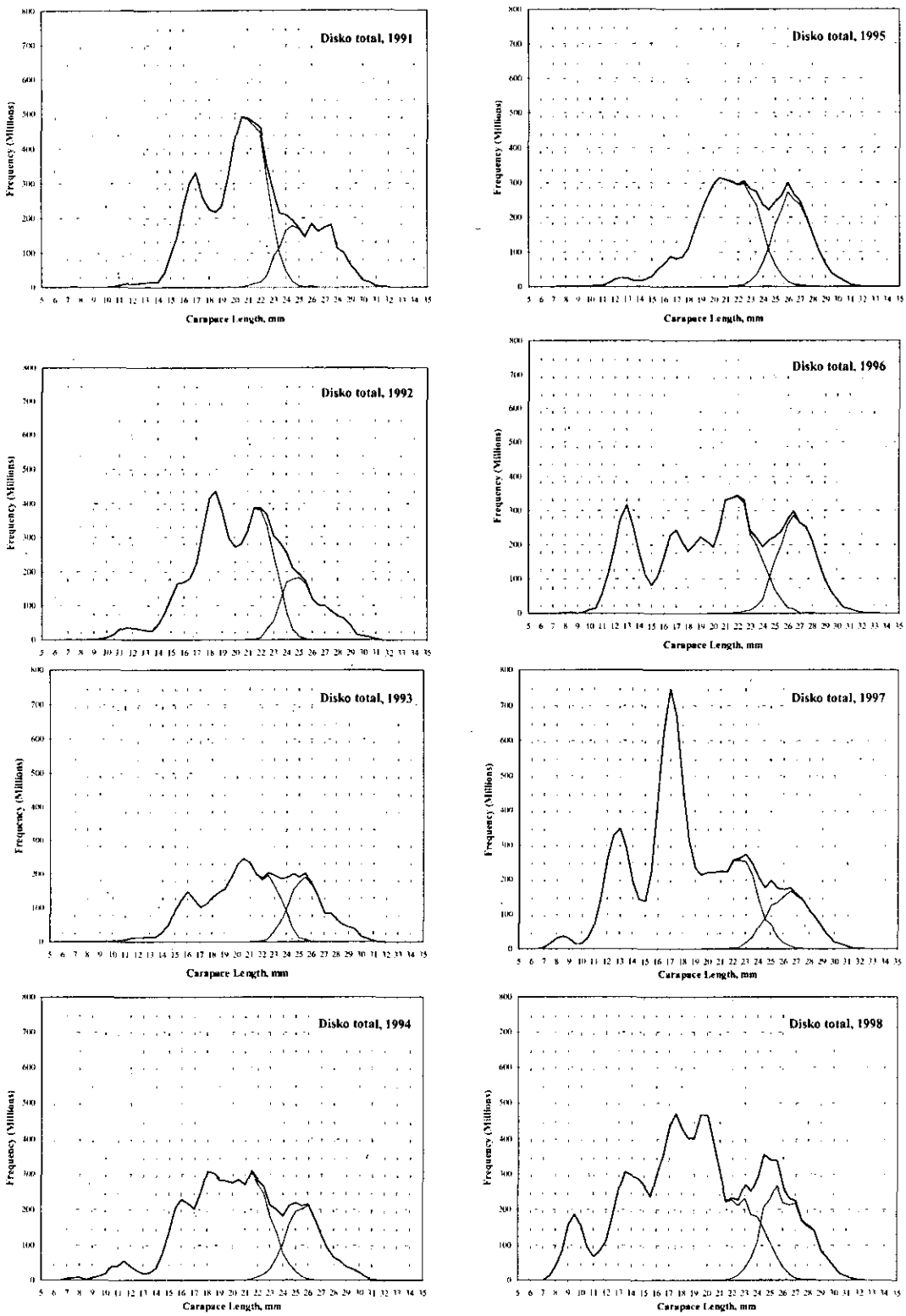

Fig. 3. Numbers of shrimp by length group (CL) in the total survey area 1991-98.

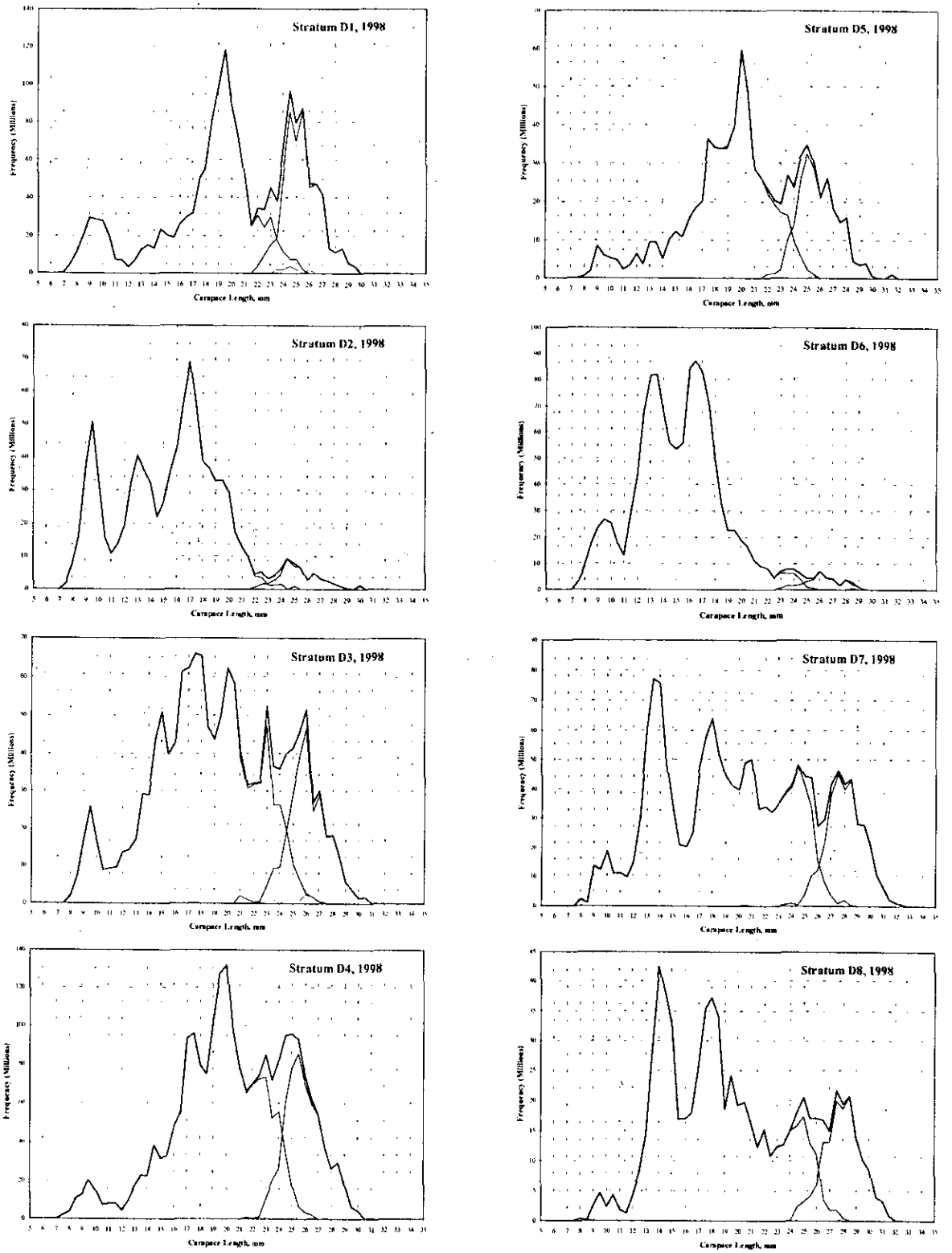

Fig. 4a. Numbers of shrimp by length group (CL) in strata D1-D8 (see Fig. 1).

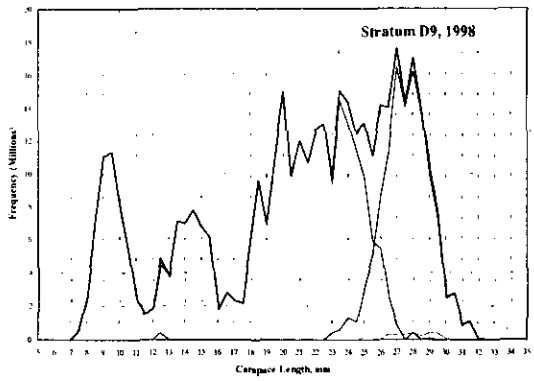

Fig. 4b. Numbers of shrimp by length group (CL) in strata D9 (see Fig. 1).

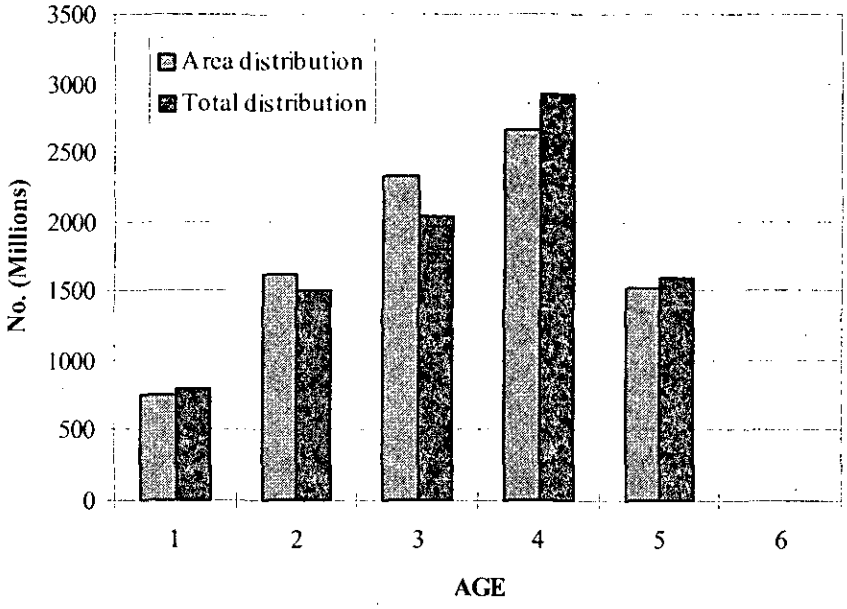

Fig. 5. Comparison of abundance of size groups based on modal analysis of length distributions from stratification areas and modal analysis of total area length distribution.