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The Commercial Shrimp Fishery in Denmark Strait in 1994 and January-October 1995

by

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Introduction

In November 1994 STACFIS advised that the TAC of shrimp in the Denmark Strait of 5,000 tons recommended for 1994 remain for 1995 to allow for a continued improvement in stock size. Like in 1993 and 1994 the effective TAC for 1995 in the Greenland zone alone was set to 9,563 tons of which 3,888 tons was allocated to Greenland. No effective TAC is set for the Icelandic zone.

Besides Greenland, Denmark, the Faroe Islands and Norway participated in the fishery in the Greenland zone in 1994 and 1995. The total catches by these nations as reported to Greenland authorities amounted to 8,261 tons in 1994 and 5,751 tons in 1995 until October. Catches by Greenland vessels alone accounted in 1994 for 48% of the total catches amounting to 3,924 tons. By the end of October 1995 Greenland vessels accounted for approximately 45% of this years catches equalling 2,614 tons.

Log book records provided preliminary information on fleet performance and geographical distribution of the fishery in 1995 and samples from the commercial fleet on size composition of catches. These data together with an update of data from previous years will be presented in this paper.

Materials and Methods

Based on compulsory weekly reporting to Greenland authorities by vessels above 75 GRT, total catch and number of vessels in the Greenland zone were compiled by nation and month.

Logbook data were analyzed to show the spatial distribution of the fishery and the overall distribution of catches by year, and of catch, effort and catch rates by month.

Logbook data from 32 Greenland trawlers were used in a multiplicative model (Carlsson & Lassen, 1991) to calculate standardized annual catch rate indices for the years 1987-1995 in the traditional fishing area north of 65°N (Siegstad & Carlsson, 1994). Indices were calculated for total catch, and - to avoid the influence of unreported discard of smaller shrimp - for shrimp larger than 8.5 g (Carlsson & Lassen, 1991).

Catch and effort were aggregated by vessel, month and year. All cells in the matrix with less than 10 hours of effort or with 10% or more of the catch not being sorted by shrimp size were excluded to avoid the influence of cells with few hauls and non sorted catch.. Significant interactions between year-month, year-vessel, and vessel-month exist in the data but their contribution to the variation is small in relation to that explained by the main effects (vessel, month, year). The final analysis were therefore run with main effects only.

Size composition of shrimp catches by year were generated from samples from the commercial Greenland fishery. Samples taken by observers before processing were sorted by sexual characteristics (McCrary, 1971) and measured to the nearest 0.1 mm carapace length. The data were then pooled in 0.5 mm length groups and adjusted by ratio of weight to the number caught in the set. Numbers from all sets for the month were totalled and adjusted by weight to the monthly catch reported in vessel logs. The numbers from all months were totalled and adjusted by weight to the total catch of the year.

Annual length frequency distributions of catches in the traditional fishing area north of 65°N from 1991 to 1995 were analyzed by modal analysis (Macdonald & Pitcher, 1979) in an attempt to isolate year classes. The number of age components and initial estimates of their mean lengths were unknown and the iterations were allowed to run freely for best fit, except for a fixed coefficient of variation at 0.045.

Results and Discussion

Reported Catches 1994 - October 1995

The tables below show catches by month and nation in tons and the numbers of reporting vessels in the Denmark Strait in 1994 and 1995 as reported to Greenland authorities.

Total reported catch in 1994 was 8,261 tons, an increase from the 5,086 tons reported in 1993 and larger than the preliminary figures for 1995 of 5,751 tons. In 1994 the figures for the same period (Jan. to Oct.) was 6,213 tons. Thus the 1995 catches might end up at the same level as in 1994 i.e. about 8,000 tons.

A total of 45 vessels participated in the fishery in 1994 and until October 1995 a total of 44 vessels have been registered.

The seasonal distribution of the fishery was similar to previous years with minimum activity in the summer period.

Catch (tons):

Year	Nation	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1994	Denmark	18	8	29	49	14	0	0	150	43	139	133	103	686
	Faroe Isl.	284	188	73	127	69	0	0	0	0	31	194	179	1145
	Greenland	1053	892	488	229	96	0	9	447	3	8	462	237	3924
	Norway	135	269	336	510	196	0	0	124	189	134	505	108	2506
	Total	1490	1357	926	915	375	0	9	721	235	312	1294	627	8261
1995	Denmark	137	101	2	0	16	0	131	170	49	29	-	-	635
	Faroe Isl.	276	227	136	28	0	0	0	5	57	29	-	-	758
	Greenland	1356	641	208	0	193	0	5	197	14	0	-	-	2614
	Norway	392	87	274	115	80	0	0	140	410	246	-	-	1744
	Total	2161	1056	620	143	289	0	136	512	530	304	-	-	5751

Number of vessels:

Year	Nation	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1994	Denmark	1	1	1	1	1	0	0	2	1	2	2	2	2
	Faroe Isl.	4	5	2	4	6	0	0	0	0	2	3	6	9
	Greenland	15	16	11	5	3	0	1	4	1	1	6	3	18
	Norway	4	4	9	12	10	0	0	7	8	9	10	8	16
	Total	24	26	23	22	20	0	1	13	10	14	21	19	45
1995	Denmark	2	2	1	0	1	0	1	1	1	1	-	-	2
	Faroe Isl.	7	7	6	3	0	0	0	1	2	2	-	-	7
	Greenland	15	12	7	0	3	0	1	6	1	0	-	-	16
	Norway	9	6	12	8	4	0	0	6	14	16	-	-	19
	Total	33	27	26	11	8	0	2	14	18	19	-	-	44

Geographical Distribution of the Greenland Fishery

The fishing pattern in the Denmark Strait has changed since 1993 when new fishing areas were found south of 65°N. These and the traditional fishing area north of 65°N can be seen in Fig. 1 and 2 which show the geographical distribution of the Greenland catches in 1994 and 1995 respectively as recorded in vessel logs.

The fishery north of 65°N were in 1994 concentrated between 65°30'N to 67°N and between 30°W and 31°W. In 1995 the northern limit of the fished area has moved a little southwards in return for a broadening to the west to about 32°W.

The new fishing areas south of 65°N got a lot of attention in 1994 and more than half of the total Greenland fishing effort in the Denmark Strait were spent between 60°N and 65°N. Most catches were taken between 62°N and 62°30'N but other concentrations were also located (Fig. 1). In 1995 the preliminary data suggest a substantial decrease in trawling hours and with that catches in the "new" areas compared to 1994 (Table 4-6). The spatial distribution of the fishery however is almost the same (Fig. 1 and 2).

Figure 3 shows the monthly distribution of catch rates in 1994 and 1995 by statistical unit of 7.5' latitude and 15' longitude. The largest catch rates are found in the southern area.

Catch, Effort and Unstandardized CPUE from Vessel Logs

Monthly, semi-annual and annual catch, effort and mean catch rates based on logbooks from the Greenland, Danish and Ferreous fishery in the Denmark strait are given in Tables 1-6.

The Greenland fishery in the traditional area north of 65°N has gradually changed from an all year activity with a minimum in the summer months, to effort only being spent in the first 3 or 4 month of the year. This time of year though generally produces the highest catch rates in the area.

The Danish and Ferreous fleet also allocate least effort in the summer months but generally spread their activity more over the year.

In the "new" fishing areas south of 65°N no decisive seasonal pattern is yet visible. After the discovery of the fishing grounds in 1993 where fishery only took place in half of the year, 1994 was the year for all to try the new area and approximately 60% of the total effort in the Denmark Strait was spent south of 65°N distributed over all months except June. In spite of catch rates being almost twice as high as north of 65°N (Tables 1-6) popularity of the new fishing areas seems to fade in 1995 where about 75% of the three fleets effort are being spent in the traditional fishing area - probably due to less favourable bottom conditions for trawling in the southern area. This trend is also reflected in the catch data (Fig. 4)

Total fishing effort (Denmark, Faroe Isl. & Greenland) in the Denmark Strait has shown a declining trend from about 50,000 hr's in 1989 to about 23,000 hr's in 1994 but the preliminary data for 1995 suggests the tendency to stabilize (Fig. 5). The catches followed the same trend until 1993 when the new fishing grounds south of 65°N enhanced catch rates and made catches peak in 1994 at almost 6,000 tons (Fig 5). In 1995 catches will probably reach the same level as in 1994.

Standardized CPUE from Greenland Vessel Logs

Results of the multiple regression analysis to standardize catch rates of both large shrimp (>8.5 g) and total catch (Tables 7-8) show that all main effects are highly significant ($p<0.0001$) and their combined effects explain 70.4% and 66.0% of the variation in CPUE respectively. All first-order interactions between the effects of year, month and vessel are also highly significant, suggesting that the effects of year on CPUE differs from month to month and from vessel to vessel. The contribution of these interactions to the variability within the data set however are small compared to that of the main effects thus the basic model without interactions were considered a good description of the data.

The annual catch rate indices for large shrimp and total catch as calculated from the regression analysis are presented in Fig. 6. The two curves are almost parallel showing a declining trend from 1987 to 1992, stability between 1992 and 1993 succeeded by an increase in 1994 an again stability between 1994 and 1995. T-values indicate that from 1987 to 1989 catch rates were significantly higher and in 1992 and 1993 significantly lower than in 1995. No statistical difference to the 1995 CPUE index was observed in 1990, 1991 and 1994.

Length Distributions

In 1995 sampling from the commercial Greenland trawlers only took place in January (13 samples) and March (15 samples) and only from the traditional area north of 65°N (Table 9). The catches in January 1995 were composed of an almost equal distribution of shrimps in the 21.5-30 mm size groups dominated by a broad male peak at 21.5-25 mm and a multiparae peak at around 29 mm carapace length (Fig. 8). The smaller group of primiparous caught has an average length of approximately 27.5 mm. Males formed 58% of this months catches, primiparous 9% while multiparous accounted for 33%.

In March 1995 a male component constituting 70% of the catches makes the length-frequency distribution peak at about 24.5 mm. The multiparous part of the catches has dropped to 21% but now with maximum count around 29.5 mm (Fig. 8). Primiparous continue to make up 9% at an average length of 27.5 mm.

In the years 1991 to 95 mean shrimp size caught in the area north of 65°N declined 1.4 mm from 26.8 mm to 25.4 mm (Fig. 10). Unfortunately not all samples were sorted by sexual characteristics but the decline in mean catch-size was most probably caused by males making up a larger and larger part of the catches. This is supported by the disappearance of the large-"female" peaks that existed in 1991-92. If the 1.4 mm drop in mean size from 1991-95 is caused by the disappearance of the largest shrimps this corresponds to a reduction in mean age of shrimp caught in the Denmark Strait by approximately one year.

A special situation (probably) occurred in 1994 in the north where primiparous constituted nearly 50% of the catches. This could however be due to faulty sorting.

Figure 9 shows the length distribution in the southern area in 1993 and 1994 (samples from 1995 are missing). In 1993 where the fishery started in the southern areas the mean shrimp size in the catches were smaller than north of 65°N, namely 25.9 mm compared to 26.7 mm. This relation changed in 1994 when the mean size had grown to 26.6 mm and the catches were dominated by a female component of 67%.

Modal analysis were applied to the yearly length frequency distributions of the Greenland catches in the traditional fishing area north of 65°N (Table 10). Runs with 6 age components produced the best fits and estimated reasonable consistent mean lengths from year to year. Skúladóttir (1994) also found 6 age components in a similar analysis and the estimated mean lengths agree very well with her findings -our "x1" group corresponding to her age 3 etc..
Due to lack of knowledge of shrimp growth in the Denmark Strait assigning of absolute age to the found age components are still a matter of belief and therefore this was not done in Table 10.

The estimated proportions caught at age (Table 10) show that the major contribution to the catches (67-84%) come from year class x3, x4 and x5 while year class x1 are almost invisible. Year class x2 and x6+ equally contributes 5-18%. The earlier mentioned reduction in the large shrimp component was confirmed in the declining proportions of year class x6+ from 1991 to 1995.

The estimated proportions were applied to the total catch numbers to produce a catch-at-age matrix which was subsequently divided by the unstandardized fishing effort to produce age-specific indices of abundance (Table 10). The general trend in the catch rates was stability from 1991 to 1992 followed by a decline in 1993 and an increase until 1995 (Fig. 7). This development in catch rates based on numbers parallel the trend in catch rate based on weight (Greenland trawlers, only). All year classes follows this optimistic pattern from 1993 to 1995 and especially a large increase in catch rate of year class x1 and -2 is noticeable, perhaps indicating incoming of two good year classes to join the fishery in 1996 and 1997.

The conclusions or suggestions above should be viewed in the context that the annual length frequency distributions, although based on a lot of measured individuals, do not represent a complete coverage of the fishery in time and space.

Conclusion

The geographical distribution of the fishery in the Denmark Strait in 1994 was maintained in 1995. Catches in 1995 will probably reach the same level as in 1994 i.e. 8,000 tons. The effort spent in the area seems to stabilize at around 25,000 hours following a decline from more than 50,000 hours in 1991.

The unstandardized catch rate more than doubles from 1993 to 1994 partly due to an improved utilization of the new fishing grounds south of 65°N, but also caused by an increased abundance in the area north of 65°N as indicated by the standardized CPUE. In 1995 this enhanced level of abundance is maintained in the northern area. The unstandardized catch rate calculated for the entire Denmark Strait however declined from 1994 to 1995. The shift in the allocation of fishing effort from 1994 to 1995 now again in advance of the traditional fishing grounds north of 65°N with lower catch rates, is probably the main reason to this.

The mean size of shrimp caught in the Denmark Strait has decreased in the resent five years. Both due to a reduction in the female component but in the last two years also caused by an increased recruitment of males to the fishery as indicated by the increase in catch rates of age class x1, -2 and -3. If this interpretation is true catch rates might improve in the following years as the individuals of these year classes grow bigger.

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Table 1. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) from 1989 to October 1995 in the traditional fishing area north of 65°N, based on logbooks from the Greenland fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1989	Jan	251	6596	1657	Jul	21	19	0
	Feb	214	6381	1365	Aug	43	724	31
	Mar	132	3909	515	Sep	59	2311	136
	Apr	197	3508	691	Oct	96	2611	249
	May	67	2356	158	Nov	68	7039	477
	Jun	39	137	5	Dec	84	7155	604
	Subtotal	192	22887	4391	Subtotal	75	19859	1497
	Total	192	23343	4471	Total	75	20039	1510
1990	Jan	139	8629	1202	Jul	95	82	8
	Feb	185	8314	1540	Aug	56	369	21
	Mar	142	8371	1191	Sep	63	712	45
	Apr	474	1050	498	Oct	59	1736	102
	May	455	2143	974	Nov	66	2125	140
	Jun	45	116	5	Dec	79	5196	411
	Subtotal	189	28623	5409	Subtotal	71	10220	727
	Total	189	28956	5478	Total	71	10298	732
1991	Jan	142	6812	964	Jul	0	38	0
	Feb	129	7205	926	Aug	0	0	0
	Mar	101	6403	646	Sep	73	404	30
	Apr	128	7700	987	Oct	64	375	24
	May	85	5084	434	Nov	91	505	46
	Jun	73	471	34	Dec	105	897	95
	Subtotal	118	33675	3991	Subtotal	87	2219	194
	Total	118	33684	3980	Total	87	2572	225
1992	Jan	94	3698	346	Jul	0	0	0
	Feb	113	3802	431	Aug	0	0	0
	Mar	123	5423	665	Sep	0	0	0
	Apr	73	3682	268	Oct	33	143	5
	May	101	1260	127	Nov	83	358	30
	Jun	0	0	0	Dec	104	1669	174
	Subtotal	103	17865	1838	Subtotal	97	2170	209
	Total	103	17639	1811	Total	97	2073	201
1993	Jan	85	6216	528	Jul	0	0	0
	Feb	93	5066	469	Aug	0	0	0
	Mar	120	2347	282	Sep	0	0	0
	Apr	85	390	33	Oct	0	0	0
	May	15	26	0	Nov	0	0	0
	Jun	0	0	0	Dec	176	95	17
	Subtotal	93	14045	1312	Subtotal	176	95	17
	Total	93	15077	1408	Total	176	97	17
1994	Jan	216	844	183	Jul	0	0	0
	Feb	172	3037	523	Aug	0	0	0
	Mar	155	2194	340	Sep	0	0	0
	Apr	37	76	3	Oct	0	0	0
	May	0	2	0	Nov	0	0	0
	Jun	0	0	0	Dec	0	0	0
	Subtotal	170	6153	1048	Subtotal	0	0	0
	Total	170	6200	1056	Total	0	0	0
1995	Jan	262	3801	996	Jul	0	0	0
	Feb	193	2691	518	Aug	0	0	0
	Mar	174	1907	332	Sep	0	0	0
	Apr	0	0	0	Oct	0	0	0
	May	0	1	0	Nov			
	Jun	0	0	0	Dec			
	Subtotal	220	8400	1846	Subtotal	0	0	0
	Total	220	8550	1879	Total	0	0	0

Table 2. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) from 1989 to October 1995 in the traditional fishing area north of 65°N, based on logbooks from the Danish fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1989	Jan	232	346	80	Jul	0	0	0
	Feb	273	485	132	Aug	52	112	6
	Mar	170	415	71	Sep	51	418	22
	Apr	0	0	0	Oct	68	305	21
	May	0	0	0	Nov	48	337	16
	Jun	13	105	1	Dec	72	264	19
	Subtotal	211	1351	285	Subtotal	58	1436	84
	Total	211	1336	282	Total	58	1450	84
1990	Jan	98	248	24	Jul	46	316	15
	Feb	74	140	10	Aug	43	454	19
	Mar	92	341	31	Sep	38	373	14
	Apr	0	0	0	Oct	47	414	19
	May	0	0	0	Nov	45	411	19
	Jun	0	0	0	Dec	17	186	3
	Subtotal	91	729	66	Subtotal	41	2154	89
	Total	91	3304	302	Total	42	2120	88
1991	Jan	0	0	0	Jul	0	0	0
	Feb	0	0	0	Aug	0	0	0
	Mar	52	351	18	Sep	45	230	10
	Apr	81	424	35	Oct	47	767	36
	May	78	328	26	Nov	0	3	0
	Jun	0	0	0	Dec	52	294	15
	Subtotal	71	1103	78	Subtotal	47	1294	61
	Total	71	3295	234	Total	58	2123	124
1992	Jan	59	70	4	Jul	0	0	0
	Feb	0	0	0	Aug	0	0	0
	Mar	41	293	12	Sep	0	0	0
	Apr	42	212	9	Oct	0	0	0
	May	0	0	0	Nov	37	115	4
	Jun	0	0	0	Dec	53	217	12
	Subtotal	43	575	25	Subtotal	47	332	16
	Total	43	3013	131	Total	47	613	29
1993	Jan	35	456	16	Jul	0	0	0
	Feb	46	566	26	Aug	0	0	0
	Mar	44	477	21	Sep	0	0	0
	Apr	33	222	7	Oct	0	0	0
	May	0	0	0	Nov	0	0	0
	Jun	0	0	0	Dec	73	167	12
	Subtotal	41	1721	71	Subtotal	73	167	12
	Total	41	2075	85	Total	73	342	25
1994	Jan	148	147	22	Jul	0	0	0
	Feb	72	65	5	Aug	0	0	0
	Mar	103	283	29	Sep	56	41	2
	Apr	52	110	6	Oct	72	125	9
	May	58	59	3	Nov	61	122	8
	Jun	0	0	0	Dec	178	557	99
	Subtotal	97	664	65	Subtotal	140	845	118
	Total	97	667	65	Total	140	953	133
1995	Jan	203	659	134	Jul	0	0	0
	Feb	109	721	78	Aug	0	0	0
	Mar	224	127	29	Sep	0	0	0
	Apr	0	0	0	Oct	0	0	0
	May	0	0	0	Nov			
	Jun	0	0	0	Dec			
	Subtotal	160	1507	241	Subtotal	0	0	0
	Total	160	1509	241	Total	0	0	0

Table 3. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) from 1989 to October 1995 in the traditional fishing area north of 65°N, based on logbooks from the Faeroese fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1989	Jan	157	871	137	Jul	0	0	0
	Feb	121	789	95	Aug	0	0	0
	Mar	108	781	85	Sep	0	0	0
	Apr	291	235	69	Oct	0	0	0
	May	0	0	0	Nov	51	430	22
	Jun	0	0	0	Dec	109	1202	131
	Subtotal	145	2676	385	Subtotal	93	1632	153
	Total	145	3035	439	Total	93	1672	156
1990	Jan	94	1208	113	Jul	0	0	0
	Feb	109	1311	143	Aug	0	0	0
	Mar	85	961	82	Sep	0	0	0
	Apr	24	113	3	Oct	0	0	0
	May	256	668	171	Nov	45	307	14
	Jun	0	0	0	Dec	95	1353	128
	Subtotal	122	4261	512	Subtotal	82	1660	142
	Total	122	5631	685	Total	82	1925	158
1991	Jan	113	1984	223	Jul	0	0	0
	Feb	92	2937	269	Aug	0	0	0
	Mar	69	1793	123	Sep	83	262	22
	Apr	129	330	43	Oct	48	274	13
	May	0	0	0	Nov	60	1335	80
	Jun	0	0	0	Dec	88	2787	245
	Subtotal	93	7044	658	Subtotal	77	4658	360
	Total	93	8610	801	Total	77	2659	206
1992	Jan	69	2052	141	Jul	0	0	0
	Feb	66	1536	102	Aug	0	0	0
	Mar	94	1154	109	Sep	0	0	0
	Apr	52	356	18	Oct	32	290	9
	May	50	1245	62	Nov	81	2133	172
	Jun	0	0	0	Dec	104	2800	290
	Subtotal	68	6343	432	Subtotal	96	5223	471
	Total	68	7446	508	Total	96	6095	584
1993	Jan	66	2634	175	Jul	0	0	0
	Feb	70	2394	167	Aug	0	0	0
	Mar	62	1674	105	Sep	0	0	0
	Apr	56	721	41	Oct	0	0	0
	May	61	23	1	Nov	0	0	0
	Jun	0	0	0	Dec	0	0	0
	Subtotal	66	7446	488	Subtotal	0	0	0
	Total	66	8446	554	Total	0	0	2
1994	Jan	395	133	53	Jul	0	0	0
	Feb	172	596	103	Aug	0	0	0
	Mar	168	293	49	Sep	0	0	0
	Apr	66	235	15	Oct	0	0	0
	May	90	189	17	Nov	52	287	15
	Jun	0	0	0	Dec	177	381	68
	Subtotal	164	1446	237	Subtotal	123	668	82
	Total	164	1745	286	Total	123	665	82
1995	Jan	114	1569	179	Jul	0	0	0
	Feb	82	1242	102	Aug	0	0	0
	Mar	97	1106	107	Sep	0	0	0
	Apr	46	259	12	Oct	0	0	0
	May	0	0	0	Nov			
	Jun	0	0	0	Dec			
	Subtotal	96	4176	400	Subtotal	0	0	0
	Total	96	5879	563	Total	0	0	63

Table 4. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) in the new fishing areas south of 65°N from 1993 when the fishery started in this area to October 1995, based on logbooks from the Greenland fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1993	Jan	151	74	11	Jul	0	0	0
	Feb	70	350	24	Aug	0	0	0
	Mar	162	802	130	Sep	0	0	0
	Apr	181	2422	438	Oct	0	0	0
	May	329	923	304	Nov	0	0	0
	Jun	0	0	0	Dec	1138	80	91
	Subtotal	199	4571	908	Subtotal	1138	80	91
	Total	199	4165	827	Total	1138	80	91
1994	Jan	439	2015	884	Jul	463	19	9
	Feb	322	1123	362	Aug	460	904	416
	Mar	191	642	123	Sep	383	92	35
	Apr	288	835	240	Oct	250	32	8
	May	239	493	118	Nov	512	813	416
	Jun	0	0	0	Dec	320	878	281
	Subtotal	338	5108	1727	Subtotal	425	2738	1165
	Total	338	5038	1703	Total	425	2742	1166
1995	Jan	362	785	284	Jul	439	31	14
	Feb	163	452	74	Aug	371	476	177
	Mar	33	24	1	Sep	0	0	0
	Apr	0	0	0	Oct	0	0	0
	May	481	405	195	Nov			
	Jun	0	0	0	Dec			
	Subtotal	332	1666	553	Subtotal	375	507	190
	Total	332	1560	518	Total	375	576	216

Table 5. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) in the new fishing areas south of 65°N from 1993 when the fishery started in this area to October 1995, based on logbooks from the Danish fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1993	Jan	0	0	0	Jul	0	0	0
	Feb	0	0	0	Aug	0	0	0
	Mar	0	0	0	Sep	0	0	0
	Apr	65	361	23	Oct	0	0	0
	May	120	183	22	Nov	0	0	0
	Jun	0	0	0	Dec	0	0	0
	Subtotal	83	544	45	Subtotal	0	0	0
	Total	83	576	48	Total	0	0	0
1994	Jan	110	10	1	Jul	0	0	0
	Feb	0	8	0	Aug	268	473	127
	Mar	0	0	0	Sep	184	331	61
	Apr	157	303	48	Oct	175	744	130
	May	92	120	11	Nov	232	432	100
	Jun	0	0	0	Dec	205	57	12
	Subtotal	135	441	60	Subtotal	211	2037	430
	Total	135	392	53	Total	211	2053	433
1995	Jan	0	0	0	Jul	577	247	143
	Feb	0	0	0	Aug	326	427	139
	Mar	0	2	0	Sep	277	257	71
	Apr	0	0	0	Oct	0	0	0
	May	418	39	16	Nov			
	Jun	0	0	0	Dec			
	Subtotal	398	41	16	Subtotal	379	931	353
	Total	398	38	15	Total	379	1002	380

Table 6. Monthly and semiannual mean catch rate (kg/hr), effort (hr) and catch (tons) in the new fishing areas south of 65°N from 1993 when the fishery started in this area to October 1995, based on logbooks from the Faeroese fleet. Total semiannual catches represent the catches from the logbooks (subtotal) weighted up to total catches as reported to Greenland authorities, and total semiannual efforts are calculated from these figures and the CPUE's.

Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1993	Jan	0	0	0	Jul	0	0	0
	Feb	40	153	6	Aug	0	0	0
	Mar	74	875	64	Sep	0	0	0
	Apr	65	1332	87	Oct	0	0	0
	May	32	180	6	Nov	0	0	0
	Jun	0	0	0	Dec	1889	38	72
	Subtotal	64	2540	163	Subtotal	1889	38	72
	Total	64	2378	153	Total	1889	38	71
1994	Jan	326	500	163	Jul	0	0	0
	Feb	183	556	102	Aug	0	0	0
	Mar	168	161	27	Sep	0	0	0
	Apr	228	380	87	Oct	131	254	33
	May	106	310	33	Nov	237	554	131
	Jun	0	0	0	Dec	288	472	136
	Subtotal	216	1907	412	Subtotal	235	1280	301
	Total	216	2106	455	Total	235	1367	321
1995	Jan	0	2	0	Jul	0	0	0
	Feb	92	520	48	Aug	0	0	0
	Mar	85	181	15	Sep	0	0	0
	Apr	70	268	19	Oct	0	0	0
	May	0	0	0	Nov			
	Jun	0	0	0	Dec			
	Subtotal	84	971	82	Subtotal	0	0	0
	Total	84	1235	104	Total	0	0	28

Table 7. Standardization of CPUE for total shrimp catches in the Denmark Strait north of 65°N: ANOVA table and parameter estimates (output from the GLM procedure of the SAS-Application).

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	50	173.2704624	3.4654092	25.90	0.0001
Error	668	89.3840086	0.1338084		
Corrected Total	718	262.6544709			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.659690	7.582206	0.365798	4.824431

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESS	31	41.98506046	1.35435679	10.12	0.0001
YR	8	57.09938617	7.13742327	53.34	0.0001
MO	11	74.18601573	6.74418325	50.40	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESS	31	48.64657516	1.56924436	11.73	0.0001
YR	8	72.46155813	9.05769477	67.69	0.0001
MO	11	74.18601573	6.74418325	50.40	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		4.482707077 B	43.00	0.0001	0.10424506
VESS	OUIN	0.029163796 B	0.27	0.7898	0.10934103
	OUIQ	0.324354937 B	2.80	0.0052	0.11563503
	OUKV	0.454306187 B	2.32	0.0204	0.19543415
	OUOQ	0.044024874 B	0.49	0.6246	0.08992670
	OUPJ	0.204950182 B	2.43	0.0152	0.08422278
	OUTM	-0.299518817 B	-3.08	0.0022	0.09731061
	OUWH	0.152495847 B	1.76	0.0789	0.08665253
	OUYM	-0.491536754 B	-3.24	0.0013	0.15187571
	OWDV	-0.289229050 B	-2.01	0.0448	0.14389713
	OWGG	0.406213516 B	2.95	0.0033	0.13791055
	OWLQ	-0.346801684 B	-3.51	0.0005	0.09867703
	OWQU	0.483706258 B	5.21	0.0001	0.09281040
	OWSH	-0.145073925 B	-1.47	0.1415	0.09856303
	OWUD	-0.179712072 B	-0.67	0.5013	0.26707783
	OWUJ	-0.359576167 B	-1.85	0.0642	0.19393593
	OWVM	-0.226270876 B	-2.37	0.0180	0.09542519
	OWWP	0.312240038 B	3.52	0.0005	0.08863323
	OWZR	-0.446497903 B	-2.90	0.0039	0.15410276
	OXSY	-0.302281777 B	-1.97	0.0490	0.15329130
	OYAQ	-0.297232095 B	-1.82	0.0690	0.16319116
	OYBZ	0.268935370 B	3.12	0.0019	0.08607362
	OYCK	0.194789895 B	1.99	0.0475	0.09808603
	OYFF	0.173887705 B	1.42	0.1563	0.12253252
	OYHO	0.575371457 B	7.69	0.0001	0.07486143
	OYKK	-0.154535007 B	-1.89	0.0596	0.08190949
	OYNR	0.021420666 B	0.24	0.8092	0.08866775
	OYNS	-0.074219088 B	-0.85	0.3956	0.08731977
	OYRK	0.154099270 B	1.43	0.1524	0.10756741
	OYRT	0.155500434 B	1.82	0.0699	0.08565122
	OYXT	0.317275568 B	3.67	0.0003	0.08636321
	OZKQ	0.371406709 B	4.05	0.0001	0.09180928
	ZZZZ	0.000000000 B	.	.	.
YR	87	0.552360893 B	6.23	0.0001	0.08866374
	88	0.391913024 B	4.78	0.0001	0.08206934
	89	-0.008232049 B	-0.10	0.9176	0.07955690
	90	-0.098472244 B	-1.22	0.2214	0.08044844
	91	-0.296548991 B	-3.62	0.0003	0.08194068
	92	-0.632356642 B	-7.43	0.0001	0.08515384
	93	-0.706233718 B	-8.11	0.0001	0.08704484
	94	0.032352366 B	0.33	0.7381	0.09672281
	95	0.000000000 B	.	.	.
MO	1	0.626590318 B	11.66	0.0001	0.05374345
	2	0.579185171 B	10.91	0.0001	0.05306961
	3	0.371054109 B	6.83	0.0001	0.05431904
	4	0.305714187 B	4.55	0.0001	0.06719423
	5	0.030577198 B	0.41	0.6801	0.07413564
	6	-0.416131400 B	-2.63	0.0087	0.15816822
	7	-0.390564120 B	-1.77	0.0765	0.22015627
	8	-0.516884454 B	-4.30	0.0001	0.12018841
	9	-0.433459386 B	-4.28	0.0001	0.10119533
	10	-0.281058579 B	-3.41	0.0007	0.08245682
	11	-0.413351574 B	-6.02	0.0001	0.06863487
	12	0.000000000 B	.	.	.

Table 8. Standardization of CPUE for catches of large shrimp (>8.5 g) in the Denmark Strait north of 65°N: ANOVA table and parameter estimates (output from the GLM procedure of the SAS-Application).

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	50	171.5052601	3.4301052	31.19	0.0001
Error	655	72.0410558	0.1099863		
Corrected Total	705	243.5463159			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.704200	6.993659	0.331642	4.742037

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESS	31	35.15728634	1.13410601	10.31	0.0001
YR	8	58.72336056	7.34042007	66.74	0.0001
MO	11	77.62461319	7.05678302	64.16	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESS	31	40.73522583	1.31403954	11.95	0.0001
YR	8	81.55020098	10.19377512	92.68	0.0001
MO	11	77.62461319	7.05678302	64.16	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		4.192662076	B	44.09	0.0001	0.09509793
VESS	OUIN	0.099662659	B	1.00	0.3173	0.09957640
	OUIQ	0.340886714	B	3.24	0.0013	0.10517640
	OUKV	0.573644644	B	3.23	0.0013	0.17740804
	OUOQ	0.167770813	B	1.98	0.0480	0.08470279
	OUPJ	0.229363340	B	2.99	0.0029	0.07681985
	OUTM	-0.240000436	B	-2.71	0.0070	0.08864298
	OUWH	0.233826131	B	2.93	0.0035	0.07976989
	OUYM	-0.444672819	B	-3.22	0.0013	0.13797912
	OWDV	-0.245685021	B	-1.88	0.0606	0.13072346
	OWGG	0.419780196	B	3.35	0.0009	0.12529441
	OWLQ	-0.261551366	B	-2.91	0.0038	0.08991971
	OWQU	0.535982641	B	6.34	0.0001	0.08456388
	OWSH	-0.099106055	B	-1.10	0.2701	0.08978293
	OWUD	-0.260993257	B	-1.08	0.2819	0.24234773
	OWUJ	-0.378187172	B	-2.15	0.0321	0.17605898
	OWVM	-0.203338686	B	-2.31	0.0213	0.08810935
	OWWP	0.373482172	B	4.62	0.0001	0.08081767
	OWZR	-0.385792008	B	-2.75	0.0061	0.14014504
	OXSY	-0.237420222	B	-1.70	0.0887	0.13926104
	OYAQ	-0.269261477	B	-1.82	0.0697	0.14820636
	OYBZ	0.305028346	B	3.85	0.0001	0.07916456
	OYCK	0.176170156	B	1.97	0.0491	0.08937161
	OYFF	0.171556336	B	1.54	0.1241	0.11141405
	OYHO	0.488704087	B	7.12	0.0001	0.06860244
	OYKK	-0.025166041	B	-0.33	0.7432	0.07677623
	OYNR	0.058339975	B	0.72	0.4706	0.08080847
	OYNS	-0.032140488	B	-0.40	0.6865	0.07958726
	OYRK	0.196933505	B	2.01	0.0446	0.09786832
	OYRT	0.250377393	B	3.18	0.0015	0.07870217
	OYXT	0.362195652	B	4.60	0.0001	0.07876509
	OZKQ	0.431064753	B	5.15	0.0001	0.08365909
	ZZZZ	0.000000000	B	.	.	.
YR	87	0.670516639	B	8.29	0.0001	0.08091879
	88	0.642922937	B	8.62	0.0001	0.07462225
	89	0.234575699	B	3.25	0.0012	0.07218638
	90	0.081864407	B	1.12	0.2641	0.07324347
	91	-0.166660539	B	-2.24	0.0254	0.07437575
	92	-0.502648924	B	-6.48	0.0001	0.07753908
	93	-0.619276868	B	-7.82	0.0001	0.07917670
	94	-0.010845784	B	-0.12	0.9016	0.08769949
	95	0.000000000	B	.	.	.
MO	1	0.650474000	B	13.28	0.0001	0.04899639
	2	0.594534389	B	12.27	0.0001	0.04844580
	3	0.352194914	B	7.11	0.0001	0.04953232
	4	0.288796503	B	4.63	0.0001	0.06231416
	5	-0.017929521	B	-0.26	0.7963	0.06944426
	6	-0.488890275	B	-3.41	0.0007	0.14351348
	7	-0.366271164	B	-1.83	0.0671	0.19968132
	8	-0.507639328	B	-4.65	0.0001	0.10918770
	9	-0.466594708	B	-5.08	0.0001	0.09193119
	10	-0.333026642	B	-4.44	0.0001	0.07505108
	11	-0.396139922	B	-6.15	0.0001	0.06437246
	12	0.000000000	B	.	.	.

Table 9. Number of biological sample(s) taken in the commercial shrimp fishery and actual number of individuals measured (n) to examine size composition of catches north of 65°N.

Year/	1991		1992		1993		1994		1995	
Month	n	s	n	s	n	s	n	s	n	s
1	14898	30	0	0	0	0	0	0	3505	13
2	20127	28	4834	20	16258	56	6682	19	0	0
3	17872	42	0	0	6560	10	0	0	6124	15
4	24286	75	0	0	27933	37	0	0	0	0
5	9861	38	0	0	0	0	0	0	0	0
6	12181	24	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	-	-
9	0	0	0	0	0	0	0	0	-	-
10	0	0	0	0	0	0	0	0	-	-
11	0	0	0	0	0	0	0	0	-	-
12	0	0	0	0	0	0	0	0	-	-
Total	99225	237	4834	20	50751	103	6682	19	9629	28

Table 10. Output from the modal analysis of annual length frequency distributions in the commercial Greenland catches north of 65°N in the Denmark Strait. Numbers caught as derived from the calculated proportions and age specific catch rates are also shown. The age classes do not refer to actual age (indicated by the "x" prefix).

Mean Cpl. length (mm)

Year/Year class	1991	1992	1993	1994	1995
x1	18.9	19.0	18.7	19.1	19.2
x2	21.2	21.5	21.4	20.7	21.2
x3	23.5	24.0	23.3	22.9	23.0
x4	26.0	26.7	25.9	25.0	25.2
x5	29.4	29.6	28.8	27.9	28.9
x6+	31.2	31.1	31.5	31.1	30.9

Proportion of total catch

Year/Year class	1991	1992	1993	1994	1995
x1	0.02	0.03	0.01	0.01	0.05
x2	0.12	0.11	0.06	0.05	0.12
x3	0.22	0.15	0.18	0.22	0.20
x4	0.18	0.20	0.38	0.32	0.27
x5	0.27	0.34	0.25	0.30	0.27
x6+	0.18	0.18	0.12	0.10	0.08

Number caught (x1000)

Year/Year class	1991	1992	1993	1994	1995
x1	8718	7298	1081	877	8095
x2	52309	26758	6488	4383	19428
x3	95900	36489	19464	19286	32380
x4	78464	48651	41091	28053	43714
x5	117696	82707	27034	26300	43714
x6+	78464	43786	12976	8767	12952
Total	435909	243257	108135	87666	161902

Number caught per hour (unstandardized)

Year/Year class	1991	1992	1993	1994	1995
x1	243	364	76	142	964
x2	1457	1336	459	712	2313
x3	2672	1821	1377	3134	3855
x4	2186	2428	2906	4559	5204
x5	3279	4128	1912	4274	5204
x6+	2186	2185	918	1425	1542
Total	12144	12142	7647	14248	19274

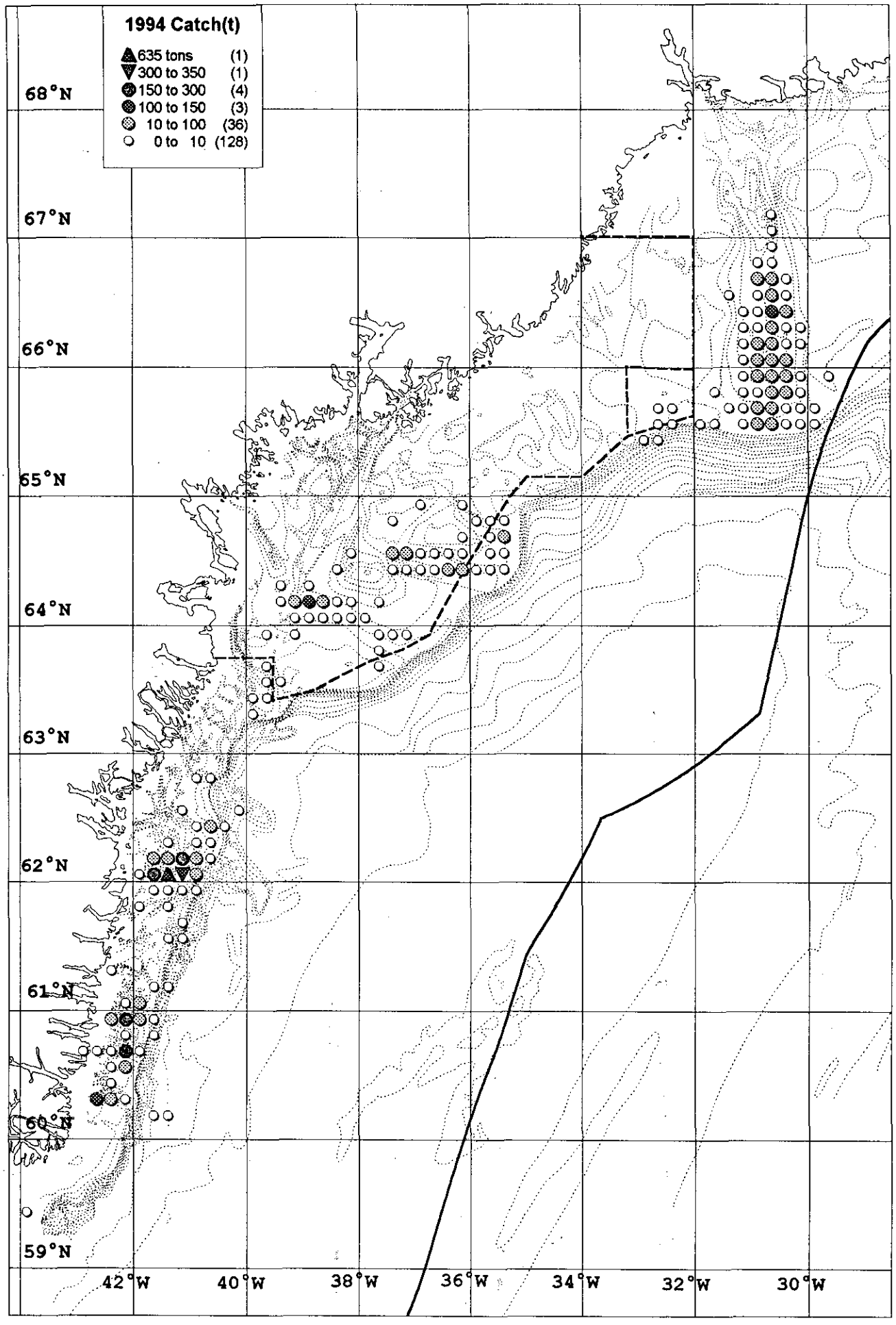


Fig. 1. The geographical distribution of the Greenland catches in 1994 as recorded in vessel logs.

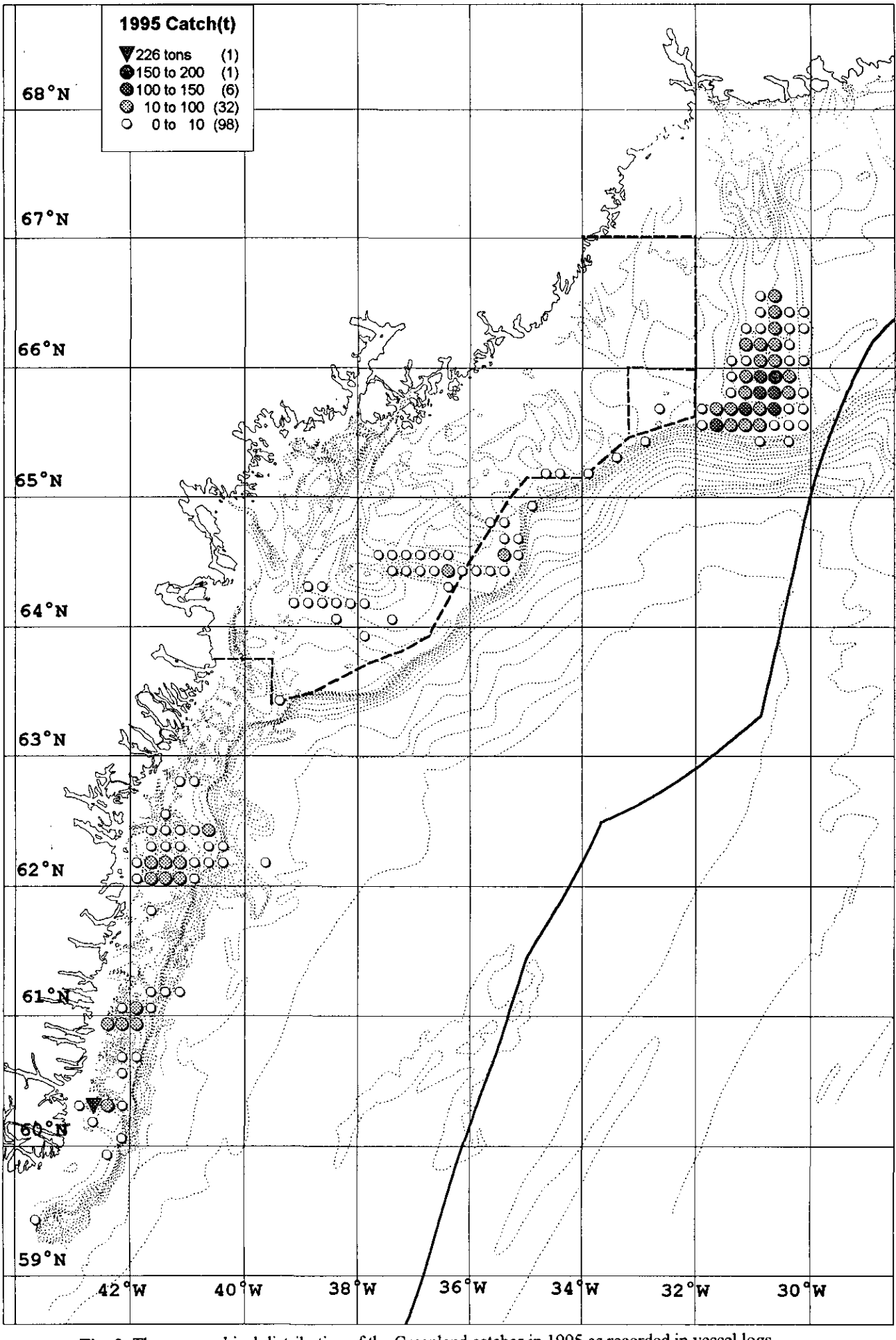


Fig. 2. The geographical distribution of the Greenland catches in 1995 as recorded in vessel logs.

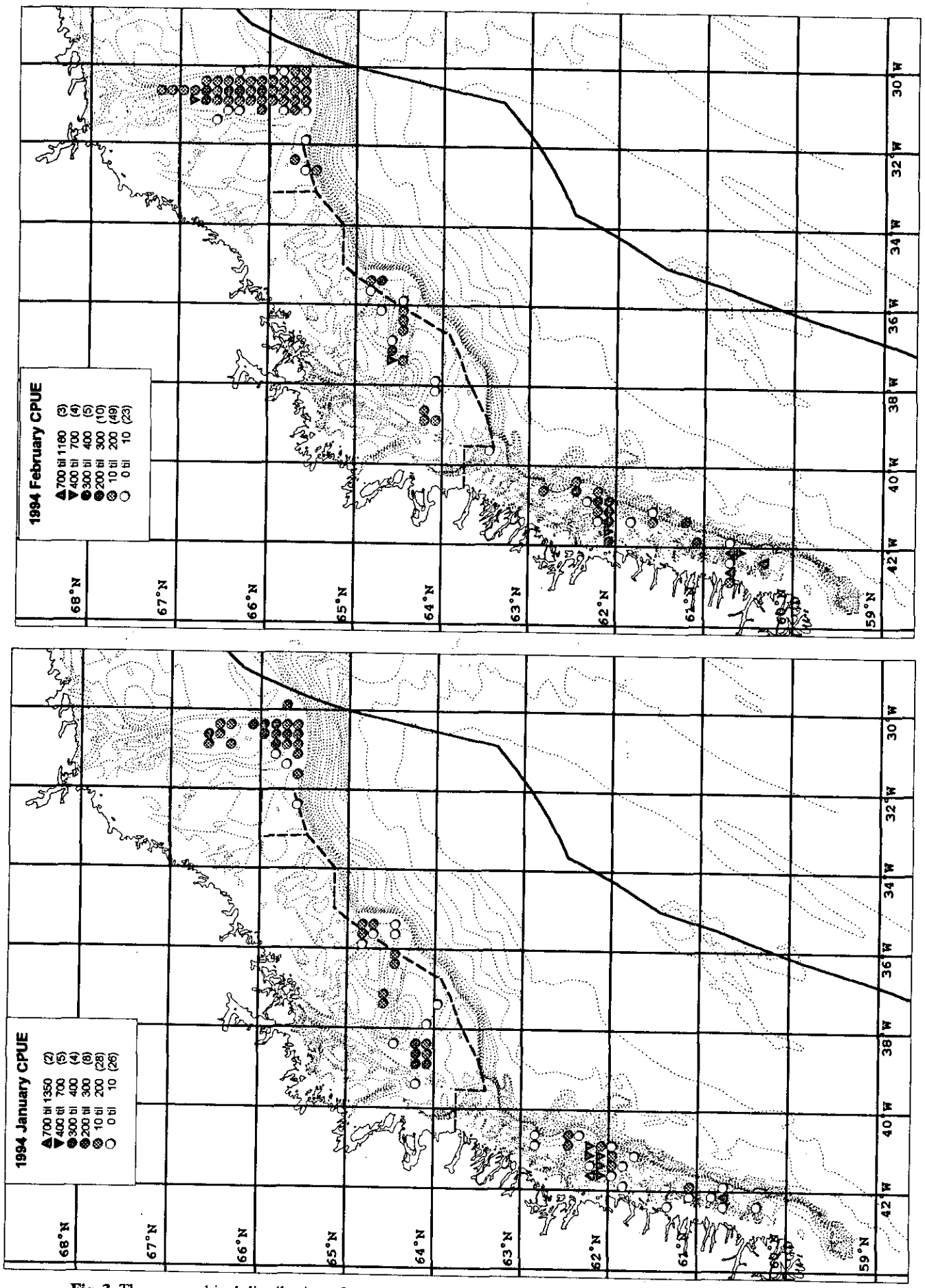


Fig. 3. The geographical distribution of unstandardized catch rates accomplished by Greenland vessels (logbook data) by month from January 1994 to August 1995. Note the figure continues on the following pages.

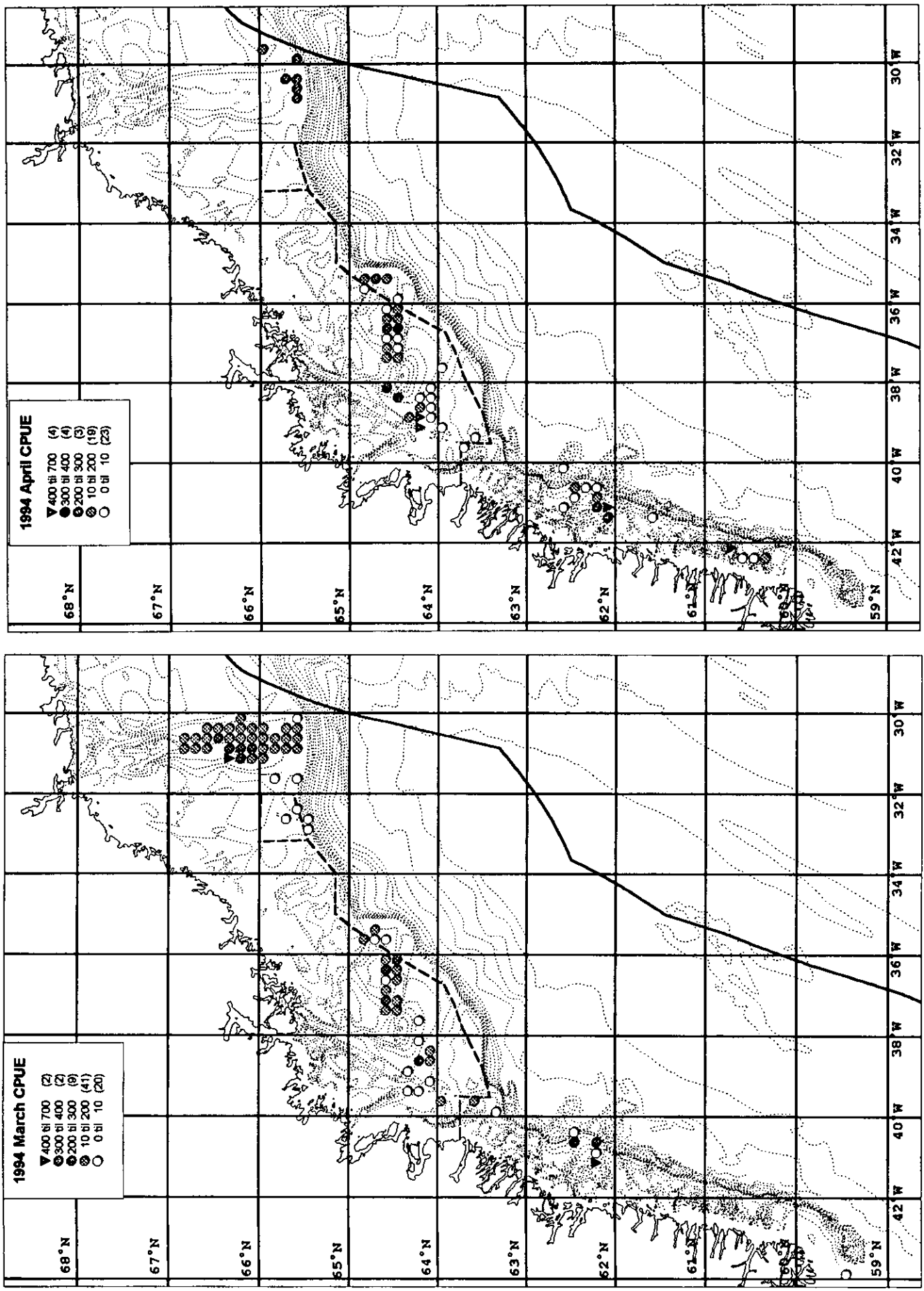
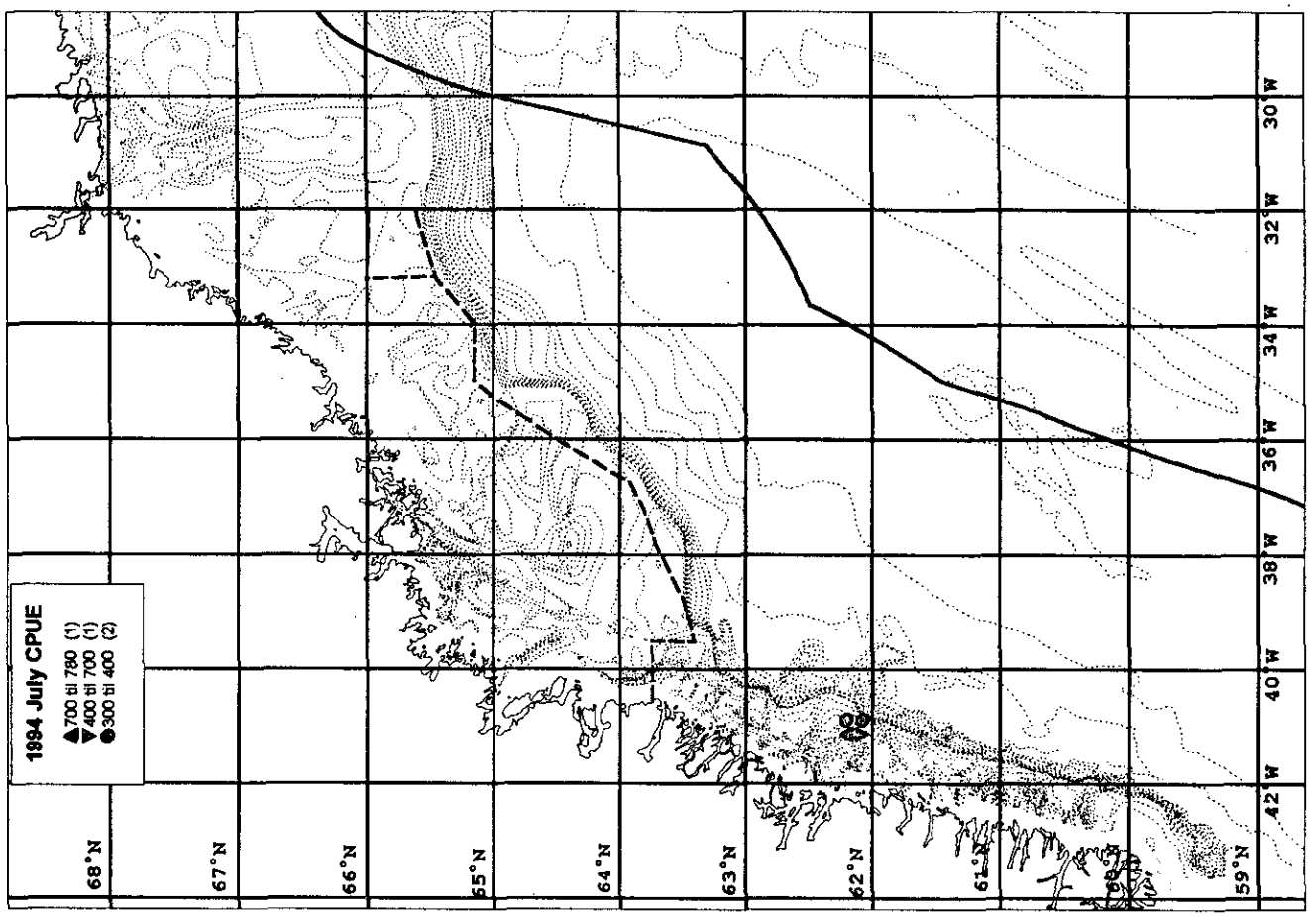


Fig. 3. continued...



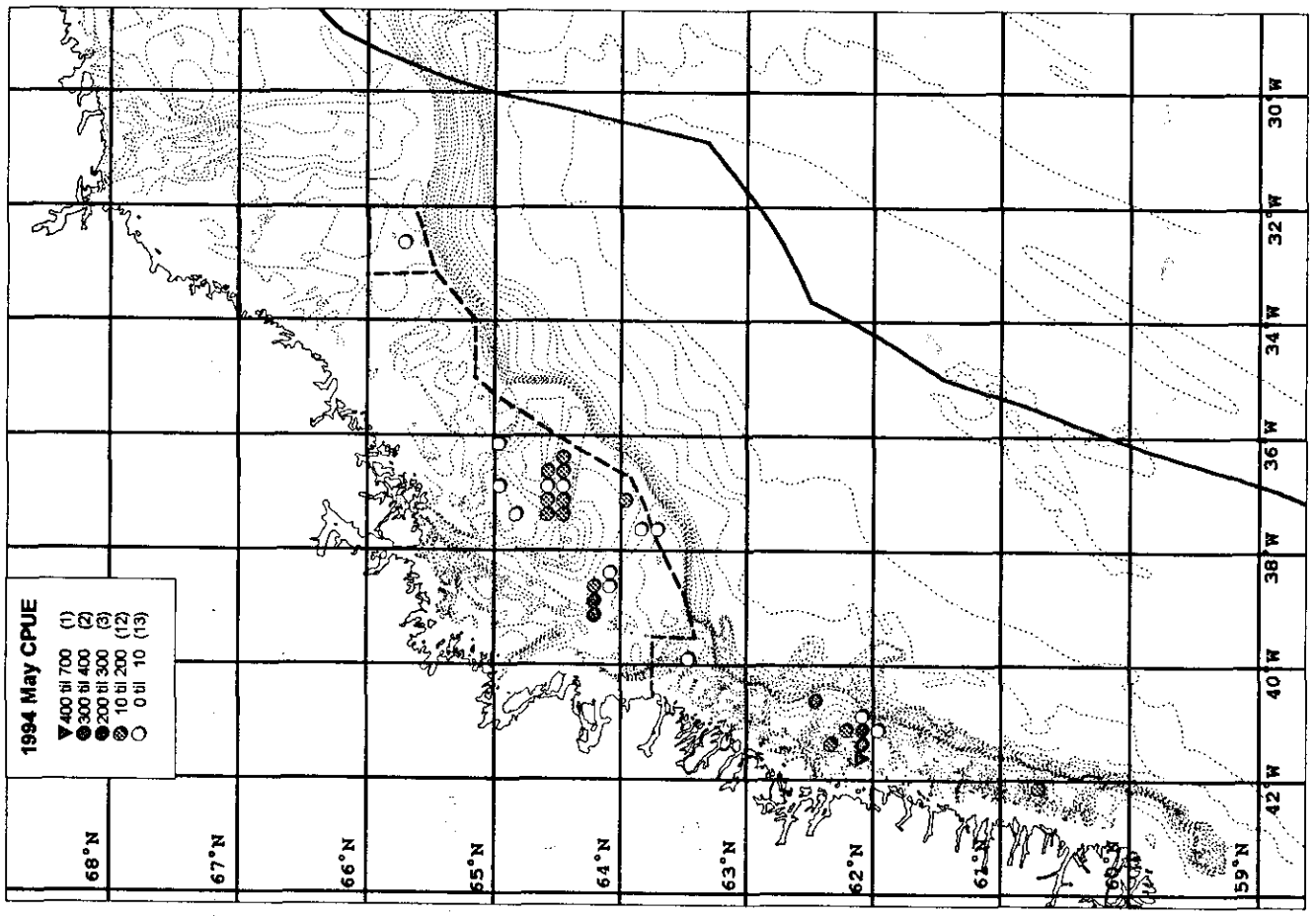
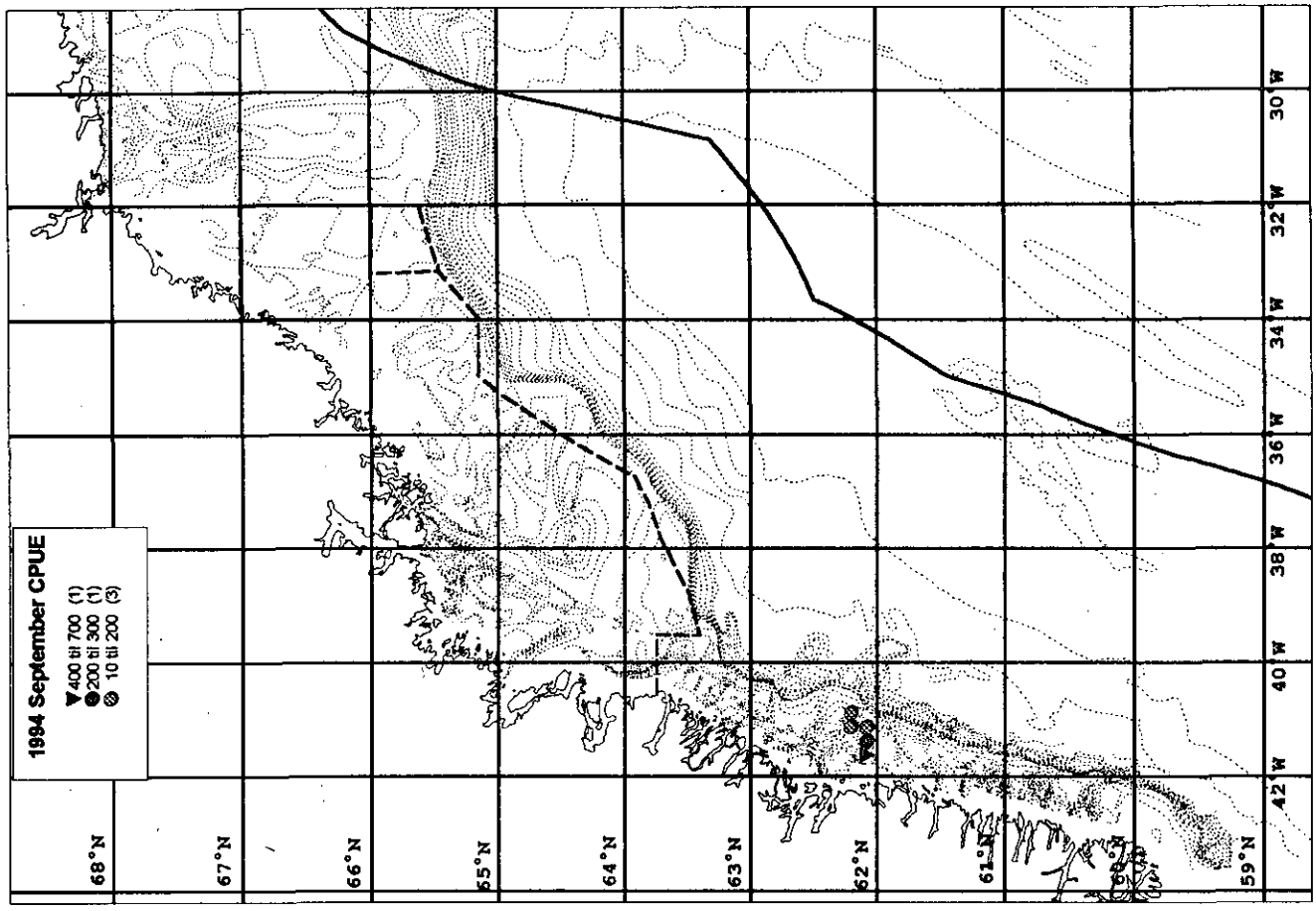


Fig. 3. continued...



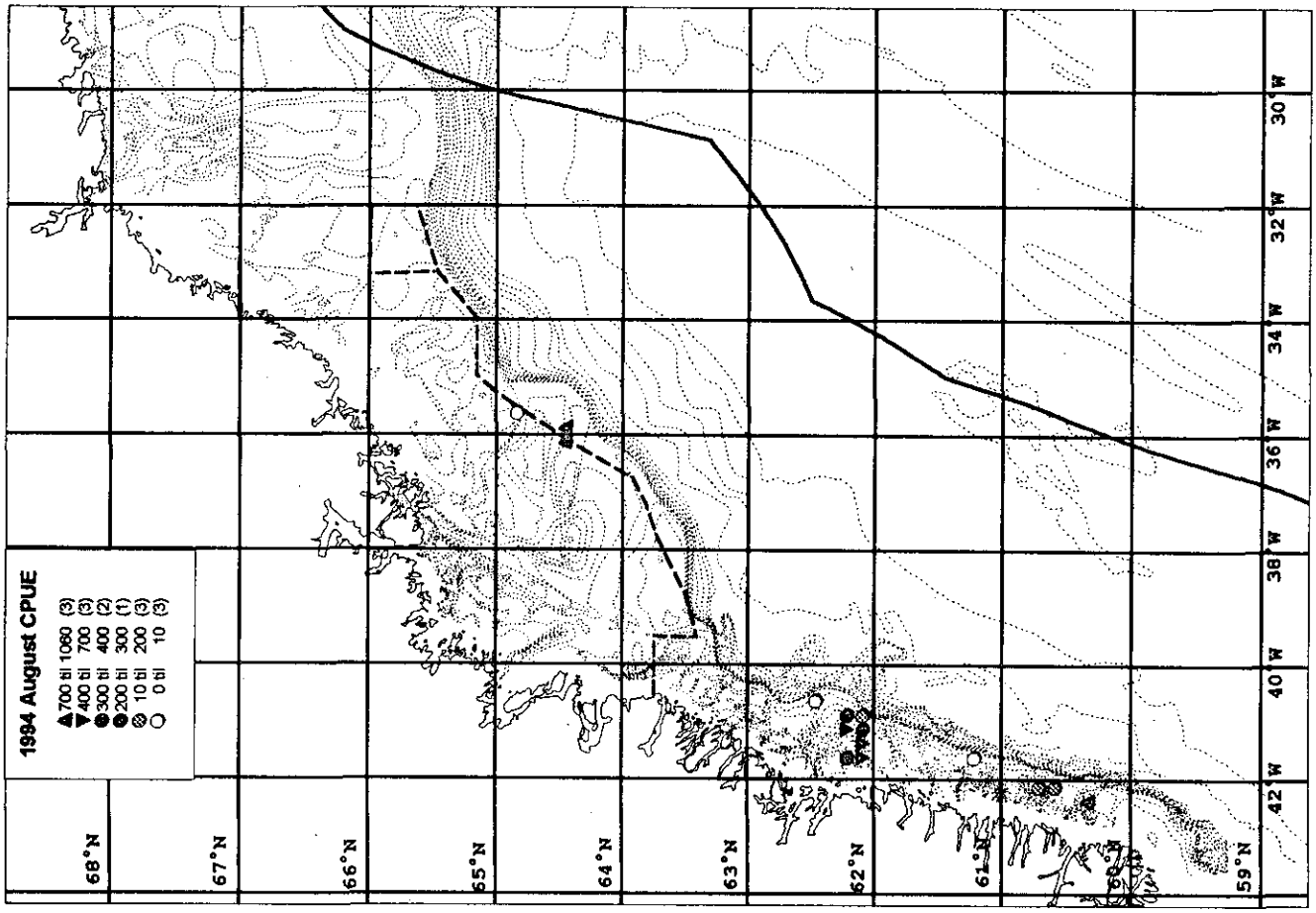
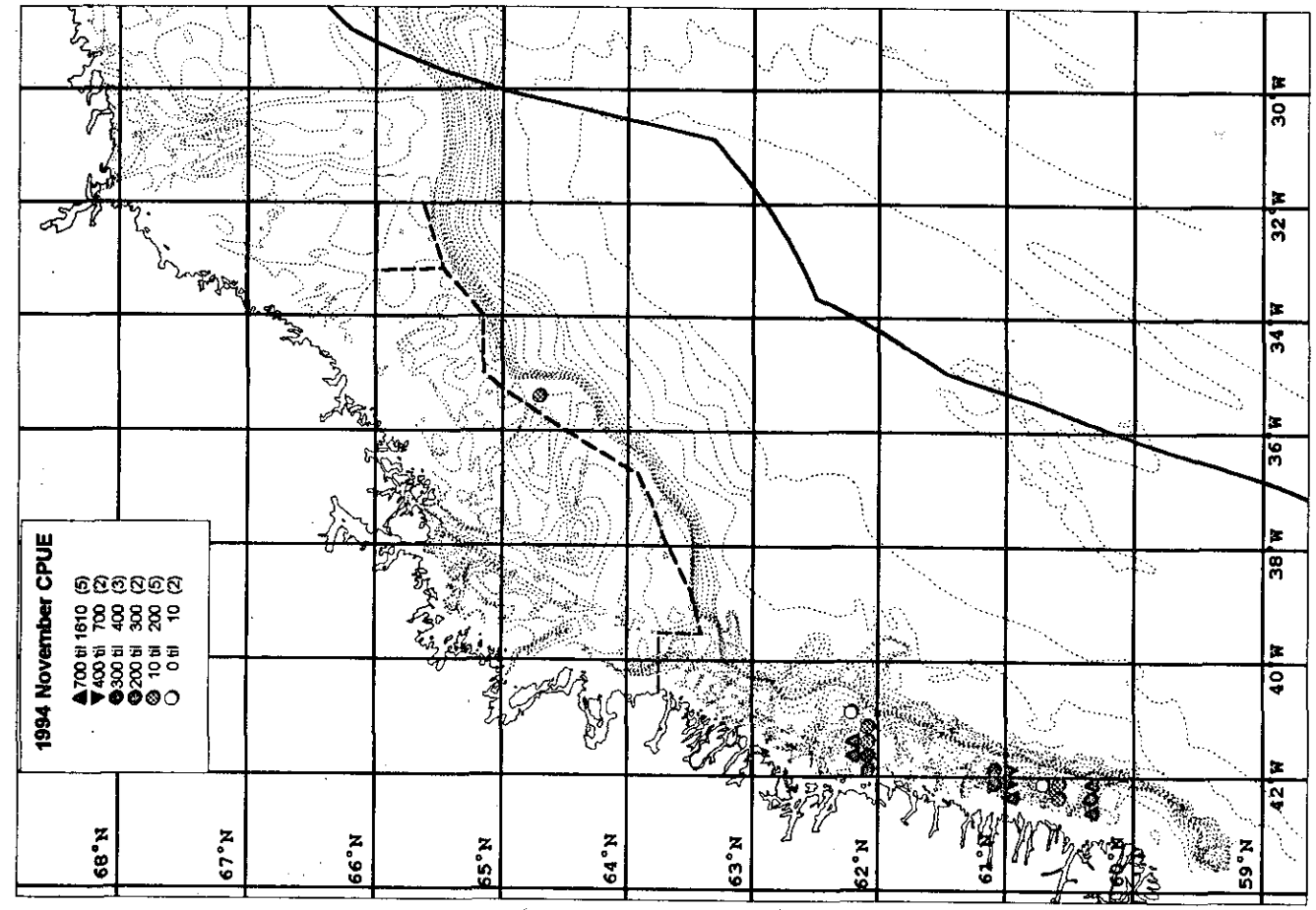


Fig. 3. continued...



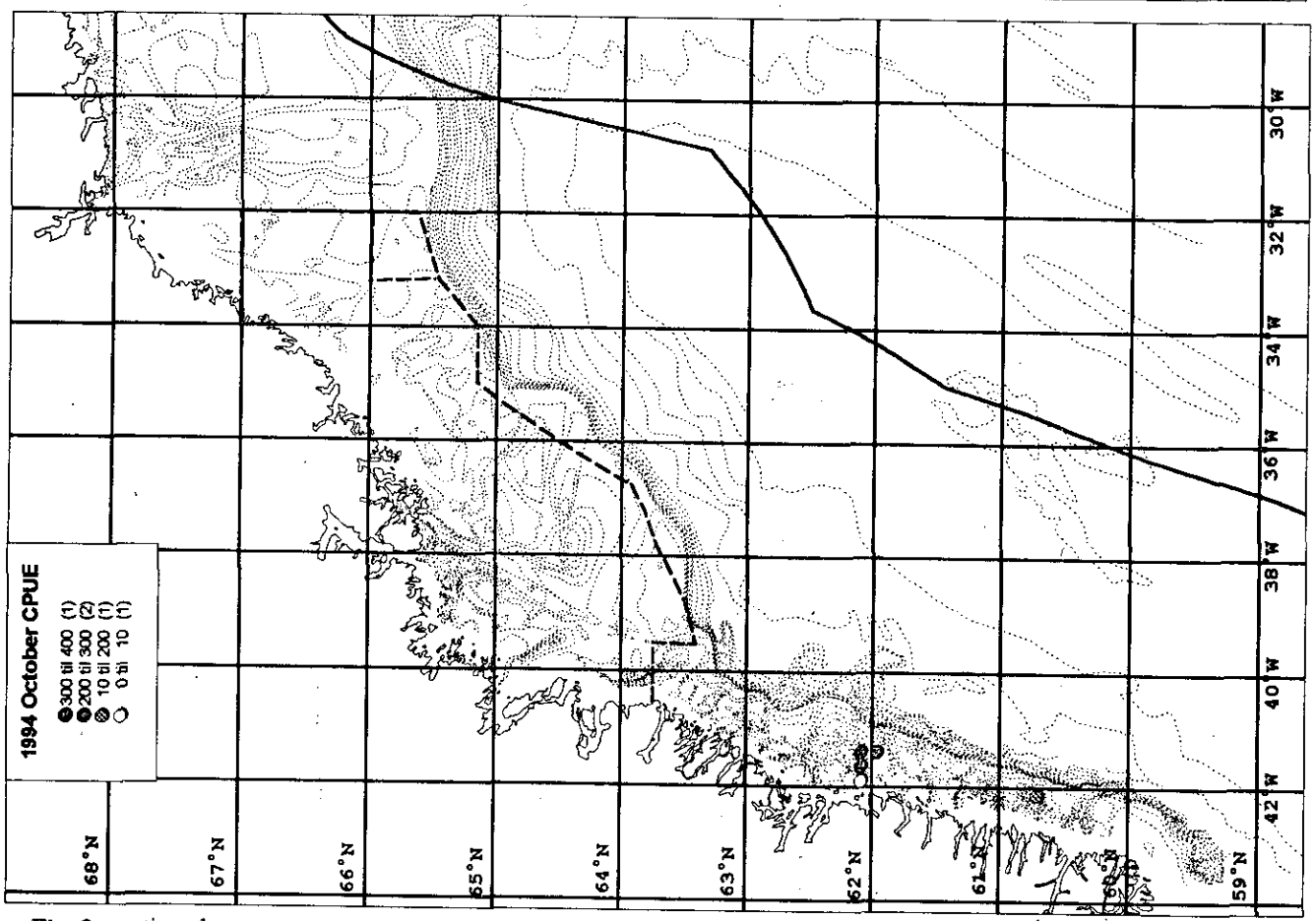


Fig. 3. continued...

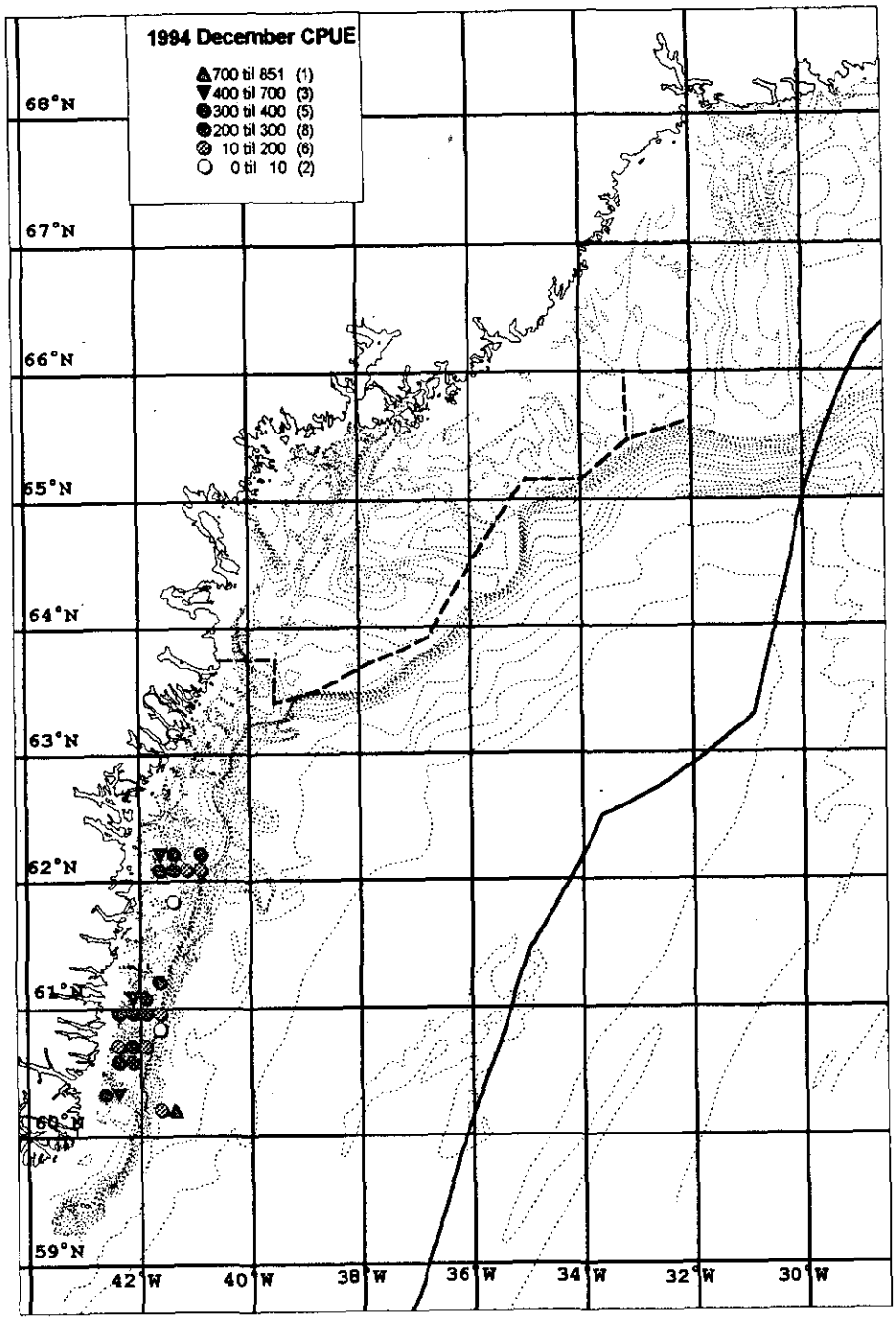
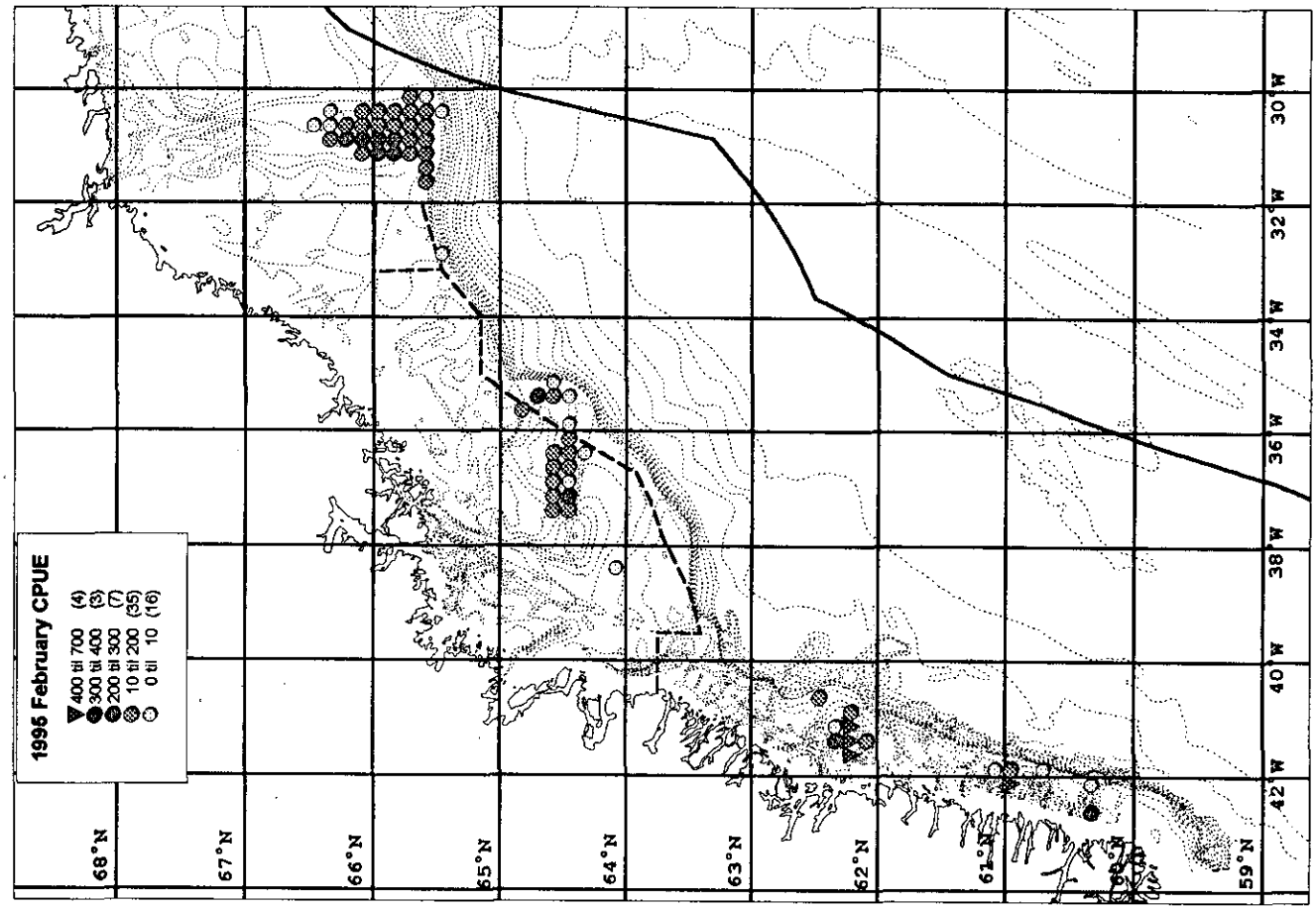


Fig. 3. continued...



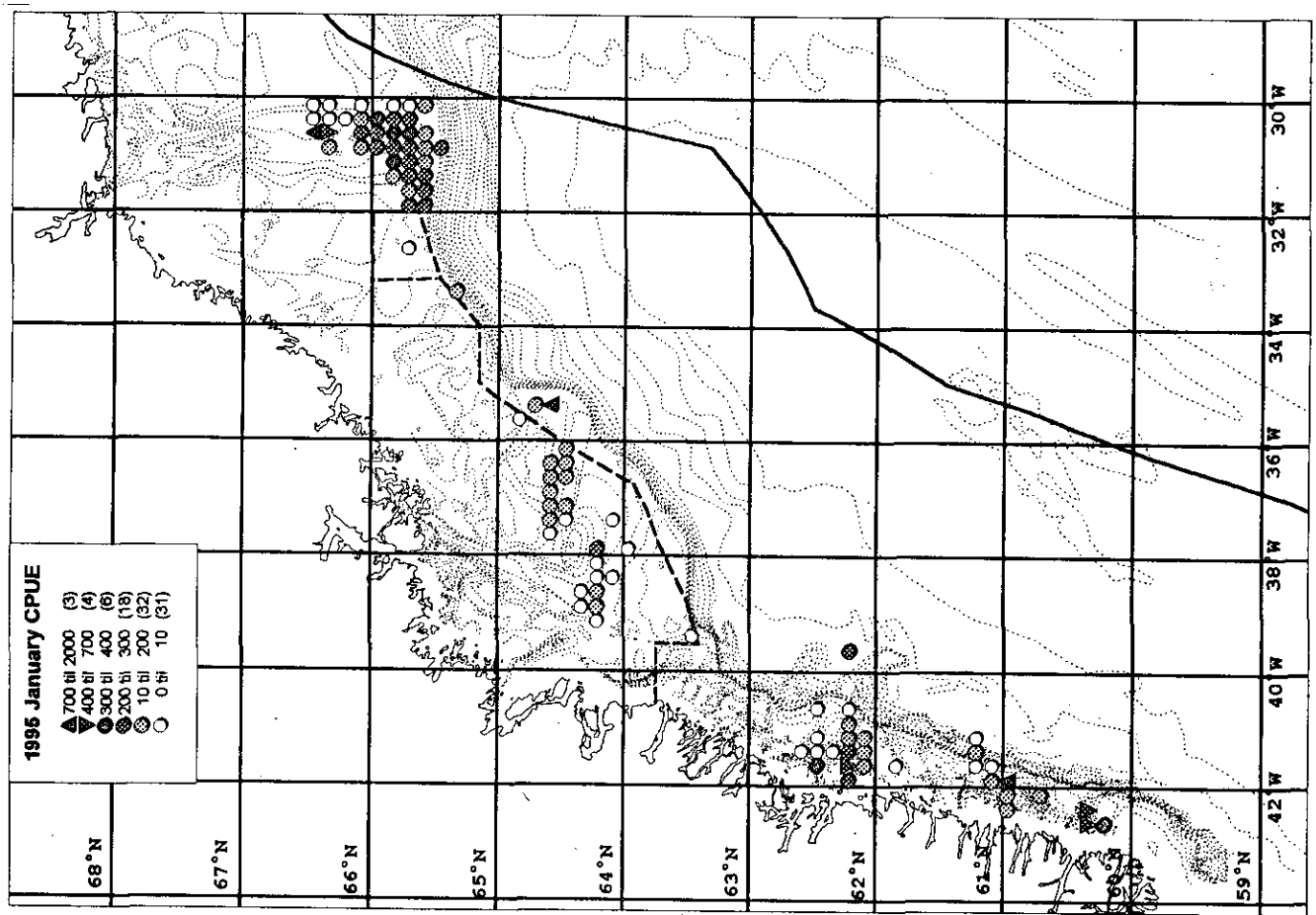
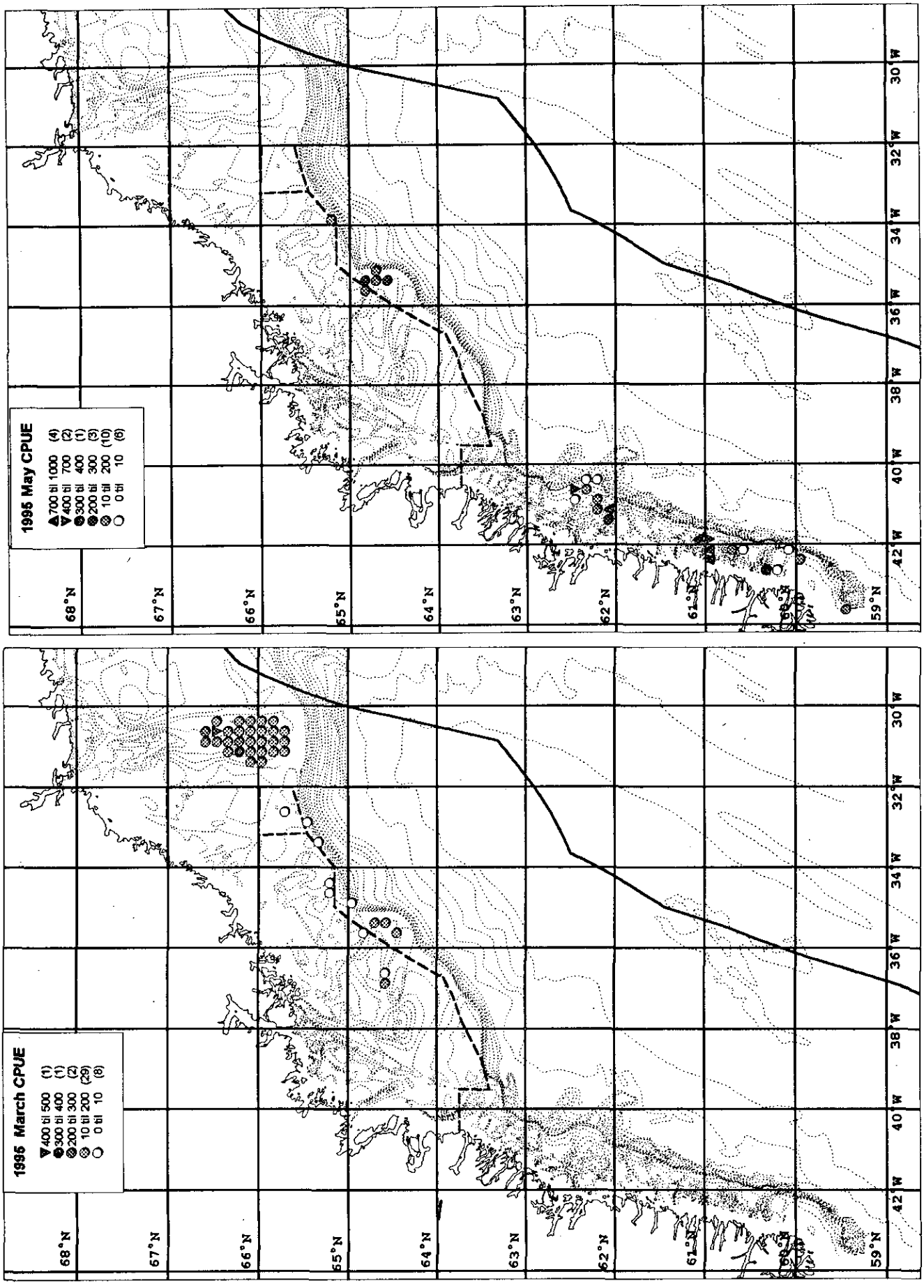


Fig. 3. continued...



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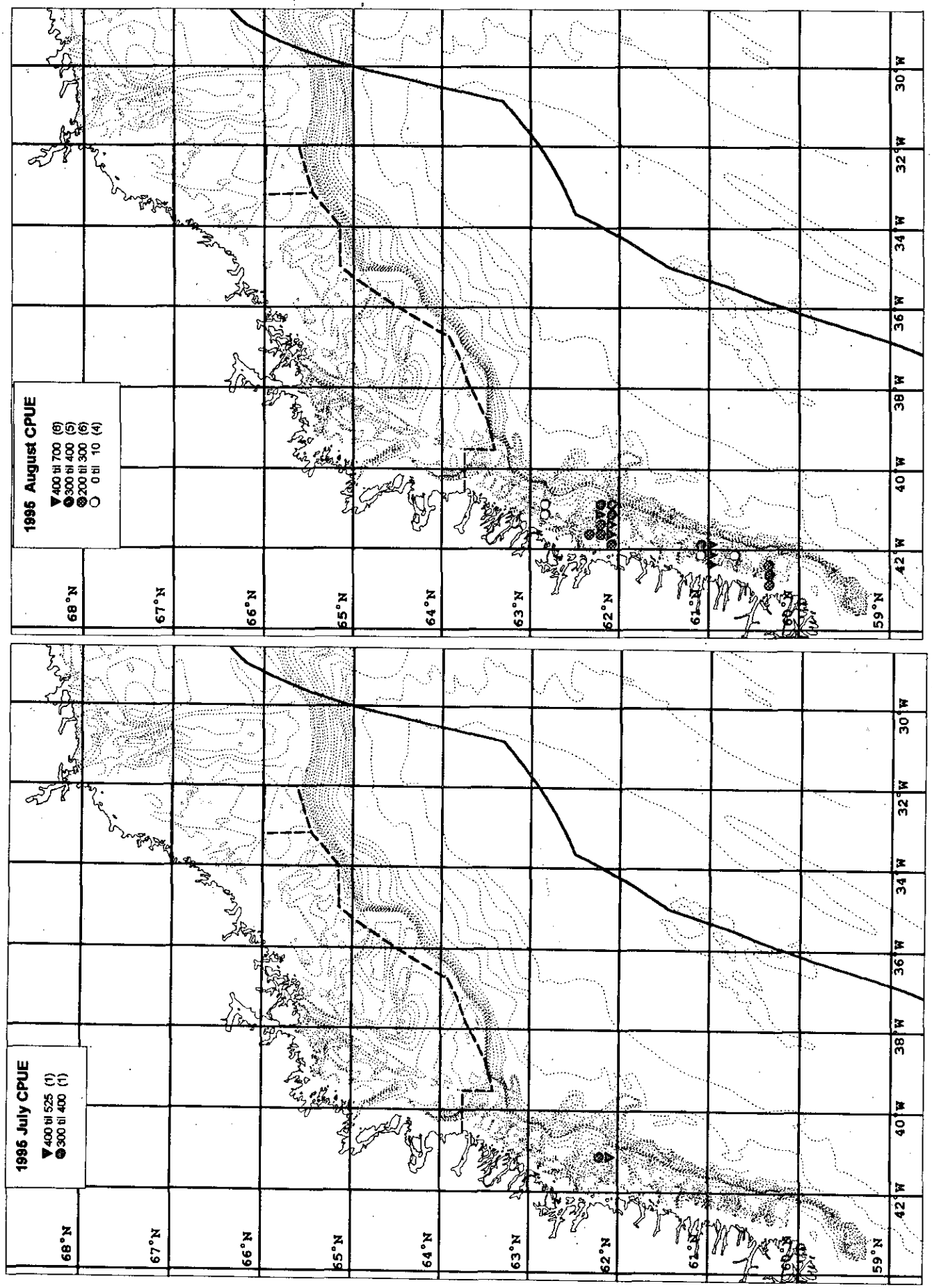

Fig. 3. continued...

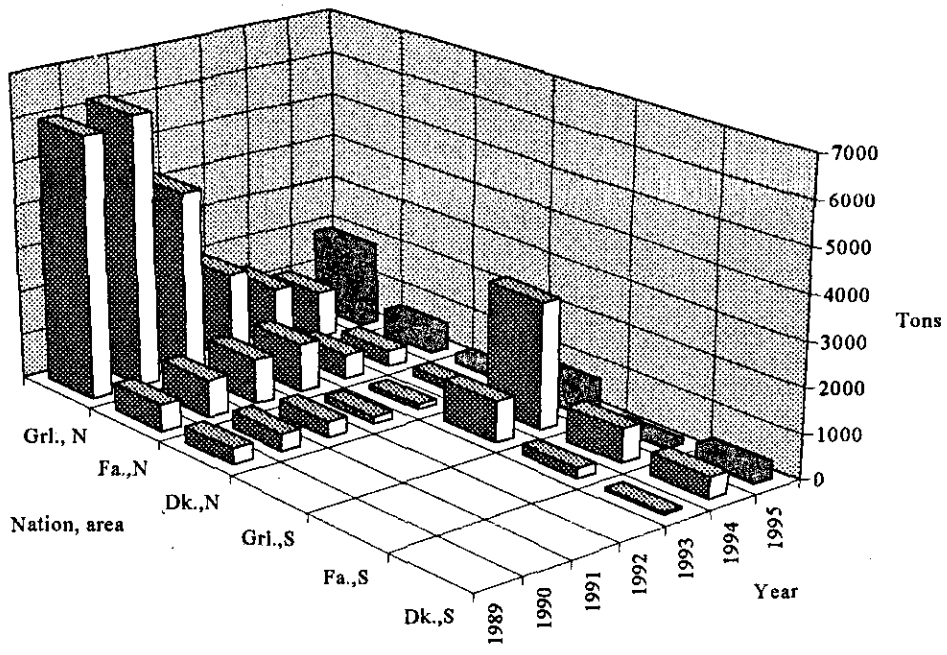

Fig. 4. Catch in tons by year and nation north (N) and south (S) of 65°N from 1989 to October 1995 as reported in vessel logs and weihgted up to catches reported to Greenland authorities. Grl.=Greenland, Fa.=Faroe Islands, Dk.= Denmark. (Note: 1995 incomplete).

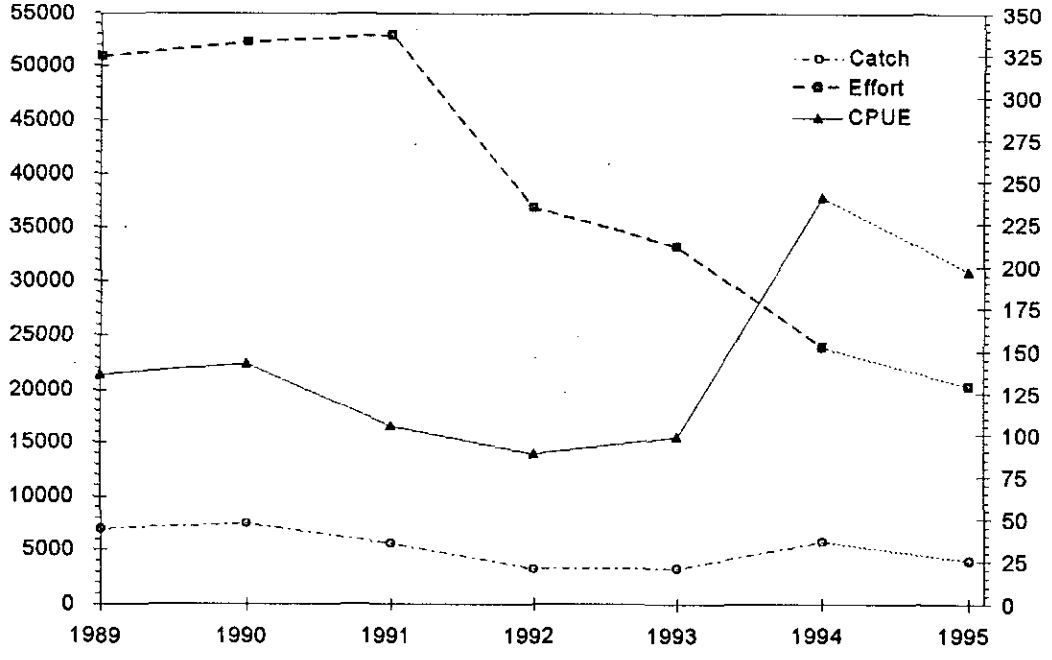

Fig. 5. Total catch (tons) and effort (hr) in the Denmark Strait (all of the Greenland zone) from 1989 to October 1995 based on Greenland, Danish and Faeroese log books and weighted up to catches reported to Greenland authorities.

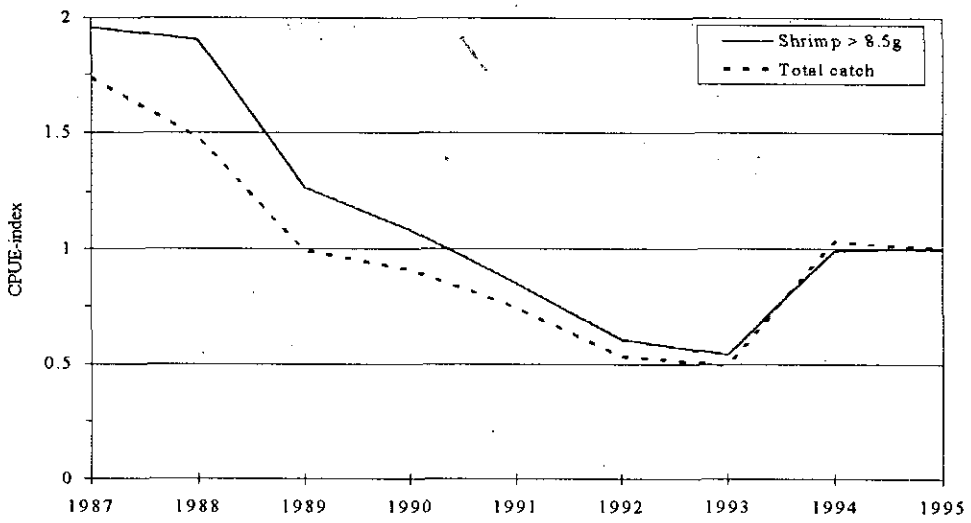

Fig. 6. Annual CPUE-indices calculated for shrimp > 8.5 g and for total catch by 32 Greenland trawlers in Denmark strait north of 65°N from 1987 to 1995. (1995 incomplete).

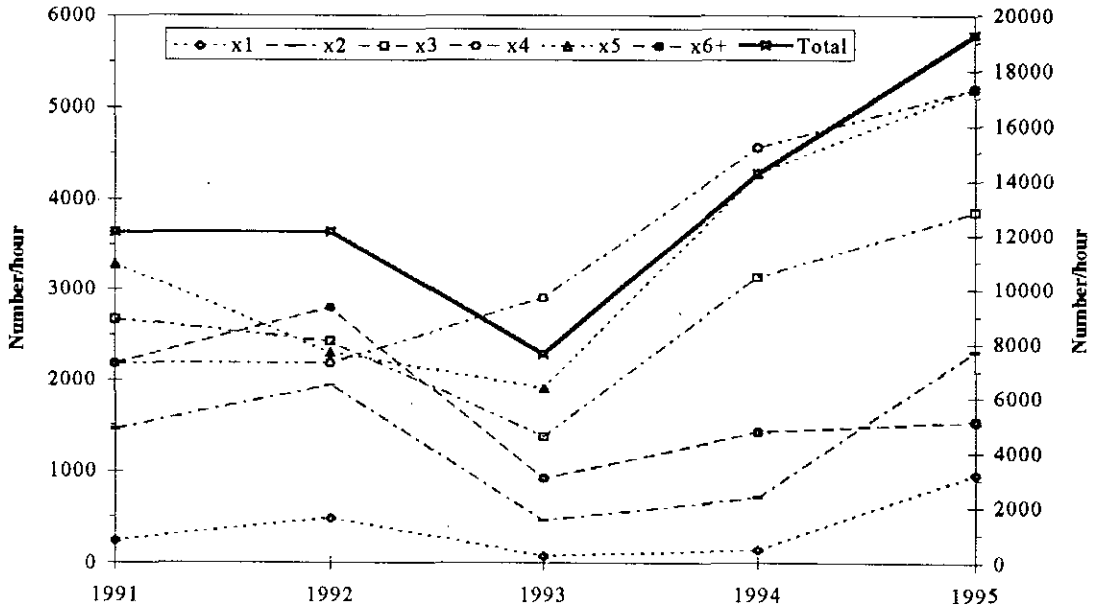

Fig. 7. Age specific catch rates by Greenland trawlers in the Denmark Strait north of 65°N, as calculated by applying proportions from the modal analysis output to total numbers caught. x1, x2 etc. refers to year classes (see table 9).

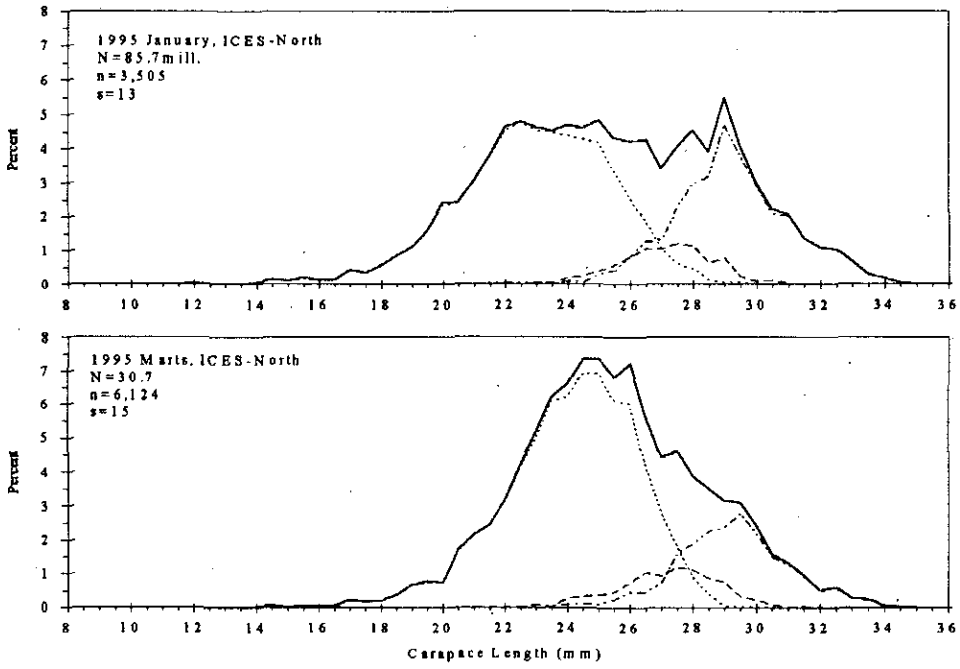

Fig. 8. Commercial length frequencies by month, 1995, in the fishing area north of 65°N. Mean shrimp lengths caught were 25.3mm and 25.4mm in the months January and February respectively(N=total number caught; n=number measured; s=number of samples)

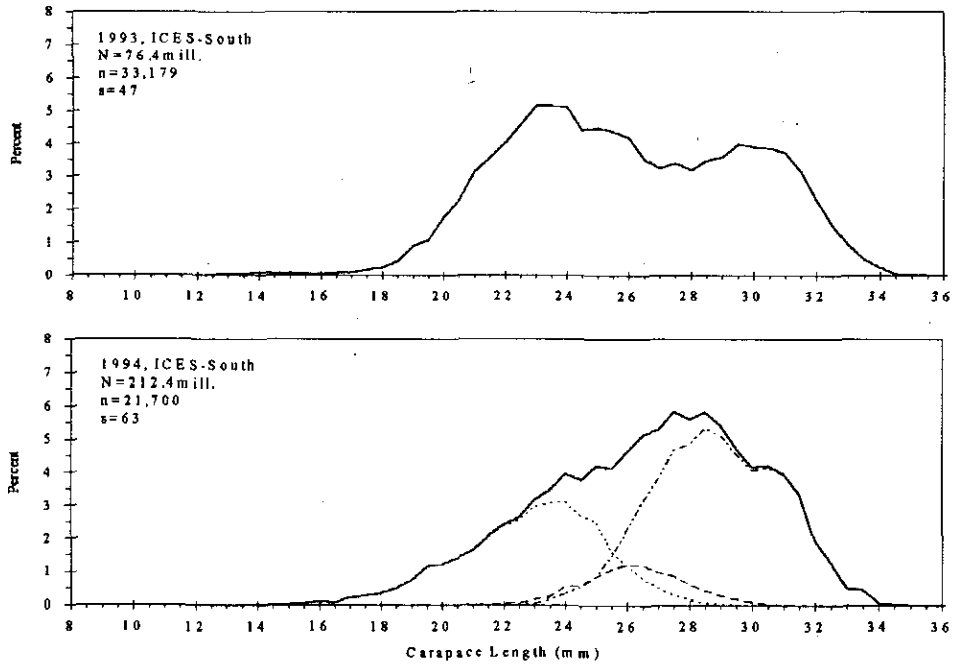

Fig.9. Commercial length frequencies in 1993 and 1994 (1995 missing) in the fishing area north of 65°N in Denmark Strait. Mean shrimp lengths caught were 25.9mm and 26.6mm in the years 1993 and 1994 respectively.(N=total number caught; n=number measured; s=number of samples).

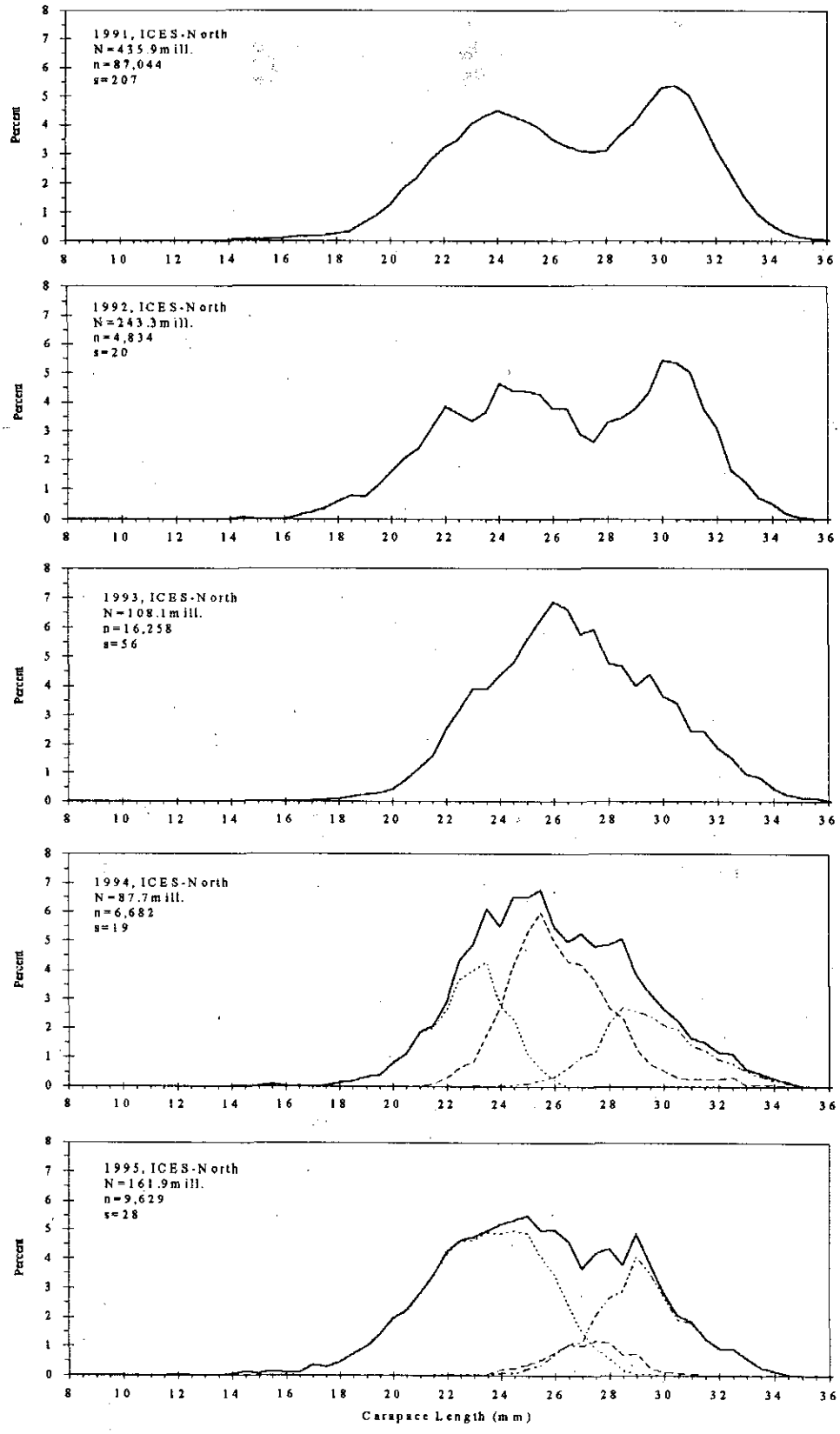

Fig.10. Commercial length frequencies by year from 1991-95 in the fishing area north of 65°N in the Denmark Strait. Mean shrimp lengths caught were 26.8mm, 27.5mm, 26.7mm, 26.0mm and 25.4mm in the years 1991-95 respectively. (N=total number caught; n=number measured; s=number of samples).