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The Fishery for Northern Shrimp (*Pandalus borealis*) off East Greenland in 1999 and 2000

by

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Abstract

Northern shrimp (*Pandalus borealis*) occurs off East Greenland from Cape Farewell to about 70°N in Greenlandic waters and in adjacent Icelandic waters in the Dohrn and Strede Bank area. The stock is assessed as a single population and managed by Total Allowable Catch in the Greenlandic zone. There is no management of the stock component in the Icelandic zone.

A multinational fleet is exploiting the stock, with annual catches in the order of 7500-11500 tons during the 1990's. Before 1993 the fishery was conducted in areas between 65° and 68°N, but since then various smaller fishing grounds south to Cape Farewell have also been exploited. In recent years effort has been equally distributed among the northern and southern areas. The overall spatial distribution of the 2000 fishery is expected to be similar to that of the years before.

From the fishery in the Greenlandic zone logbooks are available from Greenlandic, Faeroese and Danish vessels. The overall annual effort spent by these fleets has declined from more than 50000 hours in 1990 to about 18000 hours in recent years. Annual catches declined from a level of about 7000 tons in the late 1980's to 3000 tons in 1992 and 1993, after which exploitation of the new fishing grounds south of 65°N enhanced overall catch rates and made catches increase again to a level of 6000-7000 tons per year since 1994. Catches in 2000 by these nations are projected to be at the same level.

A combined standardized CPUE index for the total area indicated that the stock was reduced by a factor 3 in the period 1987-1993 after which it has been rebuilding at a corresponding rate. Standardized effort indicated a decreasing trend in fishing mortality since 1990.

Size structure of catches indicates fair recruitment to the female group in 2000 and 2001 in both the northern and the southern areas.

Introduction

Northern shrimp (*Pandalus borealis*) occurs off East Greenland in ICES Divisions XIVb and Va. The stock is distributed from Cap Farewell to about 70°N in depths down to around 800 meters (Fig. 1). The highest concentrations occur from 150-600 m. There is no evidence of distinct sub-populations and the stock is assessed as a single population.

The shrimp fishery off East Greenland began in the late 1970's by Icelandic trawlers and soon became a multinational fishery with annual catches increasing rapidly to more than 10000 tons during the following 10-years period. In the 1990's catches have fluctuated between 7500 and 11500 tons. The fishery was originally conducted north of 65°N in the Dohrnbank-Stredebank area on both sides of the territorial midline between Greenland and Iceland and on the slopes of Storfjord Deep. However, in 1993 a fishery was also initiated in various smaller areas extending south to the Cap Farewell (Fig. 1). Catches in the Greenlandic zone accounts for around 70-90% of the total annual catch. In the Greenlandic zone the stock is managed by a Total Allowable Catch (TAC). There are no restrictions for the fishery in the Icelandic zone.

Fleets from Greenland, Denmark, the Faroe Islands and Norway participated in the fishery in the Greenlandic zone in 1999 and 2000. All vessels are large factory trawlers in the range of 1000-3000 GRT. Logbooks are available since 1987 from Greenlandic, Faeroese and Danish trawlers, which account for 75-80% of the catches in the Greenlandic zone.

This paper updates time series of total catch, effort, CPUE-indices, catch composition and geographical distribution of the shrimp fishery conducted by the Greenlandic, Faeroese and Danish fleets off East Greenland in the Greenlandic zone. A new combined standardized CPUE index including the fishery of these fleets and the fishery by Icelandic trawlers in the Icelandic zone is also presented.

Materials and Methods

Logbook data from the Danish, Faroese and Greenlandic fleets were analysed to show the spatial distribution of the fishery and the overall annual distribution of catch, effort and catch rates.

A new standardized combined CPUE index was constructed, based on logbook data from Greenlandic, Faroese and Danish fleets, operating exclusively in the Greenlandic zone, and from the Icelandic fleet fishing exclusively in the Icelandic zone. As there is no area overlap between the two vessel groups data cannot be processed in a single General Linear Model (GLM) but must be dealt with in two individual models before being combined.

The development of the two individual indices and the combining of the results follow the method described in Hvingel *et al.* (2000). Standardized indices were derived separately for each area using multiplicative models, including the following variables: (1) individual vessel fishing power, (2) seasonal availability of shrimp, (3) spatial availability of shrimp and (4) annual mean CPUE. Input data were mean CPUE by vessel, area, month and year. The calculations were done using the SAS statistical software (Anon., 1988). The multiplicative model was represented in logarithmic form:

$$\ln(CPUE_{ijkl}) = \ln(u) + \ln(A_i) + \ln(S_j) + \ln(V_k) + \ln(Y_l) + e_{ijkl},$$

where

$CPUE_{ijkl}$ is the mean CPUE for vessel k, fishing in area i in month j during year l
(k = 1,...,n; i = 1,…,a; j = 1,…,s; l = 1,…,y)
$\ln(u)$ is overall mean $\ln(CPUE)$
A_i is effect of the i^{th} area
S_j is the effect of the j^{th} month
V_k is the effect of the k^{th} vessel
Y_l is the effect of the l^{th} year
e_{ijkl} is the error term assumed to be normally distributed $N(0,\sigma^2/n)$,
where n is the number of observations in the cell.

The standardized CPUE indices are the antilog of the year coefficient.

Parameter estimates of the vessel, month and area variable from a first run of model 1 were compared. Levels within each variable were combined in subsequent analyses if the parameter estimates were within the distance of one mean standard error. This was done to reduce the number of empty cells in the models.

The Greenlandic zone index:

Fifty-two of 67 vessels met the criteria for inclusion in the analysis (at least three years of fishing in the area) i.e. 37 Greenlandic, 9 Faeroese and 6 Danish vessels. Based on an exploratory run of the main effects model the vessel effect was collapsed into 8 groups consisting of 4-8 vessels with similar fishing power. The month effect was reduced to 3 levels by grouping months with similar indices of relative shrimp availability. The area effect had two levels pertaining to the fishing areas north and south of 65°N (this index was further partitioned in separate indices for the northern and southern area).

The Icelandic zone index:

126 different Icelandic vessels had been registered in the area since 1987. The 61 vessels qualifying for the index were collapsed into 19 groups consisting of 1-8 vessels of equal fishing power. The month effect was reduced to 9 levels. No area effect was included. A two level trawl effect was introduced to account for the effect of twin trawling.

The combined Denmark Strait index:

A single combined index of the development of the population biomass in the Denmark Strait was derived by aggregating the indices from the multinational fleet fishing in the Greenlandic zone and the Icelandic fleet in their national zone. This was done using a least squares method. Individual CPUE series for the i^{th} fleet, μ_{ij}, was assumed to reflect an overall biomass series, Y_j, and a constant fleet coefficient, v_i, so that $\mu_{ij} = v_i Y_j + e_{ij}$. The error, e_{ij}, were considered to be distributed with mean zero and variance σ_i^2. For the purpose of fitting we assumed that e_{ij}, had variances inversely proportional to the area of fishing ground, a_i, covered by fleet i. Hence, the combined index could be constructed by fitting v_i and Y_j to minimise a weighted sum of squares:

$$\sum_i a_i \sum_j (\mu_{ij} - v_i Y_j)^2 / v_i^2$$

The area weighting factor, a_i, for the Greenlandic and Icelandic zone was estimated to 0.875 and 0.125 respectively.

Size compositions of shrimp catches were generated from samples from the Greenlandic fishery. Samples taken by observers before processing were sorted by sexual characteristics (McCrary, 1971) and measured to the nearest 0.1 mm carapace length. Data were 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 in the respective areas.

Results and Discussion

Geographical distribution of the fishery

The fishery for shrimp off East Greenland was originally conducted north of 65°N in the Dohrnbank and Stredebank areas and at the slopes of Storfjord Deep. Since 1993 the fishing pattern has changed as new fishing grounds were found south of 65°N. Fig. 1 shows the overall distribution in the period 1988-1998 of trawl hauls by Greenlandic trawlers, showing the position of shrimp fishing grounds. The fishery of Greenlandic, Faroese and Danish trawlers was generally distributed in the same areas in 1998, 1999 and 2000 (Fig. 2). In the same years fishing effort was equally distributed among the northern and southern areas (Fig 3B).

Catch, effort and unstandardized CPUE from Danish, Faroese and Greenlandic vessel logs

The fishery has gradually changed from an all year activity with a minimum in the summer months, to effort being spent only in the winter months (Nov-April). This time of year generally produces the highest catch rates.

Compared to 1990 catch and effort in the area north of 65°N has been reduced by about 75% (Table 1 and Figure 3A and B). According to Greenlandic skippers this was due to a decline in catch rates of large shrimp, which was the primary target of the Greenlandic fishery in Denmark Strait. Fishing opportunities elsewhere, i.e. at Flemish Cap, and the

development of the new fishery south of 65°N may also have contributed to the reduced attractiveness of the traditional fishing grounds.

South of 65°N the largest catches are generally taken Nov.-Feb. Although catch rates are about twice as high as in the northern area (Figure 3C) a large part of the effort is still spent in the north - mostly due to less favourable bottom conditions for trawling in the southern areas.

Total effort in the Greenland zone has shown a declining trend from more than 50000 hours in 1990 to about 18000 hours in recent years (Table 1 and Figure 3B). The data for 2000 suggests a fishing effort at the same level. Total catches followed a similar downward trend from about 7500 tons in 1990 to 3000 tons in 1993 (Fig 3A) when the new fishing grounds south of 65°N enhanced overall catch rates and made catches increase to a new level of around 6000 tons in the years thereafter. Catches in 2000 are projected to be at the same level.

Standardized CPUE and effort

Diagnostic outputs from GLM run of models for standardization of CPUE in the Greenlandic and Icelandic zone are shown in Appendix 1 and Appendix 2, respectively. As too few observations were available from the northern Greenlandic zone in 2000, data pertaining to this year was excluded from the calculations for this area and hence from the combined indices.

Results of the two multiple regression analysis to standardize catch rates showed that all main effects were highly significant ($p<0.01$). The r-squared of the models were 63 and 84%, respectively. The model diagnostical outputs (residual plots, Cook's D influence statistics, test of normality etc., see appendix) indicate that the model and error structures were correct. All first-order interactions between the effects of YEAR, MONTH and VESSEL were also highly significant, suggesting that the effect of YEAR on CPUE differ from month to month and from vessel to vessel. The contributions of these interactions to the variability within the data set however were small compared to that of the main effects. Thus, the basic model without interactions was considered a good descriptor of the data.

The two individual indices are shown in Figure 4C and 4D. The indices are in reasonable agreement until 1995 but show divergence in most recent years. The combined index (Fig. 5B) indicates that the stock declined by more than a factor 3 in the period 1987-1993 after which it has been rebuilding at a corresponding rate.

The partitioned Greenlandic zone index is shown in Fig. 4. The index for the northern area (Fig. 4A) has declined from 1987 to 1993 succeeded by an overall increasing trend. The 1999 value, however, was lower than that of the preceding year. The CPUE indices of the southern area (Fig. 4B), starting in 1993, have increased throughout the time series.

A standardized effort based on combined CPUE index for all areas was calculated by applying it to the total catches (Fig. 5A). This series indicate a decreasing trend in fishing mortality since 1997. The 1999 value is the lowest since the beginning of the time series in 1987.

The standardization method used accounts for the increase in efficiency from renewal of the fleet but does not account for the technological improvements, which results from the upgrading of older vessels. The standardized effort may therefore be underestimated in which case the standardized CPUE time series interpreted as a biomass index is expected to give a slightly optimistic view of the stock development (for further discussion of the CPUE index as a stock indicator see Hvingel *et al.*, 2000).

Length distributions

The numbers of samples available from the Greenlandic fishery are presented in Table 2, and mean size of shrimp, numbers caught and estimated abundance calculated from logbook data and catch samples are given in Table 3. Calculated length frequency distributions of Greenlandic catches in the northern and southern areas are shown in Figures 6A and 6B, but are - however - not representative of actual catch composition due to incomplete coverage over time and areas.

In the northern area data are available for 1991-1995 and 1998-2000, indicating that female shrimp dominated catches in numbers in most years except for 1995 and 2000 (data for 2000 are preliminary and based on very few samples). In the southern area data indicate that catch composition in numbers was dominated by males in most years (except 1994, but also based on very few samples).

For the total area several year-classes of male and female shrimp are evident in sampling data in recent years, indicating fair recruitment to the female group in 2000 and 2001.

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Table 1. Nominal catch, effort and CPUE by Danish, Faroese and Greenlandic trawlers fishing off East Greenland 1990-2000. North and South areas are separated by 65ºN. Effort is based on logbook information weighted by nominal catch. Nominal catch in 2000 from January to November 1.

Catch, tons

	Denmark			Faroe Islands			Greenland			Total		
Year	North	South	Total	North	South	Total	North	South	Total	North	South	Total
1990	390	-	390	843	-	843	6210	-	6210	7443	-	7443
1991	358	-	358	1007	-	1007	4205	-	4205	5570	-	5570
1992	160	-	160	1092	-	1092	2012	-	2012	3264	-	3264
1993	111	48	159	554	225	779	1425	918	2343	2090	1191	3281
1994	199	488	687	368	776	1144	1056	2870	3926	1623	4134	5757
1995	242	585	827	745	236	981	1913	2135	4048	2900	2956	5856
1996	21	938	959	800	323	1123	289	4257	4546	1110	5518	6628
1997	68	1328	1396	509	526	1035	84	3767	3851	661	5621	6282
1998	317	1027	1344	1002	109	1111	510	3120	3630	1829	4256	6085
1999	630	870	1500	689	360	1049	488	3945	4433	1807	5175	6982
2000	456	1025	1481	717	69	786	163	3028	3191	1336	4122	5458

Effort, hours

Year	Denmark			Faroe Islands			Greenland			Total		
	North	South	Total	North	South	Total	North	South	Total	North	South	Total
1990	7221	-	7221	6165	-	6165	39312	-	39312	52698	-	52698
1991	5591	-	5591	8128	-	8128	36062	-	36062	49781	-	49781
1992	3566	-	3566	9848	-	9848	19702	-	19702	33116	-	33116
1993	2552	576	3128	5171	1771	6942	15169	4275	19444	22892	6622	29514
1994	1654	2480	4134	2053	3171	5224	6200	7788	13988	9907	13439	23346
1995	1532	2096	3628	6978	1858	8836	9437	5923	15360	17947	9877	27824
1996	225	2825	3050	5755	1998	7753	2575	12036	14611	8555	16859	25414
1997	618	3591	4209	3576	2867	6443	651	7970	8621	4845	14428	19273
1998	1097	3298	4395	4020	595	4615	2324	6270	8594	7441	10163	17604
1999	3307	2667	5974	3822	1064	4886	2607	5186	7793	9736	8917	18653
2000	2851	3140	5991	3065	116	3181	1520	4564	6084	7436	7820	15256

Area

CPUE, kg/hour

Year	Denmark			Faroe Islands			Greenland			Total		
	North	South	Total	North	South	Total	North	South	Total	North	South	Total
1990	54	-	54	137	-	137	158	-	158	141	-	141
1991	64	-	64	124	-	124	117	-	117	112	-	112
1992	45	-	45	111	-	111	102	-	102	99	-	99
1993	43	83	51	107	127	112	94	215	120	91	180	111
1994	120	197	166	179	245	219	170	369	281	164	308	247
1995	158	279	228	107	127	111	203	360	264	162	299	210
1996	93	332	314	139	162	145	112	354	311	130	327	261
1997	110	370	332	142	183	161	129	473	447	136	390	326
1998	289	311	306	249	183	241	219	498	422	246	419	346
1999	191	326	251	180	338	215	187	761	569	186	580	374
2000	160	326	247	234	595	247	107	663	524	180	527	358

Table 2. Catch samples from Greenlandic trawlers 1991-2000 summed by month and by area north and south of 65°N.

North

Year	Month	Number of samples	Sample weight	Numbers measured	Sample represent catch (kg)
91	1	30	184.6	12041	21898
91	2	28	235.4	16196	15250
91	3	42	211.5	16147	30367
91	4	74	318.8	24067	52571
91	5	32	142.0	9861	18707
92	2	20	63.4	1502	9437
93	2	55	203.3	5014	21953
94	2	19	79.9	6682	14025
95	1	13	42.1	3505	11098
95	3	15	67.3	6124	31757
96	10	10	28.4	2643	4861
98	1	10	25.7	1875	11300
98	2	19	75.9	5485	19775
98	10	10	35.2	2412	5153
98	11	18	53.4	4082	5554
98	12	16	37.3	2665	14610
99	5	6	11.9	823	6517
99	6	3	6.2	435	9304
0	3	3	9.8	873	7092
0	4	3	9.7	759	5609
0	5	9	37.5	2474	9304
	Total	435	1879	125665	326142

South

Year	Month	Number of samples	Sample weight	Numbers measured	Sample represent catch (kg)
93	3	10	58.6	6323	7758
93	4	37	355.5	27169	76376
94	1	30	134.3	9957	61702
94	2	8	41.0	2712	10137
94	3	14	52.7	3916	8288
94	4	11	62.0	5115	14623
96	4	10	38.3	4973	16717
96	5	7	33.9	2571	2222
96	8	12	39.9	4405	11257
96	11	24	72.3	6444	31013
97	7	3	10.3	1214	13252
97	11	6	14.0	1951	5705
97	12	9	31.6	2982	10388
98	2	12	40.6	3951	14551
98	3	34	101.2	11618	47672
98	10	15	44.2	5313	21344
98	11	19	40.9	5317	25422
98	12	8	15.8	2224	10128
99	4	1	1.8	181	2796
99	6	5	9.6	1073	9932
99	8	13	23.0	3336	57346
99	10	12	35.5	4076	27714
99	11	30	111.1	13959	53996
99	12	1	4.5	664	1035
0	3	4	10.0	1199	17721
0	4	1	3.0	414	5117
0	5	3	10.0	1369	6196
0	6	12	41.7	5038	29904
	Total	351	1437	139464	600311

Table 3. Mean shrimp size, numbers caught and estimated abundance calculated from logbook data and catch samples from the Greenlandic fishery in Denmark Strait north and south of 65°N 1991-2000. The sign "-" denotes missing data. Data for 2000 are preliminary.

Area

Mean size

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cpl (mm)	27.0	26.5	26.7	26.0	26.2	-	-	27.6	27.4	26.7
Weight (g)	12.2	12.6	13.2	12.1	12.7	-	-	13.9	14.4	12.9
Count (no/kg)	82	79	76	83	79	-	-	72	70	78

Proportion of total catch

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	-	-	29%	51%	-	-	36%	41%	57%
Primi	-	-	-	48%	7%	-	-	8%	-	-
Multi	-	-	-	23%	41%	-	-	55%	-	-
Females total	-	-	-	71%	49%	-	-	64%	59%	43%

Number caught (millions)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	-	-	25	77	-	-	13	14	22
Primi	-	-	-	42	11	-	-	3	-	-
Multi	-	-	-	20	62	-	-	20	-	-
Females Total	-	-	-	62	73	-	-	23	20	16
Total	344	159	108	87	151	-	-	36	34	38

Abundance index

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	-	-	2.0	2.8	-	-	3.4	2.9	-
Primi	-	-	-	3.3	0.4	-	-	0.8	-	-
Multi	-	-	-	1.6	2.2	-	-	5.3	-	-
Females total	-	-	-	5.0	2.6	-	-	6.0	4.1	-

Area

Mean size

Year	1993	1994	1995	1996	1997	1998	1999	2000
Cpl (mm)	26.0	26.5	-	24.8	23.6	22.8	22.7	22.9
Weight (g)	11.5	12.7	-	9.1	9.6	6.5	7.3	7.6
Count (no/kg)	87	78	-	109	104	154	137	131

Proportion of total catch

Year	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	32%	-	55%	74%	77%	78%	88%
Primi	-	15%	-	11%	2%	4%	-	-
Multi	-	54%	-	34%	24%	18%	-	-
Females total	-	68%	-	45%	26%	23%	22%	12%

Number caught (millions)

Year	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	72	-	258	293	339	423	455
Primi	-	33	-	52	6	18	-	-
Multi	-	120	-	156	95	81	-	-
Females Total	-	153	-	208	101	99	119	63
Total	80	225	-	466	395	439	542	518

Abundance index

Year	1993	1994	1995	1996	1997	1998	1999	2000
Males	-	1.1	-	2.9	3.7	6.5	8.6	11.5
Primi	-	0.5	-	0.6	0.1	0.3	-	-
Multi	-	1.8	-	1.8	1.2	1.5	-	-
Females total	-	2.3	-	2.4	1.3	1.9	2.4	1.6

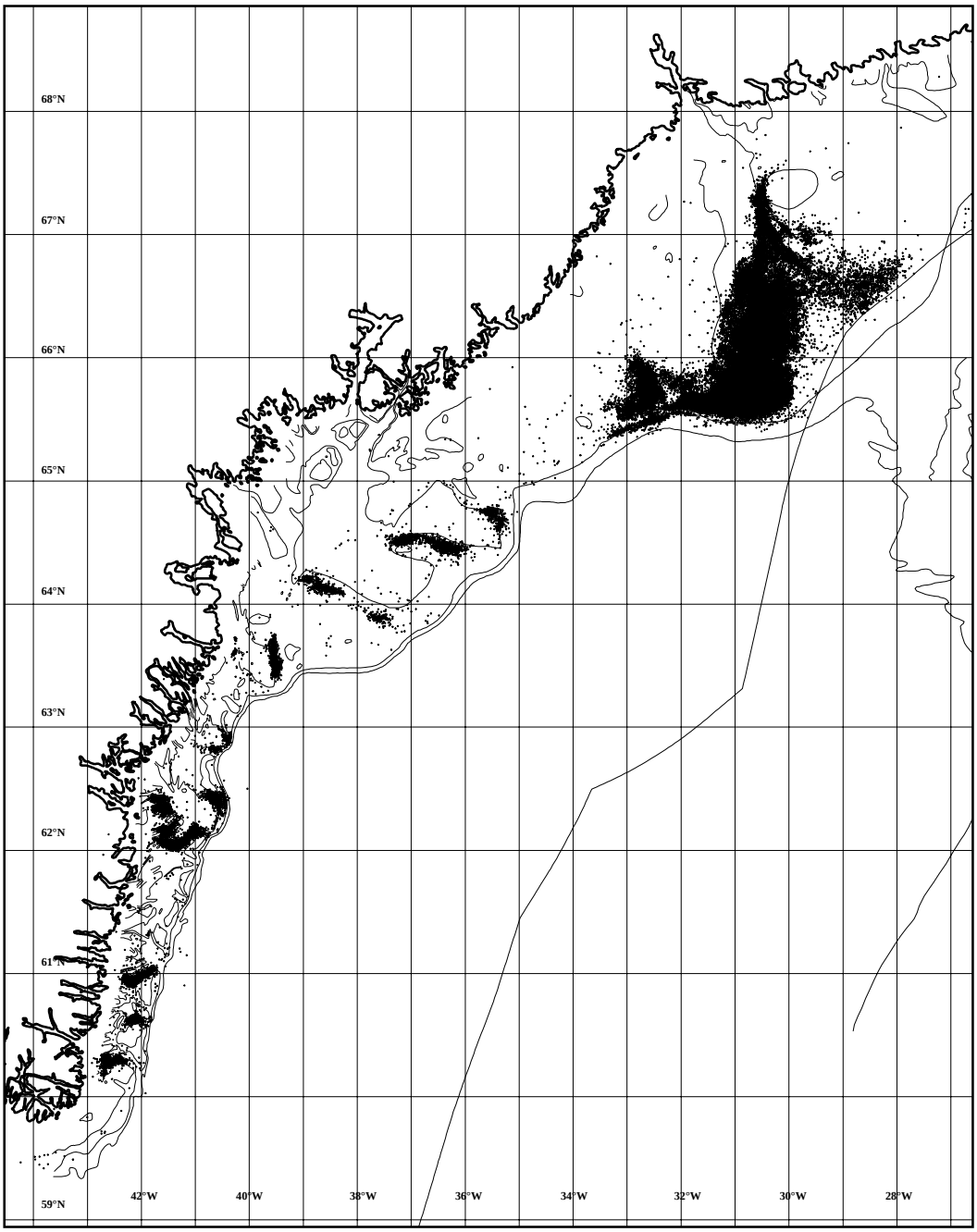


Fig. 1. Overall distribution of hauls by Greenlandic trawlers in the shrimp fishery off East Greenland 1988-1998. 400 and 600 meters depth curves are shown.

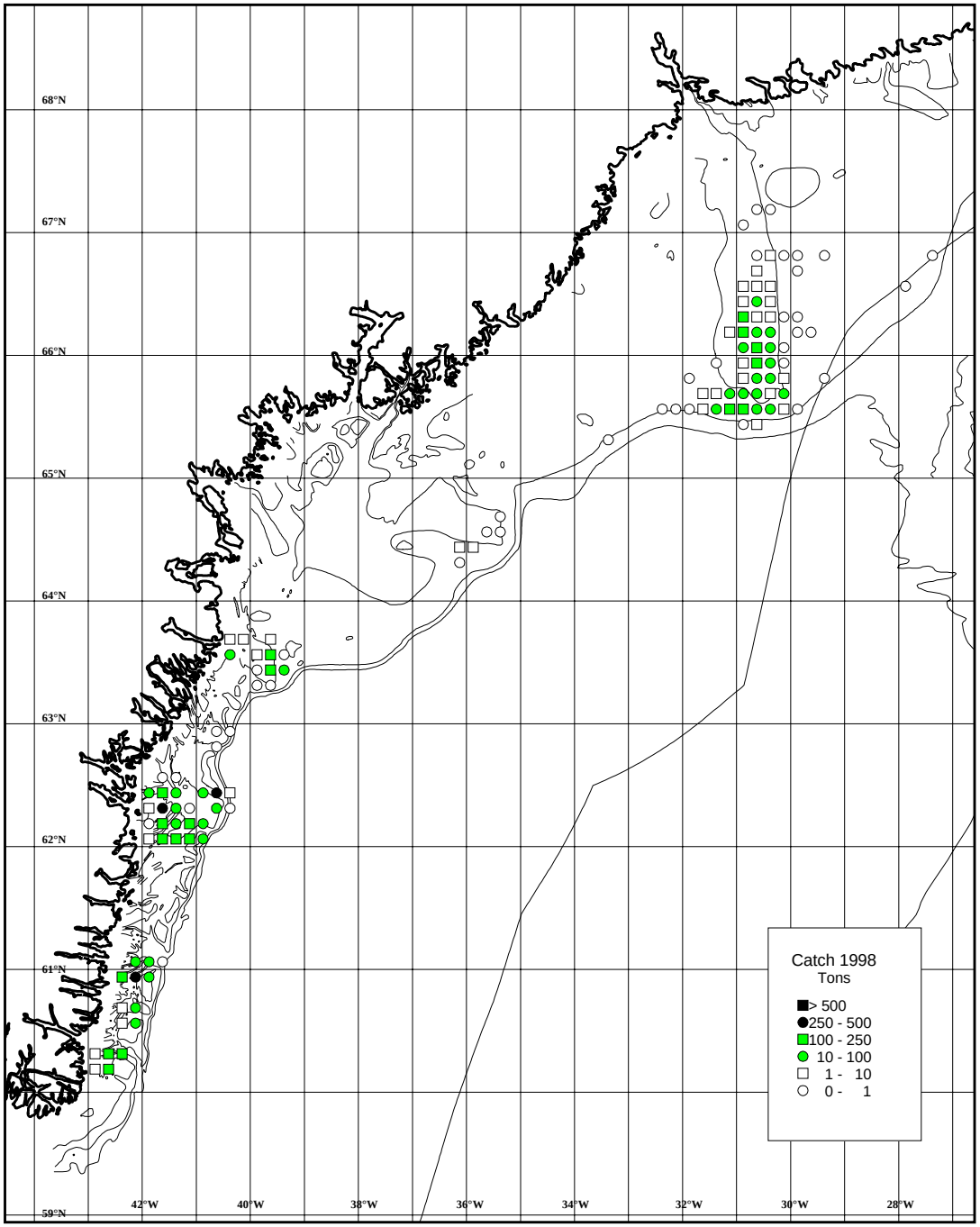


Fig. 2a. Distribution of catches of shrimp by Danish, Faroese and Greenlandic trawlers off East Greenland in 1998.

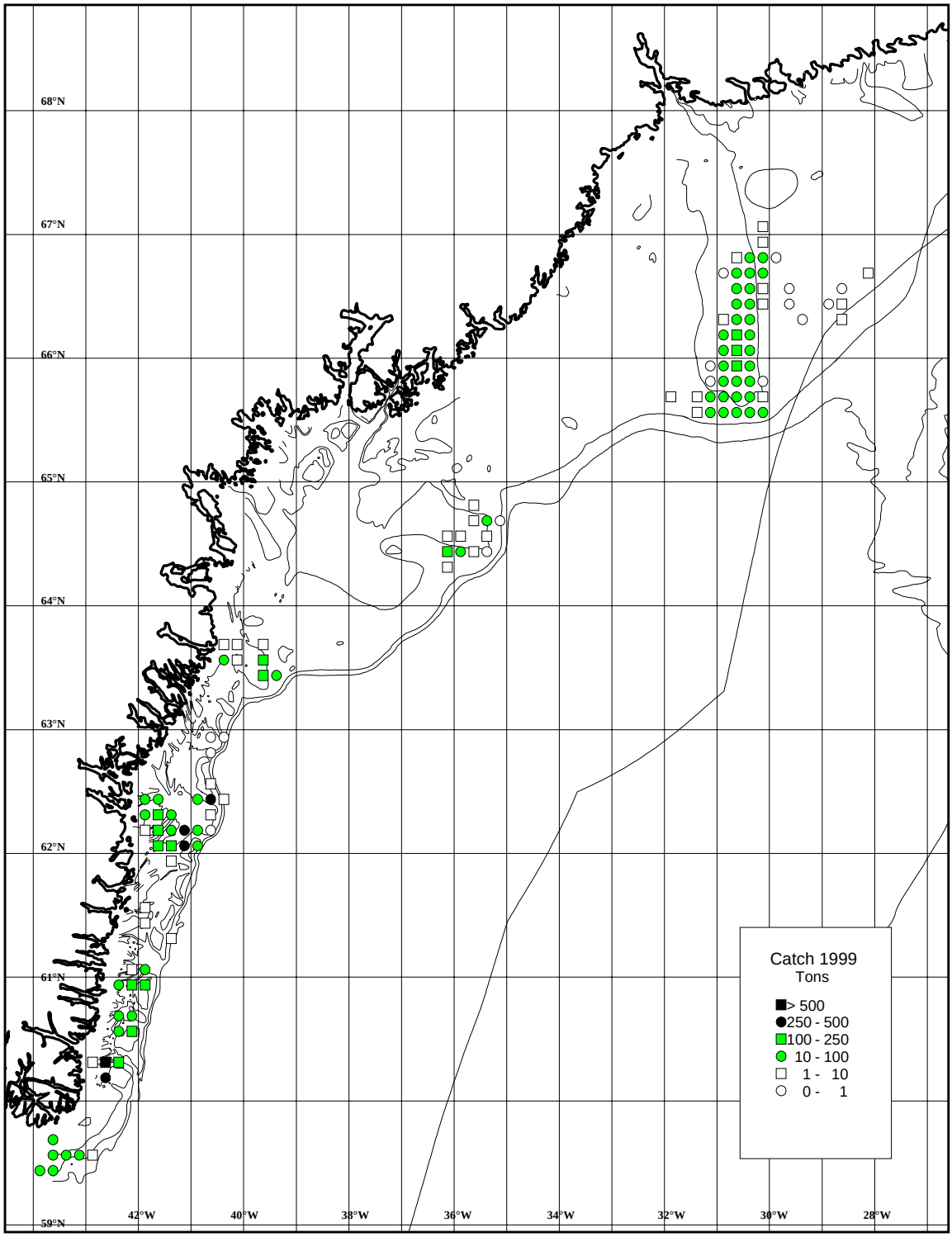


Fig. 2b. Distribution of catches of shrimp by Danish, Faroese and Greenlandic trawlers off East Greenland in 1999.

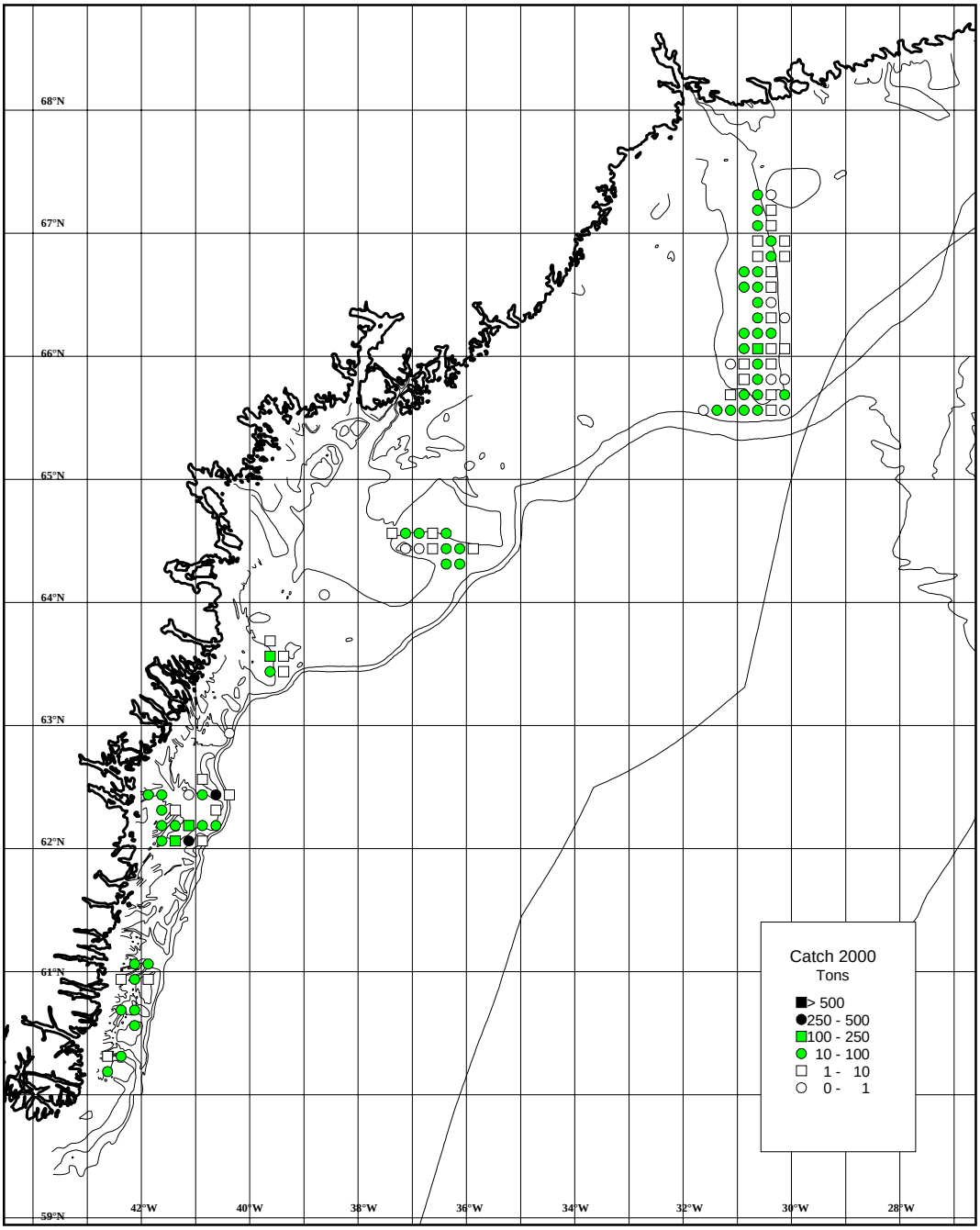


Fig. 2c. Distribution of catches of shrimp by Danish, Faroese and Greenlandic trawlers off East Greenland in 2000 (preliminary, logbook data from January-July period).

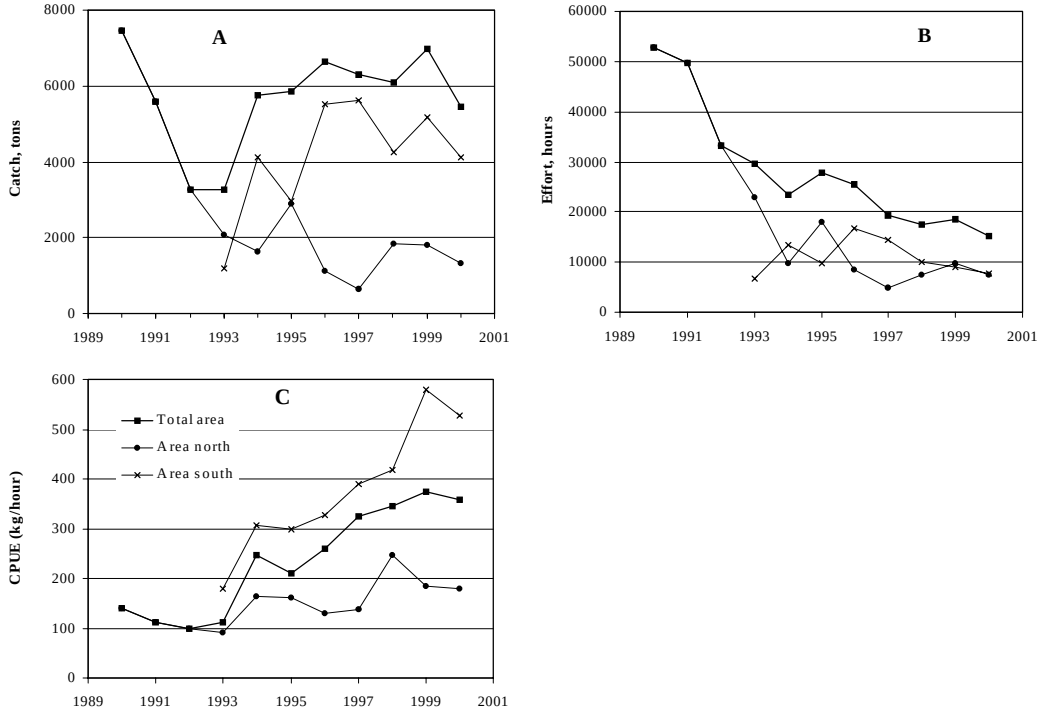


Fig. 3. Nominal catch (A), effort (B) and CPUE (C) by Danish, Faroese and Greenlandic trawlers fishing off East Greenland in the Greenlandic zone 1990-2000 (north of 65ºN, south of 65ºN and total area). Data for 2000 preliminary, nominal catch from January to November 1., effort (weighted by nominal catch) and CPUE from logbook data January-July.

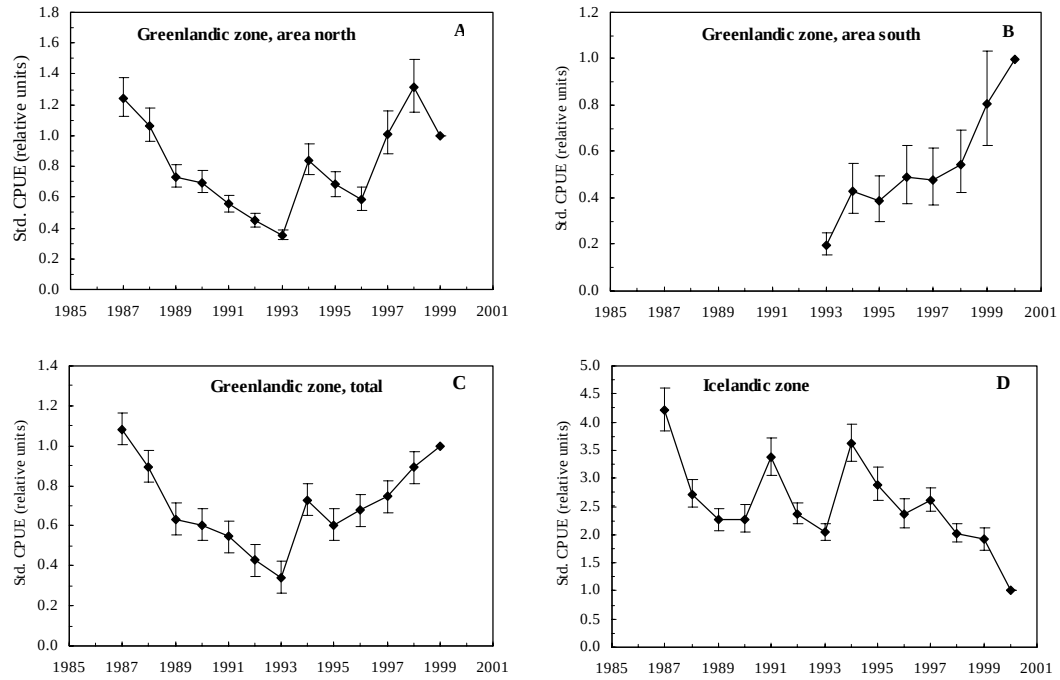


Fig. 4. Standardised CPUE indices for the Greenlandic zone (A: area north of 65ºN , B: area south of 65ºN and C: total Greenlandic area, based on logbook data from Danish, Faroese and Greenlandic vessels) and for the Icelandic zone (D, logbooks from Icelandic vessels).

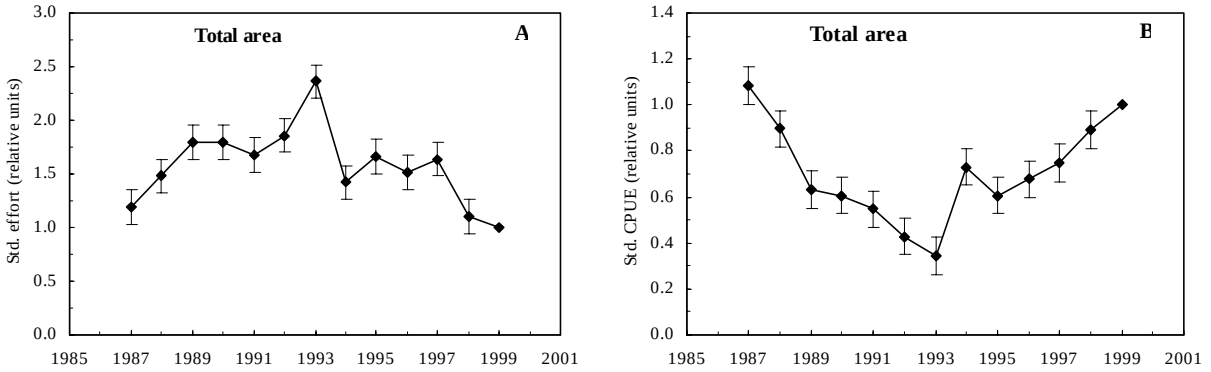


Fig. 5. Combined standardised effort (A) and standardised CPUE-index (B) for total area, based (for the Greenlandic zone) on logbook data from Danish, Faroese and Greenlandic vessels and (for the Icelandic zone) logbooks from Icelandic vessels.

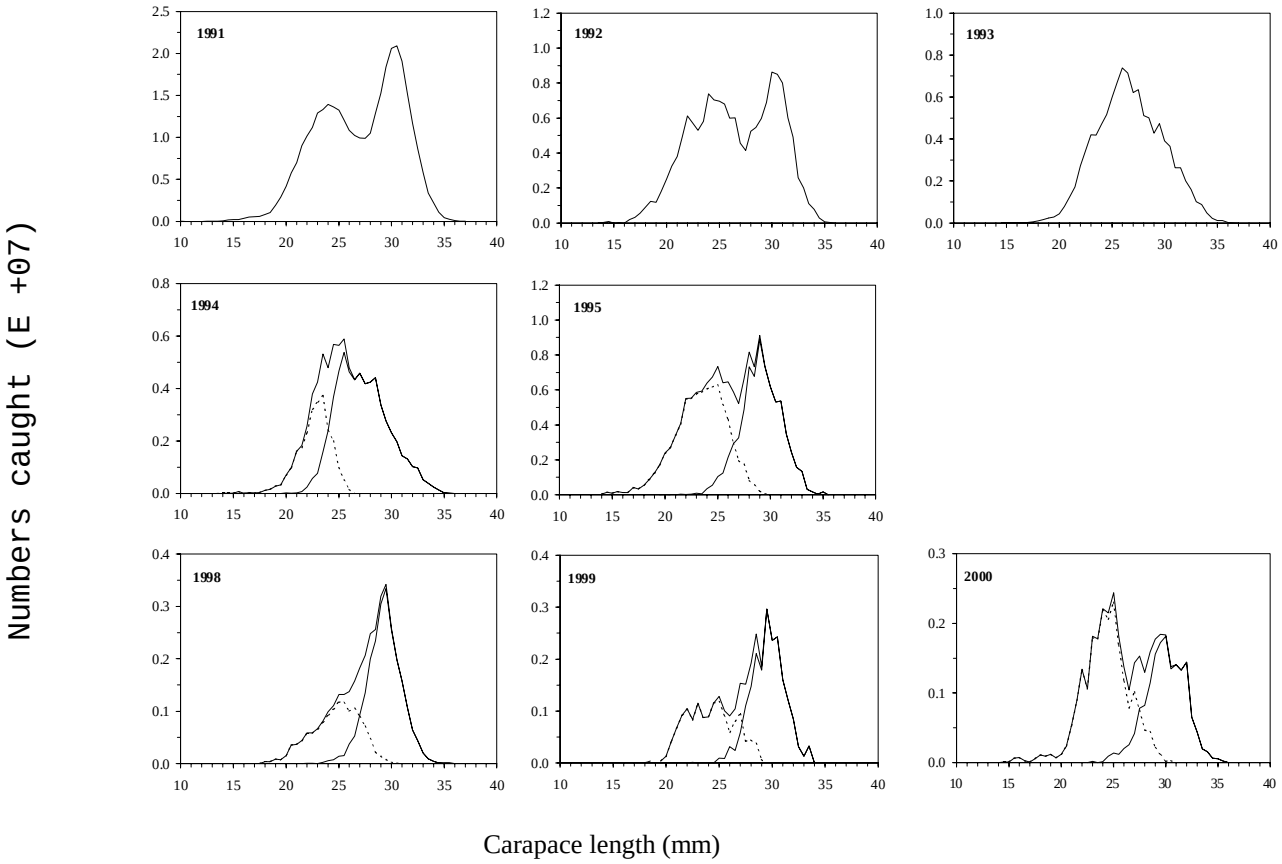


Fig. 6A. Length frequency distributions of commercial shrimp catches off East Greenland north of 65°N, 1991 - 2000 (no data available for 1996-1997). The distribution of male shrimp is shown by a dotted line, females by a thin line and overall distribution by a bold line. Data for 2000 preliminary.

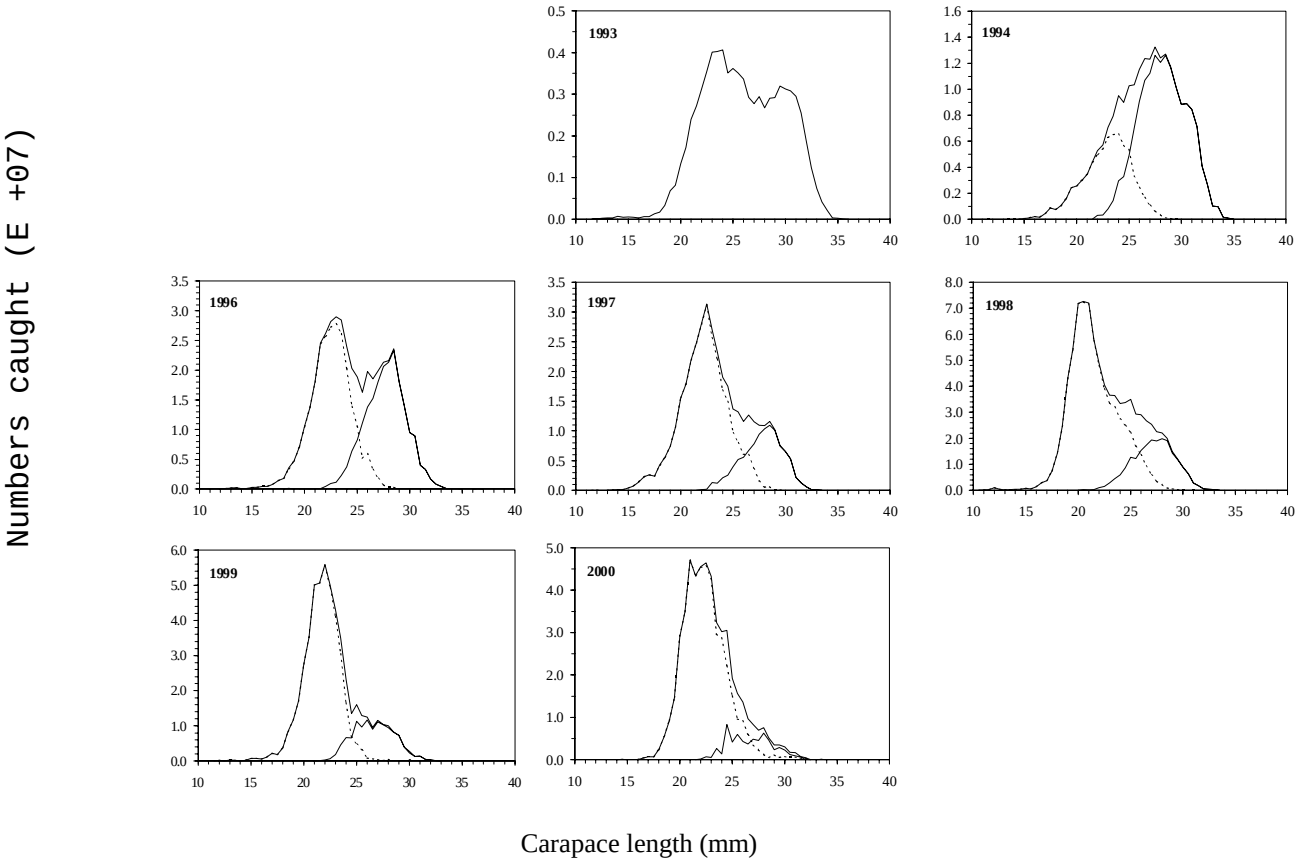


Fig. 6B. Length frequency distributions of commercial shrimp catches off East Greenland South of 65°N, 1993-2000 (no data available for 1995). The distribution of male shrimp is shown by a dotted line, females by a thin line and overall distribution by a bold line. Data for 2000 preliminary.

Appendix 1. Diagnostical outputs from GLM run of model for standardising CPUE in Greenlandic zone 1987-1999. Data from Greenlandic, Faeroese and Danish vessels. Index is shown in Fig. 4C

Class	Levels	Values
VESSEL	8	AAAA BBBB CCCC DDDD EEEE FFFF HHHH IIII
YEAR	13	87 88 89 90 91 92 93 94 95 96 97 98 99
MONTH	5	1 3 5 6 12

Number of observations in data set = 1129

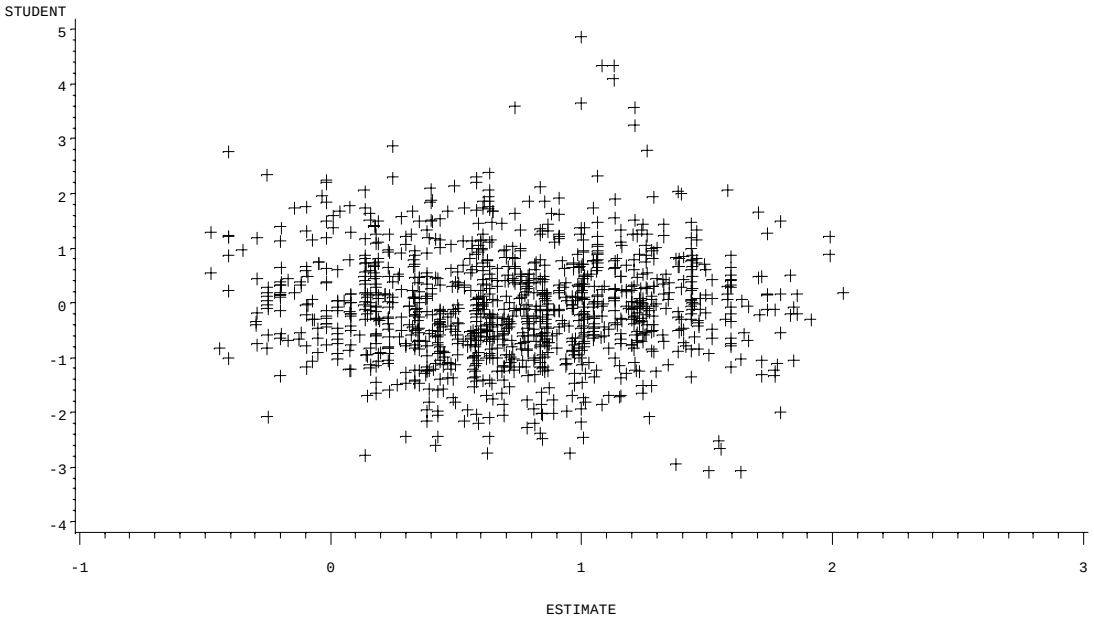
Dependent Variable: LNCPUE
Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	17368.364102	755.146265	81.09	0.0001
Error	1105	10290.615023	9.312774		
Corrected Total	1128	27658.979125			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.627947	411.6549	3.0516838	0.7413209

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	7	5421.0333957	774.4333422	83.16	0.0001
YEAR	12	8236.7980710	686.3998392	73.71	0.0001
MONTH	4	5379.8550224	1344.9637556	144.42	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.625669249 B	5.37	0.0001	0.11656272
VESSEL	AAAA	0.153718908 B	2.82	0.0048	0.05442711
	BBBB	0.451395982 B	6.87	0.0001	0.06575221
	CCCC	0.571870343 B	9.71	0.0001	0.05889755
	DDDD	-0.366706676 B	-3.61	0.0003	0.10156973
	EEEE	-0.125715944 B	-2.18	0.0297	0.05775936
	FFFF	0.306424324 B	5.62	0.0001	0.05457102
	HHHH	0.700599752 B	11.97	0.0001	0.05852747
	IIII	0.000000000 B	.	.	.
YEAR	87	0.219530250 B	2.04	0.0419	0.10779150
	88	0.063835356 B	0.61	0.5409	0.10436580
	89	-0.310898548 B	-3.00	0.0028	0.10367408
	90	-0.361595341 B	-3.50	0.0005	0.10340513
	91	-0.588832098 B	-5.69	0.0001	0.10347106
	92	-0.795949732 B	-7.52	0.0001	0.10588546
	93	-1.039803753 B	-9.64	0.0001	0.10791296
	94	-0.174152527 B	-1.44	0.1489	0.12057671
	95	-0.385298273 B	-3.44	0.0006	0.11206964
	96	-0.533262454 B	-3.96	0.0001	0.13482709
	97	0.010519020 B	0.07	0.9458	0.15472822
	98	0.273394773 B	1.94	0.0523	0.14071649
	99	0.000000000 B	.	.	.
MONTH	1	0.442696343 B	12.08	0.0001	0.03664596
	3	0.246241150 B	6.18	0.0001	0.03982931
	5	0.163227576 B	2.65	0.0081	0.06153695
	6	-0.388754256 B	-8.90	0.0001	0.04366802
	12	0.000000000 B	.	.	.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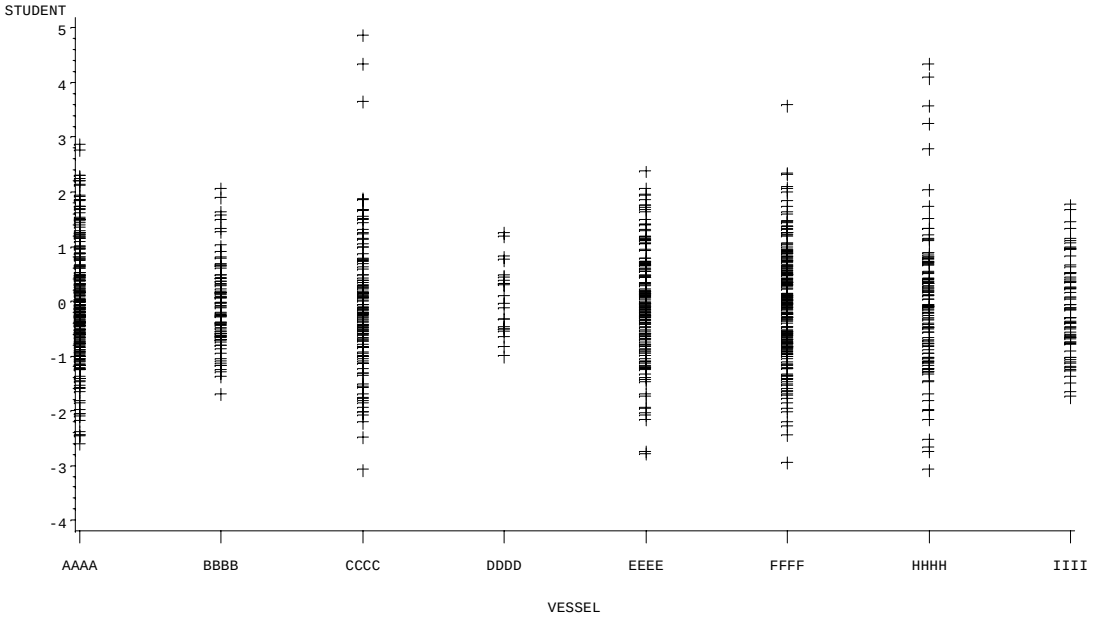
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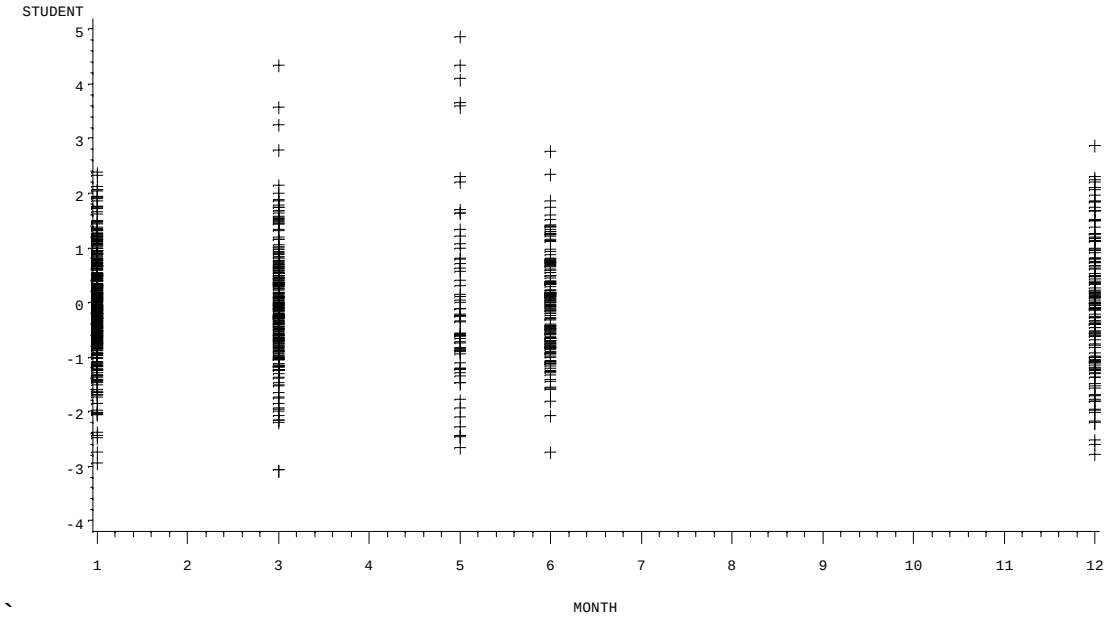
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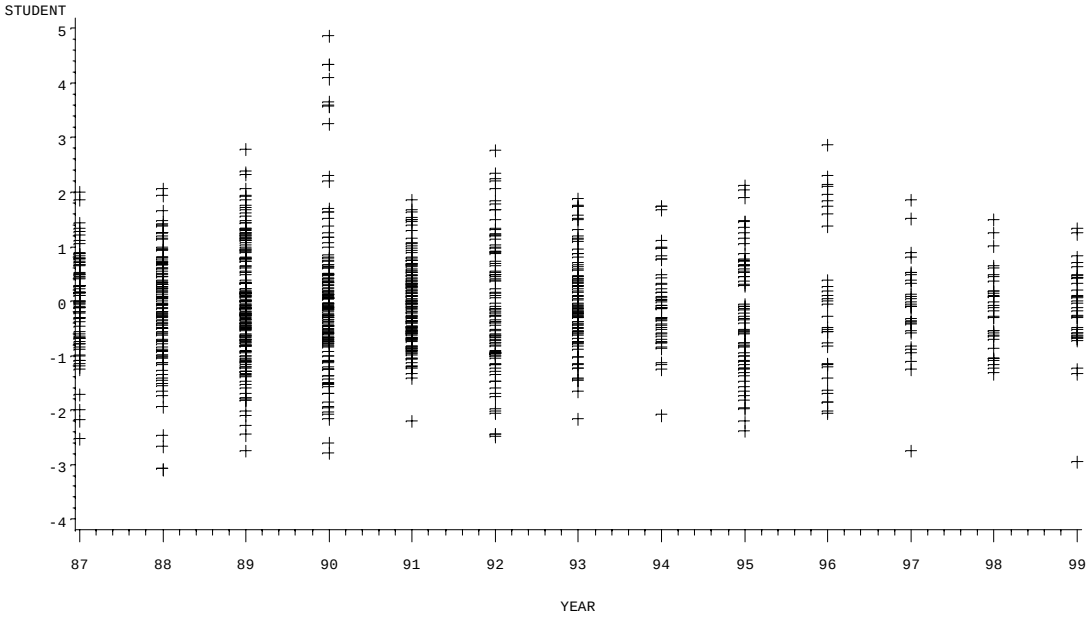
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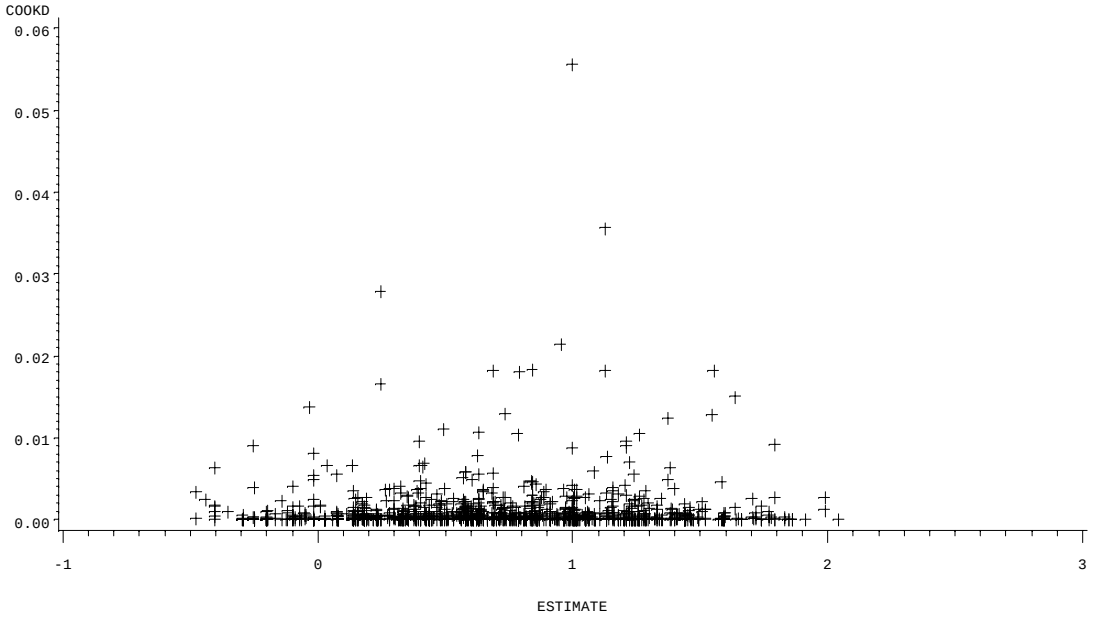
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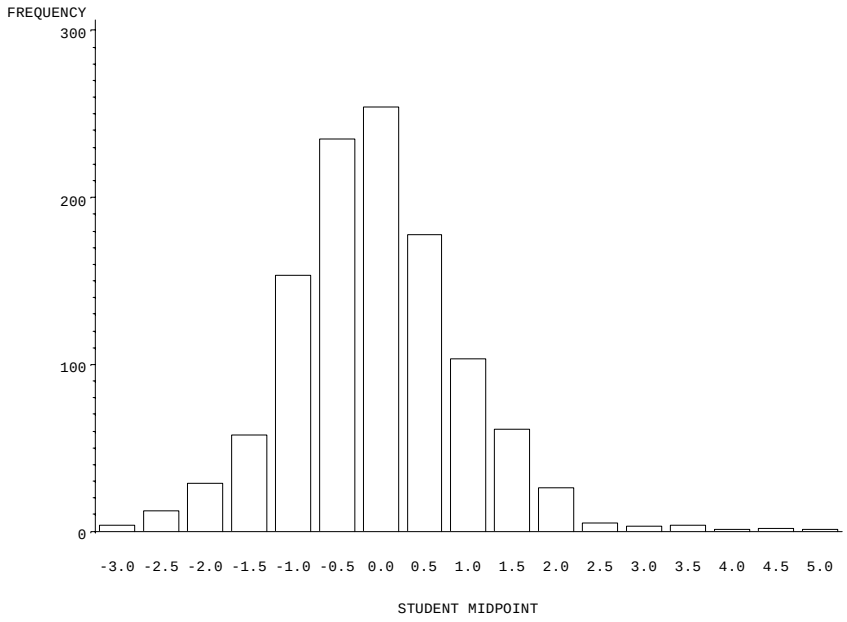
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Appendix 2. Diagnostical outputs from GLM run of model for standardising CPUE in Icelandic zone. Data from Icelandic vessels only. Index is shown in Fig. 4D.

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	14	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
MONTH	9	1 2 3 4 5 6 9 10 11
SHIP	19	253 1046 1586 1753 2061 2155 2204 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000 4100 4200
TRAWL	2	1 2

Number of observations in data set = 852

Dependent Variable: LNCPUE
Weight: EFFORT EFFORT

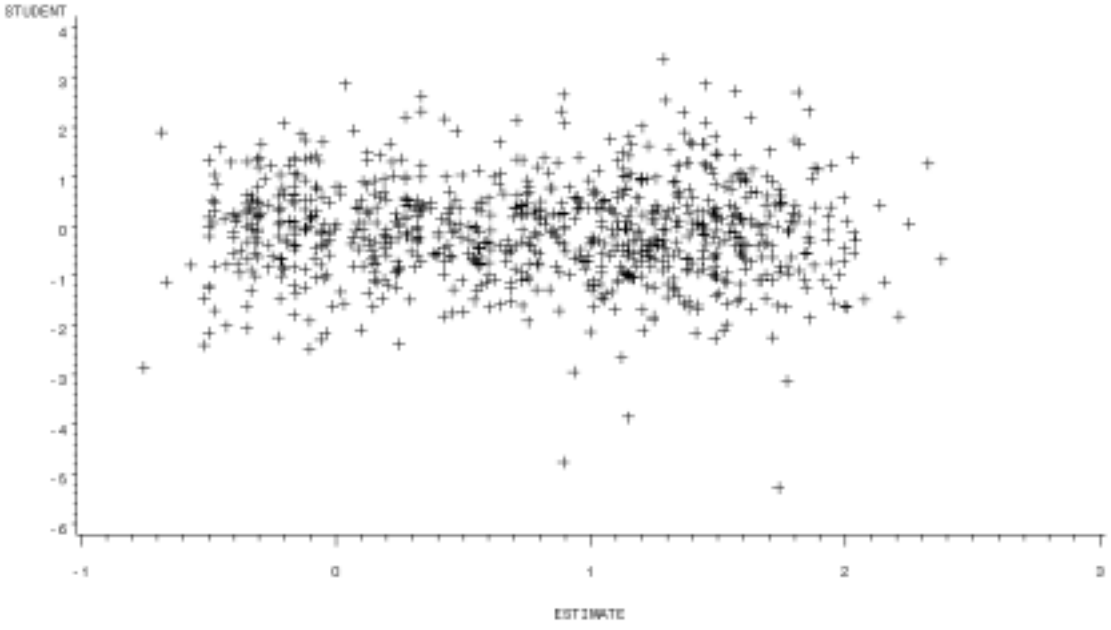
Source	DF	Sum of Squares	F Value	Pr > F
Model	40	2679812.49335	104.84	0.0001
Error	811	518262.05340		
Corrected Total	851	3198074.54675		

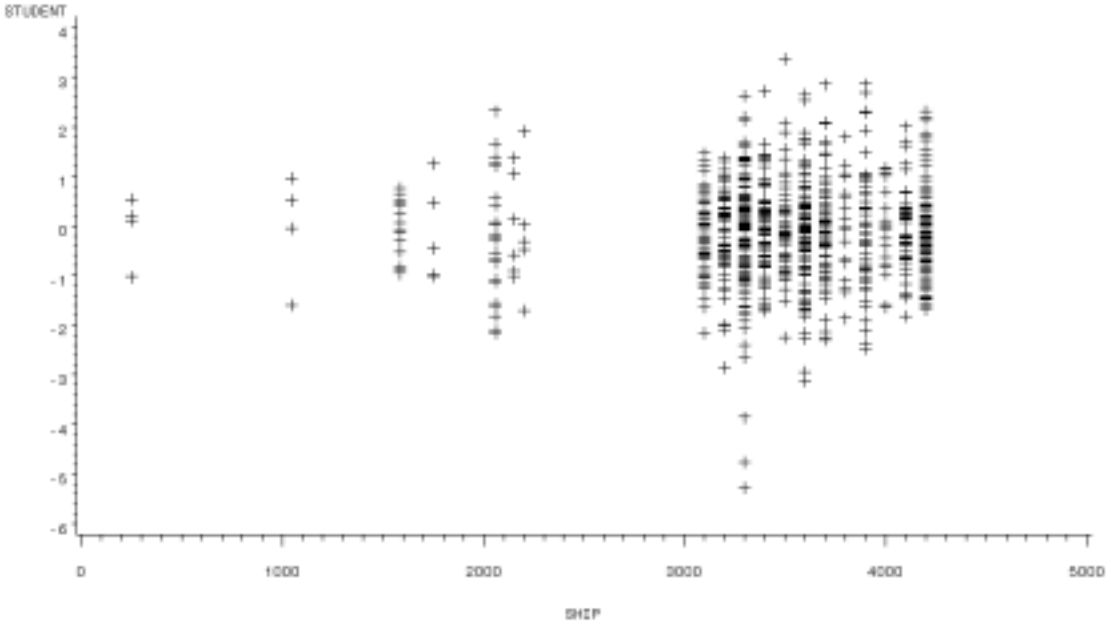
R-Square	C.V.	LNCPUE Mean
0.837946	4007.400	0.63081441

Source	DF	Type III SS	F Value	Pr > F
MONTH	8	422760.494792	82.69	0.0001
SHIP	18	248958.139838	21.64	0.0001
YEAR	13	214079.454378	25.77	0.0001
TRAWL	1	5457.707072	8.54	0.0036

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-0.778613629	B	-3.61	0.0003	0.21545534
MONTH	1	0.578962544	B	4.09	0.0001	0.14167361
	2	1.853820411	B	15.45	0.0001	0.12002691
	3	1.756343978	B	16.62	0.0001	0.10565895
	4	1.814306012	B	18.19	0.0001	0.09974401
	5	1.409660451	B	14.79	0.0001	0.09533557
	6	0.849519205	B	9.36	0.0001	0.09078969
	9	0.351760966	B	4.40	0.0001	0.08001730
	10	0.183233659	B	2.17	0.0301	0.08432034
	11	0.000000000	B	.	.	.
SHIP	253	-0.915950286	B	-6.12	0.0001	0.14974106
	1046	0.162504578	B	0.29	0.7708	0.55769822
	1586	-0.408250390	B	-5.58	0.0001	0.07310196
	1753	0.250382362	B	0.88	0.3773	0.28346807
	2061	0.112278651	B	1.31	0.1890	0.08541468
	2155	-0.910306788	B	-7.61	0.0001	0.11957888
	2204	-1.254957178	B	-5.29	0.0001	0.23710570
	3100	-0.696624895	B	-11.38	0.0001	0.06122857
	3200	-0.599132801	B	-9.99	0.0001	0.05997007
	3300	-0.546024186	B	-11.23	0.0001	0.04862443

	3400	-0.505148621	B	-9.67	0.0001	0.05224565
	3500	-0.419653558	B	-7.15	0.0001	0.05870004
	3600	-0.361895756	B	-6.96	0.0001	0.05197005
	3700	-0.256267664	B	-4.70	0.0001	0.05448579
	3800	-0.217539269	B	-2.29	0.0221	0.09487600
	3900	-0.133962827	B	-2.31	0.0214	0.05809523
	4000	-0.071872481	B	-0.74	0.4617	0.09759150
	4100	-0.054319442	B	-0.89	0.3740	0.06106380
	4200	0.000000000	B	.	.	.
YEAR	1987	1.438777052	B	7.33	0.0001	0.19635773
	1988	1.000007775	B	5.13	0.0001	0.19493189
	1989	0.816268539	B	4.22	0.0001	0.19342255
	1990	0.822671456	B	4.04	0.0001	0.20342862
	1991	1.213997963	B	6.12	0.0001	0.19830187
	1992	0.860243030	B	4.54	0.0001	0.18950880
	1993	0.711932686	B	3.80	0.0002	0.18713433
	1994	1.287685340	B	6.75	0.0001	0.19077939
	1995	1.061856422	B	5.69	0.0001	0.18673670
	1996	0.855707106	B	4.44	0.0001	0.19277364
	1997	0.957310737	B	5.18	0.0001	0.18473608
	1998	0.705306364	B	3.73	0.0002	0.18884996
	1999	0.650522235	B	3.35	0.0009	0.19431360
	2000	0.000000000	B	.	.	.
TRAWL	1	-0.190179453	B	-2.92	0.0036	0.06507629
	2	0.000000000	B	.	.	.

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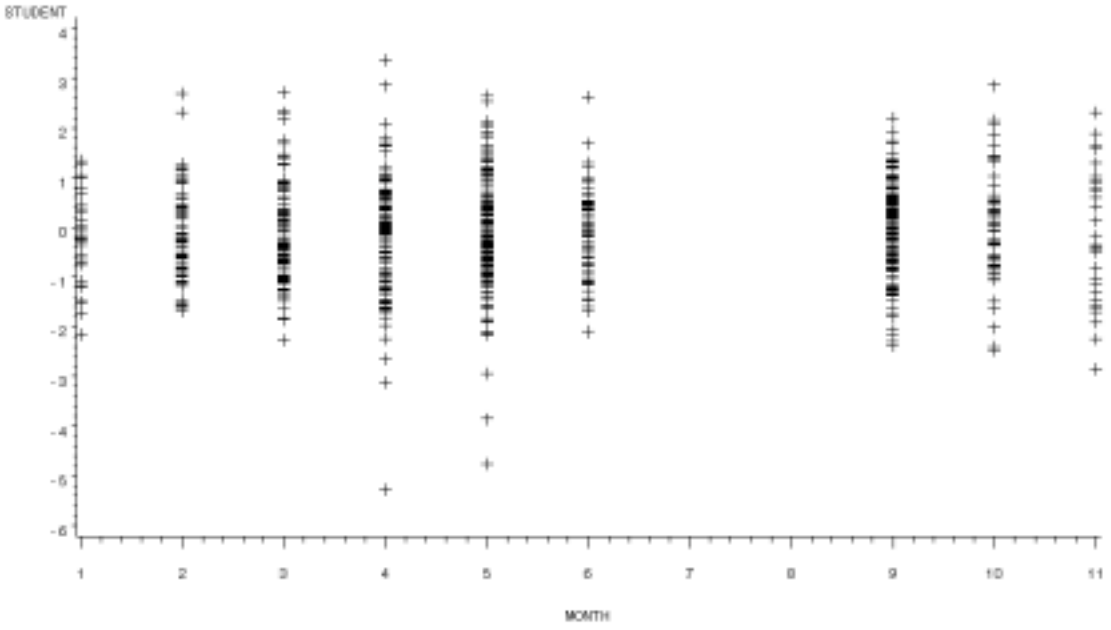
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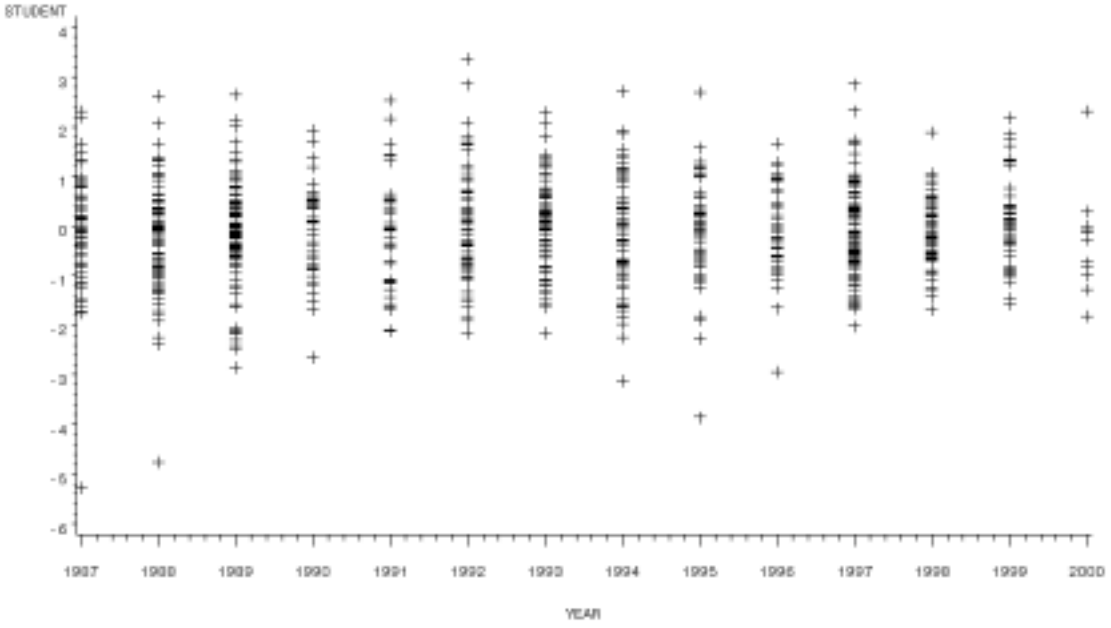
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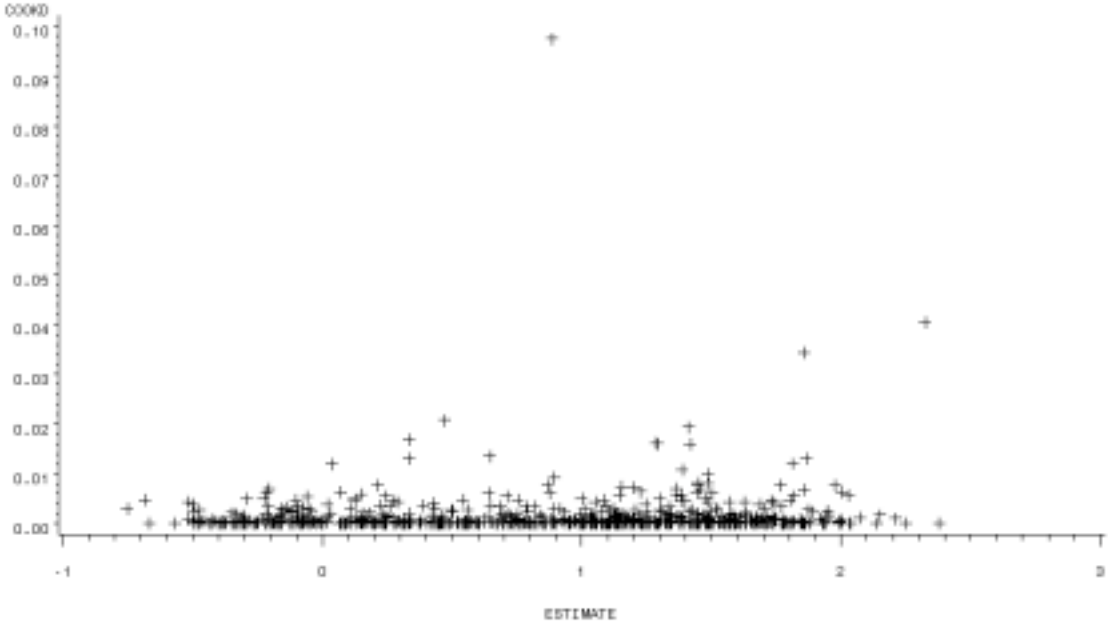
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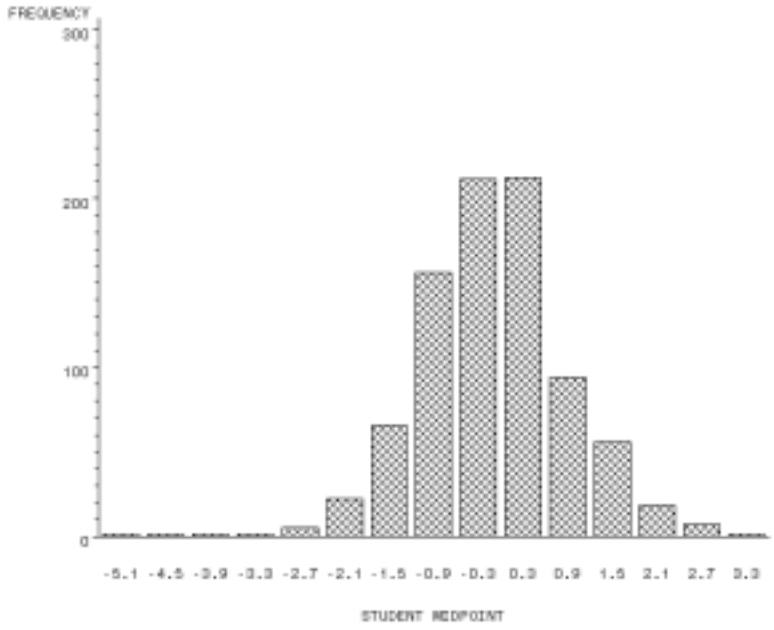
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STUDENT MIDPOINT