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An assessment of the shrimp stock in Denmark Strait / off East Greenland – 2008.

by

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Abstract

Northern shrimp (*Pandalus borealis*) occurs off East Greenland from Cape Farewell to about 70°N in depths down to about 800m. North of 65°N the stock spans the adjacent Greenlandic and Icelandic economic zones. The stock is assessed as a single population by evaluation of fishery dependent data only. The stock is managed by catch quotas in the Greenlandic zone. There are no management related restrictions on the fishery in the Icelandic zone.

A multinational fleet of large factory trawlers exploits the stock taking annual catches close to 12000 tons from 1994 to 2003. Catches decreased to 4612 tons in 2007 and preliminary data indicate that catches will stay at that level in 2008. A biomass index indicates that the stock decreased steadily from 1987 to 1993, but has shown an increasing trend until the beginning of the 2000s, and fluctuated at this level thereafter. Fishing mortality indices have declined since 1993 and recent levels are the lowest of the time series.

Sampling of the commercial fishery in recent years has been insufficient to obtain annual estimates of catch composition.

The status of the shrimp stock in Denmark Strait / off East Greenland indicates an increasing trend in the fishable biomass from 1993 to beginning of 2000s with stabilities thereafter. However, part of the fishing fleet has decreased their effort in recent years, which gives some uncertainty on whether recent values are a true reflection of the stock biomass.

Introduction

Northern shrimp (*Pandalus borealis*) occurs off East Greenland in ICES Divisions XIVb and Va. The stock is distributed from Cap Farewell, up through the Denmark Strait to about 70°N in depths down to around 800 meters. The highest concentrations occur from 150-600 m (Fig.1). There is no evidence of distinct sub-populations and the stock is assessed as a single population. The assessment is based on fishery dependent data only and is largely done by evaluation of trends in biomass indices and size distributions in response to catch levels.

The exploitation of this stock began in the late 1970's initiated by Icelandic trawlers. It soon became a multinational fishery with annual catches increasing rapidly to more than 15000 tons during the following 10-year period. Total catches fluctuated around 12000 tons from 1994 to 2003 (Table 1, Fig. 2A). Catches decreased to 4612 tons in 2007 and preliminary data indicate that catches will stay at that level in 2008. 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 (Fig.1). However, in 1993 a fishery was also initiated in various smaller areas extending south to the Cap Farewell. At any time access to fishing grounds depends on ice conditions.

During the recent ten years fleets from Greenland, EU-Denmark, the Faroe Islands and Norway have participated in the fishery in the Greenlandic zone. Annual catches in this area accounts for around 70-98% of the total and the fishery is managed by a Total Allowable Catch (TAC). Icelandic vessels operate exclusively in the Icelandic EEZ and the fishery is

unrestricted by management initiatives. Vessels taking part in the fishery on both sides of the national midline are large factory trawlers in the range of 1000-4000 GRT.

This paper presents and analyses data from the shrimp fishery in Denmark Strait / off East Greenland to provide a basis for the assessment of the shrimp stock in this area i.e. time series of catch, fishing effort, geographical distribution and catch-per-unit-effort based biomass indices and indices of harvest rate.

Materials and methods

Raw data

Logbooks from Greenland, Iceland, Faroe Islands and EU-Denmark since 1980, from Norway since 2000 and from EU-France for the years 1980 to 1991 supplied data on catch and effort (hours fished) on a by haul basis. Since 2004 more than 60% of all hauls were performed with double trawl and the 2008 assessment included both single and double trawl in the standardized catch rates calculations. The catches in the Greenland EEZ were corrected "overpack" according to Hvingel 2003.

Catches and corresponding effort were compiled by year and by areas north and south of 65°N. Catch-Per-Unit-Effort (CPUE) was calculated and applied to the total catch of the year to estimate the total annual effort. The geographical distribution of the fishery are shown by plotting the unstandardized CPUE by statistical units of 7.5' latitude and 15' longitude.

Catch rate indices

Three standardised CPUE indices were constructed: one for each of the areas north and south of 65°N and a combined index series representing the total area. The indices were based on logbook data from Greenlandic, Faeroese, EU (Danish, Lithuania, Estonia), and Norwegian vessels, operating exclusively in the Greenlandic zone and from the Icelandic fleet fishing exclusively in the Icelandic zone (north of 65°N). Until 2005 Norwegian fishery data was considered to have too sparse information on the different areas fished and data was therefore not included in the standardized catch rates calculations. In 2006 Norwegian fishery data was included in the catch rates calculations after a positive evaluation of new logbook data from Greenland License Office, where Norwegian fishery data has been recorded in standard format since 2000.

For the indices of the northern areas and the total areas this involved a two-step process. In the first step multiplicative General Linear Modelling (GLM) techniques were used to standardise the CPUE data from the Greenlandic and Icelandic zones separately. There is no area overlap between the vessels fishing in the two zones. Therefore annual CPUE indices cannot be derived from a single GLM-run as such a model will not be able to estimate the relative fishing power of the vessels. The "first step" was performed following the method described in Hvingel *et al.* (2000). The multiplicative models, included the following variables: (1) individual vessel fishing power, (2) seasonal availability of shrimp, (3) spatial availability of shrimp, (4) annual mean CPUE and (5) single and double trawl. Input data were mean CPUE by vessel, area, month and year. The calculations were done using the SAS statistical software (Anon., 1988). The main effects model was represented in logarithmic form:

$$\ln(CPUE_{mjki}) = \ln(u) + \ln(A_m) + \ln(S_j) + \ln(V_k) + \ln(Y_i) + e_{mjki}$$

Where $CPUE_{ijki}$ is the mean CPUE for vessel k, fishing in area m in month j during year i (k = 1,...,n; m = 1,…,a; j = 1,…,s; i = 1,…,y); ln(u) is overall mean ln($CPUE$); A_m is effect of the mth area; S_j is the effect of the jth month; V_k is the effect of the kth vessel; Y_i is the effect of the ith year; e_{mjki} is the error term assumed to be normally distributed N(0,σ^2/n) where n is the number of observations in the cell. The standardised CPUE indices are the antilog of the year coefficient.

Parameter estimates of the vessel, month and area variable from a first run of the model were compared. Levels within each variable were combined in subsequent analyses if the parameter estimates did not differ by more than 5%. This was done to reduce the number of empty cells in the models.

For the model pertaining to the Greenlandic zone 53 of 72 vessels met the criteria for inclusion in the analysis (at least three years of fishing in the area) i.e. 41 Greenlandic, 14 Faeroese, 5 Danish, 12 Norwegian vessels. Based on an exploratory run of the main effects model the vessel effect was collapsed into 14 groups consisting of 4-8 vessels with similar fishing power. The month effect was reduced to 5 levels by grouping months with similar indices of relative

shrimp availability. The area effect had two levels - one for each of the fishing areas north and south of 65°N. The year*area cross-effect was calculated to give separate indices for the northern and southern areas.

In the Icelandic zone 126 different Icelandic vessels had been registered in the area from 1987 to 2005. Almost no fishery has been conducted in 2005 (21 tons) and there has been no fishery from 2006 to 2008. The 61 vessels qualifying for the index were collapsed into 18 groups consisting of 1-8 vessels of equal fishing power. The month effect was reduced to 6 levels. No area effect was included. A two level trawl effect was introduced to account for the effect of twin trawling.

Results and diagnostically output from the GLM run show that data from the Icelandic zone in 2005 (catches was very small in 2005) was unsuitable to further analyses and therefore not included.

The index of the area south of 65°N
From this first step of calculations the biomass index for the areas south of 65°N came directly as the 'year-area south' cross effect of the Greenlandic zone model (see appendix 1).

The combined index of the area north of 65°N
In the second calculation step the biomass index for the areas north of 65°N was derived by combining the year coefficients of the Icelandic zone model (appendix 2) and the year effects for the northern areas in the Greenlandic zone model (i.e. the 'year-area north' cross effect, see appendix 1). A Monte Carlo Markov Chain (MCMC) sampling process was used to construct distributions of likelihoods of possible values of the combined index. This was done within the programming framework WinBUGS v.1.4, (www.mrc-bsu.cam.ac.uk/bugs; Gilks *et al.* 1994; Spiegelhalter *et al.* 2000). The individual CPUE series for the p^{th} fleet, μ_{pi}, was assumed to reflect an overall biomass series, Y_i, and a constant fleet coefficient, v_p, so that:

$$\mu_{pi} = v_p Y_i \exp(e_{pi})$$

The error, e_{pi}, were considered to be distributed with mean zero and variance σ_{pi}^2. The error term was assumed that e_{pi}, have variances inversely proportional to the area of fishing ground, a_p, covered by fleet p. The factor, a_p, was taken to be the area of sea bottom between 150-600 m. Hence, σ_{pi}^2 was calculated by:

$$\sigma_{pi}^2 = \frac{cv_{pi}^2}{a_p}$$

Where cv_{pi} is the annual fleet specific coefficient of variation as calculated in the GLM-run. The area weighting factors, a_p, for the Greenlandic area north of 65 and the Icelandic zone were estimated to 0.8 and 0.2 respectively.

The combined index of the total area
In a similar second calculation step a single combined index of the development of the population biomass in the whole area was derived by aggregating the overall year coefficients from the Greenlandic zone model and the year coefficients from the Icelandic zone model. This was also done by the method described above using an area-weighting factor of 0.875 for the Greenlandic zone data and thus 0.125 for the Icelandic zone data.

Harvest rate indices
Indices of harvest rate were calculated by dividing total annual catch of the area by the respective standardised CPUE indices.

Results and Discussion

Geographical distribution of the fishery
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 (Fig. 1). In 1993 a fishery was also initiated in various smaller areas extending south to the Cap Farewell. From 1996 to 2003 catches in the area south of 65°N accounted for more than 60% of the total catch. Since 2004 catches and effort in the area south of 65°N appears to be decreasing (Fig. 5a,b,c, d).

Catch

As the fishery developed, catches increased rapidly to more than 15000 tons in 1987-88, but declined thereafter to about 9000 tons in 1992-93(Fig. 2A, Table 1 and 2). Following the area expansion of the fishery south of 65°N catches increased again reaching 13700 tons in 1997. Catches from 1998 to 2004 have been between 10000 and 14 000 tons (Fig. 2A). The 2007 catch decreased to 4612 tons and preliminary data indicate that catches will stay at that level in 2008 (projected from October).

In the northern area the amount caught has declined by about 75%, i.e. from 15000 tons in 1988 to about 2000 tons in 2001 (Fig. 2A). Catch and effort more than doubled in 2002, but decreased again thereafter to around 4.000 tons and 10.000 hours. According to Greenlandic skippers the reduced effort spent was due to reduced catch rates of large shrimp, which was the primary target of the Greenlandic fishery.

Catches in the southern area increased from 1900 tons in 1993 - the first year of fishery in this area - to about 11.000 tons in 2001 (Fig. 2A). Since 2001 catches in the southern area has declined to 1.286 tons in 2007. 2008 figures are expected to be at the 2007 level.

Fishing effort

The high increase in catches during the first ten-year period was mainly driven by increased fishing effort (Fig. 2B, Table 2). Between 1981 and 1989, total effort increased from about 20000 hr's to a peak of more than 119000 hr's and then declined again to a low of less than 20 000 hr's in 2002. Since then total effort had been declining to less than 11.000 hr's in 2007 - the 2008-value is expected to be at the 2007 level (Fig. 2B).

The historic development of fishing effort spent in the northern area follows the one described for the total area closely – except for 2001, when a lot of effort shifted to the south. In the southern areas, effort increased from about 10000 hours in 1993 to 25000 hours in 1997. In 1999 it reached a low of 7500 hr's but increased again to 20000 hr's in 2001. Since then effort in the southern area has been declining to less than 2.000 hr's in 2007 - the 2008-value is expected to be at the 2007 level (Fig. 2B, Table 2).

Catch rate

Catch rates (total area) decreased from 278 kg/hr to 109 kg/hr in the period 1980-1989, but has shown an increasing trend since then reaching about 502 kg/hr in 2003 (Fig. 2C, Table 2). The catch rates in the last four years (2004 to 2007) are down to around 400 kg/hr. Preliminary data from 2008 indicates an increase to 466 kg/hr.

In the southern areas CPUE increased from 204 kg/hr in 1993 to 925 kg per hour in 1999. During the following years the mean CPUE obtained in this area fluctuated between 500 and 700 kg/hr. Preliminary data from 2008 indicates a CPUE at this level.

Catch rates in the northern area follow the same trend as the overall figures until 1993 as the fishery in the southern areas had not yet been initiated. From 1994-2002 CPUE's have fluctuated around 225 kg/hr except for an extreme of 129 kg/hr in 1996. From 2003 to 2007 annual mean CPUE fluctuated around 350 kg/hr. Preliminary data indicates catch rates around 470 kg/hr.

Standardised catch rate indices

Results of the two multiple regression analysis to standardise catch rates showed that all main effects were highly significant ($p<0.01$). The r-squared of the models were 67% and 78%, respectively. The model-diagnostical outputs (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 description of the data.

The CPUE index series of the northern areas (Fig. 3) declined from 1987 to 1993 thereafter an increasing trend was observed and by the turn of the century the index values had reached the level seen at the offset of the time series. For the recent four years the mean index values have stabilized at a level one third above that of 1987. The CPUE index series of the southern area (Fig. 3) increased until 1999, with stability thereafter.

The combined index for the total area (Fig. 3) indicated that the stock was more than halved during the period 1987-1993. After that it has been rebuilding at a corresponding rate reaching the level of 1987 in the late 1990's. The mean index values increased thereafter and have stabilized at a level one third above that of 1987.

The standardisation 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 standardised effort may therefore be underestimated in which case the standardised 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).

Indices of harvest rate

The standardised effort, i.e. the index of harvest rate, showed a decreasing trend since 1993 for the total area (Fig. 4). The separate indices for the northern and southern areas are also shown in Fig. 4. As mentioned in the previous section the development in the harvest rate indices might be to optimistic. Furthermore, the index of 2008 also depends on the precision with which the catch is projected to the end of the year.

Conclusions

Total catches fluctuated around 12000 tons from 1994 to 2003 (Table 1, Fig. 2A). Catches decreased thereafter to 4612 tons in 2007. Preliminary data indicate that catches will stay at that level in 2008.

There is no recent information on stock size composition.

A combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993(Fig. 3C), showed an increasing trend until 2000, and fluctuated at this level thereafter.

Indices of harvest rate have shown a decreasing trend since 1993.

State of the stock: Standardized CPUE data for all the areas combined indicate an increasing trend in the fishable biomass from 1993 to beginning of 2000s and fluctuated at this level after. However, part of the fishing fleet has decreased their effort in recent years, which gives some uncertainty on whether recent values is a true reflection of the stock biomass.

References

Anon., 1988. SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute Inc., 1988. 1028 pp.

Hvingel, C., H. Lassen and D.G. Parsons (2000). A biomass index for northern shrimp (*Pandalus borealis*) in Davis Strait based on multiplicative modelling of commercial catch-per-unit-effort data (1976 - 1997). *J. Northw. Atl. Fish. Sci. vol.26:25–36.*

Hvingel, C. (2002). Data for the assessment of the shrimp (Pandalus borealis) stock in Denmark Strait/off East Greenland, 2002. *NAFO SCR Doc. 02/147 Ser. No.N4776.*.

HVINGEL, C. 2003. Correction of reported past catches of Northern Shrimp within the Greenland EEZ to conform to a revision of reporting practices. NAFO SCR Doc., No. 03/74 Ser. No. N4913. 3 pp.

Table 1. Catch (tons) of shrimp by the fishery in Denmark Strait/off East Greenland 1981 to October 2007. Values for the fishery in the Greenland EEZ by EU-Denmark, Faeroe Islands, France, Greenland and Norway are corrected according to Hvingel 2003.

Area/Nation	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004[1,5]	2005[1]	2006[1]	2007[1]	2008[1,2]
North of 65°N																									
EU (DK,EST,LTU)	554	442	626	703	554	454	476	450	199	138	250	302	26	85	401	793	459	72	744	785	439	267	619	421	389
Faroe Islands	836	843	910	754	847	738	1029	1265	1355	689	462	931	995	635	1268	867	956	214	1029	1062	894	615	342	319	613
France	626	803	976	1305	616	472	62	148	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-
Greenland	2815	3248	7232	8396	9304	7408	7580	5283	2496	1771	1326	2390	359	105	646	614	115	650	638	695	578	446	223	802	676
Iceland	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566	2856	1421	769	132	10	1231	703	411	29	0	0	0
Norway	2662	2566	2535	2586	2561	2601	3052	3146	3102	1831	2180	2402	1544	797	1628	1783	2759	1291	1630	2861	2700	2624	2705	1783	1000
Total	8235	9696	13428	15073	15313	12999	12480	10757	8901	6982	5731	7176	3490	4478	5364	4827	4420	2237	5272	6107	5022	3981	3889	3326	2678
South of 65°N																									
Denmark (EU)	-	-	-	-	-	-	-	-	-	60	613	731	1167	1657	1300	1095	1900	2473	2309	1903	1065	646	685	431	251
Faroe Island	-	-	-	-	-	-	-	-	-	280	974	295	402	656	138	453	340	2402	1013	303	255	176	227	169	14
Greenland	-	-	-	-	-	-	-	-	-	1141	3603	2667	5295	4701	3950	4966	5235	4943	4333	4194	3488	2687	316	639	0
Norway	-	-	-	-	-	-	-	-	-	424	1011	720	1590	2261	670	378	157	1855	1098	197	186	181	76	48	0
Total	-	-	-	-	-	-	-	-	-	1904	6201	4412	8453	9276	6057	6893	7632	11674	6056	6598	4994	3690	1304	1286	265
Total area																									
EU (DK,EST,LTU)	554	442	626	703	554	454	476	450	199	198	863	1033	1193	1742	1701	1888	2358	2545	2548	2688	1504	913	1304	852	640
Faroe Islands	836	843	910	754	847	738	1029	1265	1355	968	1436	1225	1397	1292	1406	1321	1296	2616	1322	1365	1149	791	569	488	627
France	626	803	976	1305	616	472	62	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenland	2815	3248	7232	8396	9304	7408	7580	5283	2496	2912	4929	5057	5655	4806	4595	5581	5349	5593	4484	4890	4066	3133	539	1441	676
Iceland	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566	2856	1421	769	132	10	1231	703	411	29	0	0	0
Norway	2662	2566	2535	2586	2561	2601	3052	3146	3102	2255	3190	3122	3133	3059	2298	2160	2917	3147	1743	3059	2886	2805	2781	1831	1000
Total	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944	13754	11422	11719	12053	13911	11329	12705	10016	7671	5193	4612	2943
Total all areas	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944	13754	11422	11719	12053	13911	11242	12637	9985	7671	5193	4612	2943
Advised TAC	4200	5000	-	-	-	100003	100003	100003	8000	5000	5000	5000	5000	5000	5000	9600	9600	9600	9600	9600	12400	12400	12400	12400	12400
Effective TAC[3]	5245	6090	75255	75255	87255	90255	14100	14500	13000	9563	9563	9563	9563	9563	9563	10600	12600	10600	10600	10600	15043	12400	12400	12400	12400

[1]Provisional
[2]Catch in 2008 until October
[3]For Greenland zone only; no restrictions in Iceland zone
[4]Not including Greenland fishery north of 66°30'N

Table 2. Catch (tons), effort (hrs) and Catch-Per-Unit-Effort (kg/hr) by trawlers fishing in Denmark Strait / off East Greenland in areas north and south of 65°N.

	Area north			Area south			Total area		
Year	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE
1980	10325	37198	278				10325	37198	278
1981	5964	19986	298				5964	19986	298
1982	6133	23081	266				6133	23081	266
1983	5212	23855	219				5212	23855	219
1984	8235	34983	235				8235	34983	235
1985	9696	62911	154				9696	62911	154
1986	13428	61863	217				13428	61863	217
1987	15073	79881	189				15073	79881	189
1988	15313	109455	140				15313	109455	140
1989	12999	119629	109				12999	119629	109
1990	12480	72736	172				12480	72736	172
1991	10757	78714	137				10757	78714	137
1992	8901	68349	130				8901	68349	130
1993	6982	52381	133	1904	9335	204	8886	61003	146
1994	5731	31417	182	6201	18371	338	11932	49428	241
1995	7176	33953	211	4412	13157	335	11588	46927	247
1996	3490	27029	129	8453	24589	344	11944	51049	234
1997	4478	22175	202	9276	25992	357	13754	47519	289
1998	5364	20881	257	6057	10498	577	11422	31205	366
1999	4827	19388	249	6893	7449	925	11719	25742	455
2000	4420	17474	253	7632	10705	713	12053	28096	429
2001	2237	9822	228	11674	20435	571	13911	29933	465
2002	5272	19783	267	6056	8648	700	11329	22843	496
2003	6107	17833	342	6598	9425	700	12705	25295	502
2004	5022	15716	320	4994	9048	552	10016	27450	365
2005	3981	11258	354	3690	7902	467	7671	19144	401
2006	3889	10419	373	1304	2439	535	5193	12859	404
2007	3326	9009	369	1286	1975	651	4612	10980	420
2008*	2678	5716	468	265	585	454	2943	6310	466

*until Oct.

Table 3. Means and standard errors (se) of standardised CPUE and effort index values based on logbook information from trawlers fishing in Denmark Strait/off East Greenland in areas north and south of 65°N and total area until October 2008.

	Area north				Area south				Total			
	Std.CPUE		Std. Effort		Std.CPUE		Std. Effort		Std.CPUE		Std. Effort	
Year	mean	se	mean	se	mean	se	mean	se	mean	se	mean	se
1987	1,00	-	1,00	-					1,00	-	1,00	-
1988	0,87	0,08	1,16	0,11					0,84	0,06	1,21	0,09
1989	0,61	0,06	1,41	0,13					0,57	0,04	1,51	0,11
1990	0,61	0,06	1,35	0,13					0,57	0,04	1,44	0,10
1991	0,52	0,05	1,38	0,13					0,48	0,04	1,48	0,11
1992	0,42	0,04	1,40	0,13					0,39	0,03	1,51	0,11
1993	0,35	0,03	1,32	0,13	1,00	-	1,00	-	0,37	0,03	1,59	0,12
1994	0,81	0,09	0,47	0,05	2,33	0,19	1,40	0,11	0,99	0,08	0,80	0,06
1995	0,67	0,07	0,71	0,07	1,93	0,19	1,20	0,11	0,72	0,06	1,06	0,09
1996	0,60	0,07	0,38	0,04	2,62	0,22	1,69	0,13	0,97	0,08	0,81	0,07
1997	0,78	0,10	0,38	0,05	2,51	0,22	1,94	0,16	1,06	0,09	0,86	0,07
1998	1,04	0,13	0,34	0,04	2,87	0,28	1,11	0,10	1,17	0,10	0,65	0,06
1999	0,89	0,11	0,36	0,05	3,72	0,45	0,97	0,11	1,17	0,11	0,67	0,06
2000	1,11	0,12	0,26	0,03	3,76	0,36	1,07	0,10	1,31	0,11	0,61	0,05
2001	0,99	0,14	0,15	0,02	2,77	0,22	2,21	0,17	1,32	0,11	0,70	0,06
2002	1,04	0,13	0,34	0,04	3,55	0,32	0,90	0,08	1,48	0,13	0,51	0,04
2003	1,02	0,11	0,40	0,04	3,00	0,28	1,16	0,10	1,17	0,09	0,72	0,06
2004	1,39	0,15	0,24	0,03	2,92	0,33	0,90	0,10	1,33	0,12	0,50	0,04
2005	1,37	0,16	0,19	0,02	3,68	0,42	0,53	0,06	1,49	0,14	0,34	0,03
2006	1,50	0,18	0,17	0,02	3,49	0,49	0,20	0,03	1,51	0,15	0,23	0,02
2007	1,31	0,16	0,17	0,02	3,78	0,60	0,18	0,03	1,35	0,13	0,23	0,02
2008	1,79	0,27	0,10	0,01	2,36	0,67	0,06	0,01	1,64	0,23	0,12	0,02

Figure 1. Thematic mapping of different values of effort (in hours) in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2000-2005.

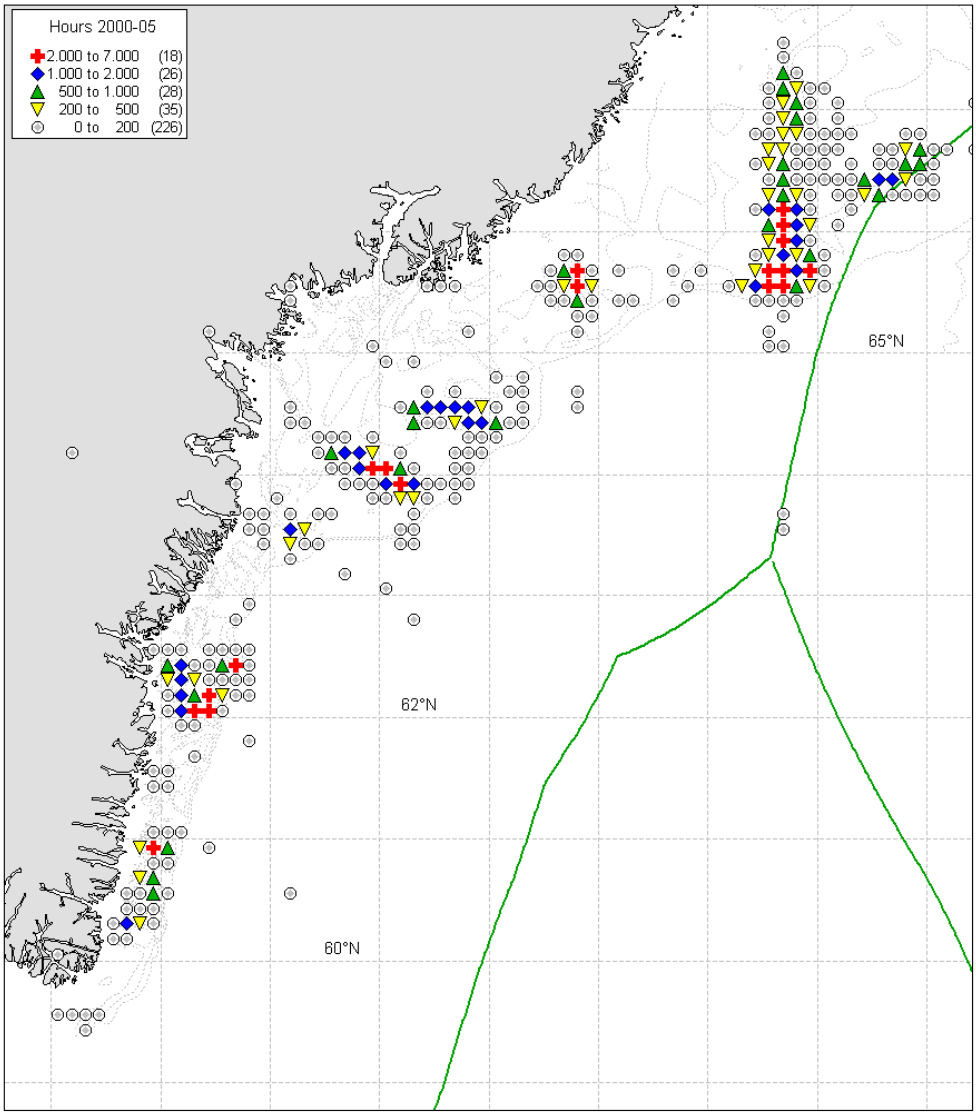


Figure 2. Catch (A), fishing effort (B) and catch-per-unit-effort (C) by shrimp trawlers fishing in Denmark Strait/off East Greenland. Series are given for the areas north and south of 65°N and overall.

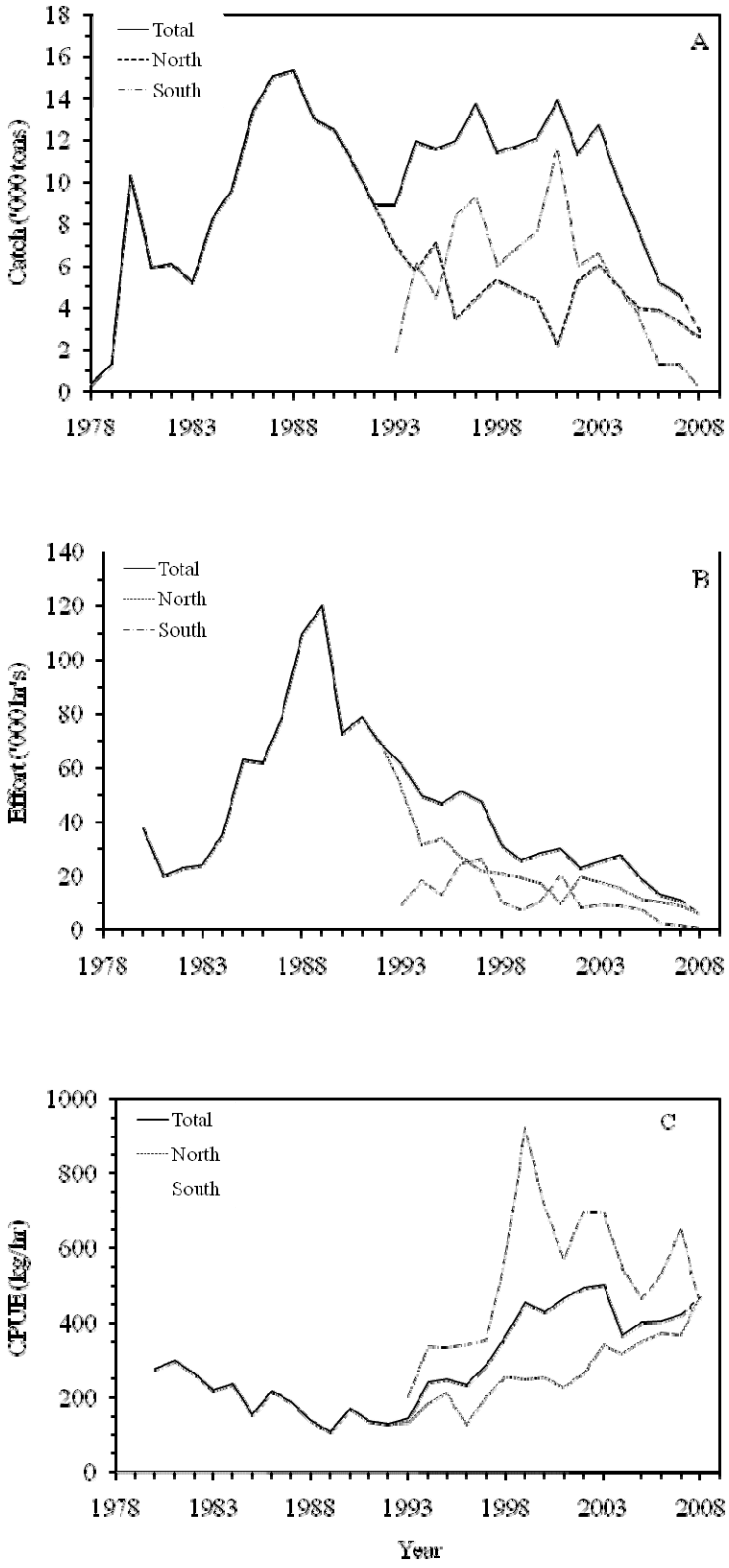


Figure 3. Standardized Catch-Per-Unit-Effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas south of 65°N, in Iceland EZZ, overall fishery north of 65°N (both in Greenland and Iceland EEZ), and overall standardized CPUE for the stock. Estimates are based on data until October 2008.

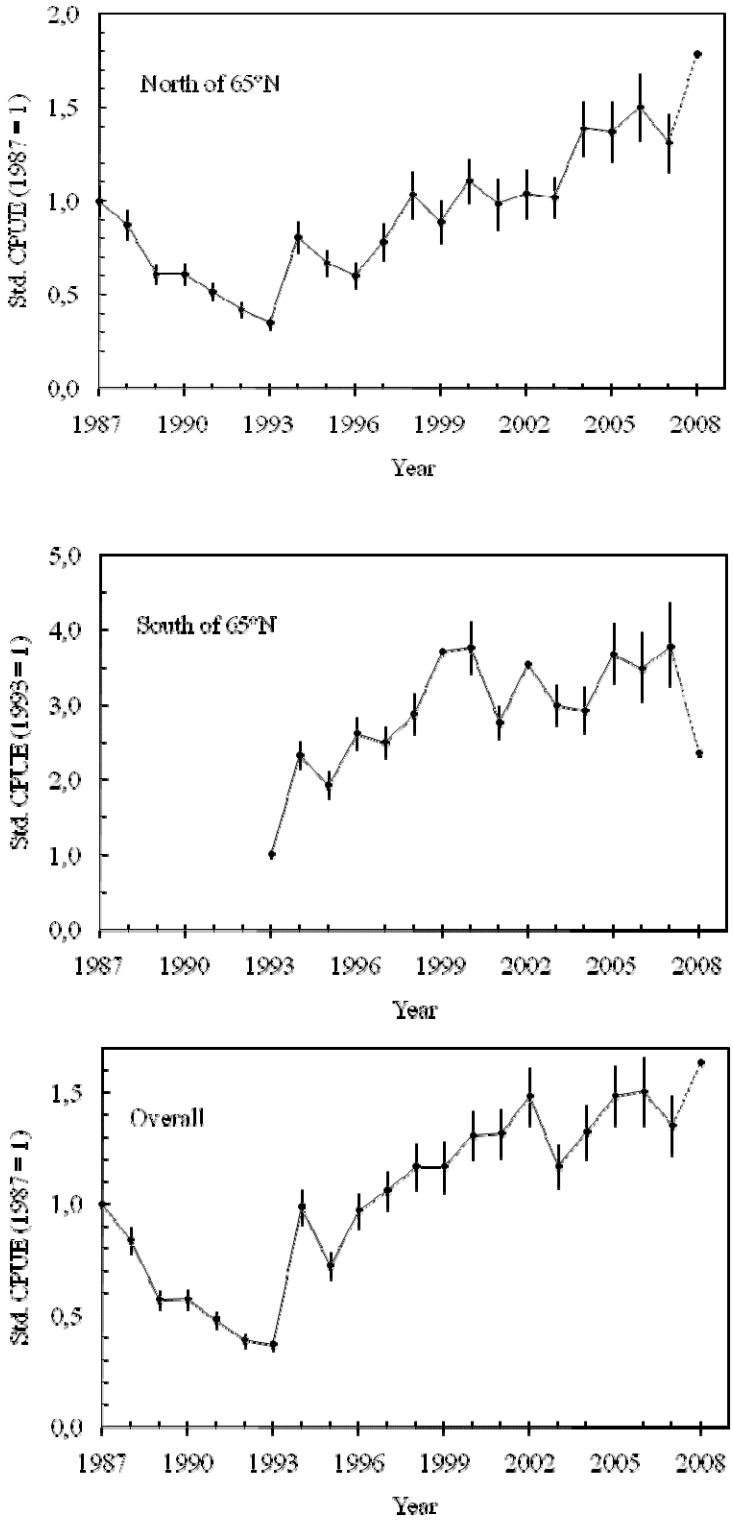


Figure 4. Standardised effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas north of 65°N, south of 65°N and overall. Estimates are based on data until October 2008

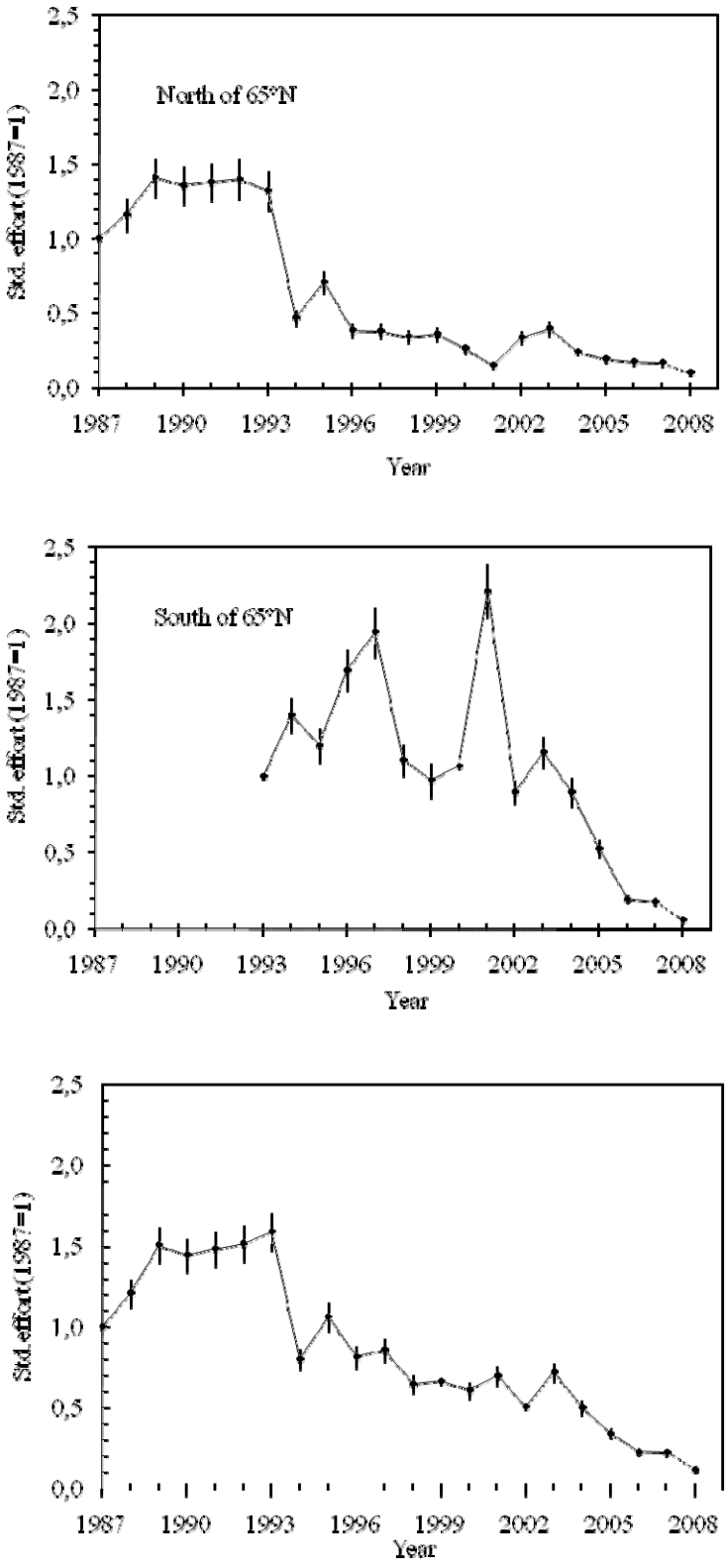


Figure 5a. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2005.

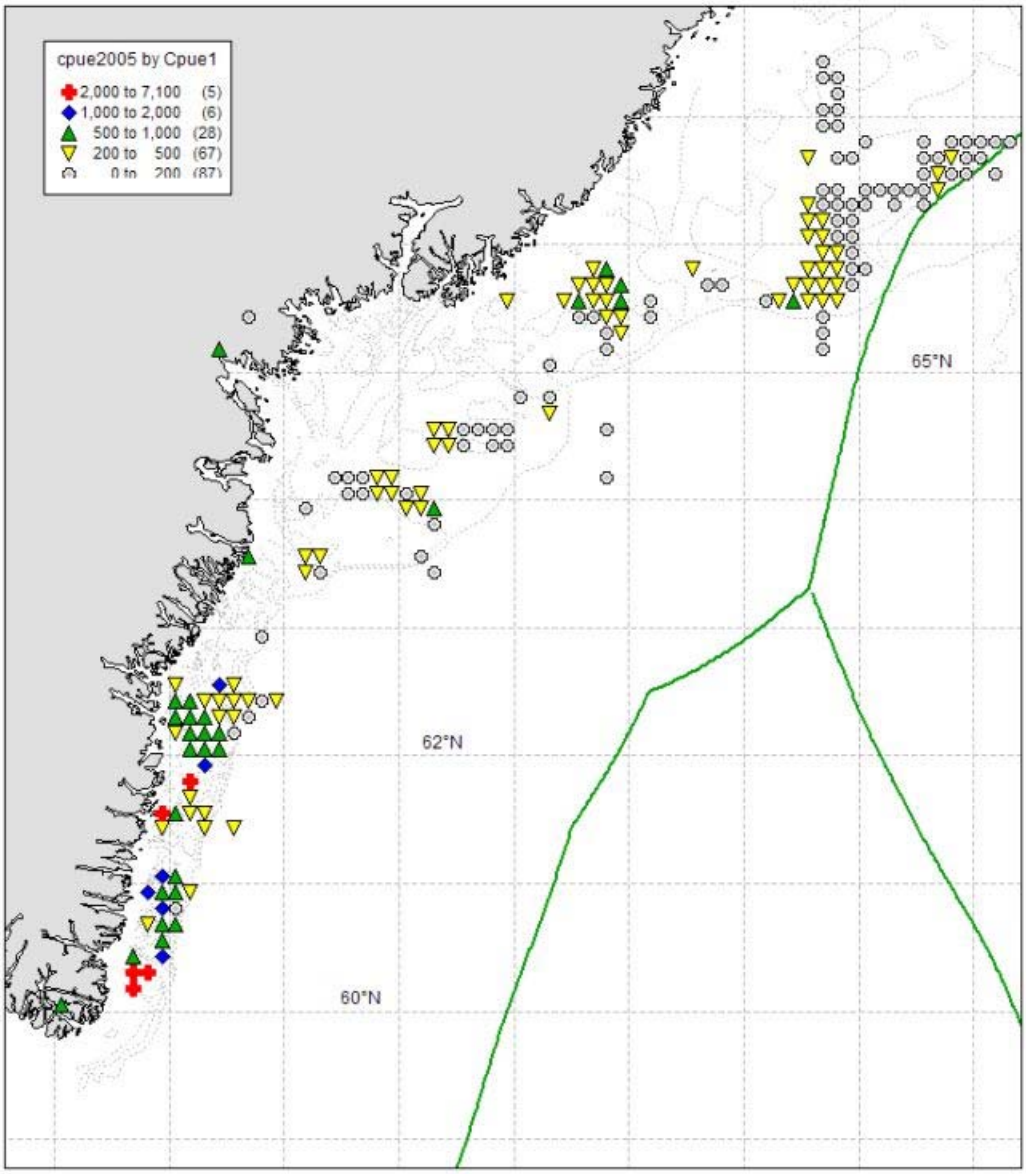


Figure 5b. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2006.

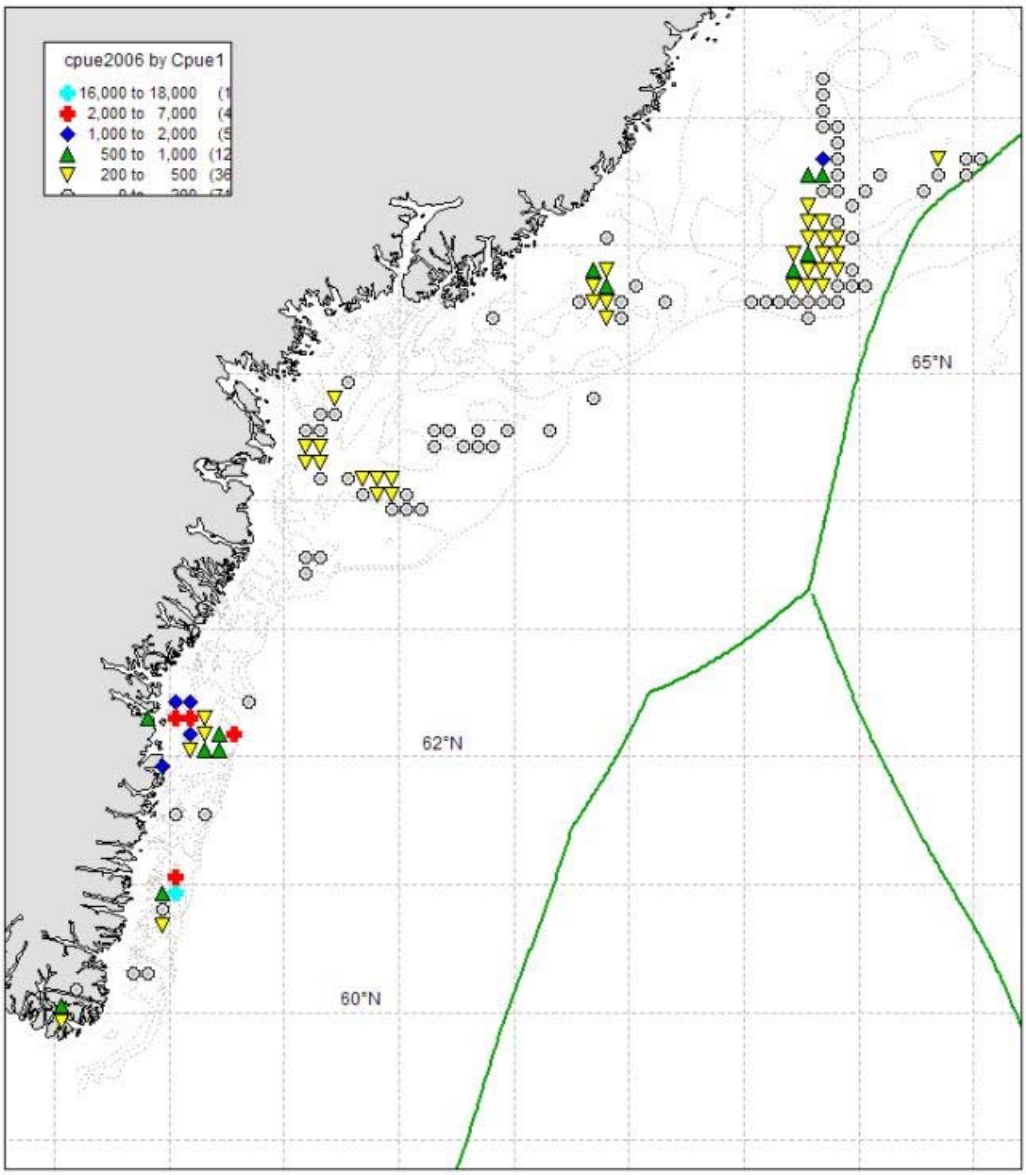


Figure 5c. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2007.

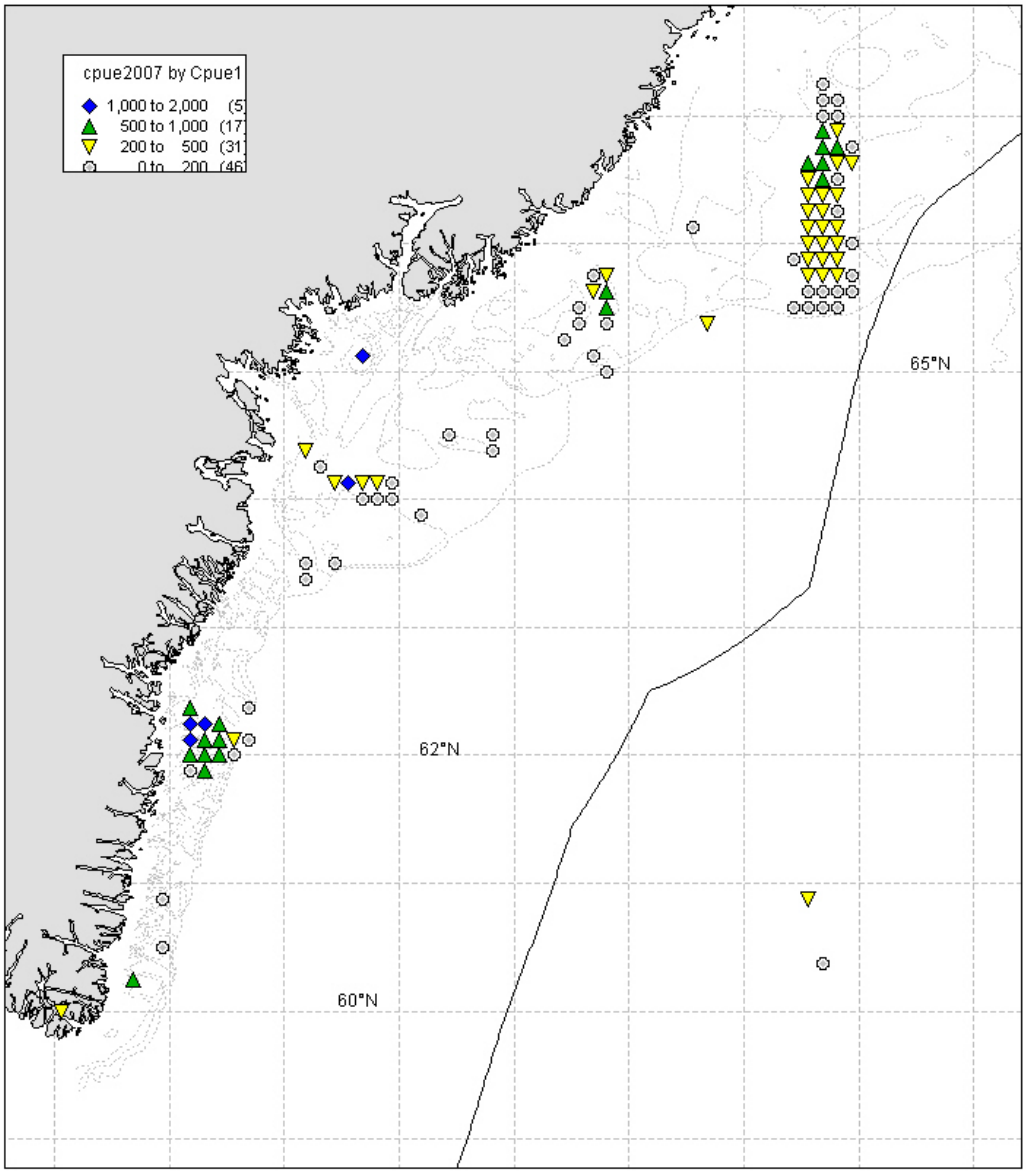
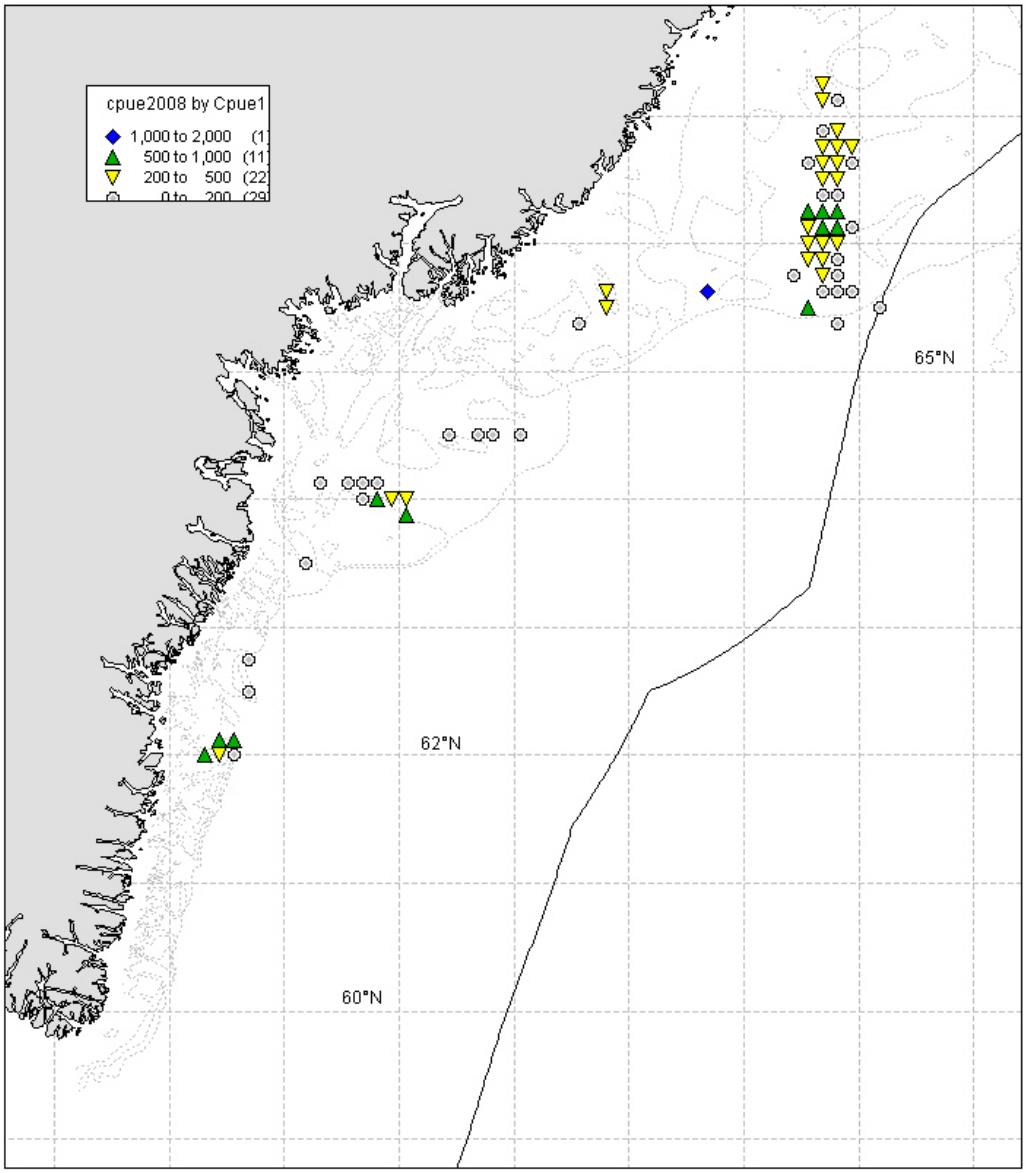


Figure 5d. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2008 (until October).



Appendix 1. Results and diagnostical outputs from GLM run of model for standardising CPUE in Greenlandic zone. Data from Greenlandic, Faeroese, Norway and EUvessels.

```
Class       Levels  Values
BAAD          14    AAAA BBBB CCCC DDDD EEEE FFFF GGGG HHHH IIII JJJJ
                    KKKK LLLL MMMM XXXX
YEAR          22    87 88 89 90 91 92 94 95 96 97 98 99 100 101 102
                    103 104 105 106 107 108 111
MONTH          5    1 4 7 9 12
AREA           2    21 22
HOLD           2    2 9

               Number of Observations Read        3027
               Number of Observations Used        3027

Dependent Variable: LNCPUE
Weight: Hauls
                                    Sum of
Source                      DF        Squares    Mean Square   F Value     Pr > F

Model                       55    47265.99565      859.38174    108.28     <.0001
Error                     2971    23578.80070        7.93632
Corrected Total           3026    70844.79635

         R-Square     Coeff Var      Root MSE    LNCPUE Mean
         0.667177      261.6864      2.817147       1.076536

Source                      DF      Type I SS    Mean Square   F Value      Pr > F
BAAD                        13    19642.96598     1510.99738    190.39      <.0001
YEAR*AREA                   37    24015.98821      649.08076     81.79      <.0001
MONTH                        4     3601.71920      900.42980    113.46      <.0001
AREA                         0        0.00000             .         .
HOLD                         1        5.32227        5.32227      0.67      0.4129

Source                      DF    Type III SS    Mean Square   F Value       Pr > F
BAAD                        13     8682.72684      667.90206     84.16       <.0001
YEAR*AREA                   36    14490.23847      402.50662     50.72       <.0001
MONTH                        4     3587.57313      896.89328    113.01       <.0001
AREA                         1     2874.40242     2874.40242    362.18       <.0001
HOLD                         1        5.32227        5.32227      0.67       0.4129

                                              Standard
Parameter                Estimate                Error   t Value   Pr > |t|
Intercept             0.821896822 B     0.18282275      4.50     <.0001
BAAD      AAAA       -0.850268377 B     0.17373995     -4.89     <.0001
BAAD      BBBB       -0.663728087 B     0.17312952     -3.83     0.0001
BAAD      CCCC       -0.503346088 B     0.17251870     -2.92     0.0036
BAAD      DDDD       -0.382037184 B     0.17270198     -2.21     0.0270
BAAD      EEEE       -0.306988352 B     0.17247811     -1.78     0.0752
BAAD      FFFF       -0.274771217 B     0.17255302     -1.59     0.1114
BAAD      GGGG       -0.181939338 B     0.17369149     -1.05     0.2950
BAAD      HHHH       -0.133971347 B     0.17546628     -0.76     0.4452
BAAD      IIII       -0.062316304 B     0.17197638     -0.36     0.7171
BAAD      JJJJ        0.028127758 B     0.17294017      0.16     0.8708
BAAD      KKKK        0.070874011 B     0.17315077      0.41     0.6823
BAAD      LLLL        0.138708327 B     0.17424130      0.80     0.4261
BAAD      MMMM        0.278558335 B     0.18678066      1.49     0.1360
BAAD      XXXX        0.000000000 B      .               .        .
YEAR*AREA 87 21       0.702661719 B     0.07233279      9.71     <.0001
YEAR*AREA 88 21       0.500802697 B     0.06828715      7.33     <.0001
YEAR*AREA 89 21       0.097988414 B     0.06738458      1.45     0.1460
YEAR*AREA 90 21       0.098988910 B     0.06736852      1.47     0.1418
YEAR*AREA 91 21      -0.104386471 B     0.06654871     -1.57     0.1169
YEAR*AREA 92 21      -0.309963445 B     0.06975177     -4.44     <.0001
YEAR*AREA 94 21       0.353793024 B     0.08518381      4.15     <.0001
YEAR*AREA 94 22       0.846009260 B     0.07815930     10.82     <.0001
YEAR*AREA 95 21       0.180061747 B     0.07686525      2.34     0.0192
YEAR*AREA 95 22       0.656359837 B     0.09410391      6.97     <.0001
YEAR*AREA 96 21       0.074455212 B     0.09268461      0.80     0.4219
YEAR*AREA 96 22       0.963128473 B     0.07924685     12.15     <.0001
```

YEAR*AREA	97 21	0.366048063	B	0.11404025	3.21	0.0013
YEAR*AREA	97 22	0.919016302	B	0.08308053	11.06	<.0001
YEAR*AREA	98 21	0.742410510	B	0.10586884	7.01	<.0001
YEAR*AREA	98 22	1.055337511	B	0.09358905	11.28	<.0001
YEAR*AREA	99 21	0.537890219	B	0.10927687	4.92	<.0001
YEAR*AREA	99 22	1.312755200	B	0.11402967	11.51	<.0001
YEAR*AREA	100 21	0.709674519	B	0.08337819	8.51	<.0001
YEAR*AREA	100 22	1.325131179	B	0.09155869	14.47	<.0001
YEAR*AREA	101 21	0.575050139	B	0.11567111	4.97	<.0001
YEAR*AREA	101 22	1.018826097	B	0.07769514	13.11	<.0001
YEAR*AREA	102 21	0.575332921	B	0.11212940	5.13	<.0001
YEAR*AREA	102 22	1.266566430	B	0.08611971	14.71	<.0001
YEAR*AREA	103 21	0.634161295	B	0.08631650	7.35	<.0001
YEAR*AREA	103 22	1.098068611	B	0.08881545	12.36	<.0001
YEAR*AREA	104 21	0.948028119	B	0.08276083	11.46	<.0001
YEAR*AREA	104 22	1.072894448	B	0.10603147	10.12	<.0001
YEAR*AREA	105 21	0.901211021	B	0.09207452	9.79	<.0001
YEAR*AREA	105 22	1.302816890	B	0.10856582	12.00	<.0001
YEAR*AREA	106 21	0.992433596	B	0.09347077	10.62	<.0001
YEAR*AREA	106 22	1.249812543	B	0.13224509	9.45	<.0001
YEAR*AREA	107 21	0.857655610	B	0.09526278	9.00	<.0001
YEAR*AREA	107 22	1.329548267	B	0.14692583	9.05	<.0001
YEAR*AREA	108 21	1.156294801	B	0.12756630	9.06	<.0001
YEAR*AREA	108 22	0.857944589	B	0.24995480	3.43	0.0006
YEAR*AREA	111 21	-0.502892028	B	0.07291397	-6.90	<.0001
YEAR*AREA	111 22	0.000000000	B	.	.	.
MONTH	1	0.284337139	B	0.02802565	10.15	<.0001
MONTH	4	0.132317618	B	0.02921326	4.53	<.0001
MONTH	7	0.166404752	B	0.05928524	2.81	0.0050
MONTH	9	-0.219549345	B	0.03138812	-6.99	<.0001
MONTH	12	0.000000000	B	.	.	.
AREA	21	0.000000000	B	.	.	.
AREA	22	0.000000000	B	.	.	.
HOLD	2	0.025901996	B	0.03162965	0.82	0.4129
HOLD	9	0.000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.


Plot of STUDENT*ESTIMATE. Legend: A = 1 obs, B = 2 obs, etc.
5.5
5.0
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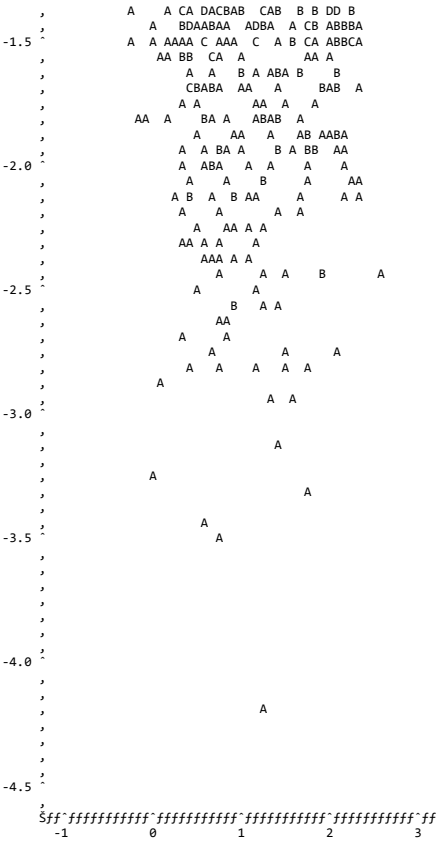
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0


-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-1
0
1
2
3

Appendix 2. Results and diagnostical outputs from GLM run of model for standardising CPUE in Islandic Zone zone. Data from Icelandic vessel only.

```
Class       Levels  Values
YEAR            18  1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
                    2003 2004 2010
MONTH            6  1 3 5 8 10 12
SHIP             8  3100 3200 3300 3400 3500 3600 3700 3800
T                2  1 2
                           Number of Observations Read         839
                           Number of Observations Used         839
Dependent Variable: LNCPUE
Weight: EFFORT   EFFORT
                                        Sum of
       Source                     DF         Squares     Mean Square    F Value    Pr > F
       Model                      30     2464912.001       82163.733      96.60    <.0001
       Error                     808      687281.482         850.596
       Corrected Total           838     3152193.482

                     R-Square     Coeff Var      Root MSE    LNCPUE Mean
                     0.781967      4129.035      29.16498       0.706339

       Source                     DF       Type I SS     Mean Square    F Value    Pr > F
       MONTH                       5     1876847.067      375369.413     441.30    <.0001
       SHIP                        7      264825.858       37832.265      44.48    <.0001
       YEAR                       17      320504.417       18853.201      22.16    <.0001
       T                           1        2734.659        2734.659       3.21    0.0733

       Source                     DF     Type III SS     Mean Square    F Value    Pr > F
       MONTH                       5     213264.7800      42652.9560      50.14    <.0001
       SHIP                        7     206529.8841      29504.2692      34.69    <.0001
       YEAR                       17     321650.1454      18920.5968      22.24    <.0001
       T                           1       2734.6593       2734.6593       3.21    0.0733

                                           Standard
           Parameter             Estimate      Error    t Value    Pr > |t|
           Intercept          1.321660414 B 0.17677189       7.48      <.0001
           MONTH     1       -0.637490260 B 0.34899235      -1.83      0.0681
           MONTH     3        0.520015729 B 0.14642095       3.55      0.0004
           MONTH     5        0.374949284 B 0.14508139       2.58      0.0099
           MONTH     8       -0.305620232 B 0.15027424      -2.03      0.0423
           MONTH     10      -0.398342709 B 0.14775544      -2.70      0.0072
           MONTH     12       0.000000000 B        .            .         .
           SHIP      3100    -1.005896125 B 0.13011552      -7.73      <.0001
           SHIP      3200    -0.754134016 B 0.09518021      -7.92      <.0001
           SHIP      3300    -0.629918759 B 0.08330996      -7.56      <.0001
           SHIP      3400    -0.466377476 B 0.08262698      -5.64      <.0001
           SHIP      3500    -0.346546409 B 0.08400094      -4.13      <.0001
           SHIP      3600    -0.195926626 B 0.09089502      -2.16      0.0314
           SHIP      3700    -0.160251597 B 0.08478247      -1.89      0.0591
           SHIP      3800     0.000000000 B        .            .         .
           YEAR      1988    -0.416075081 B 0.05186956      -8.02      <.0001
           YEAR      1989    -0.552896972 B 0.05802895      -9.53      <.0001
           YEAR      1990    -0.658864060 B 0.09128576      -7.22      <.0001
           YEAR      1991     0.068570010 B 0.10014730       0.68      0.4937
           YEAR      1992     0.023186723 B 0.08068950       0.29      0.7739
           YEAR      1993    -0.056355141 B 0.07407438      -0.76      0.4470
           YEAR      1994     0.259254899 B 0.08880591       2.92      0.0036
           YEAR      1995     0.270286784 B 0.11045958       2.45      0.0146
           YEAR      1996     0.100701767 B 0.11649502       0.86      0.3876
           YEAR      1997     0.103795279 B 0.08403396       1.24      0.2171
           YEAR      1998    -0.141329513 B 0.08330010      -1.70      0.0902
           YEAR      1999    -0.204163719 B 0.10246696      -1.99      0.0467
           YEAR      2000    -0.070998031 B 0.17514782      -0.41      0.6853
           YEAR      2001    -0.722745562 B 0.43162545      -1.67      0.0944
           YEAR      2002     0.500462085 B 0.09994008       5.01      <.0001
           YEAR      2003     0.252323432 B 0.10446284       2.42      0.0159
           YEAR      2004     0.108196462 B 0.12127255       0.89      0.3726
           YEAR      2010     0.000000000 B        .            .         .
           T         1       -0.154977333 B 0.08643273      -1.79      0.0733
            T        2        0.000000000 B        .            .         .

                   Plot of STUDENT*ESTIMATE.  Legend: A = 1 obs, B = 2 obs, etc.

STUDENT ,
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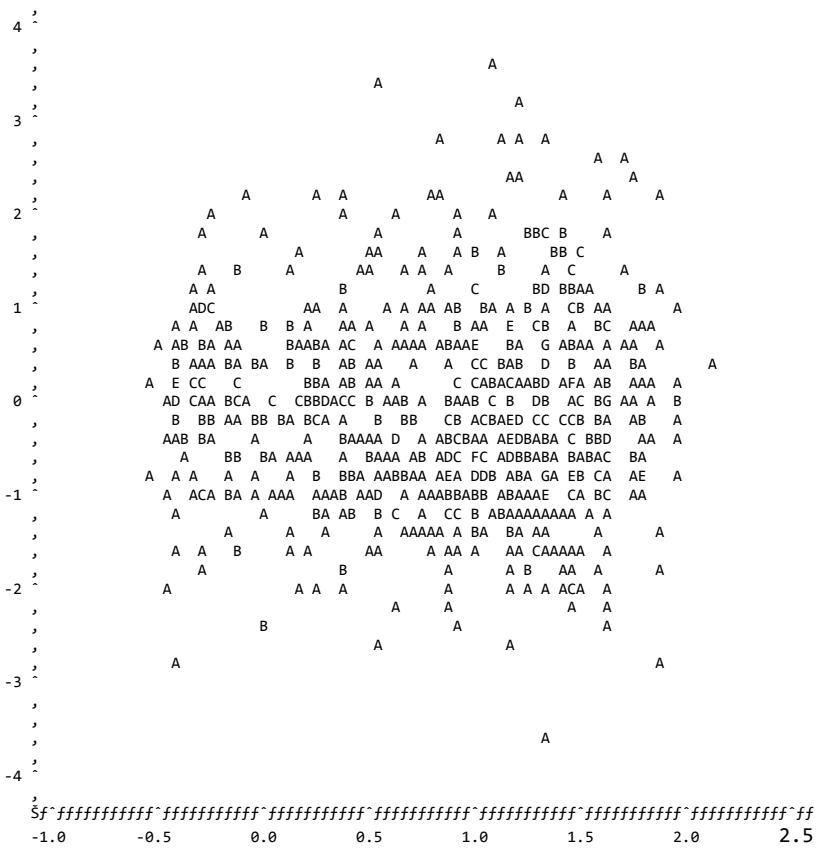
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