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The Fishery for Northern Shrimp (*Pandalus borealis*) in Denmark Strait / off East Greenland – 2011.

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 800 m. North of 65°N the stock spans the adjacent Greenlandic and Icelandic economic zones. The stock has been assessed as a single population by evaluation of fishery dependent data only, until this year, where survey data for the period 2008-2011 became available. The stock is managed by catch quotas in the Greenlandic zone. There is no management related restrictions on the fishery in the Icelandic zone.

A multinational fleet of large factory trawlers exploited the stock taking annual catches between 11 500 tons and 14 000 tons from 1994 to 2003. Since then catches have decreased to 2 800 tons in 2008, the lowest level since 1980. Catches were close to 4500 tons in 2009 and decreased to 3.700 tons in 2010 and are expected to decrease further in 2011. A biomass index decreased steadily from 1987 to 1993, but then showed an increasing trend until the beginning of the 2000s. It fluctuated without trend until 2008, and then nearly doubled in 2009. In 2010 and 2011 the biomass index is back to the level seen since the beginning of the 2000s. The index of harvest rates have declined since 1993 and recent levels are the lowest of the time series.

Sampling of the commercial fishery is nonexistent and consequently insufficient to obtain annual estimates of catch composition.

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. There is no evidence of distinct sub-populations and the stock is assessed as a single population. Until this year the assessment was based on fishery dependent data only, and was largely done by evaluation of trends in biomass indices. Surveys have been performed since 2008 and the result is presented this year (Siegstad 2011).

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 15 000 tons during the following 10-year period. Total catches fluctuated around 12 000 tons from 1994 to 2003 (Table 1, Fig. 2A), and have been decreasing since then, reaching a record-low catch of 2.800 tons in 2008. The fishery was originally conducted north of 65°N on both sides of the territorial midline between Greenland and Iceland. 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. The fishery is managed by a Total Allowable Catch (TAC) in the Greenlandic EEZ. Icelandic vessels operate exclusively in the Icelandic EEZ and the fishery is unrestricted by management initiatives. Annual catches in the Greenlandic zone from 1999 to 2005 accounted for 70-99 % of the total catches. Since 2006 there has been no fishery in the Icelandic zone. 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 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 CPUE 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. From 1998 approximately 40% of all hauls were performed with double trawl and since 2004 more than 60% of all hauls were performed with doubletrawl. The 2011 assessment included both single and double trawl in the standardized catch rates calculations. The catches in the Greenland EEZ were corrected for "overpacking" according to Hvingel 2003.

Catches and corresponding effort were compiled by year and by areas north and south of 65°N. CPUE was calculated and applied to the total catch of the year to estimate the total annual effort. The geographical distribution of the fishery is shown by plotting the unstandardised CPUE by statistical units of 7.5' latitude and 15' longitude (fig. 4).

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 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 the Greenland Fishery and Licence Control (GFLK), 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:

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

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 m^{th} area; S_j is the effect of the j^{th} month; V_k is the effect of the k^{th} vessel; Y_i is the effect of the i^{th} year; e_{mjki} 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 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. To reduce the number of empty cells in the models, classes of effect variables were combined, if a pairwise contrast analyses had an F statistic less than one. However, posterior grouping on the basis of similar effects causes uncertainty to be underestimated.

For the model pertaining to the Greenlandic zone 78 of 112 vessels met the criteria for inclusion in the analysis (at least three years of fishing in the area). Based on an exploratory run of the main effects model the vessel effect was collapsed into 15 groups consisting of 2-11 vessels with similar fishing power. The month effect was reduced to 9 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 since 2006. 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. This analysis has not been repeated since 2006.

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 3) 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). 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 be 0.9 and 0.1 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 (appendix 2) and the year coefficients from the Icelandic zone model (appendix 3). 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. In 1993 a fishery was also initiated in various smaller areas extending south to the Cap Farewell.

Catch

As the fishery developed, catches increased rapidly to more than 15 000 tons in 1987-88, but declined thereafter to about 9 000 tons in 1992-93(Fig. 1A, Table 1 and 2). Following the area expansion of the fishery south of 65°N in 1993 catches increased again reaching 11 900 tons in 1994. From 1994 to 2003 catches fluctuated between 11 500 and 14 000 tons (Fig. 1A). In 2004 the catches started dropping, from 10 000 tons in 2004 to a low of 2800 tons in 2008. Catches were close to 4500 tons in 2009 and decreased to 3.700 tons in 2010 and are expected to decrease further in 2011.

In the northern area the amount caught declined by about 85% from 1988 to 2001, i.e. from 15 000 tons to 2 200 tons (Fig. 1A, Table 2). Catches more than doubled in the period 2002-2004 (Table 2, Fig. 1A), but have been decreasing since then.

Catches in the southern area increased from 1 900 tons in 1993 (the first year of fishery in this area) to about 11 700 tons in 2001 (Fig. 1A). Since 2001 catches in the southern area has declined, being below 600 tons since 2008.

From 1996 to 2005 catches in the area south of 65°N accounted for between 50% and 85% of the total catch (Fig. 1A). Since then catches in the area south of 65°N has been decreasing. The proportion of the catch taken in the southern area has been around 10% since 2008.

Fishing effort

The high increase in catches during the first ten-year period was mainly driven by increased fishing effort (Fig. 1B, Table 2). Between 1981 and 1989, total effort increased from about 20 000 hr's to a peak of nearly 120 000 hours and has declined since (Table 2, Fig. 1B).

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 10 000 hours in 1993 to 25 000 hours in 1997. In 1999 it reached a low of 7 500 hr's but increased again to 20 000 hr's in 2001. Since then effort in the southern area has been declining (Fig. 1B, Table 2).

According to Greenlandic skippers the reduced effort spent was due to reduced catch rates of large shrimp, which is the primary target of the Greenlandic fishery in East Greenland.

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 502 kg/hr in 2003 (Fig. 1C, Table 2). Since then the catch rate has been around 400 kg/hr except for 2009, where the catch rate was 640 kg/hr, the highest value ever obtained.

In the southern areas CPUE increased from 204 kg/hr in 1993 to 925 kg/hour in 1999. Until 2008 the mean CPUE in this area fluctuated between 450 and 700 kg/hr. In 2009 the catch rate reached 989 kg/hr and 2010 CPUE increased again, however the catches in the area was very low. In 2011 no fishery has been conducted in the area.

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 1995-2002 CPUE's have fluctuated around 225 kg/hr except for an extreme low of 129 kg/hr in 1996. From 2003 to 2007 annual mean CPUE fluctuated around 350 kg/hr. In 2009 the catch rate reached a value of 607kg/hr, the highest value ever obtained. 2010 and 2011 data showed catch rates on the same level obtained in 2003-2007.

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 for Greenland and Iceland were 68% 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 combined CPUE index for the total area (Fig. 2, Table 3) indicated that the stock was more than halved during the period 1987-1993. Since then it has been rebuilding reaching the level of 1987 in the mid 1990's. The mean index values increased thereafter and stabilized at a level one third above that of 1987. In 2009 the index more than doubled compared to 1987, but is back to the 1987 level in 2010 and 2011.

The CPUE index series of the northern areas (Fig. 2, Table 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. From 2004 to 2007 the mean index values have stabilized at a level one third above that of 1987. In 2008 the index started increasing reaching a record high level in 2009. The 2010 and 2011 value is back to the level seen in 2004-2007.

The CPUE index series of the southern area (Fig. 3, Table 3) increased until 1999, with stability until 2007. In 2008 it dropped down to a low of 2.32, the lowest value obtained since 1997. In 2009 the index obtained the highest value ever obtained, whereas the value for 2010 is back to the level from 2000-2007.

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, have shown a decreasing trend since the mid 1990s for the total area (Table 3, Fig. 3) reaching its lowest levels in 2008 and 2009. The separate indices for the Northern and Southern areas are also shown in Fig. 3 and they follow the trend seen for the total area.

Conclusions

Total catches fluctuated around 12000 tons from 1994 to 2003 (Table 1, Fig. 1A). Catches decreased thereafter to 2 800 tons in 2008. Catches doubled in 2009 compared to 2008 and the 2010 catch level stayed at that level. 2011 catches are expected to decrease to 2008 level.

A combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993(Fig. 2), showed an increasing trend until 2000, and has fluctuated at this level until today, except for a record high value in 2009.

Since the mid 1990s exploitation rate index (standardized effort) has decreased, reaching the lowest levels seen in the time series from 2008-2011.

State of the stock: Standardized CPUE data for all the areas combined indicates an increasing trend in the fishable biomass from 1993 to beginning of the 2000s and has fluctuated at this level until 2009, where an increase was seen. The standardized CPUE in 2011 is back to the level seen in the period from 2000-2008. However, 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.

References

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Table 1. Catch (tons) of shrimp by the fishery in Denmark Strait/off East Greenland 1981 to October 2009. Values for the fishery in the Greenland EEZ by EU-Denmark, Faeroe Islands, France, Greenland and Norway are corrected according to Hvingel 2003.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011[1]
North of 65°N																			
EU (DK,EST,LTU)	138	250	302	26	85	401	793	459	72	816	861	482	304	618	421	389	892	1337	927
Faroe Islands	689	462	931	995	635	1268	867	956	214	1029	1062	894	615	342	319	612	1325	781	0
France	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Greenland	1771	1326	2390	359	105	646	614	115	650	638	695	578	454	223	802	14	844	426	121
Iceland	2553	1514	1151	566	2856	1421	769	132	10	1231	703	411	29	0	0	0	0	0	0
Norway	1831	2180	2402	1544	797	1628	1783	2759	1291	1630	2861	2700	2614	2704	1771	1514	883	769	0
Total	6982	5731	7176	3490	4478	5364	4827	4420	2237	5344	6183	5065	4016	3887	3314	2529	3945	3313	1048
South of 65°N																			
Denmark (EU)	60	613	731	1167	1657	1300	1095	1900	2473	2309	1827	1022	644	683	431	251	28	101	36
Faroe Island	280	974	295	402	656	138	453	340	2402	1013	303	255	176	227	169	14	28	134	0
Greenland	1141	3603	2667	5295	4701	3950	4966	5235	4943	4333	4194	3488	2737	316	639	0	447	178	0
Norway	424	1011	720	1590	2261	670	378	157	1855	1098	197	186	180	76	48	0	107	0	0
Total	1904	6201	4412	8453	9276	6057	6893	7632	11674	5985	6522	4951	3737	1302	1286	266	610	413	0
Total area																			
EU (DK,EST,LTU)	198	863	1033	1193	1742	1701	1888	2358	2545	2548	2688	1504	948	1301	852	640	920	1438	963
Faroe Islands	968	1436	1225	1397	1292	1406	1321	1296	2616	1322	1365	1149	791	569	488	627	1354	915	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenland	2912	4929	5057	5655	4806	4595	5581	5349	5593	4484	4890	4066	3191	539	1441	14	1292	605	121
Iceland	2553	1514	1151	566	2856	1421	769	132	10	1231	703	411	29	0	0	0	0	0	0
Norway	2255	3190	3122	3133	3059	2298	2160	2917	3147	1743	3059	2886	2794	2780	1819	1514	990	769	0
Total	8886	11932	11588	11944	13754	11422	11719	12053	13911	11329	12705	10016	7753	5189	4600	2794	4555	3727	1084
Total all areas	8886	11932	11588	11944	13754	11422	11719	12053	13911	11242	12637	9985	7753	5189	4600	2794	4555	3727	1084
Advised TAC	5000	5000	5000	5000	5000	5000	9600	9600	9600	9600	9600	12400	12400	12400	12400	12400	12400	12400	12400
Effective TAC[2]	9563	9563	9563	9563	9563	9563	10600	12600	10600	10600	10600	15043	12400	12400	12400	12400	12835	11835	12400

[1]Catch until October

[2]For Greenland zone only; no restrictions in Iceland zone

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	21%
1994	5731	31417	182	6201	18371	338	11932	49428	241	52%
1995	7176	33953	211	4412	13157	335	11588	46927	247	38%
1996	3490	27029	129	8453	24589	344	11944	51049	234	71%
1997	4478	22175	202	9276	25992	357	13754	47519	289	67%
1998	5364	20881	257	6057	10498	577	11422	31205	366	53%
1999	4827	19388	249	6893	7449	925	11719	25742	455	59%
2000	4420	17474	253	7632	10705	713	12053	28096	429	63%
2001	2237	9822	228	11674	20435	571	13911	29933	465	84%
2002	5344	20052	267	5985	8546	700	11329	22843	496	53%
2003	6183	18053	342	6522	9317	700	12705	25295	502	51%
2004	5065	15848	320	4951	8972	552	10016	27450	365	49%
2005	4016	11251	357	3737	8004	467	7753	19257	403	48%
2006	3887	10413	373	1302	2436	534	5189	12851	404	25%
2007	3314	8977	369	1286	1974	651	4600	10951	420	28%
2008	2529	6106	414	266	585	454	2794	6691	418	10%
2009	3945	6500	607	610	617	989	4555	7117	640	13%
2010	3313	10263	323	413	263	1571	3727	10526	354	11%
2011*	1048	2997	350	0		0	1084	3100	350	0%

*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.

	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	0.88	0.08	1.15	0.11					0.85	0.06	1.19	0.00
1989	0.62	0.06	1.38	0.13					0.59	0.04	1.47	0.10
1990	0.62	0.06	1.34	0.13					0.58	0.04	1.42	0.10
1991	0.52	0.05	1.36	0.13					0.49	0.04	1.45	0.10
1992	0.42	0.04	1.40	0.14					0.40	0.03	1.49	0.11
1993	0.35	0.03	1.34	0.13	1.00	-	1.00	-	0.38	0.03	1.56	0.12
1994	0.80	0.09	0.47	0.05	2.25	0.18	1.45	0.11	1.05	0.08	0.76	0.06
1995	0.67	0.07	0.71	0.07	1.88	0.18	1.23	0.11	0.81	0.06	0.94	0.07
1996	0.60	0.07	0.39	0.05	2.64	0.21	1.68	0.13	1.04	0.08	0.76	0.06
1997	0.81	0.10	0.37	0.05	2.52	0.22	1.93	0.16	1.23	0.10	0.74	0.06
1998	1.03	0.13	0.34	0.04	2.87	0.28	1.11	0.10	1.30	0.11	0.58	0.05
1999	0.89	0.11	0.36	0.05	3.72	0.44	0.97	0.11	1.50	0.14	0.52	0.05
2000	1.08	0.12	0.27	0.03	3.59	0.34	1.12	0.10	1.39	0.11	0.58	0.05
2001	0.96	0.13	0.16	0.02	2.73	0.22	2.25	0.17	1.42	0.12	0.65	0.05
2002	0.98	0.12	0.36	0.05	3.35	0.30	0.94	0.08	1.60	0.13	0.47	0.04
2003	0.95	0.11	0.43	0.05	2.82	0.26	1.21	0.11	1.21	0.10	0.70	0.06
2004	1.32	0.14	0.25	0.03	2.73	0.30	0.95	0.10	1.32	0.11	0.50	0.04
2005	1.34	0.16	0.20	0.02	3.45	0.39	0.57	0.06	1.54	0.14	0.33	0.03
2006	1.39	0.17	0.19	0.02	3.28	0.46	0.21	0.03	1.43	0.14	0.24	0.02
2007	1.23	0.15	0.18	0.02	3.64	0.57	0.19	0.03	1.29	0.13	0.24	0.02
2008	1.53	0.20	0.11	0.01	2.32	0.65	0.06	0.01	1.43	0.16	0.13	0.01
2009	2.28	0.29	0.11	0.01	4.47	1.15	0.07	0.02	2.20	0.24	0.14	0.02
2010	1.16	0.14	0.19	0.02	3.34	1.50	0.07	0.02	1.15	0.13	0.21	0.02
2011	1.41	0.39	0.05	0.01	0.00	0.00	0.00	0.00	1.24	0.37	0.06	0.02

* Until Oct.

Figure 1. 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. (Data for 2011 is part-years data, until October).

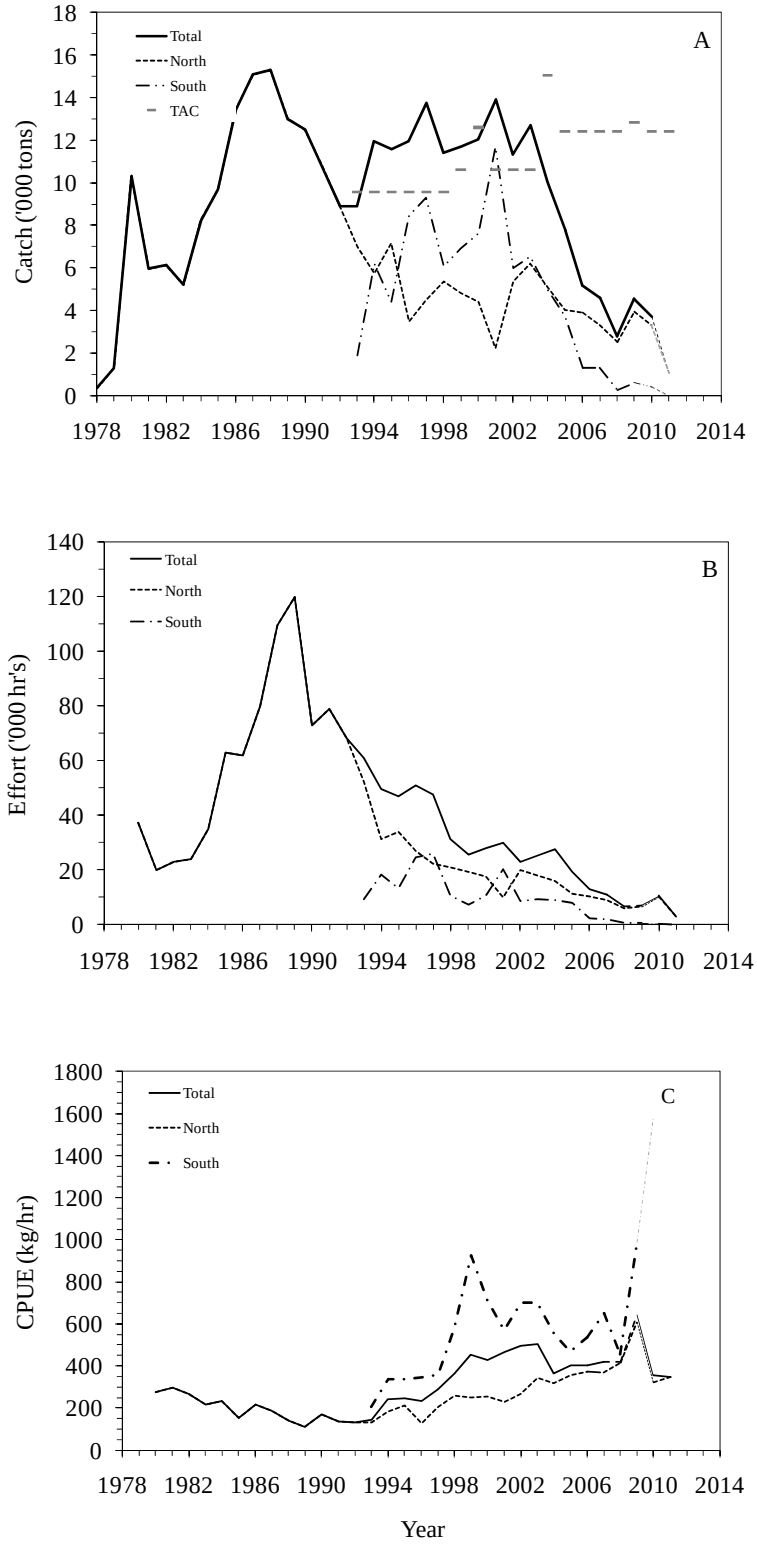


Figure 2. Standardized Catch-Per-Unit-Effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas south of 65°N, in Iceland EZZ, overall fishery north of 65°N (both in Greenland and Iceland EEZ), and overall standardized CPUE for the stock (Estimates for 2011 are based on data until October).

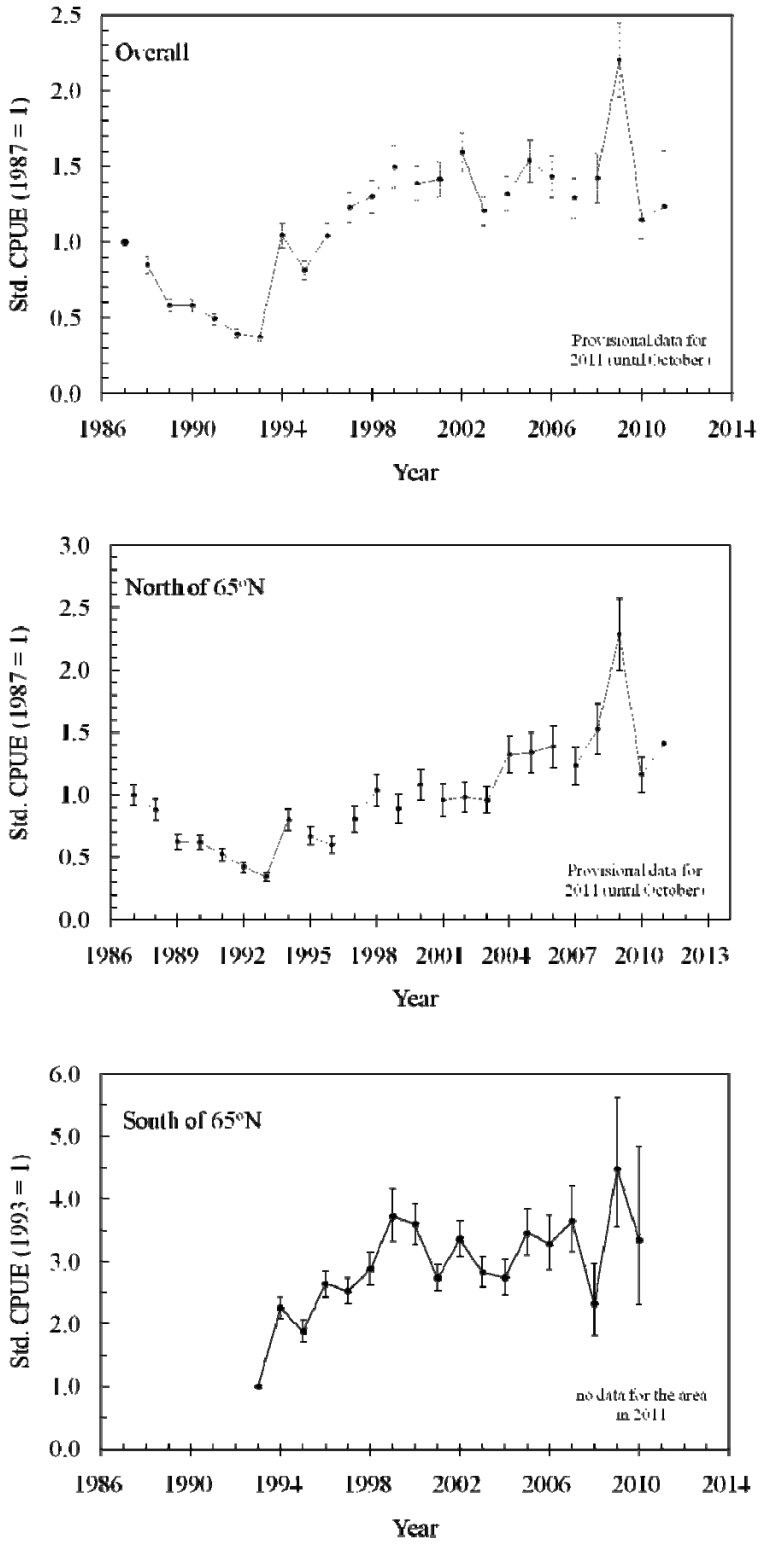


Figure 3. Standardised effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas north of 65°N, south of 65°N and overall (Estimates for 2011 are based on data until October).

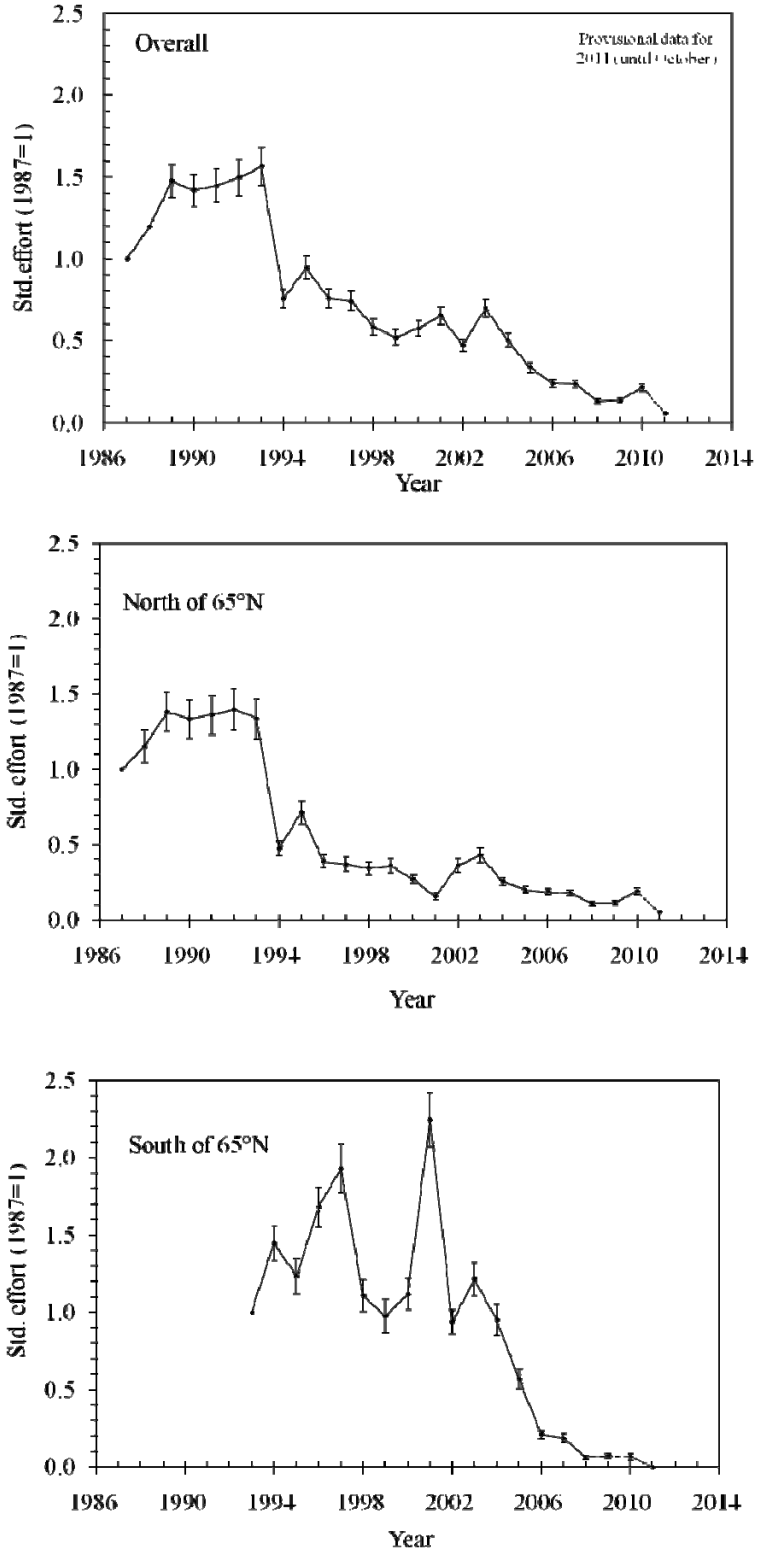


Figure 4a. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland 2006-2011.

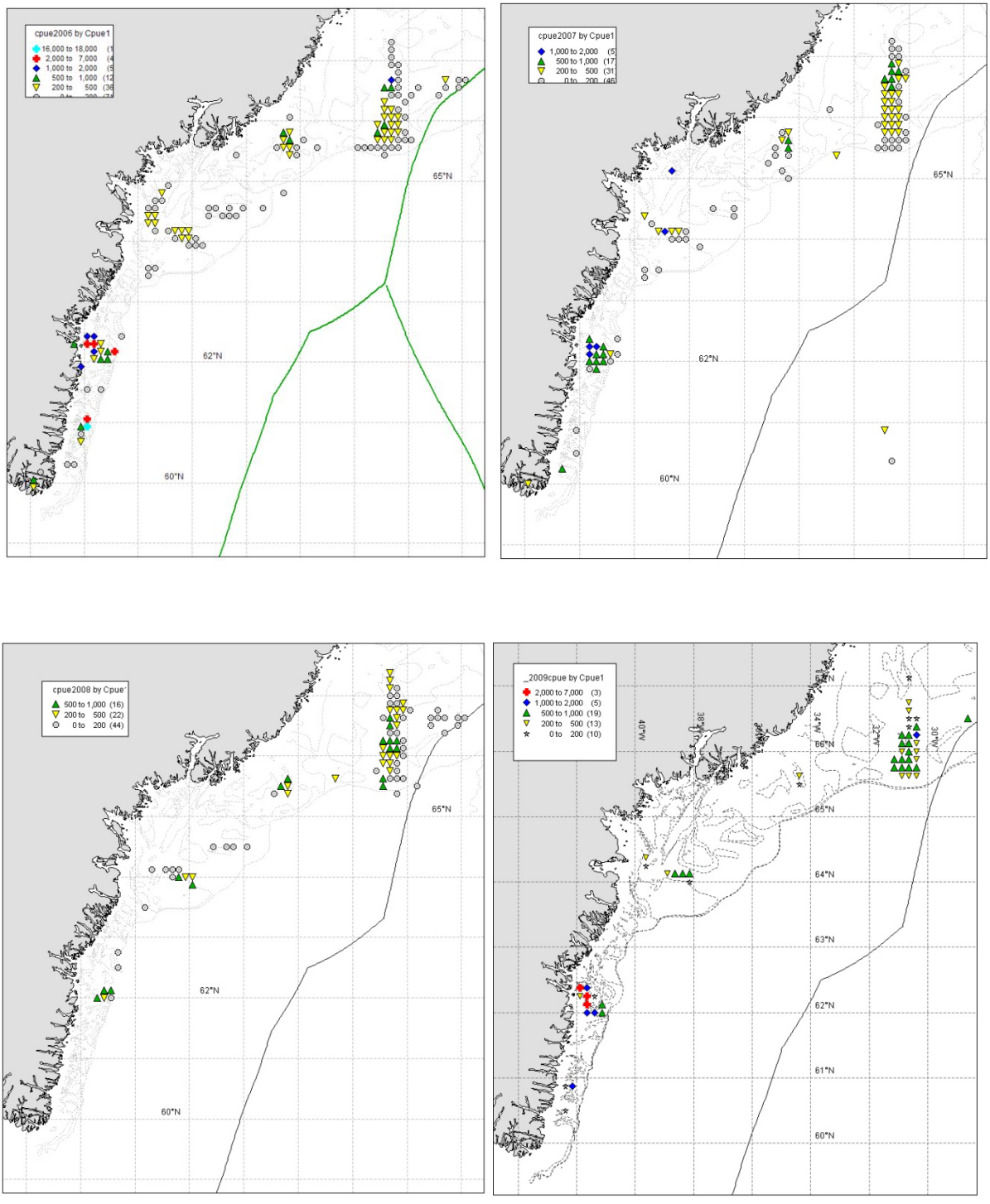
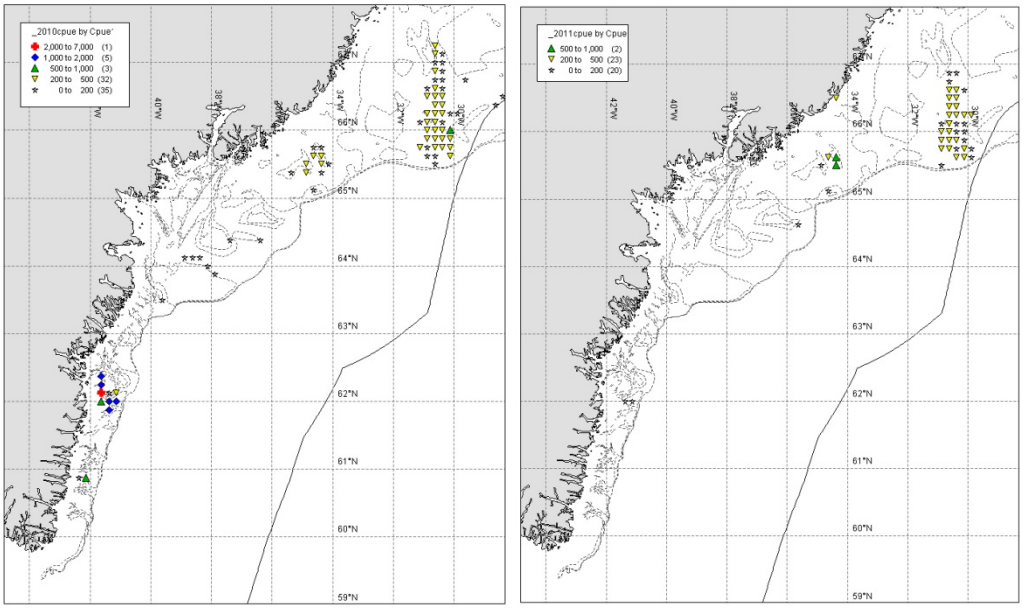


Figure 4b. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland 2006-2011. 2011 (until October).



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

The GLM Procedure

Class Level Information

Class	Levels	Values
BAAD	15	E004 E008 E013 E019 E025 E031 E033 E043 E047 E050 E057 E065 E070 E074 E078
YEAR	25	87 88 89 90 91 92 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 999
MONTH	9	1 2 4 5 6 7 8 11 12
AREA	2	21 22
HOLD	2	2 9

Number of Observations Read 3190
Number of Observations Used 3190

Dependent Variable: LNCPUE
Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	65	51135.67561	786.70270	101.84	<.0001
Error	3124	24131.83442	7.72466		
Corrected Total	3189	75267.51003			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.679386	252.9178	2.779327	1.098905

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BAAD	14	23987.29684	1713.37835	221.81	<.0001
YEAR*AREA	42	22839.91145	543.80742	70.40	<.0001
MONTH	8	4295.29561	536.91195	69.51	<.0001
AREA	0	0.00000	.	.	.
HOLD	1	13.17172	13.17172	1.71	0.1917

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BAAD	14	8885.26838	634.66203	82.16	<.0001
YEAR*AREA	41	15252.87134	372.02125	48.16	<.0001
MONTH	8	4274.45035	534.30629	69.17	<.0001
AREA	1	1590.53922	1590.53922	205.90	<.0001
HOLD	1	13.17172	13.17172	1.71	0.1917

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		1.091707031	B	0.10292347	10.61	<.0001
BAAD	E004	-1.225186026	B	0.10392274	-11.79	<.0001
BAAD	E008	-1.113781227	B	0.08658904	-12.86	<.0001
BAAD	E013	-1.002380286	B	0.09003367	-11.13	<.0001
BAAD	E019	-0.921045259	B	0.08834931	-10.43	<.0001
BAAD	E025	-0.823365052	B	0.08458509	-9.73	<.0001
BAAD	E031	-0.740226976	B	0.08344200	-8.87	<.0001
BAAD	E033	-0.663899492	B	0.08653758	-7.67	<.0001
BAAD	E043	-0.586633038	B	0.08215852	-7.14	<.0001
BAAD	E047	-0.538011731	B	0.08572905	-6.28	<.0001
BAAD	E050	-0.476591644	B	0.09202409	-5.18	<.0001
BAAD	E057	-0.417652004	B	0.08420583	-4.96	<.0001
BAAD	E065	-0.334184813	B	0.08084458	-4.13	<.0001
BAAD	E070	-0.237551651	B	0.08154140	-2.91	0.0036
BAAD	E074	-0.138455762	B	0.08526711	-1.62	0.1045
BAAD	E078	0.000000000	B	.	.	.
YEAR*AREA	87 21	0.714879619	B	0.07121422	10.04	<.0001
YEAR*AREA	88 21	0.514068685	B	0.06730975	7.64	<.0001
YEAR*AREA	89 21	0.126158745	B	0.06654716	1.90	0.0581
YEAR*AREA	90 21	0.116736252	B	0.06632880	1.76	0.0785
YEAR*AREA	91 21	-0.086852717	B	0.06559659	-1.32	0.1856
YEAR*AREA	92 21	-0.302824684	B	0.06882354	-4.40	<.0001
YEAR*AREA	94 21	0.350162588	B	0.08402438	4.17	<.0001
YEAR*AREA	94 22	0.811616103	B	0.07718514	10.52	<.0001
YEAR*AREA	95 21	0.176631228	B	0.07591141	2.33	0.0200
YEAR*AREA	95 22	0.630480069	B	0.09314286	6.77	<.0001
YEAR*AREA	96 21	0.068475374	B	0.09165206	0.75	0.4550
YEAR*AREA	96 22	0.970440695	B	0.07830161	12.39	<.0001
YEAR*AREA	97 21	0.404598699	B	0.11394558	3.55	0.0004

YEAR*AREA	97 22	0.925870507	B	0.08198636	11.29	<.0001
YEAR*AREA	98 21	0.744070428	B	0.10476242	7.10	<.0001
YEAR*AREA	98 22	1.055176490	B	0.09243842	11.41	<.0001
YEAR*AREA	99 21	0.540944637	B	0.10818055	5.00	<.0001
YEAR*AREA	99 22	1.313996970	B	0.11247593	11.68	<.0001
YEAR*AREA	100 21	0.688279398	B	0.08295118	8.30	<.0001
YEAR*AREA	100 22	1.278430099	B	0.09084601	14.07	<.0001
YEAR*AREA	101 21	0.547589984	B	0.11206983	4.89	<.0001
YEAR*AREA	101 22	1.003892107	B	0.07667306	13.09	<.0001
YEAR*AREA	102 21	0.518668054	B	0.10902110	4.76	<.0001
YEAR*AREA	102 22	1.209544870	B	0.08447529	14.32	<.0001
YEAR*AREA	103 21	0.560650812	B	0.08517949	6.58	<.0001
YEAR*AREA	103 22	1.037868408	B	0.08796979	11.80	<.0001
YEAR*AREA	104 21	0.897756133	B	0.08072008	11.12	<.0001
YEAR*AREA	104 22	1.005880335	B	0.10472911	9.60	<.0001
YEAR*AREA	105 21	0.883427317	B	0.08966101	9.85	<.0001
YEAR*AREA	105 22	1.238430225	B	0.10630078	11.65	<.0001
YEAR*AREA	106 21	0.915020677	B	0.09337133	9.80	<.0001
YEAR*AREA	106 22	1.188570161	B	0.13133271	9.05	<.0001
YEAR*AREA	107 21	0.797524848	B	0.09408144	8.48	<.0001
YEAR*AREA	107 22	1.293200034	B	0.14415028	8.97	<.0001
YEAR*AREA	108 21	1.007961696	B	0.10502608	9.60	<.0001
YEAR*AREA	108 22	0.841559053	B	0.24648949	3.41	0.0006
YEAR*AREA	109 21	1.413421620	B	0.09976298	14.17	<.0001
YEAR*AREA	109 22	1.497999531	B	0.22964310	6.52	<.0001
YEAR*AREA	110 21	0.737965656	B	0.09659022	7.64	<.0001
YEAR*AREA	110 22	1.204602195	B	0.37049023	3.25	0.0012
YEAR*AREA	111 21	0.843420344	B	0.25107901	3.36	0.0008
YEAR*AREA	999 21	-0.507435409	B	0.07166324	-7.08	<.0001
YEAR*AREA	999 22	0.000000000	B	.	.	.
MONTH	1	0.323054500	B	0.03018938	10.70	<.0001
MONTH	2	0.279030377	B	0.03012210	9.26	<.0001
MONTH	4	0.154378636	B	0.02915687	5.29	<.0001
MONTH	5	0.095544525	B	0.04205741	2.27	0.0232
MONTH	6	-0.031726056	B	0.07938555	-0.40	0.6894
MONTH	7	0.338246383	B	0.07208485	4.69	<.0001
MONTH	8	0.063211854	B	0.05248967	1.20	0.2286
MONTH	11	-0.260144830	B	0.03165054	-8.22	<.0001
MONTH	12	0.000000000	B	.	.	.
AREA	21	0.000000000	B	.	.	.
AREA	22	0.000000000	B	.	.	.
HOLD	2	0.038637211	B	0.02958859	1.31	0.1917
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.

Appendix 2. Results and diagnostical outputs from GLM run of model without area interaction for standardising CPUE in Greenlandic zone. Data from Greenlandic, Faeroese, Norway and EUvessels.

The GLM Procedure
Class Level Information

Class	Levels	Values
BAAD	15	E004 E008 E013 E019 E025 E031 E033 E043 E047 E050 E057 E065 E070 E074 E078
YEAR	25	88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 999
MONTH	9	1 2 4 5 6 7 8 11 12
HOLD	2	2 9

Number of Observations Read 3721
Number of Observations Used 3721

Dependent Variable: LNCPUE

Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	57011.12213	1213.00260	131.08	<.0001
Error	3673	33990.76814	9.25422		
Corrected Total	3720	91001.89027			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.626483	259.9751	3.042076	1.170141

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BAAD	14	29996.88923	2142.63494	231.53	<.0001
YEAR	24	23932.10554	997.17106	107.75	<.0001
MONTH	8	3003.22820	375.40352	40.57	<.0001
HOLD	1	78.89917	78.89917	8.53	0.0035

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BAAD	14	14380.73144	1027.19510	111.00	<.0001
YEAR	24	22387.82915	932.82621	100.80	<.0001
MONTH	8	3037.33703	379.66713	41.03	<.0001
HOLD	1	78.89917	78.89917	8.53	0.0035

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		2.158172557	B	0.08285407	26.05	<.0001
BAAD	E004	-1.659412644	B	0.10016980	-16.57	<.0001
BAAD	E008	-1.463289142	B	0.07918868	-18.48	<.0001
BAAD	E013	-1.309114514	B	0.08332830	-15.71	<.0001
BAAD	E019	-1.269152852	B	0.08118023	-15.63	<.0001
BAAD	E025	-1.164398709	B	0.07669605	-15.18	<.0001
BAAD	E031	-1.099037683	B	0.07499728	-14.65	<.0001
BAAD	E033	-0.920834147	B	0.07872232	-11.70	<.0001
BAAD	E043	-0.916170033	B	0.07326565	-12.50	<.0001
BAAD	E047	-0.882722976	B	0.07793685	-11.33	<.0001
BAAD	E050	-0.755241358	B	0.08622734	-8.76	<.0001
BAAD	E057	-0.722763337	B	0.07564780	-9.55	<.0001
BAAD	E065	-0.575469071	B	0.07202164	-7.99	<.0001
BAAD	E070	-0.471235181	B	0.07241778	-6.51	<.0001
BAAD	E074	-0.278590598	B	0.07629887	-3.65	0.0003
BAAD	E078	0.000000000	B	.	.	.
YEAR	88	-0.195141905	B	0.04873879	-4.00	<.0001
YEAR	89	-0.599578272	B	0.04772840	-12.56	<.0001
YEAR	90	-0.588980534	B	0.04814060	-12.23	<.0001
YEAR	91	-0.780876046	B	0.04789774	-16.30	<.0001
YEAR	92	-1.011901600	B	0.05267893	-19.21	<.0001
YEAR	93	-1.050065426	B	0.05269055	-19.93	<.0001
YEAR	94	-0.002836273	B	0.05439177	-0.05	0.9584
YEAR	95	-0.254207208	B	0.05385458	-4.72	<.0001
YEAR	96	0.009532598	B	0.05531160	0.17	0.8632
YEAR	97	0.200647497	B	0.06007425	3.34	0.0008
YEAR	98	0.294005308	B	0.06685962	4.40	<.0001
YEAR	99	0.432318521	B	0.07488397	5.77	<.0001
YEAR	100	0.297608383	B	0.05970261	4.98	<.0001
YEAR	101	0.307368947	B	0.05873882	5.23	<.0001
YEAR	102	0.425901736	B	0.06424105	6.63	<.0001
YEAR	103	0.160273182	B	0.06065704	2.64	0.0083
YEAR	104	0.246776436	B	0.06371006	3.87	0.0001
YEAR	105	0.382265405	B	0.06986702	5.47	<.0001
YEAR	106	0.308635862	B	0.07783704	3.97	<.0001
YEAR	107	0.205359140	B	0.07963655	2.58	0.0100

YEAR	108	0.299106011	B	0.09667133	3.09	0.0020
YEAR	109	0.735446713	B	0.09156652	8.03	<.0001
YEAR	110	0.087022488	B	0.08995553	0.97	0.3334
YEAR	111	0.050795607	B	0.26946574	0.19	0.8505
YEAR	999	0.000000000	B	.	.	.
MONTH	1	0.195681875	B	0.03126728	6.26	<.0001
MONTH	2	0.174126677	B	0.03129193	5.56	<.0001
MONTH	4	0.095879301	B	0.03025137	3.17	0.0015
MONTH	5	0.029981521	B	0.04453285	0.67	0.5008
MONTH	6	0.016134005	B	0.08278347	0.19	0.8455
MONTH	7	0.427753023	B	0.06921919	6.18	<.0001
MONTH	8	0.164164178	B	0.05149787	3.19	0.0014
MONTH	11	-0.240618678	B	0.03220574	-7.47	<.0001
MONTH	12	0.000000000	B	.	.	.
HOLD	2	-0.090967660	B	0.03115450	-2.92	0.0035
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.