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The Fishery for Northern Shrimp (*Pandalus borealis*) in Denmark Strait / off East Greenland 1978 - 2012.

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 2011, where data from an annual survey series starting in 2008 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. The fishery in the Icelandic zone ceased in 2006.

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 1 235 tons in 2011, the lowest level seen since the fishery started in 1978. In 2012 the catch taken until September is about 2 100 tons. 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, then nearly doubled in 2009. Since then the biomass index has been declining and is now lower than during the 2000's. 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 2011 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 (Siegstad 2011 and 2012).

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 1 235 tons in 2011. 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 south of 65°N extending south to the Cap Farewell. At any time access to fishing grounds depends on ice conditions.

Since 1994 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 double trawl. The 2012 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:

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

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.

For the model pertaining to the Greenlandic zone 82 of 112 vessels met the criteria for inclusion in the analysis (at least three years of fishing in the area). 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 (Siegstad and Hvingel 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 (Siegstad and Hvingel 2006) 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 south of 65°N 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 1 235 tons in 2011. In 2012 the catch taken until September is around 2 100 tons.

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 reaching a low of 1 150 tons in 2011.

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 then catches in the southern area has declined, reaching a low of 89 tons in 2011.

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 about 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). In 2011 total effort was the lowest ever seen, being 3327 hours.

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) and only 25 hours was spent fishing in the southern area in 2011. From 2010 – 2012 less than 3% of total effort has been spent in the southern area.

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. In addition to this fuel prices has gone up during the last years, so going to East Greenland has become more costly which means that the profit from fishing has gone down.

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 between 340 and 420 kg/hr except for 2009, where the catch rate was 640 kg/hr, the highest value ever obtained.

In the southern area 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 with a mean of 600 kg/hr. Since then catch rates has increased reaching a high of 3 576 kg/hr in 2011. –However only 7 hauls were conducted in the southern area in 2011. The catch rate in 2012 fell to 1726 kg/hr, but is based on only 47 hauls. The catch rate in 2010 was nearly the same as in 2012, but is also based on a low number of hauls (72).

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. Data from 2010 to 2012 showed catch rates slightly lower than the level seen from 2003-2007.

The catch rate for the total area has reflected the catch rate for the northern area during the last 5 years. This is because 90% of the total catch has been taken in the northern area and the effort spent in the southern areas has been 9% from 2008-2009 and less than 2.5% during the last 3 years.

Standardised catch rate indices

The CPUEs for the southern area in 2011 and 2012 were omitted from the GLMs because of the low number of hauls conducted in this area during the last 2 years.

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 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 then increased until the end of the 1990s, and stabilized at a level one third above that of 1987. Since then the biomass index has been fluctuating without a trend until 2009 where the index more than doubled compared to 1987. Since then the combined index has been declining and is now lower than during the 2000's.

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 stabilised at a level one third above that of 1987. In 2008 the index started increasing reaching a record high level in 2009. Since then the index has been going down reaching the values seen in the late nineties and early 2000s.

The CPUE index series of the southern area (Fig. 3, Table 3) increased until 1999 and has since then fluctuated without a trend. No index for the southern area was calculated in 2011 and 2012.

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 2011 and 2012. 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. No standardised effort for the southern area was calculated for 2011 and 2012.

Conclusions

Total catches fluctuated around 12000 tons from 1994 to 2003 (Table 1, Fig. 1A). Catches has since decreased. In 2011 the total catch was 1 235 tons, the lowest level ever caught. Total catch for the first 8 months in 2012 is about 2 100 tons.

The combined CPUE index for the total area (Fig. 2, Table 3) indicated that the stock 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 then increased until the end of the 1990s, and stabilized at a level one third above that of 1987. Since then the biomass index

has been fluctuating without a trend until 2009 where the index more than doubled compared to 1987. Since then the combined index has been declining and is now lower than during the 2000's.

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

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 without trend until 2009. Since 2010 the standardised CPUE index has been going down and is now below the level seen in the period from 2000 to 2009.

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Table 1. Catch (tons) of shrimp by the fishery in Denmark Strait/off East Greenland from 1978 to September 2012. Values for the fishery in the Greenland EEZ by EU-Denmark, Faeroe Islands, France, Greenland and Norway are corrected according to Hvingel 2003.

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
North of 65°N																			
EU (DK,EST,LTU)	-	0	878	727	926	255	554	442	626	703	554	454	476	450	199	138	250	302	26
Faroe Islands	-	0	5296	892	922	554	836	843	910	754	847	738	1029	1265	1355	689	462	931	995
France	-	0	63	442	518	364	626	803	976	1305	616	472	62	148	0	0	0	0	0
Greenland	-	0	250	1256	1395	1835	2815	3248	7232	8396	9304	7408	7580	5283	2496	1771	1326	2390	359
Iceland	363	485	759	125	0	43	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566
Norway	-	1001	3079	2522	2372	2161	2662	2566	2535	2586	2561	2601	3052	3146	3102	1831	2180	2402	1544
Total	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	6982	5731	7176	3490
South of 65°N																			
Denmark (EU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	613	731	1167
Faroe Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	280	974	295	402
Greenland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1141	3603	2667	5295
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	424	1011	720	1590
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1904	6201	4412	8453
Total area																			
EU (DK,EST,LTU)	-	0	878	727	926	255	554	442	626	703	554	454	476	450	199	198	863	1033	1193
Faroe Islands	-	0	5296	892	922	554	836	843	910	754	847	738	1029	1265	1355	968	1436	1225	1397
France	-	0	63	442	518	364	626	803	976	1305	616	472	62	148	0	0	0	0	0
Greenland	-	0	250	1256	1395	1835	2815	3248	7232	8396	9304	7408	7580	5283	2496	2912	4929	5057	5655
Iceland	363	485	759	125	0	43	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566
Norway	-	1001	3079	2522	2372	2161	2662	2566	2535	2586	2561	2601	3052	3146	3102	2255	3190	3122	3133
Total	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944
Total all areas	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944
Advised TAC	-	-	-	-	4200	4200	4200	5000	-	-	-	100003	100003	100003	8000	5000	5000	5000	5000
Effective TAC[1]	-	-	-	8000	4500	5725	5245	6090	75255	75255	87255	90255	14100	14500	13000	9563	9563	9563	9563

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

Table 1 (continued). Catch (tons) of shrimp by the fishery in Denmark Strait/off East Greenland from 1978 to September 2012. Values for the fishery in the Greenland EEZ by EU-Denmark, Faeroe Islands, France, Greenland and Norway are corrected according to Hvingel 2003.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012[2]
North of 65°N																
EU (DK,EST,LTU)	85	401	793	459	72	816	861	482	304	618	421	389	892	1345	927	1418
Faroe Islands	635	1268	867	956	214	1029	1062	894	615	342	319	612	1325	781	0	0
France	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-
Greenland	105	646	614	115	650	638	695	578	454	223	802	14	844	426	183	493
Iceland	2856	1421	769	132	10	1231	703	411	29	0	0	0	0	0	0	0
Norway	797	1628	1783	2759	1291	1630	2861	2700	2614	2704	1771	1514	883	769	36	0
Total	4478	5364	4827	4420	2237	5344	6183	5065	4016	3887	3314	2529	3945	3321	1146	1911
South of 65°N																
Denmark (EU)	1657	1300	1095	1900	2473	2309	1827	1022	644	683	431	251	28	101	36	0
Faroe Island	656	138	453	340	2402	1013	303	255	176	227	169	14	28	134	0	0
Greenland	4701	3950	4966	5235	4943	4333	4194	3488	2737	316	639	0	447	178	53	221
Norway	2261	670	378	157	1855	1098	197	186	180	76	48	0	107	0	0	0
Total	9276	6057	6893	7632	11674	5985	6522	4951	3737	1302	1286	266	610	413	89	221
Total area																
EU (DK,EST,LTU)	1742	1701	1888	2358	2545	2548	2688	1504	948	1301	852	640	920	1446	963	1418
Faroe Islands	1292	1406	1321	1296	2616	1322	1365	1149	791	569	488	627	1354	915	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenland	4806	4595	5581	5349	5593	4484	4890	4066	3191	539	1441	14	1292	605	236	714
Iceland	2856	1421	769	132	10	1231	703	411	29	0	0	0	0	0	0	0
Norway	3059	2298	2160	2917	3147	1743	3059	2886	2794	2780	1819	1514	990	769	36	0
Total	13754	11422	11719	12053	13911	11329	12705	10016	7753	5189	4600	2794	4555	3735	1235	2132
Total all areas	13754	11422	11719	12053	13911	11242	12637	9985	7753	5189	4600	2794	4555	3735	1235	2132
Advised TAC	5000	5000	9600	9600	9600	9600	9600	12400	12400	12400	12400	12400	12400	12400	12400	12400
Effective TAC[1]	9563	9563	10600	12600	10600	10600	10600	15043	12400	12400	12400	12400	12835	11835	12400	12400

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

[2]Catch until September

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	5344	20052	267	5985	8546	700	11329	22843	496
2003	6183	18053	342	6522	9317	700	12705	25295	502
2004	5065	15848	320	4951	8972	552	10016	27450	365
2005	4016	11251	357	3737	8004	467	7753	19257	403
2006	3887	10413	373	1302	2436	534	5189	12851	404
2007	3314	8977	369	1286	1974	651	4600	10951	420
2008	2529	6106	414	266	585	454	2794	6691	418
2009	3945	6500	607	610	617	989	4555	7117	640
2010	3321	10282	323	413	263	1571	3735	10546	354
2011	1146	3302	347	89	25	3576	1235	3327	371
2012*	1911	6201	308	221	128	1726	2132	6329	337

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	0.90	0.09	1.13	0.11					0.89	0.08	1.14	0.00
1989	0.63	0.06	1.36	0.13					0.61	0.05	1.41	0.12
1990	0.63	0.06	1.31	0.13					0.61	0.05	1.35	0.12
1991	0.53	0.05	1.34	0.13					0.52	0.05	1.37	0.12
1992	0.43	0.04	1.37	0.14					0.42	0.04	1.41	0.13
1993	0.35	0.04	1.31	0.13	1.00	-	1.00	-	0.40	0.04	1.47	0.14
1994	0.82	0.09	0.46	0.05	2.26	0.18	1.44	0.11	1.10	0.10	0.72	0.07
1995	0.68	0.07	0.70	0.07	1.89	0.19	1.22	0.12	0.87	0.08	0.89	0.08
1996	0.61	0.07	0.38	0.04	2.65	0.22	1.68	0.13	1.10	0.10	0.72	0.07
1997	0.83	0.11	0.36	0.05	2.52	0.22	1.93	0.16	1.34	0.13	0.68	0.07
1998	1.06	0.13	0.34	0.04	2.86	0.28	1.11	0.10	1.41	0.14	0.54	0.05
1999	0.91	0.12	0.35	0.05	3.71	0.45	0.98	0.11	1.60	0.17	0.49	0.05
2000	1.10	0.13	0.27	0.03	3.61	0.36	1.11	0.11	1.66	0.17	0.48	0.05
2001	0.98	0.14	0.15	0.02	2.73	0.23	2.24	0.18	1.66	0.17	0.56	0.06
2002	1.01	0.13	0.35	0.05	3.36	0.32	0.94	0.08	1.90	0.20	0.40	0.04
2003	0.97	0.11	0.42	0.05	2.83	0.27	1.21	0.11	1.47	0.15	0.57	0.06
2004	1.34	0.15	0.25	0.03	2.71	0.32	0.96	0.11	1.61	0.17	0.41	0.04
2005	1.36	0.17	0.20	0.02	3.50	0.45	0.56	0.07	1.94	0.22	0.27	0.03
2006	1.41	0.18	0.18	0.02	3.29	0.48	0.21	0.03	1.80	0.21	0.19	0.02
2007	1.25	0.16	0.18	0.02	3.61	0.58	0.19	0.03	1.57	0.19	0.19	0.02
2008	1.56	0.22	0.11	0.01	2.31	0.65	0.06	0.02	1.84	0.25	0.10	0.01
2009	2.32	0.31	0.11	0.01	4.52	1.19	0.07	0.02	2.60	0.33	0.12	0.01
2010	1.19	0.15	0.18	0.02	3.56	1.48	0.06	0.02	1.39	0.17	0.18	0.02
2011	1.29	0.23	0.06	0.01	-	-	-	-	1.42	0.27	0.06	0.01
2012	1.02	0.15	0.12	0.02	-	-	-	-	1.15	0.18	0.12	0.02

* Until Sept.

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 2012 is part-years data, until September).

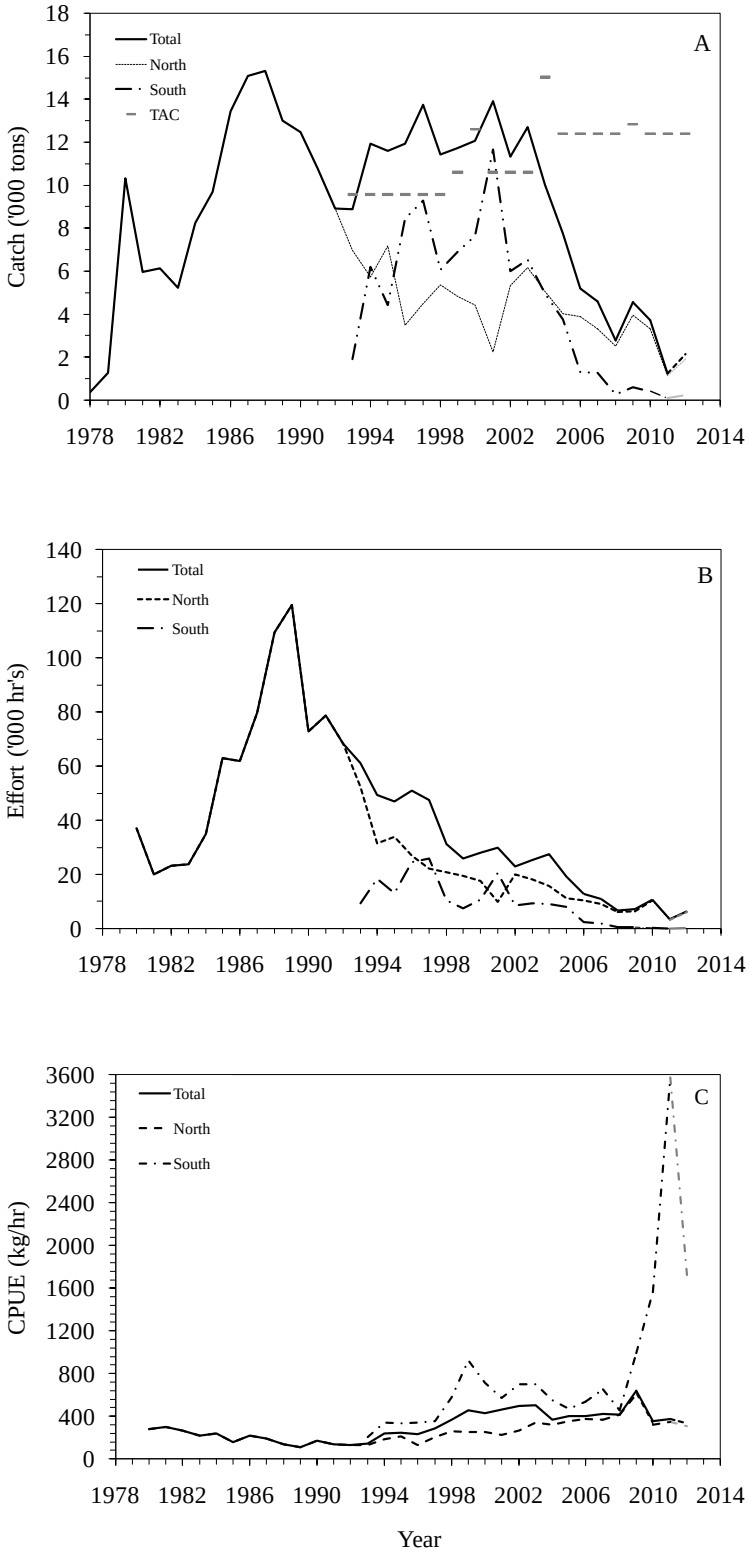


Figure 2. Standardized Catch-Per-Unit-Effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas south of 65°N, overall fishery north of 65°N (both in Greenland and Iceland EEZ), and overall standardized CPUE for the stock (Estimates for 2012 are based on data until September).

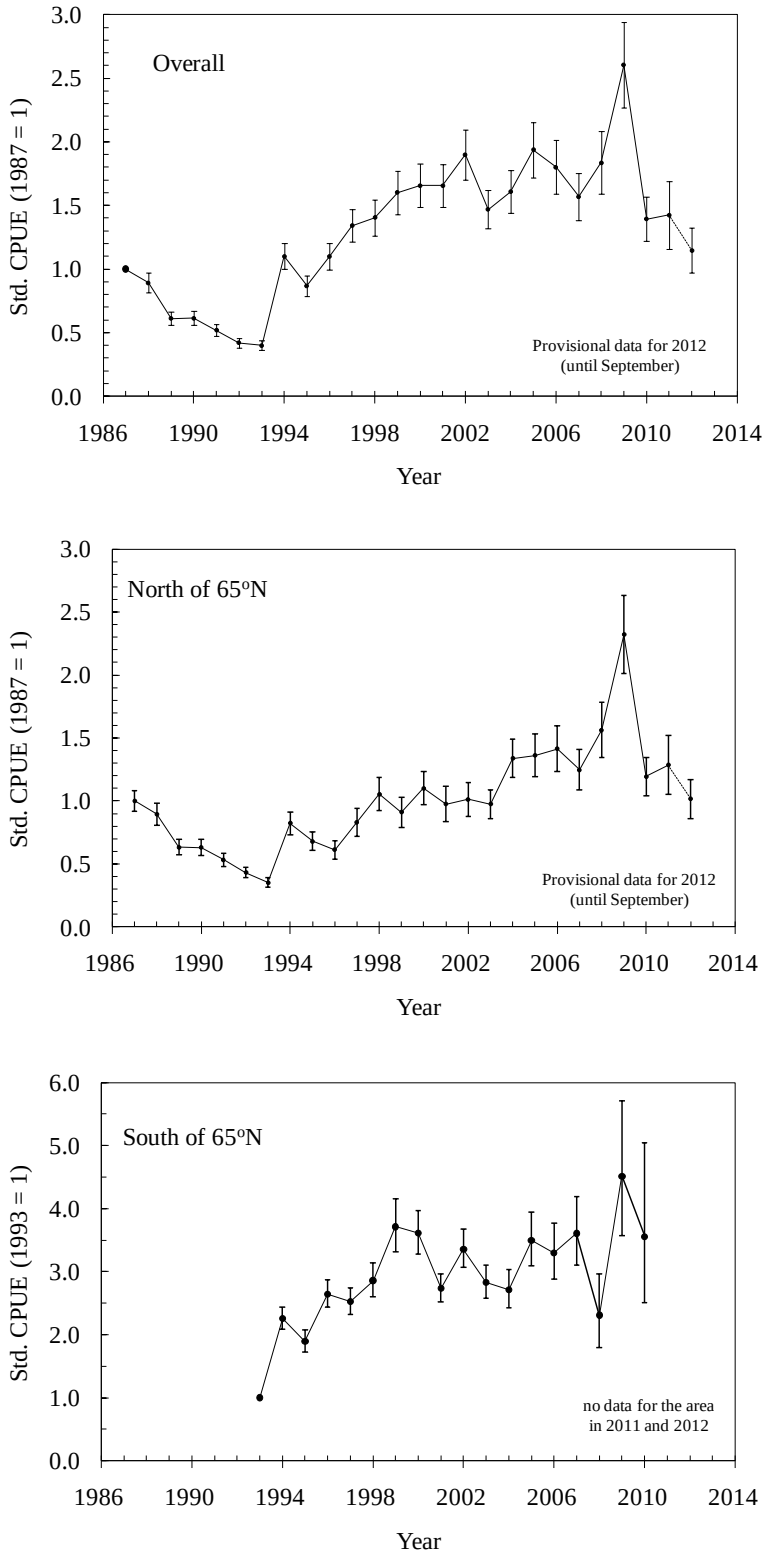


Figure 3. Standardised effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas north of 65°N, south of 65°N and overall (Estimates for 2012 are based on data until September).

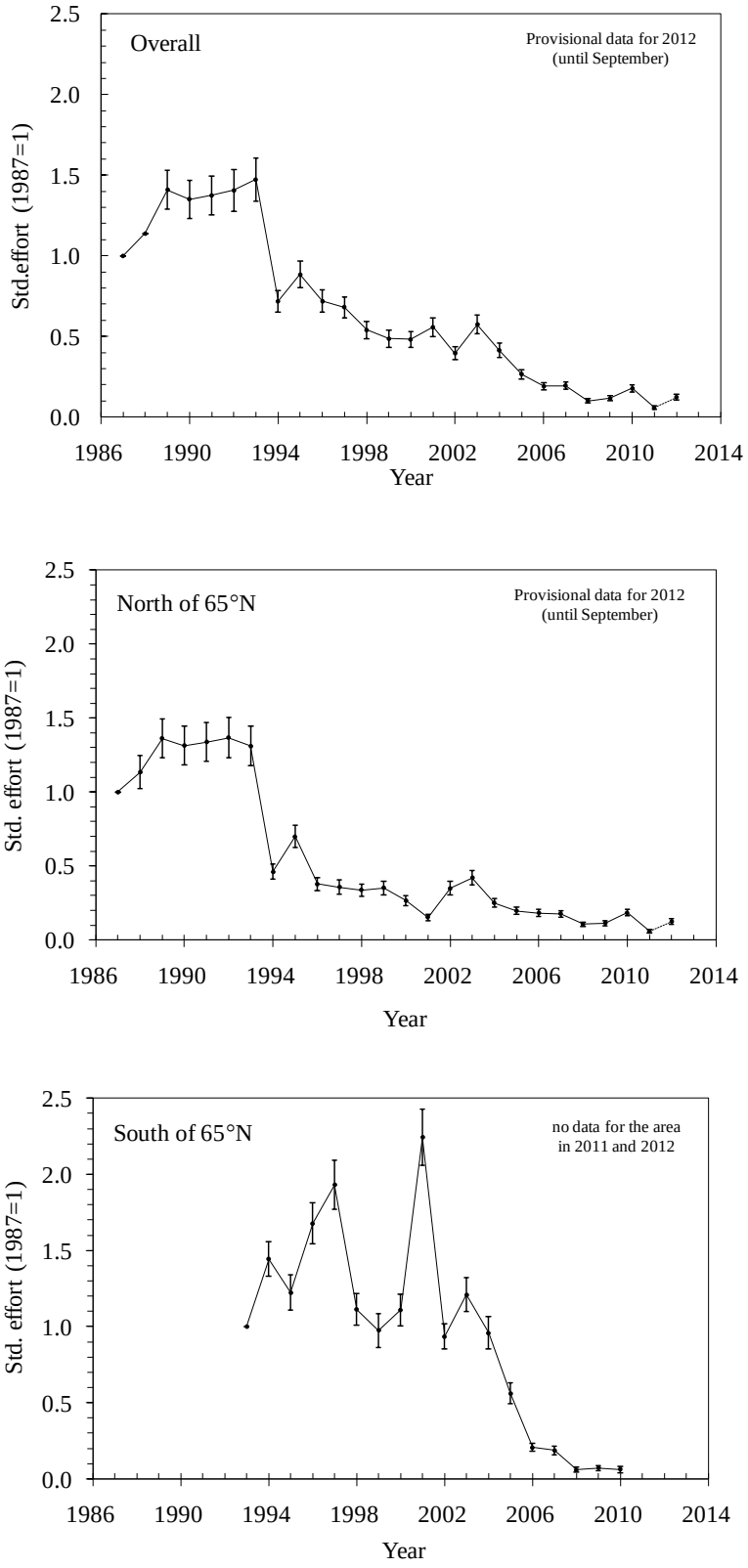


Figure 4a. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland 2007-2010.

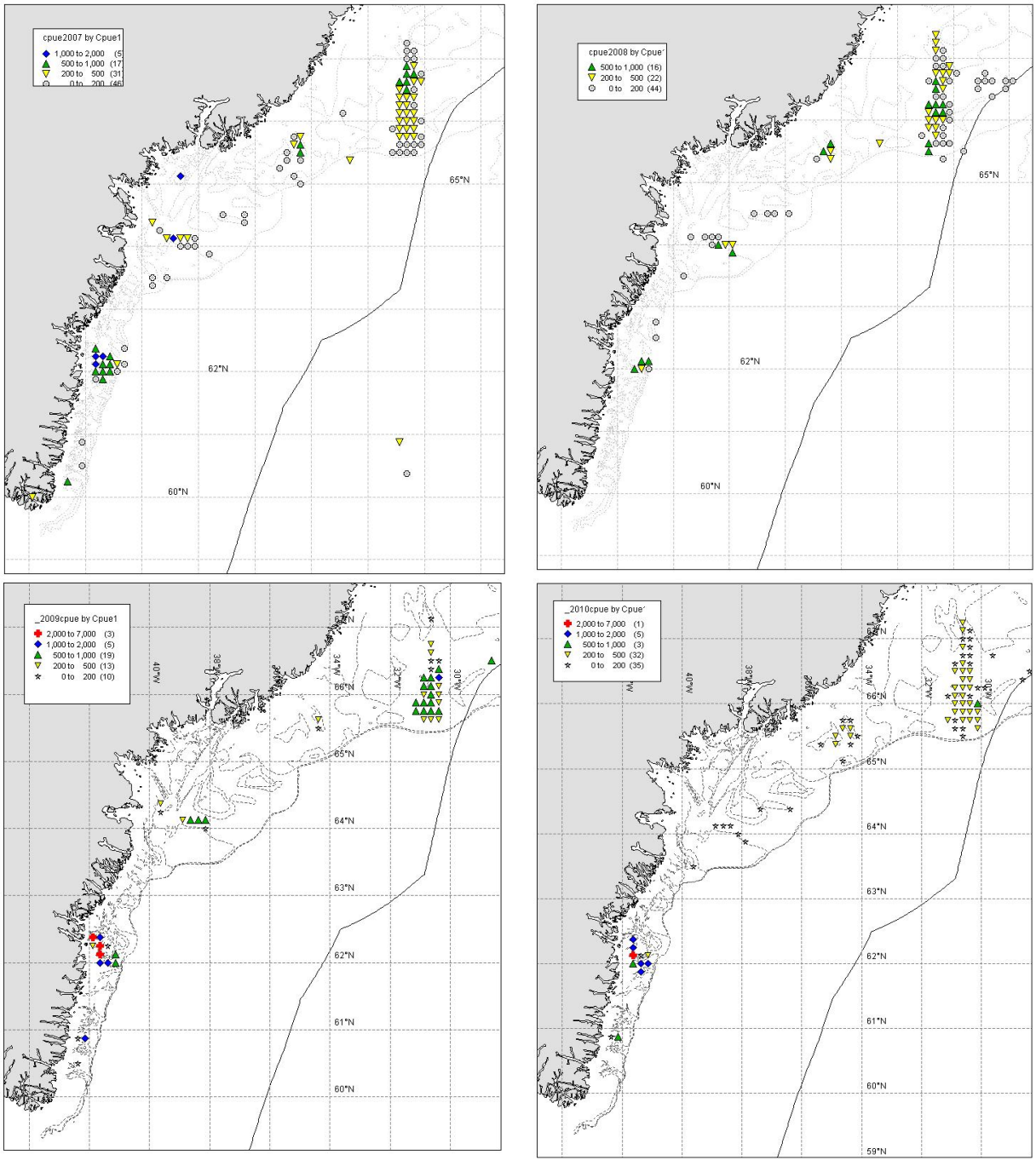
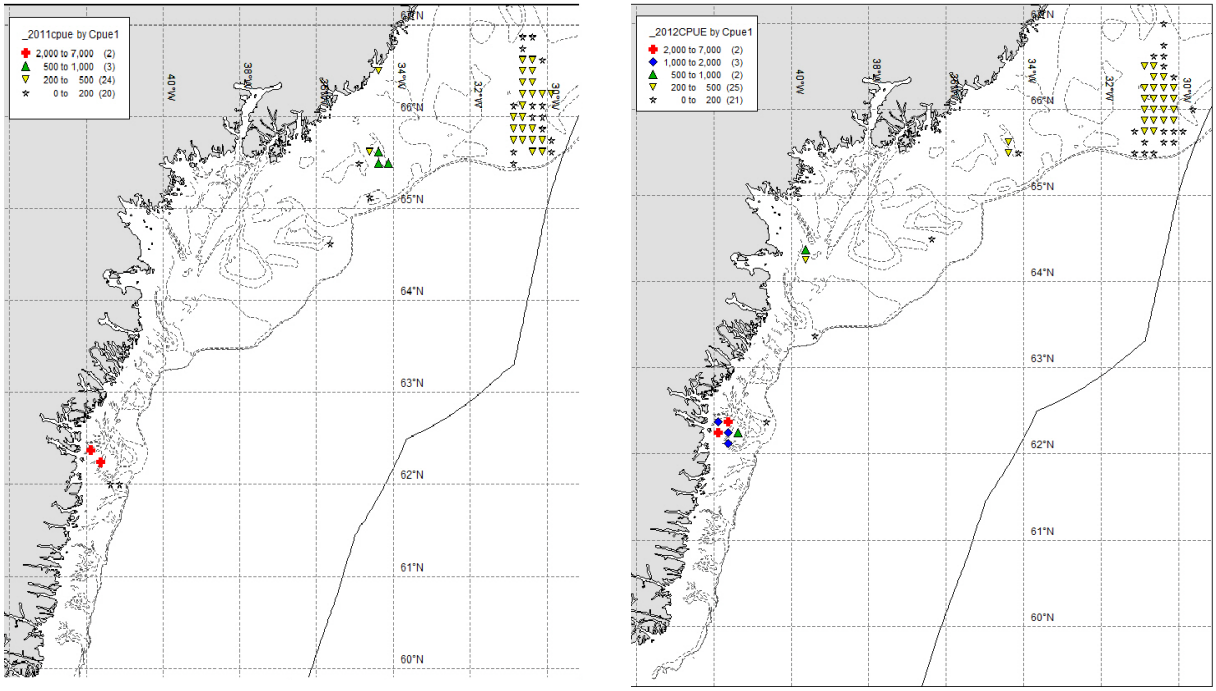


Figure 4b. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland 2011-2012. 2012 (until September).



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

The GLM Procedure

Class Level Information

Class	Levels	Values
BAAD	81	E001 E002 E003 E004 E005 E006 E007 E008 E009 E010 E011 E012 E013 E014 E015 E016 E017 E018 E019 E020 E021 E022 E023 E024 E025 E026 E027 E028 E029 E030 E031 E032 E033 E034 E035 E036 E037 E038 E039 E040 E041 E042 E043 E044 E045 E046 E047 E048 E049 E050 E051 E052 E053 E054 E055 E056 E057 E058 E059 E060 E061 E063 E064 E065 E066 E067 E068 E069 E070 E071 E072 E073 E074 E075 E076 E077 E078 E079 E080 E081 E082
YEAR	26	87 88 89 90 91 92 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 999
MONTH	9	1 2 4 5 6 7 8 11 12
AREA	2	21 22
HOLD	3	1 2 9

Number of Observations Read	3255
Number of Observations Used	3255

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	133	51739.84781	389.02141	49.93	<.0001
Error	3121	24316.83692	7.79136		
Corrected Total	3254	76056.68472			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.680280	252.2317	2.791301	1.106641

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BAAD	80	30861.51840	385.76898	49.51	<.0001
YEAR*AREA	43	16861.70997	392.13279	50.33	<.0001
MONTH	8	4004.58641	500.57330	64.25	<.0001
AREA	0	0.00000	.	.	.
HOLD	2	12.03302	6.01651	0.77	0.4621

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BAAD	80	8945.45969	111.81825	14.35	<.0001
YEAR*AREA	42	12128.80986	288.78119	37.06	<.0001
MONTH	8	3994.28357	499.28545	64.08	<.0001
AREA	1	1686.28409	1686.28409	216.43	<.0001
HOLD	2	12.03302	6.01651	0.77	0.4621

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		0.826568893 B	0.16225455	5.09	<.0001
BAAD	E001	-0.067404025 B	0.17633635	-0.38	0.7023
BAAD	E002	-0.204681842 B	0.23007405	-0.89	0.3737
BAAD	E003	-0.640564495 B	0.16849911	-3.80	0.0001
BAAD	E004	-0.329497904 B	0.21711820	-1.52	0.1292
BAAD	E005	-0.649141264 B	0.19168901	-3.39	0.0007
BAAD	E006	-0.317306297 B	0.18414149	-1.72	0.0850
BAAD	E007	-0.172717576 B	0.16349018	-1.06	0.2908
BAAD	E008	-0.648376375 B	0.26694494	-2.43	0.0152
BAAD	E009	-0.480206807 B	0.23487564	-2.04	0.0410
BAAD	E010	-0.087549258 B	0.16822806	-0.52	0.6028
BAAD	E011	-0.292763382 B	0.17841534	-1.64	0.1009
BAAD	E012	-0.138891072 B	0.16195907	-0.86	0.3912
BAAD	E013	-0.076216210 B	0.16653009	-0.46	0.6472
BAAD	E014	-0.577248155 B	0.19186585	-3.01	0.0026
BAAD	E015	-0.316200119 B	0.19712766	-1.60	0.1088
BAAD	E016	-0.207022106 B	0.16157142	-1.28	0.2002
BAAD	E017	-0.244880038 B	0.17727601	-1.38	0.1673
BAAD	E018	-0.149209155 B	0.19369115	-0.77	0.4412
BAAD	E019	-0.539510572 B	0.16816781	-3.21	0.0013
BAAD	E020	-0.095207964 B	0.17311772	-0.55	0.5824
BAAD	E021	0.154693128 B	0.16837684	0.92	0.3583
BAAD	E022	-0.369214596 B	0.16489109	-2.24	0.0252
BAAD	E023	-0.311036422 B	0.15726500	-1.98	0.0480
BAAD	E024	0.206080717 B	0.26444865	0.78	0.4359
BAAD	E025	-0.603377901 B	0.17255786	-3.50	0.0005
BAAD	E026	-0.668349526 B	0.16988764	-3.93	<.0001
BAAD	E027	0.006096616 B	0.23183490	0.03	0.9790
BAAD	E028	-0.320790538 B	0.15907069	-2.02	0.0438
BAAD	E029	-0.975545144 B	0.20247093	-4.82	<.0001
BAAD	E030	-0.495707683 B	0.41989053	-1.18	0.2379
BAAD	E031	0.327756270 B	0.20769183	1.58	0.1146
BAAD	E032	-1.009697739 B	0.20234112	-4.99	<.0001
BAAD	E033	-0.888115967 B	0.16584564	-5.36	<.0001
BAAD	E034	-0.255751345 B	0.17327595	-1.48	0.1401
BAAD	E035	-0.620256142 B	0.20763154	-2.99	0.0028
BAAD	E036	-0.830371306 B	0.16939182	-4.90	<.0001
BAAD	E037	-0.720923613 B	0.16183035	-4.45	<.0001
BAAD	E038	-0.109143151 B	0.17160137	-0.64	0.5248
BAAD	E039	-0.480928345 B	0.15990606	-3.01	0.0027
BAAD	E040	-0.920122585 B	0.20467134	-4.50	<.0001
BAAD	E041	-0.470980336 B	0.15666945	-3.01	0.0027
BAAD	E042	-0.279540876 B	0.15147476	-1.85	0.0651
BAAD	E043	-0.156100671 B	0.20296715	-0.77	0.4419
BAAD	E044	-0.819505180 B	0.18582331	-4.41	<.0001
BAAD	E045	-0.344068221 B	0.15496303	-2.22	0.0265
BAAD	E046	-0.515720204 B	0.19121631	-2.70	0.0070
BAAD	E047	-0.543451216 B	0.15314632	-3.55	0.0004
BAAD	E048	-0.719201777 B	0.19794280	-3.63	0.0003
BAAD	E049	0.010315138 B	0.16217359	0.06	0.9493
BAAD	E050	-0.745641552 B	0.16643553	-4.48	<.0001
BAAD	E051	0.117553313 B	0.15570949	0.75	0.4503
BAAD	E052	-0.576872901 B	0.16685547	-3.46	0.0006
BAAD	E053	-0.668607170 B	0.16414514	-4.07	<.0001
BAAD	E054	-0.042046643 B	0.15843959	-0.27	0.7907
BAAD	E055	-0.938872513 B	0.19725741	-4.76	<.0001
BAAD	E056	-0.341247187 B	0.17504150	-1.95	0.0513
BAAD	E057	-0.781925877 B	0.20029815	-3.90	<.0001
BAAD	E058	-0.557068452 B	0.22596488	-2.47	0.0137
BAAD	E059	-0.161780099 B	0.15687141	-1.03	0.3025

Parameter		Estimate	Standard Error	t Value	Pr > |t|
BAAD	E060	-0.301549718 B	0.16449872	-1.83	0.0669
BAAD	E061	-0.206240113 B	0.20092149	-1.03	0.3047
BAAD	E063	-0.120980133 B	0.18466584	-0.66	0.5124
BAAD	E064	0.047566988 B	0.15231505	0.31	0.7548
BAAD	E065	-0.492124884 B	0.15653951	-3.14	0.0017
BAAD	E066	-0.843023865 B	0.15761536	-5.35	<.0001
BAAD	E067	-0.305023073 B	0.16013331	-1.90	0.0569
BAAD	E068	-0.444460677 B	0.15960702	-2.78	0.0054
BAAD	E069	0.105887426 B	0.16039248	0.66	0.5092
BAAD	E070	-0.803607814 B	0.42216002	-1.90	0.0571
BAAD	E071	-0.214666367 B	0.16922089	-1.27	0.2047
BAAD	E072	-0.329659696 B	0.16107637	-2.05	0.0408
BAAD	E073	0.006842772 B	0.15275782	0.04	0.9643
BAAD	E074	0.302384522 B	0.22746347	1.33	0.1838
BAAD	E075	-0.409481190 B	0.15472805	-2.65	0.0082
BAAD	E076	-0.127714465 B	0.18616921	-0.69	0.4928
BAAD	E077	0.220271264 B	0.18875605	1.17	0.2433
BAAD	E078	-0.065930010 B	0.14729032	-0.45	0.6545
BAAD	E079	0.013813617 B	0.15736574	0.09	0.9301
BAAD	E080	-0.083719714 B	0.15877112	-0.53	0.5980
BAAD	E081	0.151844737 B	0.21226345	0.72	0.4744
BAAD	E082	0.000000000 B	.	.	.
YEAR*AREA 87	21	0.708467523 B	0.07457100	9.50	<.0001
YEAR*AREA 88	21	0.509843453 B	0.07018895	7.26	<.0001
YEAR*AREA 89	21	0.122283807 B	0.06882773	1.78	0.0757
YEAR*AREA 90	21	0.113192952 B	0.06860289	1.65	0.0990
YEAR*AREA 91	21	-0.090154736 B	0.06723638	-1.34	0.1801
YEAR*AREA 92	21	-0.302103310 B	0.06969975	-4.33	<.0001
YEAR*AREA 94	21	0.352832895 B	0.08564412	4.12	<.0001
YEAR*AREA 94	22	0.813249844 B	0.07833594	10.38	<.0001
YEAR*AREA 95	21	0.176382041 B	0.07734448	2.28	0.0226
YEAR*AREA 95	22	0.637838926 B	0.09458623	6.74	<.0001
YEAR*AREA 96	21	0.071059431 B	0.09326978	0.76	0.4462
YEAR*AREA 96	22	0.972938125 B	0.07988705	12.18	<.0001
YEAR*AREA 97	21	0.418079182 B	0.11950292	3.50	0.0005
YEAR*AREA 97	22	0.925766850 B	0.08360084	11.07	<.0001
YEAR*AREA 98	21	0.748528890 B	0.10717240	6.98	<.0001
YEAR*AREA 98	22	1.049797507 B	0.09407107	11.16	<.0001
YEAR*AREA 99	21	0.543120985 B	0.11044443	4.92	<.0001
YEAR*AREA 99	22	1.311554674 B	0.11417041	11.49	<.0001
YEAR*AREA 100	21	0.686231385 B	0.09345073	7.34	<.0001
YEAR*AREA 100	22	1.284077676 B	0.09477871	13.55	<.0001
YEAR*AREA 101	21	0.545533986 B	0.11989501	4.55	<.0001
YEAR*AREA 101	22	1.005346268 B	0.08211527	12.24	<.0001
YEAR*AREA 102	21	0.522161748 B	0.11608605	4.50	<.0001
YEAR*AREA 102	22	1.211465130 B	0.09006468	13.45	<.0001
YEAR*AREA 103	21	0.563360561 B	0.09310380	6.05	<.0001
YEAR*AREA 103	22	1.041296329 B	0.09222434	11.29	<.0001
YEAR*AREA 104	21	0.891906354 B	0.08796015	10.14	<.0001
YEAR*AREA 104	22	0.998089932 B	0.11093736	9.00	<.0001
YEAR*AREA 105	21	0.875677915 B	0.09716896	9.01	<.0001
YEAR*AREA 105	22	1.251603574 B	0.12204066	10.26	<.0001
YEAR*AREA 106	21	0.912560555 B	0.10165617	8.98	<.0001
YEAR*AREA 106	22	1.192373459 B	0.13472808	8.85	<.0001
YEAR*AREA 107	21	0.787136938 B	0.10087273	7.80	<.0001
YEAR*AREA 107	22	1.282902213 B	0.14914601	8.60	<.0001
YEAR*AREA 108	21	1.009150860 B	0.11336148	8.90	<.0001
YEAR*AREA 108	22	0.837597420 B	0.24940586	3.36	0.0008
YEAR*AREA 109	21	1.406160967 B	0.10567504	13.31	<.0001
YEAR*AREA 109	22	1.507464835 B	0.23369078	6.45	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
YEAR*AREA	110 21	0.742860128 B	0.09932294	7.48	<.0001
YEAR*AREA	110 22	1.269122903 B	0.34849698	3.64	0.0003
YEAR*AREA	111 21	0.791078289 B	0.15591184	5.07	<.0001
YEAR*AREA	112 21	0.572262450 B	0.12574002	4.55	<.0001
YEAR*AREA	999 21	-0.508607394 B	0.07247052	-7.02	<.0001
YEAR*AREA	999 22	0.000000000 B	.	.	.
MONTH	1	0.321901557 B	0.03042120	10.58	<.0001
MONTH	2	0.282706884 B	0.03034145	9.32	<.0001
MONTH	4	0.158283870 B	0.02961778	5.34	<.0001
MONTH	5	0.098231092 B	0.04224063	2.33	0.0201
MONTH	6	-0.041563642 B	0.07985928	-0.52	0.6028
MONTH	7	0.334441197 B	0.07334879	4.56	<.0001
MONTH	8	0.064636005 B	0.05351215	1.21	0.2272
MONTH	11	-0.257728042 B	0.03210350	-8.03	<.0001
MONTH	12	0.000000000 B	.	.	.
AREA	21	0.000000000 B	.	.	.
AREA	22	0.000000000 B	.	.	.
HOLD	1	-0.092935346 B	0.62378521	-0.15	0.8816
HOLD	2	0.038615146 B	0.03133313	1.23	0.2179
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	81	E001 E002 E003 E004 E005 E006 E007 E008 E009 E010 E011 E012 E013 E014 E015 E016 E017 E018 E019 E020 E021 E022 E023 E024 E025 E026 E027 E028 E029 E030 E031 E032 E033 E034 E035 E036 E037 E038 E039 E040 E041 E042 E043 E044 E045 E046 E047 E048 E049 E050 E051 E052 E053 E054 E055 E056 E057 E058 E059 E060 E061 E063 E064 E065 E066 E067 E068 E069 E070 E071 E072 E073 E074 E075 E076 E077 E078 E079 E080 E081 E082
YEAR	26	88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 999
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
HOLD	3	1 2 9

Number of Observations Read	3788
Number of Observations Used	3788

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	118	58317.47814	494.21592	54.38	<.0001
Error	3669	33346.87544	9.08882		
Corrected Total	3787	91664.35358			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.636207	256.2571	3.014767	1.176462

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BAAD	80	37138.92310	464.23654	51.08	<.0001
YEAR	25	18370.76270	734.83051	80.85	<.0001
MONTH	11	2713.52344	246.68395	27.14	<.0001
HOLD	2	94.26890	47.13445	5.19	0.0056

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BAAD	80	15214.24629	190.17808	20.92	<.0001
YEAR	25	18581.31281	743.25251	81.78	<.0001
MONTH	11	2740.90864	249.17351	27.42	<.0001
HOLD	2	94.26890	47.13445	5.19	0.0056

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Parameter		Estimate		Standard Error	t Value	Pr > |t|
YEAR	88	-0.192113490	B	0.04919063	-3.91	<.0001
YEAR	89	-0.604182502	B	0.04970952	-12.15	<.0001
YEAR	90	-0.587192398	B	0.04960347	-11.84	<.0001
YEAR	91	-0.776863916	B	0.04986747	-15.58	<.0001
YEAR	92	-0.996048931	B	0.05549738	-17.95	<.0001
YEAR	93	-1.038286012	B	0.05579081	-18.61	<.0001
YEAR	94	0.004040030	B	0.05780945	0.07	0.9443
YEAR	95	-0.234258150	B	0.05715678	-4.10	<.0001
YEAR	96	0.021555783	B	0.05876661	0.37	0.7138
YEAR	97	0.250784497	B	0.06436867	3.90	<.0001
YEAR	98	0.338221351	B	0.07132085	4.74	<.0001
YEAR	99	0.464207066	B	0.07881531	5.89	<.0001
YEAR	100	0.436945666	B	0.07016466	6.23	<.0001
YEAR	101	0.419193439	B	0.06904964	6.07	<.0001
YEAR	102	0.568166559	B	0.07419380	7.66	<.0001
YEAR	103	0.327290856	B	0.07084663	4.62	<.0001
YEAR	104	0.411920208	B	0.07510616	5.48	<.0001
YEAR	105	0.566219637	B	0.08201480	6.90	<.0001
YEAR	106	0.492974991	B	0.08708425	5.66	<.0001
YEAR	107	0.353482434	B	0.08894674	3.97	<.0001
YEAR	108	0.505836029	B	0.10613802	4.77	<.0001
YEAR	109	0.856908597	B	0.09902210	8.65	<.0001
YEAR	110	0.234029619	B	0.09395703	2.49	0.0128
YEAR	111	0.227272244	B	0.16109259	1.41	0.1584
YEAR	112	0.027396047	B	0.12631633	0.22	0.8283
YEAR	999	0.000000000	B	.	.	.
MONTH	1	0.193453647	B	0.03106510	6.23	<.0001
MONTH	2	0.184575468	B	0.03113215	5.93	<.0001
MONTH	3	0.087659747	B	0.03255701	2.69	0.0071
MONTH	4	0.153795923	B	0.03828380	4.02	<.0001
MONTH	5	0.049980713	B	0.04415540	1.13	0.2577
MONTH	6	0.004830969	B	0.08240786	0.06	0.9533
MONTH	7	0.395958188	B	0.06974317	5.68	<.0001
MONTH	8	0.153554383	B	0.05188218	2.96	0.0031
MONTH	9	-0.239301262	B	0.05324094	-4.49	<.0001
MONTH	10	-0.236178487	B	0.04518972	-5.23	<.0001
MONTH	11	-0.214255834	B	0.03814894	-5.62	<.0001
MONTH	12	0.000000000	B	.	.	.
HOLD	1	-0.156825401	B	0.67370762	-0.23	0.8159
HOLD	2	-0.104170414	B	0.03241202	-3.21	0.0013
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.