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An Assessment of the Shrimp Stock in Denmark Strait/off East Greenland – 2005

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 12 500 tons through the recent 17-year period. During the same period a biomass index indicate a decreased steadily from 1987 to 1993, showed an increasing trend until the late 1990s, and fluctuated at this level thereafter. Fishing mortality indices have decline since 1993 and recent levels are the lowest of the time series. From 1996 to 2003 catches in the area south of 65°N exceeded the catches from the northern area. Catches and effort in the area south of 65°N now appears to be decreasing, as the 2004 catches only account for 29% of the total catch.

Sampling of the commercial fishery in recent years has been 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 (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 1970s 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. Since then catches have fluctuated between 9 000-13 000 tons (Fig. 2A). 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, 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 1 000-4 000 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, Norway, Iceland, Faroe Islands and EU-Denmark since 1980 and from EU-France for the years 1980 to 1991 supplied data on catch and effort (hours fished) on a by haul basis. 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 unstandardised 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 and Danish vessels, operating exclusively in the Greenlandic zone and from the Icelandic fleet fishing exclusively in the Icelandic zone (north of 65°N). Norwegian fishery data from 2000-2005 did not include information on different area fished and therefore data was not included in the standardized catch rates calculations.

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 and (4) annual mean CPUE. Input data were mean CPUE by vessel, area, month and year. The calculations were done using the SAS statistical software (Anon., 1988). The 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 57 vessels met the criteria for inclusion in the analysis (at least three years of fishing in the area) i.e. 37 Greenlandic, 12 Faeroese and 4 Danish 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 since 1987. 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 2005 in the northern area (uncorrected data) and from the Icelandic zone (catches was very small in 2005) was unsuitable to further analyses and data from that area was 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. Catches and effort in the area south of 65°N now appears to be decreasing, as the 2004 catches only account for 29% of the total catch (Fig. 5a, b, c).

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. 2A, Table 1 and 2). Following the area expansion of the fishery south of 65°N catches increased again reaching 13 700 tons in 1997. Catches from 1998 to 2004 have been between 10-14 000 tons (Fig. 2A) and the 2005 catches are projected to be at the same level (projected from October)

In the northern area the amount caught has declined by about 75%, i.e. from 15 000 tons in 1988 to about 2 000 tons in 2002 (Fig. 2A). 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. However in 2004 and 2005 2/3 of the total catches taken until October originated from the northern areas.

Catches in the southern area increased from 1900 tons in 1993 - the first year of fishery in this area - to about 9 300 tons in 1997 (Fig. 2A). They then decreased somewhat to about 6-7 000 tons in 1998-2000. In 2001 catches reached 11700 tons declined to 9 000 tons in 2002-2003. In 2004 catches from the southern area was reported to less than 3 000 tons. 2005 figures are expected to be at the same levels.

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 20 000 hr's to a peak of more than 117 000 hr's and then declined again to a low of less than 20 000 hr's in 2002. Since then total effort had been less than 25 000 hr's - the 2005-value is expected to be at the same level as the 2004-value (Fig. 2B).

The historic development of fishing effort spent in the northern areas follow closely the one described for the total area – 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 21 000 hours in 1997. In 1999 it reached a low of 7 500 hr's but increased again to 27000 hr's in 2001. For 2002-2003 effort in the southern areas was down to approx. 11 000 hrs. The 2004 value declined to a historic low at 4 500 hr's, whereas the 2005 level is expected to increased again (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 586 kg/hr in 2003 (Fig. 2C, Table 2). The catch rates for 2004 are and 2005 is down at 400 kg/hr.

In the southern areas CPUE increased from 204 kg/hr in 1993 to 950 kg per hour in 1999. During the following two years the mean CPUE obtained in this area was halved reaching 432 kg/hr in 2001. However CPUE was back at 780 kg/hr in 2002 and 2003. For 2004 and 2005 CPUE is on 400 kg/hr (2005 level registered until October).

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 1994-2001 CPUE's have fluctuated around 225 kg/hr except for an extreme of 146 kg/hr in 1996. Since 2002 annual mean CPUE was above 300 kg/hr, with 329 kg/hr estimated for 2005.

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 70% 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 three years the mean index values have been varying a little above that of 1987. The CPUE index series of the southern area (Fig. 3) increased until 1999. A slight decreasing trend was seen thereafter with the 2005 value being the lowest.

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 1990s. The index values indicate that the stock biomass have stayed at or around this level since then.

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 2005 also depends on the precision with which the catch is projected to the end of the year.

Conclusions

Catches have been relatively stable in the recent 5-10 year period its size dictated mainly by the catch quotas set for the Greenlandic zone (Table 1).

In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. Access to all these fishing grounds depends heavily on ice conditions. From 1996 to 2003 catches in the area south of 65°N accounted for more than 60% of the total catch. Catches and effort in the area south of 65°N now appears to be decreasing, as the 2004 catches only account for 29% of the total catch.

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 the late 1990s, and fluctuated at this level thereafter

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

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..*

Table 1. Catch (tons) of shrimp by the fishery in Denmark Strait/off East Greenland 1978 to October 2005. 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	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]	2004[1,5]	2005[1,2]
North of 65°N																												
Denmark (EU	-	0	878	727	926	255	554	442	626	703	554	454	476	450	199	138	250	302	26	85	401	793	459	72	238	538	812	532
Faroe Islands	-	0	5296	892	922	554	836	843	910	754	847	738	1029	1265	1355	689	462	931	995	635	1268	867	956	214	309	744	1115	1012
France	-	0	63	442	518	364	626	803	976	1305	616	472	62	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenland	-	0	250	1256	1395	1835	2815	3248	7232	8396	9304	7408	7580	5283	2496	1771	1326	2390	359	105	646	614	115	650	152	292	2299	1052
Iceland	363	485	759	125	0	43	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566	2856	1421	769	132	10	1144	635	380	21
Norway	-	1001	3079	2522	2372	2161	2662	2566	2535	2586	2561	2601	3052	3146	3102	1831	2180	2402	1544	797	1628	1783	2759	1291	645	2569	2511	2472
Total	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	6982	5731	7176	3490	4478	5364	4827	4420	2237	2488	4778	7116	5089
South of 65°N																												
Denmark (EU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	613	731	1167	1657	1300	1095	1900	2473	2309	2151	692	1242
Faroe Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	280	974	295	402	656	138	453	340	2402	1013	621	34	138
Greenland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1141	3603	2667	5295	4701	3950	4966	5235	4943	4333	4597	1767	2103
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	424	1011	720	1590	2261	670	378	157	1855	1098	489	375	158
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1904	6201	4412	8453	9276	6057	6893	7632	11674	8753	7858	2869	3641
Total area																												
Denmark (EU	-	0	878	727	926	255	554	442	626	703	554	454	476	450	199	198	863	1033	1193	1742	1701	1888	2358	2545	2548	2688	1504	1774
Faroe Islands	-	0	5296	892	922	554	836	843	910	754	847	738	1029	1265	1355	968	1436	1225	1397	1292	1406	1321	1296	2616	1322	1365	1149	1150
France	-	0	63	442	518	364	626	803	976	1305	616	472	62	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenland	-	0	250	1256	1395	1835	2815	3248	7232	8396	9304	7408	7580	5283	2496	2912	4929	5057	5655	4806	4595	5581	5349	5593	4484	4890	4066	3155
Iceland	363	485	759	125	0	43	742	1794	1150	1330	1431	1326	281	465	1750	2553	1514	1151	566	2856	1421	769	132	10	1144	635	380	21
Norway	-	1001	3079	2522	2372	2161	2662	2566	2535	2586	2561	2601	3052	3146	3102	2255	3190	3122	3133	3059	2298	2160	2917	3147	1743	3059	2886	2630
Total	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944	13754	11422	11719	12053	13911	11242	12637	9985	8730
Total all area	363	1486	10325	5964	6133	5212	8235	9696	13428	15073	15313	12999	12480	10757	8901	8886	11932	11588	11944	13754	11422	11719	12053	13911	11242	12637	9985	8730
Advised TAC	-	-	-	-	4200	4200	4200	5000	-	-	-	10000	10000	10000	8000	5000	5000	5000	5000	5000	5000	9600	9600	9600	9600	9600	12400	12400
Effective TA	-	-	-	8000	4500	5725	5245	6090	7525[5]	7525[5]	8725[5]	9025[5]	14100	14500	13000	9563	9563	9563	9563	9563	9563	10600	12600	10600	10600	10600	15043	12399

[1]Provisional

[2]Catch in 2005 per Oct. 11.

[3]Advised for a few years as a precautionary measure

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

[5]Not including Greenland fishery north of 66°30'N

Table 2. Catch (tons), effort (hr's) 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	72738	172				12480	72738	172
1991	10757	78737	137				10757	78737	137
1992	8901	68349	130				8901	68349	130
1993	6982	52381	133	1904	9335	204	8886	61003	146
1994	5731	25444	225	6201	16361	379	11932	39725	300
1995	7176	34021	211	4412	11328	389	11588	43574	266
1996	3490	23966	146	8453	20136	420	11944	39480	303
1997	4478	19273	232	9276	18895	491	13754	37917	363
1998	5364	21379	251	6057	10231	592	11422	29524	387
1999	4827	20736	233	6893	7256	950	11719	24809	472
2000	4420	19434	227	7632	10385	735	12053	22866	527
2001	2237	9723	230	11674	26241	445	13911	33810	411
2002	2488	7513	331	8753	11579	756	11242	18812	598
2003	4778	14276	335	7858	10067	781	12637	21572	586
2004	7116	20934	340	2869	4517	635	9985	24505	407
2005*	5089	15459	329	3641	7056	516	8730	20942	417

*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 2005. (Logbooks data from the area North of 65°N was to sparse to go into the model.)

	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	0,86	0,09	1,19	0,12					0,87	0,08	1,16	0,10
1989	0,61	0,06	1,41	0,15					0,60	0,05	1,44	0,12
1990	0,61	0,07	1,35	0,15					0,60	0,05	1,38	0,11
1991	0,52	0,05	1,37	0,14					0,51	0,04	1,41	0,12
1992	0,42	0,05	1,39	0,15					0,41	0,04	1,45	0,13
1993	0,36	0,04	1,30	0,14	1,00	-	1,00	-	0,32	0,03	1,83	0,16
1994	0,81	0,10	0,47	0,06	2,48	0,22	1,31	0,11	0,71	0,06	1,12	0,10
1995	0,67	0,08	0,72	0,09	2,44	0,24	0,95	0,09	0,65	0,06	1,18	0,10
1996	0,54	0,07	0,43	0,06	2,78	0,25	1,60	0,14	0,67	0,06	1,19	0,12
1997	0,80	0,12	0,37	0,06	2,93	0,27	1,66	0,15	0,77	0,07	1,19	0,11
1998	1,01	0,14	0,35	0,05	3,50	0,37	0,91	0,09	0,92	0,09	0,83	0,08
1999	0,77	0,13	0,42	0,07	5,53	0,70	0,65	0,08	1,07	0,12	0,73	0,08
2000	0,98	0,18	0,30	0,06	4,50	0,49	0,89	0,09	1,07	0,12	0,75	0,08
2001	0,78	0,23	0,19	0,06	3,58	0,37	1,71	0,17	0,88	0,10	1,04	0,12
2002	1,25	0,29	0,13	0,03	5,15	0,55	0,89	0,09	1,31	0,15	0,57	0,07
2003	0,92	0,16	0,35	0,06	3,99	0,42	1,03	0,10	0,99	0,10	0,84	0,09
2004	1,10	0,20	0,43	0,08	4,64	0,76	0,32	0,05	1,12	0,15	0,59	0,08
2005					3,54	1,03	0,62	0,16	0,87	0,24	0,76	0,21

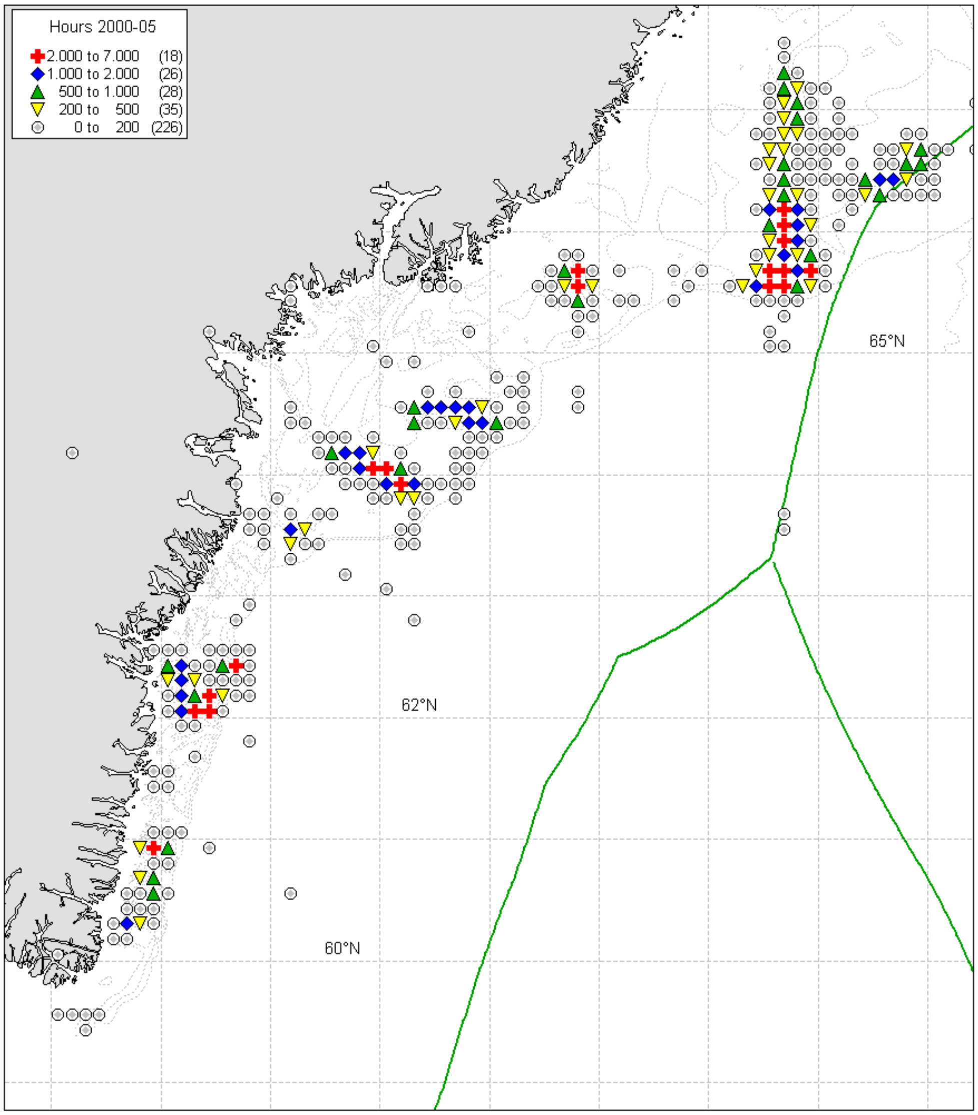


Fig. 1. Thematic mapping of different value of effort (in hours) in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2000-2005.

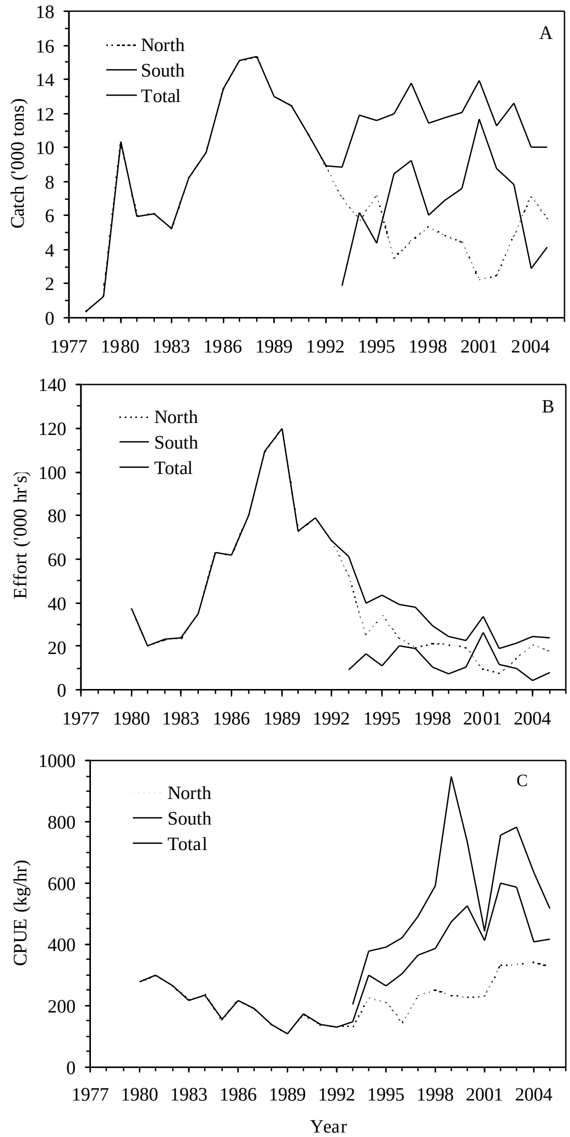


Fig. 2. Catch (A), fishing effort (B) and catch-per-unit-effort (C) by shrimp trawlers fishing in Denmark Strait/off East Greenland. Series are given for the areas north and south of 65°N and overall. Data for 2005 are projected from October to the end of the year.

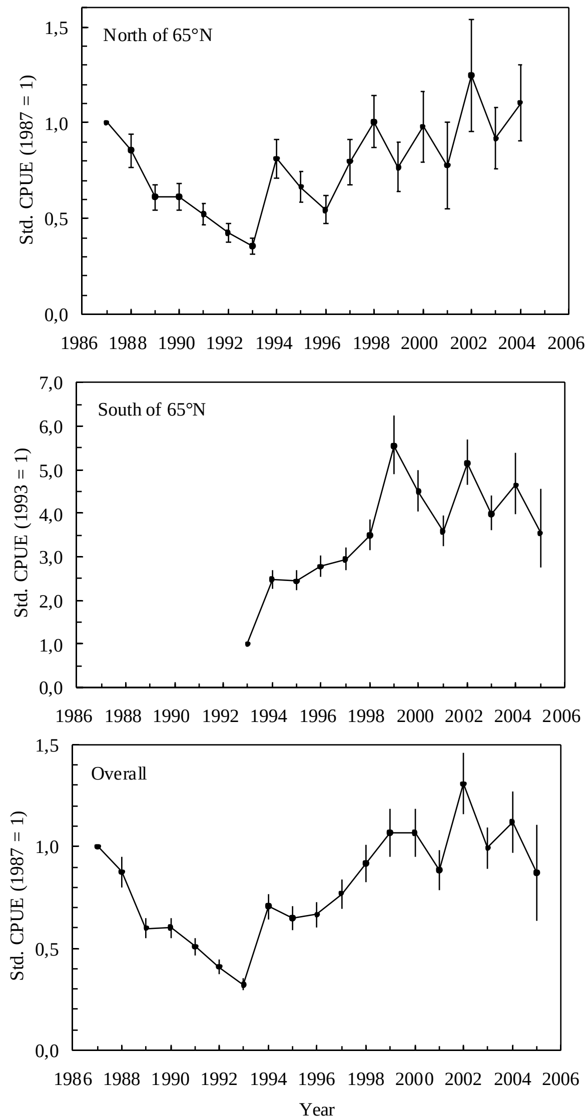


Fig. 3. Standardized Catch-Per-Unit-Effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas south of 65°N, in Iceland EZZ, overall fishery north of 65°N (both in Greenland and Iceland EEZ), and overall standardized CPUE for the stock. Estimates are based on data until September 2005.

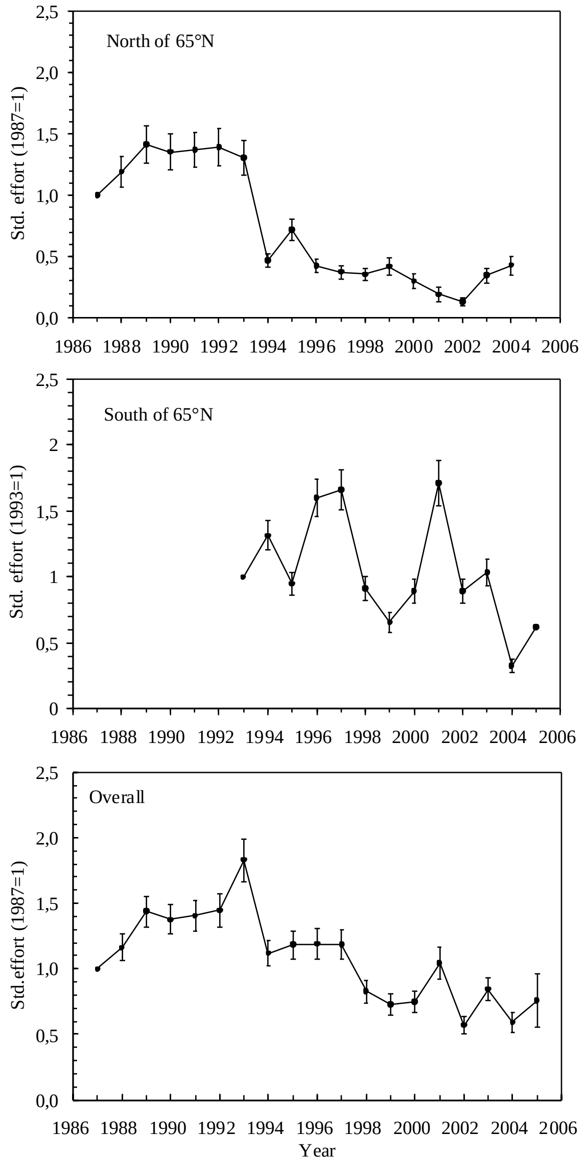


Fig. 4. Standardised effort indices of the shrimp fishery in Denmark Strait and off East Greenland in the areas north of 65°N, south of 65°N and overall. Estimates are based on data until October 2005.

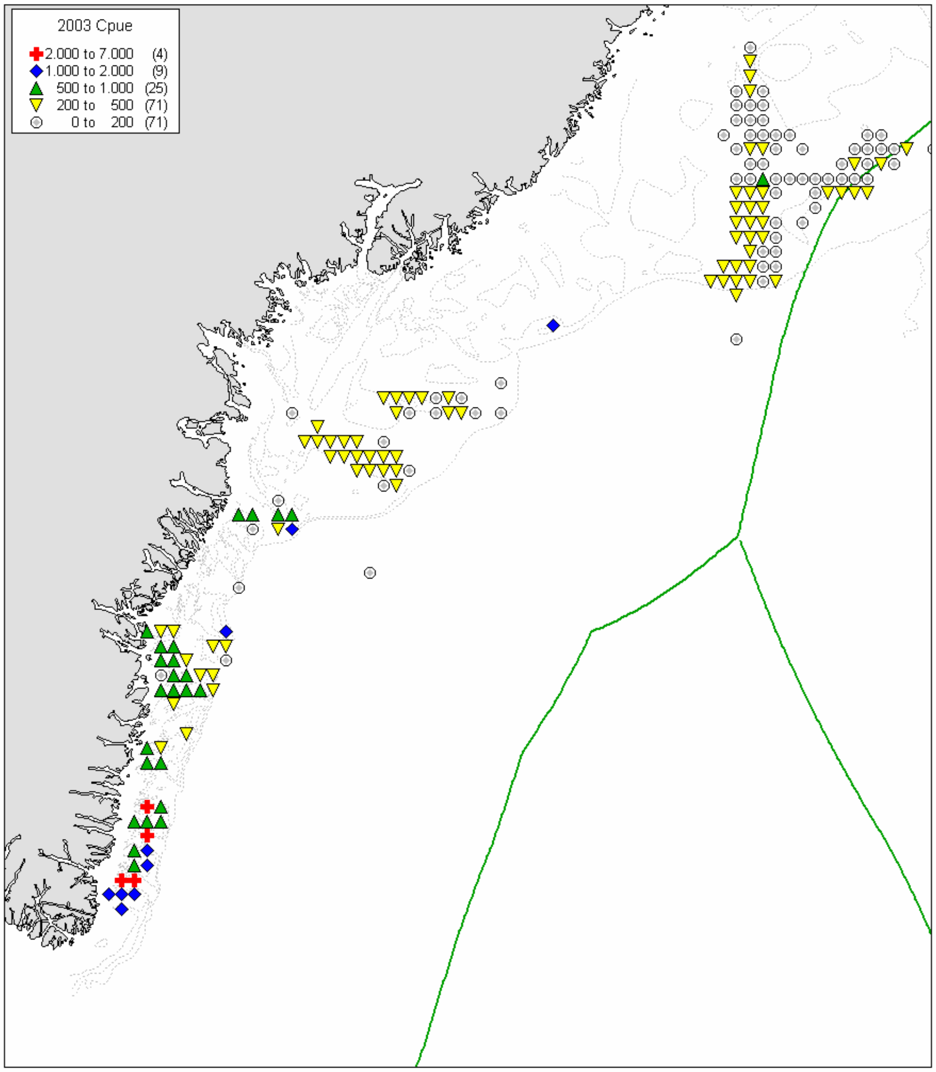


Fig. 5a. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2003.

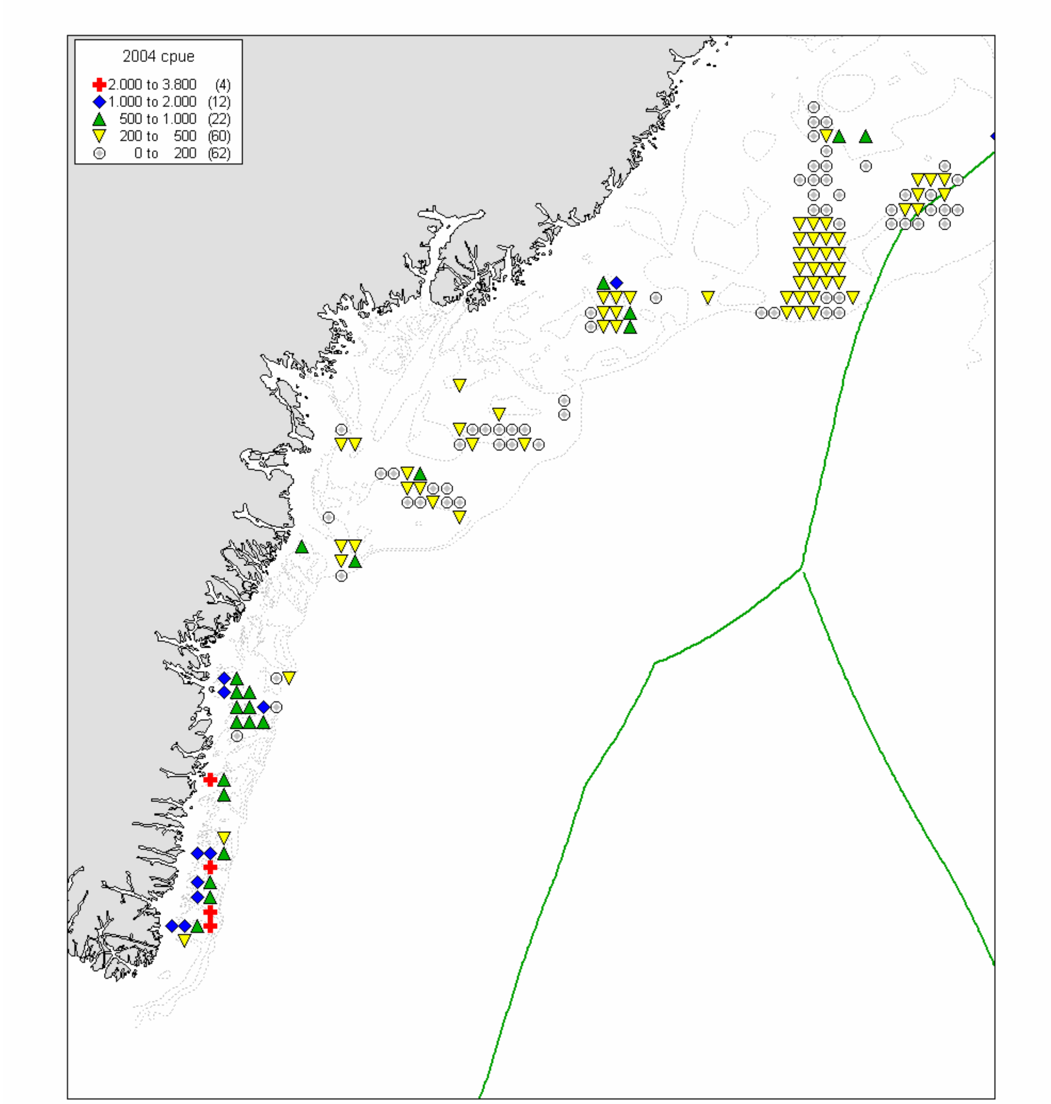


Fig. 5b. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2004.

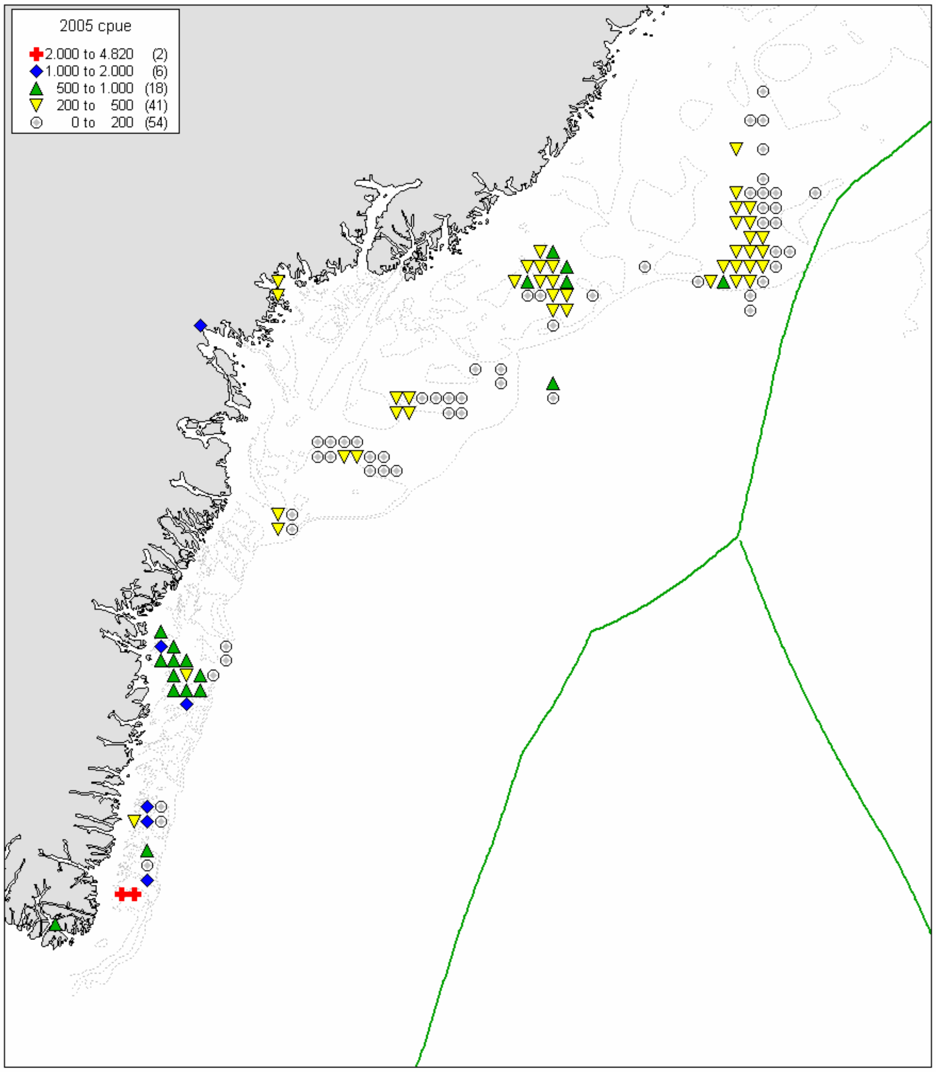


Fig. 5c. Thematic mapping of different levels of CPUE in the shrimp fishery in Denmark Strait/off East Greenland by Greenlandic, Faeroese and Danish trawlers 2005 (until October).

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

Class	Levels	Values
VESSEL	14	AAAA BBBB CCCC DDDD EEEE FFFF GGGG HHHH IIII JJJJ KKKK LLLL MMMM XXXX
YEAR	19	87 88 89 90 91 92 94 95 96 97 98 99 100 101 102 103 104 105 111
MONTH	5	1 3 5 6 12
AREA	2	21 22

Number of Observations Read 2030

Dependent Variable: LNCPUE
Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	48	50270.80860	1047.30851	104.07	<.0001
Error	1981	19935.30696	10.06325		
Corrected Total	2029	70206.11556			

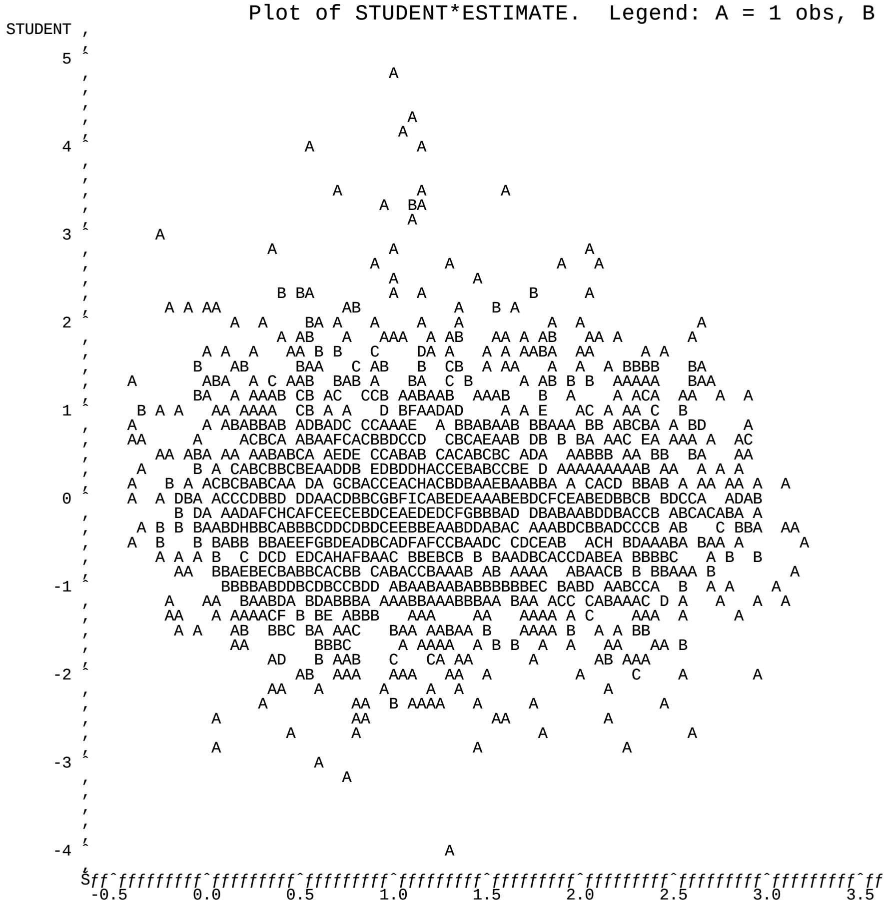
R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.716046	301.6852	3.172263	1.051515

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESSEL	13	25846.81628	1988.21664	197.57	<.0001
YEAR*AREA	31	21290.81234	686.80040	68.25	<.0001
MONTH	4	3133.17998	783.29500	77.84	<.0001
AREA	0	0.00000	.	.	.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	13	8139.81634	626.13972	62.22	<.0001
YEAR*AREA	30	11319.00137	377.30005	37.49	<.0001
MONTH	4	3133.17998	783.29500	77.84	<.0001
AREA	1	3511.19485	3511.19485	348.91	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		1.031305809	B	0.21698146	4.75	<.0001
VESSEL	AAAA	-1.028772570	B	0.20746120	-4.96	<.0001
VESSEL	BBBB	-0.823637966	B	0.20721490	-3.97	<.0001
VESSEL	CCCC	-0.678946636	B	0.20671268	-3.28	0.0010
VESSEL	DDDD	-0.641826094	B	0.20843184	-3.08	0.0021
VESSEL	EEEE	-0.566551822	B	0.20605527	-2.75	0.0060
VESSEL	FFFF	-0.462182267	B	0.20509923	-2.25	0.0243
VESSEL	GGGG	-0.411093187	B	0.21173511	-1.94	0.0523
VESSEL	HHHH	-0.336199153	B	0.20460975	-1.64	0.1005
VESSEL	IIII	-0.281322281	B	0.20789773	-1.35	0.1762
VESSEL	JJJJ	-0.177046438	B	0.21141920	-0.84	0.4025
VESSEL	KKKK	-0.095098355	B	0.20570022	-0.46	0.6439
VESSEL	LLLL	-0.068748608	B	0.20426836	-0.34	0.7365
VESSEL	MMMM	0.202941622	B	0.21175039	0.96	0.3380
VESSEL	XXXX	0.000000000	B	.	.	.
YEAR*AREA	87 21	0.654402849	B	0.08354817	7.83	<.0001
YEAR*AREA	88 21	0.480190407	B	0.07820324	6.14	<.0001
YEAR*AREA	89 21	0.062397785	B	0.07624625	0.82	0.4132
YEAR*AREA	90 21	0.069792493	B	0.07615320	0.92	0.3595
YEAR*AREA	91 21	-0.126618569	B	0.07505888	-1.69	0.0918
YEAR*AREA	92 21	-0.343725551	B	0.07867640	-4.37	<.0001
YEAR*AREA	94 21	0.313029107	B	0.09611166	3.26	0.0011
YEAR*AREA	94 22	0.896440121	B	0.08555868	10.48	<.0001
YEAR*AREA	95 21	0.129394858	B	0.08763163	1.48	0.1399
YEAR*AREA	95 22	0.892288095	B	0.09388974	9.50	<.0001
YEAR*AREA	96 21	-0.078208331	B	0.11251334	-0.70	0.4871
YEAR*AREA	96 22	1.041951311	B	0.08706692	11.97	<.0001
YEAR*AREA	97 21	0.360131503	B	0.13869006	2.60	0.0095
YEAR*AREA	97 22	1.086197455	B	0.09027624	12.03	<.0001
YEAR*AREA	98 21	0.704375897	B	0.12566366	5.61	<.0001
YEAR*AREA	98 22	1.229947646	B	0.10211470	12.04	<.0001
YEAR*AREA	99 21	0.380305611	B	0.15846150	2.40	0.0165
YEAR*AREA	99 22	1.697517197	B	0.11981264	14.17	<.0001
YEAR*AREA	100 21	0.547678752	B	0.16649672	3.29	0.0010
YEAR*AREA	100 22	1.534532539	B	0.10572402	14.51	<.0001
YEAR*AREA	101 21	0.236028963	B	0.27481877	0.86	0.3905
YEAR*AREA	101 22	1.292813228	B	0.09940522	13.01	<.0001
YEAR*AREA	102 21	0.561537166	B	0.21081781	2.66	0.0078
YEAR*AREA	102 22	1.617338102	B	0.10394396	15.56	<.0001
YEAR*AREA	103 21	0.489006912	B	0.17253770	2.83	0.0046
YEAR*AREA	103 22	1.408513841	B	0.10279619	13.70	<.0001
YEAR*AREA	104 21	0.676537044	B	0.17367563	3.90	0.0001
YEAR*AREA	104 22	1.597454537	B	0.15368477	10.39	<.0001
YEAR*AREA	105 21	-0.541840231	B	0.62619943	-0.87	0.3870
YEAR*AREA	105 22	1.322437697	B	0.25635579	5.16	<.0001
YEAR*AREA	111 21	-0.536523427	B	0.08244920	-6.51	<.0001
YEAR*AREA	111 22	0.000000000	B	.	.	.
MONTH	1	0.280312472	B	0.03269379	8.57	<.0001
MONTH	3	0.116171630	B	0.03560317	3.26	0.0011
MONTH	5	0.055613197	B	0.05465263	1.02	0.3090
MONTH	6	-0.228941979	B	0.03544280	-6.46	<.0001
MONTH	12	0.000000000	B	.	.	.
AREA	21	0.000000000	B	.	.	.
AREA	22	0.000000000	B	.	.	.

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



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

Source	DF	Sum of 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

Parameter		Estimate		Standard 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.