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The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2006

by

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Abstract

Northern shrimp (*Pandalus borealis*) occurs on the continental shelf off West Greenland in NAFO Divisions 0A and 1A-1F in depths between approximately 150 and 600 m. Greenland fishes the species in Subarea 1, Canada in Div. 0A; Canadian regulations set a separate shrimp TAC for the part of this Division lying east of 60°30'W (Canadian SFA 1). The species is assessed in these waters as a single stock and managed by catch control. The fishery has been prosecuted over time by four distinct fleets: Greenland small-vessel inshore; Greenland KGH offshore; Greenland recent offshore, and Canadian offshore.

Catches peaked in 1992 at 105 000 tons but then decreased to around 80 000 tons by 1998 owing to management measures. Since then stepwise increases of catch quotas have been accompanied by increased catches. The provisional total catch in 2005, at 138 500 tons, was the highest on record. The Total Allowable Catch (TAC) in Greenland waters for 2006 is set at 134 000 tons, and for the Canadian fishery in the eastern part of Div. 0A 18 381 tons; however, Canadian catches in recent years have stayed at little over 6 000 tons in spite of much higher TACs.

The inshore fishery prosecuted by vessels below 80 GRT accounts for around 15% of the landings.

Reported discard and by-catch of other species are alike low.

Catch and effort data from logbooks was analysed with standard linear models to create fleet-specific series of annual catch-per-unit-effort (CPUE) indices, standardised for changes in fleet composition and fishing power and for variation in the distribution of the fisheries. These were combined to give a single standard CPUE series as an index of total biomass. Standardised CPUE was variable, but on average moderately high, from 1976 through 1987, then fell to uniform lower levels until about 1997. It increased markedly to reach a maximum of about twice its 1997 value in 2004, since when it has slightly declined.

Introduction

Northern shrimp (*Pandalus borealis*) occurs on the continental shelf off West Greenland in NAFO Div. 0A and in Div. 1A-1F. The species is more or less continuously distributed from Cape Farewell to about 74°N, with the highest densities in depths between 150 and 600 m (Fig. 1). Within this habitat area, there is no evidence of sub-structure and since 1993 the species has been assessed as a single stock in these waters (Anon., 1993).

A fishery began in inshore areas in 1935. In 1970 a multinational offshore fishery started to develop and over the following 30+ years landings increased, to approximately 135 000 tons in 2004 (Fig. 2). Catch restrictions were first imposed in 1977 and the fishery has since been managed by Total Allowable Catch (TAC); a system of

Individual Transferable Quotas (ITQs) was introduced in the Greenlandic fishery in 1991. From 1981 until recent years the West Greenland fishery was limited to Greenlandic vessels in NAFO Subarea 1 and to Canadian vessels in NAFO Div. 0A, but pursuant to a new agreement on fisheries between the European Union (EU) and Greenland, an initial quota of 1 000 tons allocated to EU vessels in NAFO Subarea 1 in 2003 has been increased to 4 000 tons in subsequent years.

Two Greenlandic fleets fish in Subarea 1: an offshore fleet, at present consisting of about 9 large factory trawlers (500-4 000 GRT), and a fleet of about 60 vessels below 75 GRT/120 GT. The offshore fleet is restricted to offshore areas and by quotas. With a few exceptions vessels below 80 GRT were unrestricted until 1997, when catch regulation was introduced for this fleet as well. Since 1986 logbook recording of fishing activity has been mandatory for vessels above 50 GRT, and since 1997 logbooks have been available from all vessels. Gear restrictions in place are a mesh-size restriction of 44 mm stretched, and, for the offshore Greenlandic fleet for about the last 5 years, sorting grids with 22 mm spaces between the bars to reduce finfish bycatch. Nordmore grates are also required in the Canadian shrimp fishery in SFA 1 (Orr, pers. comm.).

The Canadian fleet fishes in the Canadian Exclusive Economic Zone, i.e. NAFO Div. 0A. In 1996-2005 on average only about 9 vessels (2 000-4 000 GRT) have participated, slightly more in the most recent years. Catches are restricted by quotas. Vessel logbooks are available since 1979.

Material and Methods

The available data consists of logbook records giving time, date and position of the start and stop of each haul, and weights of catch by product, by-catch, and discards, as well as other reporting records. Total catches were estimated from vessel logs and weekly reporting to Greenlandic authorities. Reported catches were converted to live weight including, for some past data, corrections for 'overpacking' and associated under-reporting (Hvingel, 2003). Logbook data was analysed to show the spatial and temporal distribution of the fishery.

Corrected unstandardised effort was calculated using a factor 1.6 as a multiplier for logbook recorded effort by vessels using twin trawls. Mean unstandardised CPUE was total logbook catch divided by corrected unstandardised CPUE. Unstandardised effort was calculated by dividing total statistical catch by mean CPUE. Standardised effort was calculated by dividing total statistical catch by a standardised CPUE (see below). CPUE data from Greenlandic vessels above 50 GRT fishing in Subarea 1 and Canadian vessels fishing in Div. 0A east of 60°30'W were used in multiplicative models to calculate standardised annual catch-rate indices. Four separate index series covering four fleets were derived (Hvingel *et al*., 2000), and were then combined into a single series representing the total area. Annual CPUE indices for the total area cannot be derived from a single GLM (General Linear Model) run including all fleets as they had no or too little overlap either in time or in space and such a model therefore could not estimate relative fishing power of individual vessels. The four indices included the following variables: (1) vessel fishing power, (2) seasonal availability of shrimp, (3) spatial availability of shrimp and (4) annual mean CPUE. The calculations were done using the SAS statistical software (SAS Institute, 1988). The main criterion for including an individual vessel in either of the multiplicative models was three years of participation in the fishery covered by the index. Hauls by twin-trawls (two complete trawls towed simultaneously) were excluded from the analysis. The area definition used is based on distinct fishing grounds (Fig. 1). The multiplicative model was represented in logarithmic form either as:

Model 1 $$\ln\left(CPUE_{mjki}\right) = \ln\left(u\right) + \ln\left(A_m\right) + \ln\left(S_j\right) + \ln\left(V_k\right) + \ln\left(Y_i\right) + \varepsilon_{mjki}$$

or with a MONTH*AREA interaction (see appendix 1) implying an annual migratory or behavioural pattern:

Model 2 $$\ln\left(CPUE_{mjki}\right) = \ln\left(u\right) + \ln\left(A_m\right) + \ln\left(S_j\right) + \ln\left(AS_{mj}\right) + \ln\left(V_k\right) + \ln\left(Y_i\right) + \varepsilon_{mjki}$$

where $CPUE_{mjki}$ is the observed (logbook) mean CPUE for vessel (or vessel class) k, fishing in area m in month j in year i; $\ln(u)$ is overall mean ln(CPUE); A_m is effect of the mth 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; ε_{mjki} is a variance assumed to be normally distributed as $N(0,\sigma^2/n)$ where n is the number of observations in the cell. The antilogarithms of the year effects have been used as standardised annual CPUE indices. Estimates of the vessel, month and area effects from a first run of the main effects model (Model 1) were compared. Levels within each variable were combined in subsequent analyses if the effect estimates did not differ by

more than 5 percentage points; we note however that posterior grouping on the basis of similar effects causes uncertainty to be underestimated. This was done to reduce the number of empty cells in the models. For further details on model construction and analysis see Hvingel *et al*. (2000).

The '1BCDEF index' largely covers the NAFO Div. 1B to 1F (area 1A was not included owing to misreporting from that area). 40 vessels were included providing data since 1987. These data were grouped into 10 areas (Area 4-13, Fig. 1). Based on an exploratory run of the main effects model (model 1) the vessel effect was collapsed into 27 groups consisting of 1-3 vessels with similar fishing power. The month effect was reduced to 10 levels by grouping adjacent months with similar indices of relative shrimp availability. Areas 7 and 8 and area 9 and 10 were grouped. Compared with model 1, model 2 (month-year interaction term included) produced small changes in year effects, on average about one-half of the estimated standard error, and reduced the estimated standard error of year effects by less than 0.5%. Model 1 without the month-area interaction was therefore preferred and was used.

The 'KGH index' is derived from catches in the early offshore fishery, executed by 7 sister trawlers (722 GRT) operated by the Kongelige Grønlandske Handel (KGH). This fishery only covered Div 1A and part of Div. 1B and data from Area 3, 4, 6 and 7 (Fig. 1) for the years 1976-1990 was considered for this index. The analyses for reducing variable levels showed that 6 of the seven vessels could be treated as a group in the subsequent analyses. The month variable could be reduced to 10 levels and area 4, 6 and 7 combined. This analysis was not repeated and results from Hvingel (2004) were incorporated into the present analysis.

Data for the '0A index' is available since 1980. Division 0A is small and is not subdivided for analysis. A first model for catch/effort ratios included (*inter alia*) vessel identity, tonnage class and horsepower. Tonnage class had no effect on catch effort ratios and was rejected, and horsepower had only small effect—even after tonnage class was thrown out—and was also rejected. Double- and single-trawl data was used in the analysis, the double-trawl effect being fitted by the GLM model and the data standardised to single trawl. Of 45 vessels for which data was available, 22 with reports from fewer than 3 years in the fishery were rejected, and the remainder grouped, on the basis of similar vessel effect estimates in a first GLM run, into 17 small groups. The Division is fished from June through December but effort in June and December has been sparse, especially in recent years, so these two months were not used.

The 'small vessel index' is based on vessels below 75 GRT/120 GT, which have exclusive access to the fishery in 'inshore' areas of West Greenland. This part of the fishery is prosecuted largely in areas around Disko Island in Div. 1A and 1B shown as areas 1, 2 and 3 in Fig. 1. Comprehensive data are available since 1988 and 26 vessels were used in the model. The fishery is active from March-April to December. Vessels were placed in 19 groups each comprising 1-4 vessels of similar estimated fishing power. The 9 fishing months were placed in 5 groups by posterior inspection of their effects.

One unified series of standardised CPUE, covering 1976-2002, was derived by combining these four index series. A Monte Carlo Markov Chain (MCMC) sampling process was used to construct distributions of likelihoods of possible values of this 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 pth fleet, μ_{pi}, was assumed to reflect an overall biomass series, Y_i, and a constant fleet coefficient, v_p, so that:

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

The errors, ε_{pi}, were considered to be distributed with mean zero and with variance σ_{pi}^2 assumed 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 calculat ed in the GLM run. The area weighting factors, a_p, for the 1BCD, KGH, 0A and Small vessel indices were estimated to be 0.46, 0.36, 0.05 and 0.13.

Results and Discussion

Spatial and seasonal distribution

Northern shrimp are fished on the continental shelf of Greenland between 59°N and 74°N, mainly between 150 and 600 m depth, i.e. on the gullies between the offshore banks, in Disko Bay, and on the upper shelf break (Fig. 1). However, during the period of logbook recordings (since 1975) a substantial change in the relative importance of the different areas is indicated . From the mid-1970s until the early 1980s most of the effort was on the relatively wide shelf in Div. 1A and 1B. Divisions 1C and 0A were also fished, but almost no effort was applied in Div. 1D, 1E and 1F (Table 1). From about the mid-1980s, the fishery expanded southward into Division. 1D, and from the early 1990s, significant effort and landings were recorded also in Div. 1E and 1F, although they have small areas of shrimp habitat. The crude catch-effort ratios for Div. 1E and 1F are relatively high from the mid-1990s up to the most recent data.

The southward shift of the offshore fishery 1987-1998 could be summarised by a decreasing mean latitude of effort allocation. Indications of biomass distribution from the German groundfish survey (Rätz, 1997) and the Greenlandic trawl survey (Carlsson and Kanneworff, 1997) have also suggested that the fishery was tracking a southward shift in shrimp biomass, but development of gear that could trawl more effectively on the difficult grounds in the southern areas might also have been an important factor.

The distribution of the fishery has been fairly stable, but in the most recent years there are indications that catch in the southernmost areas has declined, and that the fishery has tended to move back northwards. Preliminary data for 2005-2006 shows 24% of effort in Div. 1D-1F compared with 27% in 2000-2004 and 34% in 1995-99, and 21% of landings compared with 34% and 46% (Table 2, Table 3).

The fishery is active all year, but more so in summer and fall, when monthly landings are 2-3 times the winter minimum (Table 4). A dip in catches commonly occurs in August and September with another peak following in October. In Div. 0A the fishery usually begins in late June or early July and continues into late November, but most of the effort, and catch, comes in August–October.

Catch

Until 2003 catches of shrimp taken in the Greenland Exclusive Economic Zone (EEZ) were systematically under-reported owing to a prevalent practice of 'over-packing' accompanied by reporting of nominal package weight instead of true packed weight. Furthermore, even the nominal weight reported was that of the product, not the live weight of the catch from which it would have been produced, aggravating the problem. Since 1 January 2004 legislation has been in force to ban these practices with a view to ensuring that removals by fishing are reported as catch live weight. Earlier catch data has been revised to correct these biases, and also to correct for unreported catches (Hvingel, 2003).

In conjunction with the development of the offshore shrimp fishery total annual catch increased from about 10 000 tons in the early 1970s to more than 105 000 tons in 1992 (Fig. 2, Table 5). Measures by the Greenland Home Rule Government to reduce effort, as well as improved fishing opportunities elsewhere for the Canadian shrimp fleet, then reduced catches to about 80 000 tons in 1998. Since then increased annual quotas have been accompanied by increased catches.

Since the beginning of the 1970s catches in the inshore areas have been fluctuating between 8 000 and 23 000 tons (Table 5). Limited (no) access for vessels above 80 GRT was the only management constraint on inshore catches until 1997 when ITQs were instituted also for the small-vessel fleet. Inshore catches then decreased substantially while a major reorganisation of the fleet took place. During most of the nineties the inshore fishery had accounted for 19-24% of the total catches, but in 1998 only 13% (10 500 tons) was taken inshore. In 1999 catches were back up near 20 000 tons. However, while the catches of the offshore fishery kept increasing the catches inshore have remained stable. Thus for the most recent three years the inshore fleet has taken 15% of the total Greenlandic catch. The Canadian catches in SFA 1 fluctuated between 1 700 and 5 400 tons between 1979 and 1983, then increasing from 2 100 tons in 1984 to record levels of around 6-7 000 tons in the late 1980s to the early 1990s (Table 5). Catches thereafter declined to around 1 000 tons in 1998 coincident with increased fishing

opportunities off Labrador. From the mid-1990s to the early 2000s catches in Div. 0A have accounted for less than 4% of the total catches off West Greenland. TACs for Div. 0A in recent years have been little less than 20 000 tons, (Table 5) but the catches have been steady at a little under 7 000 tons.

By-catch and discard

The reported discard of shrimp has remained less than 1% (weight) of total catch throughout the period 1975-2004 (Table 6, Table 7). The discard of fish has shown a slightly increasing trend from about 1 to 3% of total catch in the years 1987-1998. The introduction of observers on all offshore vessels in 1991 has most likely contributed to this development by increasing the incentive to report discard. An improved market for smaller shrimp may have offset the corresponding effect of observers on the reported discard of shrimp. In the most recent years registered annual discards of fish have been around 1% of total shrimp catch. Sorting grids with 22 mm grid spacing are mandatory for stern trawlers.

From 1995 to 2006 reports have included overall annual catches of *P. montagui* in the range of about 100 to 2 000 tons (Table 6), which can be landed outside the quota on *P. borealis*. However, landings can be classified as *montagui* while including up to 70% *borealis*, so it has been possible to land substantial unrecorded catches of *borealis*. Therefore it is difficult to use the reporting of *P. montagui* in the catches to infer changes in the targeting strategy of the fishery or as an indication of the availability of this species. However there were indications of increased biomass of *P. montagui* in the mid-1990s (Kanneworff, 2003), and catches since 2000 also appear to have stayed relatively high.

Effort

From 1975, when the offshore fishery was well established, through 1984 annual unstandardised effort showed a slightly increasing trend from about 75 000 hr to about 93 000 hr (Fig. 3). In the subsequent years the offshore fleet was considerably enlarged and effort went up by almost a factor of three reaching 250 000 hr in 1991–1992. Unstandardised effort has since decreased as a result of management measures, reduced activity in Div. 0A (Table 1) and a generally increased fishing efficiency. The increase in the overall unstandardised effort reported, in particular in Div. 1A from 1996 to 1997 (Fig. 3), is due to the addition of logbooks from vessels below 50 tons to the database (introduction of new logbook system). Total unstandardised effort dropped by 34% from 2002 to 2003, but has since changed little.

The trajectory of the standardised effort time series agrees with that of the unstandardised (Table 8, Fig. 3). After 1992, when it reached its highest value, standardised effort decreased steadily—overall by about 35%—to a minimum in 1998-2000. It then increased temporarily to a maximum in 2002 and has since returned to the levels of 1998-2000.

Catch per unit of effort

The unified standardised CPUE index is an aggregate of four individual indices (Table 5) derived by GLM methods for the four fleets (Appendices 1-3). All fleets included in the analysis exploit(ed) mainly shrimp greater than 16 mm cpl. The CPUE indices are therefore indicative of the stock of females and older males combined. The overall combined index (Fig. 4) fluctuated without trend by a factor of 2 between 1976 and 1987. It then dropped precipitously to the lowest levels in the series in 1990–91, and stayed fairly flat until 1997. The CPUE index then increased markedly and sustainedly for 7 years, doubling between 1997 and 2004 to its highest-ever value. Since 2004 the index has decreased slightly by, overall, about 6%.

However, this recent decline is not uniform between the different fleets. The CPUE in the Greenland inshore fishery has increased steadily since 2001—overall by nearly 60%—while the CPUE in the fishery in Canadian SFA1, after higher values in 2002-2003, has returned in 2004-2005 to values closer to that of 2001. CPUE in the Greenland offshore fleet, on the other hand, reached a peak in 2004 and has since declined by 18%. Therefore, the weighting of the different fleets has a large influence in calculating the overall index.

The standardisation method used accounts for the increase in efficiency from renewal of the fleet but does not account for technological improvements, which are likely to occur when older vessels are refitted or upgraded.

However, the YEAR*VESSEL term had low importance in the individual models which suggested that this term could be ignored and the YEAR-effect therefore interpreted as a biomass indicator. Still, the standardised CPUE time series 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).

Catch composition (from Hvingel 2004).

The mean size of shrimp caught decreased during the 1990s. In Subarea 1 it declined by 3 mm cpl. from 1991 to 1999 corresponding to a mean individual weight reduction of about 30%. Mean shrimp size caught in the Canadian fishery in Div. 0A showed a similar declining trend since 1981. In spite of these changes, the proportions of female shrimp in the catches seemed relatively stable in the late 1990s. The decrease in size may be partly due to better market prices for small shrimp along with a thorough restructuring of the Greenlandic offshore fleet during this period, leaving most vessels with a big enough quota to make 'high-grading' less profitable. However, the decline of shrimp size in the catches was temporarily reversed in 2000, with the appearance of a relatively high proportion of females. The length distribution for 2000 showed a large peak of female shrimp at around 25 mm cpl..

The data from 2001 did not indicate an equally good catch quality. The length distribution showed a dominant peak of male shrimp at around 20 mm cpl. The female component was less prominent, but all sizes normally present in the catches were represented. For 2002 only three samples were available and therefore the size composition of the catch was uncertain. However, no major changes from the previous year were indicated. Catch compositions for 2003-2005 have not been evaluated owing to sparse—or no—sampling. However, for what it's worth, a classification of reported catches according to logbook commercial codes (Table 9) appears to support the suggestion of a decrease in size, with the proportion of the catch in the offshore fleet classified as 'large' declining even into the most recent years. The ratio of 'small' to 'large' has not changed as much, in fact being low in 2000-2004, but it is expected that the increasing proportion 'unsorted' also reflects a decreasing average size. These classification will, however, probably depend not only on the size composition of the standing stock, but also on prices and access to markets.

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Table 1. Annual catch, effort and CPUE of the shrimp fishery on the West Greenland shelf by NAFO Divisions. Data from logbooks, weighted up to annual total catch.

Year	Catch ('000 tons)							Effort ('000 hr's)							CPUE (kg/hr)						
	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F
1975	0.0	0.0	44.6	2.0	0.0	0.0	0.0	-	0.0	70.5	3.6	0.0	0.0	0.0	-	-	632	551	-	-	-
1976	0.4	0.0	54.7	6.3	0.0	0.0	0.0	-	0.1	70.1	8.0	0.1	0.8	1.1	-	-	780	785	-	-	40
1977	0.5	0.2	47.8	3.1	0.1	0.0	0.0	-	0.5	67.8	4.4	0.5	0.0	0.0	-	357	705	691	253	-	-
1978	0.1	0.5	40.9	0.5	0.2	0.0	0.0	-	1.4	80.7	1.3	0.8	0.0	0.0	-	382	507	416	259	-	-
1979	1.7	4.8	35.7	0.5	0.0	0.0	0.0	7.3	6.7	64.1	1.5	0.1	0.0	0.0	236	719	557	348	112	-	-
1980	2.7	14.6	35.0	3.3	0.3	0.0	0.0	11.6	21.2	53.3	4.9	0.5	0.0	0.0	235	690	655	668	596	-	-
1981	5.3	5.7	37.5	5.3	0.0	0.0	0.0	16.6	11.2	66.4	10.4	0.1	0.0	0.0	318	511	564	510	409	-	-
1982	2.1	0.8	43.2	8.2	0.0	0.0	0.0	6.7	1.7	65.7	13.5	0.1	0.0	0.0	309	472	657	604	388	-	-
1983	5.4	0.5	40.5	9.4	0.5	0.0	0.0	17.4	0.9	69.5	17.8	0.9	0.0	0.0	311	559	582	528	531	-	614
1984	2.1	1.2	30.4	17.0	2.1	0.0	0.0	7.7	2.7	51.1	28.4	2.7	0.0	0.1	280	431	595	598	785	-	47
1985	3.1	8.1	35.5	14.9	4.7	0.0	0.0	18.2	28.7	66.2	25.6	8.7	0.0	0.0	169	282	536	580	540	-	-
1986	3.0	26.3	32.4	9.2	6.0	0.0	0.0	6.7	54.2	55.2	14.1	9.6	0.1	0.1	445	485	586	649	624	273	-
1987	6.1	19.4	43.7	7.3	1.3	0.0	0.0	11.1	54.4	67.9	10.7	4.2	0.0	0.0	550	357	644	685	324	-	-
1988	5.9	12.4	47.5	7.1	0.5	0.0	0.1	10.7	40.9	94.3	14.7	2.0	0.0	1.0	550	302	504	486	268	-	153
1989	7.2	16.3	33.7	12.9	10.0	0.0	0.5	16.9	47.5	77.6	30.5	19.8	0.0	4.2	428	344	435	422	507	-	111
1990	6.2	12.2	30.0	22.7	12.4	0.0	0.5	13.8	42.3	77.4	56.1	30.8	0.0	2.8	446	288	387	405	403	-	165
1991	6.8	12.7	32.8	18.8	19.6	0.6	0.2	19.6	37.1	89.9	52.6	49.2	0.7	1.3	346	341	365	357	398	824	191
1992	7.5	16.3	32.8	19.9	23.4	5.0	0.6	16.6	49.4	76.1	48.0	51.7	7.8	1.3	451	330	431	415	452	642	497
1993	5.5	7.6	36.2	15.8	18.1	4.5	3.2	12.2	23.0	82.0	41.3	44.3	8.0	7.6	450	331	442	383	410	559	425
1994	4.8	7.3	33.6	15.9	19.9	7.0	4.2	15.3	23.4	84.0	40.9	42.7	9.6	9.3	312	313	401	390	467	736	450
1995	2.4	6.9	27.1	15.5	22.0	8.6	4.9	7.3	21.0	69.0	33.8	40.8	12.3	7.9	322	331	393	458	539	696	624
1996	2.6	5.4	22.4	16.8	23.3	8.3	5.3	8.4	18.5	51.0	35.0	39.3	11.8	9.1	312	293	439	481	594	700	579
1997	0.5	7.4	20.1	11.5	22.6	8.5	7.6	0.9	44.0	53.4	24.0	39.2	11.6	12.6	597	167	377	477	576	730	605
1998	0.9	4.5	22.6	13.5	21.1	8.7	9.0	2.0	20.1	48.8	25.4	34.2	10.6	13.5	473	226	463	532	618	817	671
1999	2.0	9.1	28.3	14.6	19.0	8.3	10.8	4.1	34.4	58.3	22.5	27.0	9.2	12.9	504	263	485	650	704	902	839
2000	1.6	15.0	29.0	15.0	19.0	7.0	11.5	2.0	36.6	51.3	20.3	26.2	7.7	14.1	811	409	565	737	727	909	810
2001*	3.6	14.5	27.3	17.1	20.8	8.0	11.6	4.2	41.3	49.0	21.1	27.4	7.7	11.8	868	351	558	810	760	1029	980
2002*	6.2	15.5	43.7	26.7	25.2	8.6	10.4	6.9	42.4	58.8	27.7	28.4	7.0	10.5	901	366	743	963	888	1216	989
2003*	6.6	12.9	38.9	22.8	21.3	7.4	9.9	6.1	30.2	38.1	15.9	16.1	4.9	9.3	1081	427	1021	1440	1324	1512	1061
2004*	7.1	11.9	46.8	28.7	21.0	4.9	8.2	9.2	30.2	45.7	16.3	11.9	2.5	10.1	766	393	1024	1761	1764	1918	813
2005*	6.9	10.0	64.1	29.5	15.6	4.7	7.7	7.6	20.8	52.2	14.7	9.3	4.6	13.8	911	481	1228	2008	1674	1022	557
2006**	6.1	7.5	74.8	24.2	15.0	7.0	5.4	6.8	13.9	54.9	12.1	8.5	8.2	10.2	410	541	1363	2009	1769	855	529

Table 2. Distribution (%; columns sum to 100) of landings of northern shrimp between Divisions in NAFO Subarea 1 by 5-year period.

	5-year period						
	75–79	80–84	85–89	90–94	95–99	00–04	05–06
1A	4.7	9.2	23.5	12.8	8.2	12.2	6.9
1B	91.8	72.1	56.0	38.2	29.1	33.6	51.3
1C	3.3	17.4	13.9	21.5	17.2	20.0	20.8
1D	0.2	1.3	6.4	21.5	26.0	19.0	11.6
1E	0.0	0.0	0.0	4.0	10.2	6.2	4.2
1F	0.0	0.0	0.2	2.1	9.3	9.0	5.2

Table 3. Distribution (%; columns sum to 100) of fishing effort[1] for northern shrimp between Divisions in NAFO Subarea 1 by 5-year period.

	5-year period						
	75–79	80–84	85–89	90–94	95–99	00–04	05–06
1A	4.2	9.3	30.6	16.0	16.8	25.1	16.2
1B	91.9	71.4	49.9	37.6	32.8	33.8	47.2
1C	3.4	18.1	12.6	21.9	16.2	14.1	12.2
1D	0.5	1.1	6.0	20.0	21.0	15.1	8.0
1E	0.1	0.0	0.0	2.4	6.5	4.1	5.3
1F	0.1	0.0	0.9	2.1	6.7	7.8	11.1

[1] uncorrected trawl time

Table 4. Shrimp catch on the West Greenland shelf by month 1987-2005, summed from vessel logs and weighted up** to total catch.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	5793	740	0	0	438	10930	10454	11543	11238	8232	1960	87
1977	3063	3145	2232	2783	4082	5656	5955	4979	4139	6317	5666	3597
1978	975	369	156	778	5919	6644	6126	6331	4455	3563	3522	3481
1979	2429	542	5244	6444	6184	5250	4298	3905	2349	1566	3005	1619
1980	4650	4597	4977	5892	7072	7454	6659	5224	5501	2507	0	576
1981	3563	3553	2966	4280	7156	4890	7118	7121	4474	3171	3431	2105
1982	3422	708	0	2443	8342	7736	6784	7802	4741	6905	4239	1170
1983	36	247	575	2031	7657	7838	9260	6854	5952	6783	5627	3355
1984	43	494	4425	7258	9506	8936	7733	3447	1553	3759	4238	1414
1985	2109	3513	5363	3420	5318	7221	6889	9116	6051	8734	6047	2428
1986	3337	3152	3553	5311	7038	9642	8287	6963	8376	13993	4302	2914
1987	2979	1732	4749	6167	7615	8167	9707	10339	7869	10725	4970	2912
1988	2318	2914	3588	7443	7636	7664	8835	8385	9110	7528	5412	2784
1989	2513	3029	4344	7873	6499	10254	13429	9699	6997	7884	4748	3403
1990	4097	4286	4953	8454	9011	8971	8983	8211	7383	7068	7942	4540
1991	4103	3652	4056	3835	6417	9438	11591	9941	8653	10243	11234	8326
1992	4695	3590	6037	6724	8463	11197	11440	10877	11378	13588	10273	7210
1993	2640	3164	4357	5950	7671	7990	8703	9660	10352	12585	11010	6937
1994	4321	3905	6567	8553	7342	7165	9656	9407	10677	11705	7942	5565
1995	3851	5268	7792	10377	8137	7761	8575	8932	8399	8010	6283	4004
1996	4028	6408	7885	9144	8873	8793	8842	9447	8570	6118	3302	2684
1997	3633	5995	6273	6562	7664	8185	9513	8061	7882	7277	5037	2047
1998	8626	6420	5896	9980	10438	10505	10306	5014	5366	3549	2635	1758
1999	5025	5643	7375	8133	9369	8564	11077	8737	8370	8201	6619	5078
2000	4440	6528	7491	9121	9738	11435	11580	8574	7934	6922	8377	5831
2001*	4288	5471	6248	5763	8623	11194	12545	12011	9930	10981	8164	7708
2002*	8893	6023	8055	11577	12433	12337	15797	14808	12504	11596	12820	9455
2003*	7874	7343	9764	10883	11689	10328	10019	10623	12992	10951	10042	7249
2004*	7201	7720	7971	11084	12647	12656	11505	9180	14000	12866	11564	10089
2005*	9415	7731	11198	13060	13374	13448	13529	14650	12379	11279	9218	9270
2006**	12636	11732	13937	10939	13905	10661	11716	2114				

* Provisional; ** 2006 partial data; log-book catches as reported, not weighted up.

Table 5a. Catch, effort and CPUE statistics for the shrimp fishery on the West Greenland shelf, 1970-1989.

Year	TAC (t)			Catch (t)					Effort				CPUE			
	SA 1*	Div. 0A	Total	SA 1			Div. 0A	Total	SA 1	Div. 0A	Total	Total	SA 1	Div. 0A	Total	Total
				Offshore	Inshore	Total	Offshore		Unstd. ('000 hr)			Std. (index)	Unstd. (kg/hr)			Std. ('76=1)
1970	no	no	no	1243	9272	10515	0	10515	-	-	-	-	-	-	-	-
1971	no	no	no	1978	9615	11593	0	11593	-	-	-	-	-	-	-	-
1972	no	no	no	3786	8076	11862	0	11862	-	-	-	-	-	-	-	-
1973	no	no	no	6785	8745	15530	0	15530	-	-	-	-	-	-	-	-
1974	no	no	no	15967	11070	27038	0	27038	-	-	-	-	-	-	-	-
1975	no	no	no	36977	9570	46547	0	46547	74.2	-	74	-	628	-	628	-
1976	no	no	no	52993	8030	61023	392	61415	80.1	-	80	1.00	762	-	766	1.00
1977	-	-	36000	42578	8580	51158	457	51615	73.1	-	73	0.93	699	-	706	0.91
1978	-	1000	41000	33835	8360	42195	122	42317	84.2	-	84	0.97	501	-	503	0.71
1979	-	2000	31500	32852	8250	41102	1732	42834	72.4	7.3	80	1.09	568	236	537	0.64
1980	-	2500	32000	44916	8250	53166	2726	55892	80.0	11.6	92	1.17	665	235	610	0.78
1981	35000	5000	40000	40295	8250	48545	5284	53829	88.2	16.6	105	1.20	551	318	514	0.73
1982	34800	5000	39800	43979	8250	52229	2064	54293	81.1	6.7	88	0.94	644	309	619	0.94
1983	34625	5000	39625	42553	8250	50803	5413	56216	89.0	17.4	106	1.12	571	311	528	0.82
1984	34925	5000	39925	42414	8250	50664	2142	52806	85.0	7.7	93	1.11	596	280	570	0.77
1985	42120	6120	48240	54889	8250	63139	3069	66208	129.1	18.2	147	1.33	489	169	449	0.81
1986	42120	6120	48240	65623	8250	73873	2995	76868	133.4	6.7	140	1.45	554	445	549	0.87
1987	40120	6120	46240	64222	7613	71836	6095	77931	137.1	11.1	148	1.23	524	550	526	1.03
1988	40120	6120	46240	56479	11256	67735	5881	73616	152.9	10.7	164	1.70	443	550	450	0.70
1989	45245	7520	52765	58890	14546	73436	7235	80671	179.6	16.9	196	2.27	409	428	411	0.58

Notes: in 1981–1995 quotas applied to the offshore area only;

Table 5b. Catch, effort and CPUE statistics for the shrimp fishery on the West Greenland shelf, 1990-2006.

Year	TAC (t)			Catch (t)					Effort				CPUE			
	SA 1*	Div. 0A	Total	SA 1			Div. 0A	Total	SA 1	Div. 0A	Total	Total	SA 1	Div. 0A	Total	Total
				Offshore	Inshore	Total	Offshore		Unstd. ('000 hr)			Std. (index)	Unstd. (kg/hr)			Std. ('76=1)
1990	45245	7520	52765	62800	14993	77793	6177	83970	209.5	13.8	223	2.32	371	446	376	0.59
1991	46225	8500	54725	66818	17884	84701	6788	91489	230.8	19.6	250	2.46	367	346	365	0.61
1992	44200	8500	52700	75341	22653	97994	7493	105487	234.2	16.6	251	2.57	418	451	421	0.67
1993	40600	8500	49100	65894	19627	85522	5491	91013	206.1	12.2	218	2.27	415	450	417	0.65
1994	42300	8500	50800	68109	19930	88039	4766	92805	209.8	15.3	225	2.37	420	312	412	0.64
1995	39500	8500	48000	66955	18072	85027	2361	87388	184.7	7.3	192	2.07	460	322	455	0.69
1996	63922	8500	72422	62368	19095	81463	2632	84095	164.6	8.4	173	1.94	495	312	486	0.71
1997	64600	8500	74800	62743	14868	77611	517	78128	184.9	0.9	186	1.75	420	597	421	0.73
1998	60729	7650	68379	69156	10406	79562	933	80495	152.7	2.0	155	1.62	521	473	520	0.81
1999	71000	9350	80350	71197	18948	90145	2046	92191	164.4	4.1	168	1.67	548	504	547	0.90
2000	71000	9350	80350	73013	23365	96378	1588	97966	156.2	2.0	158	1.53	617	811	619	1.04
2001'	82000	12040	94040	79291	20010	99301	3625	102926	158.3	4.2	162	1.63	627	868	633	1.03
2002'	97300	12040	109340	108135	21917	130052	6247	136299	174.8	6.9	182	1.83	744	901	750	1.21
2003'	101000	14167	115167	95875	17291	113166	7137	120303	114.4	6.6	121	1.53	989	1081	994	1.28
2004'	135352	14167	149519	102014	19415	121429	7054	128483	116.7	9.2	126	1.41	1040	766	1020	1.49
2005'	134000	14167	148167	112329	19301	131630	6921	138551	115.5	7.6	123	1.57	1140	911	1126	1.44
2006"	134000	18381	152381	115565	18435	134000	6197	140197	107.7	6.9	115	1.60	1244	410	1223	1.42

Notes: * in 1981-1995 quotas applied to the offshore area only; ' preliminary; " projected from logbook data available and assuming the Greenland quota will be caught, and the catch in Canadian SFA1 at the mean of the previous 5 years.

Table 6. Discards of shrimp and fish and landed catch reported as *P. montagui* in the shrimp fishery in NAFO Subarea 1.

Year	P. borealis		Fish		P. montagui
	discard (tons)	discard (%)	discard (tons)	discard (%)	landed (tons)
1975	0	0.0	0	0.0	0
1976	0	0.0	0	0.0	0
1977	0	0.0	23	0.0	0
1978	0	0.0	27	0.1	0
1979	0	0.0	151	0.4	0
1980	0	0.0	186	0.3	0
1981	0	0.0	725	1.5	0
1982	0	0.0	788	1.5	0
1983	0	0.0	964	1.9	0
1984	0	0.0	1311	2.6	0
1985	149	0.2	1501	2.4	0
1986	110	0.1	1639	2.2	0
1987	182	0.3	885	1.2	0
1988	209	0.3	1067	1.6	0
1989	197	0.3	1403	1.9	0
1990	263	0.3	1261	1.6	0
1991	407	0.5	2053	2.4	0
1992	335	0.3	2162	2.2	0
1993	250	0.3	1906	2.2	0
1994	331	0.4	2671	3.0	5
1995	476	0.6	2700	3.2	562
1996	324	0.4	2712	3.3	773
1997	310	0.4	2327	3.0	422
1998	314	0.4	2183	2.7	1253
1999	197	0.2	0	0.0	4
2000	268	0.3	685	0.7	305
2001*	382	0.4	1122	1.1	882
2002*	655	0.5	1285	1.0	227
2003*	587	0.5	1187	1.0	889
2004*	650	0.5	891	0.7	709
2005*	661	0.5	863	0.7	449
2006**	755	0.6	917	0.7	1927

** projections from part-year's data; * provisional data.

Table 7. Catches* (tons) of fish in Canadian offshore fisheries in eastern Davis Strait.

	Fish Catch	Shrimp	Percent
1979	186	1732	10.7
1980	104	415	25.1
1981	789	4419	17.9
1982	230	2818	8.1
1983	137	2096	6.5
1984	231	1569	14.7
1985	377	2449	15.4
1986	867	2972	29.2
1987	696	3406	20.4
1988	707	3479	20.3
1989	1848	7360	25.1
1990	1354	5663	23.9
1991	2496	6849	36.4
1992	2457	7480	32.8
1993	1426	5275	27.0
1994	1498	4355	34.4
1995	740	2275	32.5
1996	612	2673	22.9
1997	67	520	12.9
1998	115	819	14.1
1999	131	2081	6.3
2000	35	1676	2.1
2001	84	3443	2.5
2002	176	5966	3.0
2003	196	5439	3.6
2004	352	7155	4.9
2005	228	6077	3.8
2006†	5	96	5.6

* not clear whether this is by-catch in the shrimp fishery, or whether directed catches in other fisheries are included.

† very partial data

Table 8. Standardised (1990=1) CPUE series for 4 fleets fishing northern shrimp in West Greenland waters and a combined standardised (1976=1) CPUE series for the fishery.

	1BCD		**KGH**		**Small ves.**		**0A**		**Combined**		
Year	mean	se	mean	se	mean	se	mean	se	25%	median	75%
1976	-	-	1.66	0.15	-	-	-	-	0.84	1.00	1.19
1977	-	-	1.56	0.09	-	-	-	-	0.81	0.91	1.01
1978	-	-	1.23	0.07	-	-	-	-	0.64	0.71	0.77
1979	-	-	1.11	0.07	-	-	-	-	0.58	0.64	0.70
1980	-	-	1.34	0.08	-	-	-	-	0.70	0.78	0.86
1981	-	-	1.27	0.07	-	-	1.24	0.16	0.67	0.73	0.80
1982	-	-	1.61	0.10	-	-	1.26	0.26	0.83	0.94	1.05
1983	-	-	1.42	0.09	-	-	-	-	0.73	0.82	0.92
1984	-	-	1.34	0.08	-	-	-	-	0.70	0.77	0.86
1985	-	-	1.43	0.08	-	-	0.41	0.20	0.73	0.81	0.90
1986	-	-	1.49	0.09	-	-	-	-	0.77	0.87	0.97
1987	1.76	0.09	1.79	0.11	-	-	0.96	0.15	0.96	1.03	1.11
1988	1.15	0.03	1.47	0.09	1.27	0.05	0.94	0.09	0.69	0.70	0.72
1989	0.96	0.02	1.09	0.07	1.01	0.03	0.89	0.05	0.57	0.58	0.59
1990	1.00	-	1.00	-	1.00	-	1.00	-	0.59	0.59	0.59
1991	1.02	0.02	-	-	0.87	0.02	0.84	0.04	0.59	0.61	0.62
1992	1.13	0.02	-	-	0.92	0.03	0.96	0.05	0.66	0.67	0.68
1993	1.08	0.02	-	-	1.01	0.03	0.98	0.05	0.64	0.65	0.66
1994	1.09	0.02	-	-	0.88	0.02	0.70	0.04	0.63	0.64	0.65
1995	1.19	0.02	-	-	0.88	0.02	0.78	0.05	0.67	0.69	0.70
1996	1.27	0.03	-	-	0.85	0.03	0.67	0.04	0.69	0.71	0.72
1997	1.30	0.03	-	-	0.85	0.02	0.95	0.13	0.71	0.73	0.74
1998	1.41	0.03	-	-	1.00	0.03	0.76	0.08	0.78	0.81	0.83
1999	1.64	0.04	-	-	1.05	0.03	0.90	0.06	0.87	0.90	0.93
2000	1.77	0.05	-	-	1.38	0.04	1.18	0.11	1.00	1.04	1.08
2001	1.84	0.05	-	-	1.23	0.04	1.29	0.09	0.99	1.03	1.07
2002	2.11	0.05	-	-	1.53	0.05	1.51	0.10	1.16	1.21	1.27
2003	2.22	0.06	-	-	1.60	0.05	1.69	0.11	1.22	1.28	1.35
2004	2.87	0.08	-	-	1.75	0.05	1.27	0.08	1.40	1.49	1.57
2005	2.53	0.07	-	-	1.87	0.06	1.34	0.09	1.36	1.44	1.53
2006	2.35	0.09	-	-	1.95	0.09	0.40	0.31	1.32	1.42	1.53

Table 9. Percentage of catch classified as 'small', 'large' and 'unsorted' in the West Greenland shrimp fishery, 1985–2006, from logbook data.

		85–89	90–94	95–99	00–04	05–06	Overall
Inshore							
	Small, %	32.0	36.6	16.1	3.1	8.7	15.1
	Large, %	8.9	16.0	7.4	5.9	7.4	8.1
	Small:Large	3.6	2.3	2.2	0.5	1.2	1.9
	Unsorted, %	59.1	47.4	76.5	91.0	83.9	76.8
Offshore							
	Small, %	28.3	39.0	39.5	20.1	17.5	29.0
	Large, %	40.8	48.6	36.1	24.3	15.1	33.1
	Small:Large	0.7	0.8	1.1	0.8	1.2	0.9
	Unsorted, %	30.9	12.5	24.4	55.6	67.4	37.9
Overall							
	Small, %	29.2	38.4	33.8	13.9	13.4	24.7
	Large, %	32.4	40.5	29.1	17.6	11.5	25.4
	Small:Large	0.9	0.9	1.2	0.8	1.2	1.0
	Unsorted, %	38.3	21.1	37.1	68.5	75.1	49.9

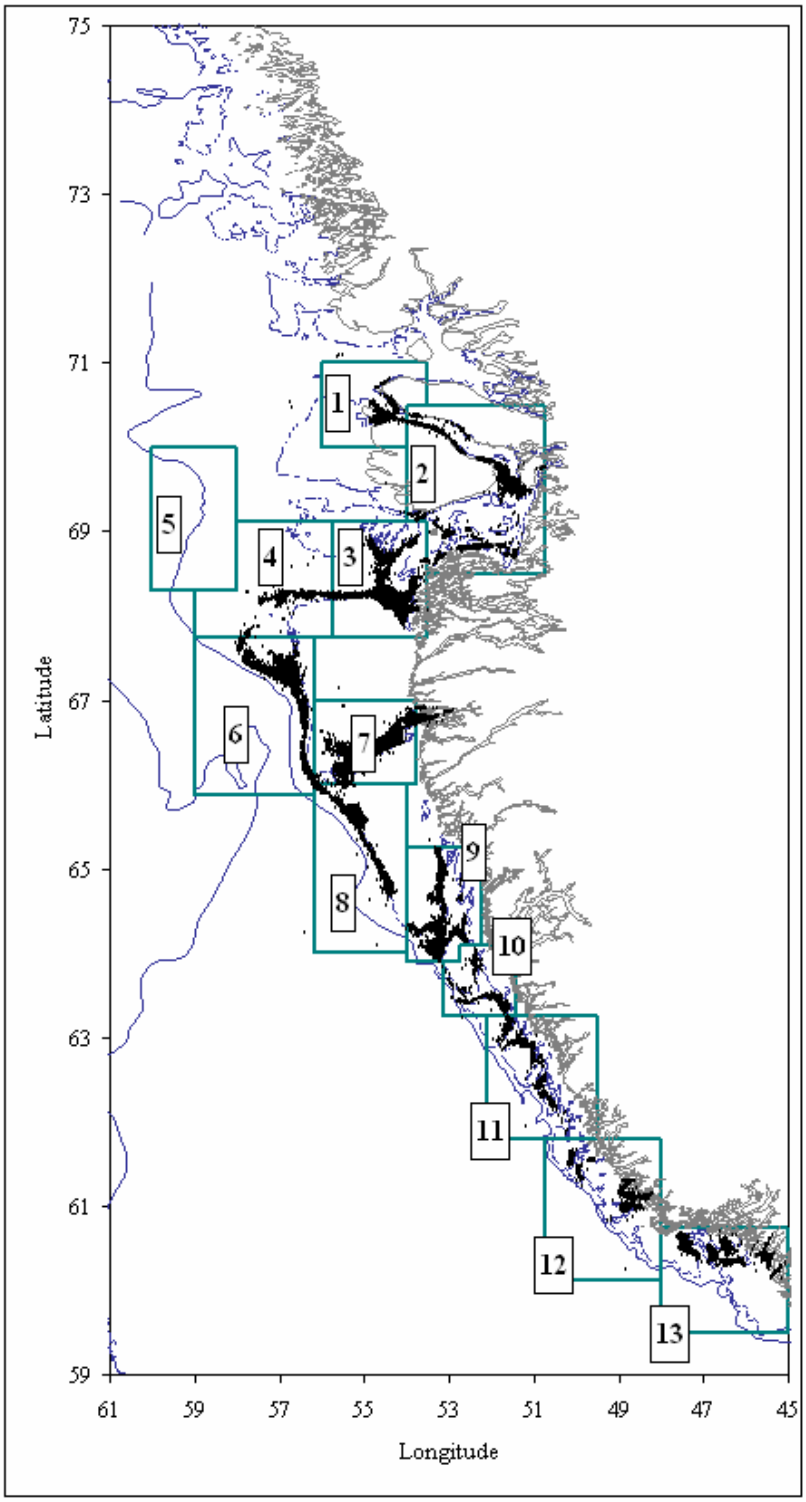

Fig. 1. Distribution of the fishery for Northern Shrimp in NAFO Subarea 1 from July 2005 through June 2006, showing subdivisions used for statistical (GLM) analyses.

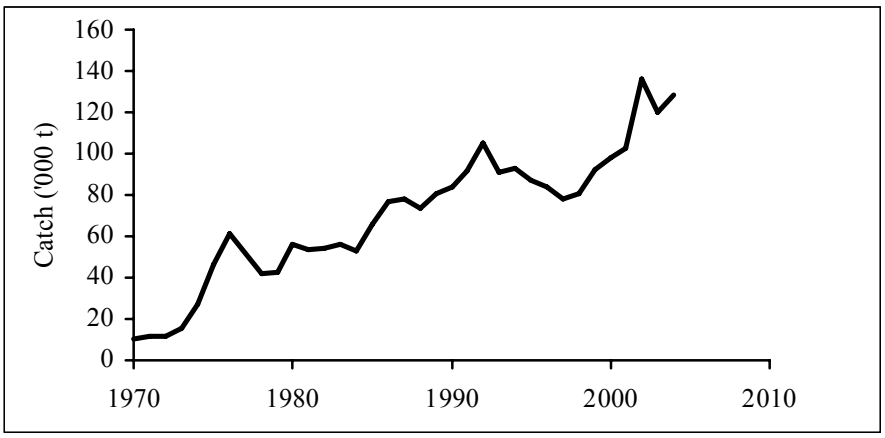

Fig. 2. Catches in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970-2005.

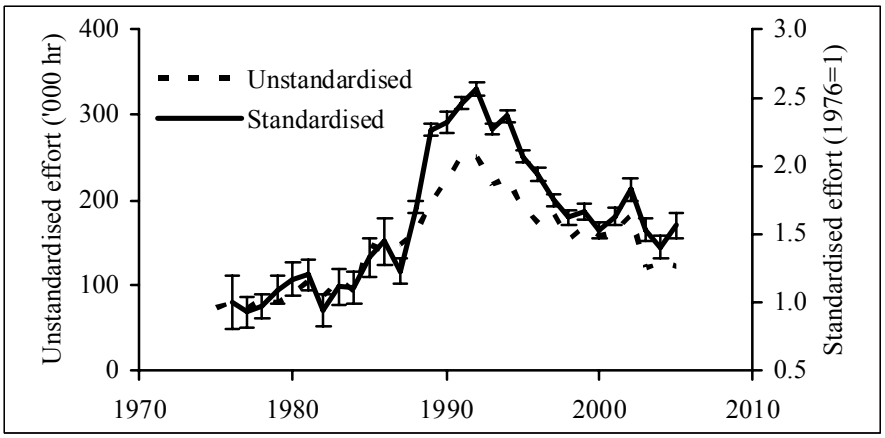

Fig. 3. Fishing effort applied in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970-2005.

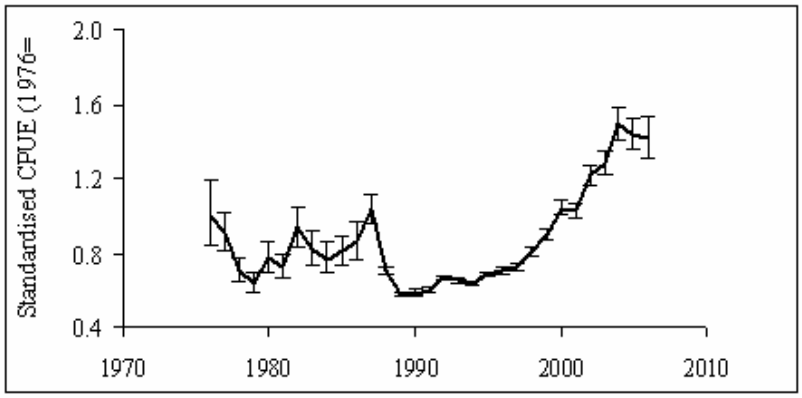

Fig. 4. Catch per unit of standardised effort in the West Greenland shrimp fishery, 1976-2006.

Appendix I: Output from a run of SAS PROC GLM to estimate a series of standardised annual CPUE values for the Greenland offshore fleet

```
                                The SAS System       09:25 Tuesday, October 17, 2006   1
                              The GLM Procedure
                           Class Level Information

Class       Levels  Values
VESSEL          17  AAAA AAAB AAAC AAAD AAAE AAAF AAAG AAAH AAAJ AAAK AAAL OURN OUYZ OYAQ OYKK
                    OZWQ OZWR
YEAR            20  87 88 89 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 109
MONTH            7  2 4 5 6 7 8 12
AREA             9  4 5 6 7 8 10 11 12 13

                        Number of Observations Read       12115
                        Number of Observations Used       12115
                                The SAS System       09:25 Tuesday, October 17, 2006   2

                              The GLM Procedure

Dependent Variable: LNCPUE

Weight: HAULS

                                          Sum of
Source                        DF         Squares     Mean Square    F Value    Pr > F

Model                         49      71052.5066       1450.0512     404.24    <.0001
Error                      12065      43278.0931          3.5871
Corrected Total            12114     114330.5996


                  R-Square     Coeff Var      Root MSE    LNCPUE Mean
                  0.621465      93.92807      1.893958       2.016392

Source                        DF       Type I SS     Mean Square    F Value    Pr > F

VESSEL                        16     43898.66161      2743.66635     764.88    <.0001
MONTH                          6      1802.21513       300.36919      83.74    <.0001
AREA                           8      9376.32892      1172.04112     326.74    <.0001
YEAR                          19     15975.30091       840.80531     234.40    <.0001

Source                        DF     Type III SS     Mean Square    F Value    Pr > F

VESSEL                        16     16623.27766      1038.95485     289.64    <.0001
MONTH                          6      1966.61953       327.76992      91.38    <.0001
AREA                           8      1249.28684       156.16085      43.53    <.0001
YEAR                          19     15975.30091       840.80531     234.40    <.0001

                                                    Standard
Parameter                  Estimate                    Error    t Value    Pr > |t|

Intercept             2.443183507 B      0.06887444      35.47      <.0001
VESSEL    AAAA       -0.140643364 B      0.06484099      -2.17      0.0301
VESSEL    AAAB       -0.243925769 B      0.06638168      -3.67      0.0002
VESSEL    AAAC       -0.339317834 B      0.06560912      -5.17      <.0001
VESSEL    AAAD       -0.688074518 B      0.06530459     -10.54      <.0001
VESSEL    AAAE       -0.786162770 B      0.06547604     -12.01      <.0001
VESSEL    AAAF       -0.866451025 B      0.06551373     -13.23      <.0001
VESSEL    AAAG       -0.939786648 B      0.06680677     -14.07      <.0001
VESSEL    AAAH       -1.049797827 B      0.07029395     -14.93      <.0001
VESSEL    AAAJ       -1.144264544 B      0.08077785     -14.17      <.0001
VESSEL    AAAK       -0.496825207 B      0.06732787      -7.38      <.0001
```

VESSEL	AAAL	-0.430100350 B	0.06755330	-6.37	<.0001
VESSEL	OURN	-0.074738748 B	0.09704515	-0.77	0.4412

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
VESSEL	OUYZ	-0.978475674 B	0.07180189	-13.63	<.0001
VESSEL	OYAQ	-1.264782453 B	0.07357181	-17.19	<.0001
VESSEL	OYKK	-0.573807090 B	0.06790186	-8.45	<.0001
VESSEL	OZWQ	0.090466745 B	0.07590692	1.19	0.2334
VESSEL	OZWR	0.000000000 B	.	.	.
MONTH	2	0.005192993 B	0.01283554	0.40	0.6858
MONTH	4	0.140691549 B	0.01143967	12.30	<.0001
MONTH	5	-0.019944842 B	0.01417364	-1.41	0.1594
MONTH	6	0.184378906 B	0.01421322	12.97	<.0001
MONTH	7	0.234138518 B	0.01356451	17.26	<.0001
MONTH	8	0.071096534 B	0.01387705	5.12	<.0001
MONTH	12	0.000000000 B	.	.	.
AREA	4	-0.213896794 B	0.01891647	-11.31	<.0001
AREA	5	-0.322782481 B	0.02569319	-12.56	<.0001
AREA	6	-0.184604101 B	0.01895794	-9.74	<.0001
AREA	7	-0.200005162 B	0.01644550	-12.16	<.0001
AREA	8	-0.239317743 B	0.01781315	-13.43	<.0001
AREA	10	-0.249516927 B	0.01557425	-16.02	<.0001
AREA	11	-0.172005741 B	0.01754727	-9.80	<.0001
AREA	12	-0.033503999 B	0.02552640	-1.31	0.1894
AREA	13	0.000000000 B	.	.	.
YEAR	87	0.565612099 B	0.04926011	11.48	<.0001
YEAR	88	0.142667026 B	0.02453865	5.81	<.0001
YEAR	89	-0.043434669 B	0.01978338	-2.20	0.0281
YEAR	91	0.016421367 B	0.01841869	0.89	0.3726
YEAR	92	0.123899915 B	0.01878528	6.60	<.0001
YEAR	93	0.080167109 B	0.01873952	4.28	<.0001
YEAR	94	0.087196305 B	0.01864861	4.68	<.0001
YEAR	95	0.174947770 B	0.01937343	9.03	<.0001
YEAR	96	0.239185425 B	0.02069339	11.56	<.0001
YEAR	97	0.259862204 B	0.02190146	11.87	<.0001
YEAR	98	0.342895667 B	0.02338647	14.66	<.0001
YEAR	99	0.496363513 B	0.02322377	21.37	<.0001
YEAR	100	0.572814497 B	0.02603397	22.00	<.0001
YEAR	101	0.610893350 B	0.02517256	24.27	<.0001
YEAR	102	0.746504176 B	0.02515618	29.67	<.0001
YEAR	103	0.797527127 B	0.02594189	30.74	<.0001
YEAR	104	1.053298302 B	0.02614735	40.28	<.0001
YEAR	105	0.927443405 B	0.02735675	33.90	<.0001
YEAR	106	0.856016152 B	0.03587816	23.86	<.0001
YEAR	109	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 II: Output from a run of SAS PROC GLM to estimate a series of standardised annual CPUE values for the Greenland inshore fleet

```
                                The SAS System     13:59 Wednesday, October 11, 2006  52
                              The GLM Procedure
                           Class Level Information

Class         Levels    Values
VESSEL            13    AAAA AAAB AAAC AAAD AAAE AAAF AAAG AAAH OUTE OVTJ OWMO OXPZ OZIQ
YEAR              19    88 89 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 109
AREA               3    1 2 3
MONTH              5    4 8 9 10 12


                         Number of Observations Read        4056
                         Number of Observations Used        4056
                                The SAS System     13:59 Wednesday, October 11, 2006  53

                              The GLM Procedure

   Dependent Variable: LNCPUE

   Weight: HAULS

                                          Sum of
   Source                       DF         Squares     Mean Square    F Value    Pr > F
   Model                        36     12343.45232       342.87368     148.42    <.0001
   Error                      4019      9284.31194         2.31010
   Corrected Total            4055     21627.76426


                  R-Square     Coeff Var      Root MSE    LNCPUE Mean
                  0.570723      89.08748      1.519903       1.706079

   Source                       DF       Type I SS     Mean Square    F Value    Pr > F

   AREA                          2     1318.506110      659.253055     285.38    <.0001
   MONTH                         4     2380.290566      595.072641     257.60    <.0001
   VESSEL                       12     2370.355642      197.529637      85.51    <.0001
   YEAR                         18     6274.300001      348.572222     150.89    <.0001

   Source                       DF     Type III SS     Mean Square    F Value    Pr > F

   AREA                          2     1103.623403      551.811702     238.87    <.0001
   MONTH                         4     1226.220018      306.555005     132.70    <.0001
   VESSEL                       12     2093.074646      174.422887      75.50    <.0001
   YEAR                         18     6274.300001      348.572222     150.89    <.0001

                                                    Standard
         Parameter                 Estimate             Error    t Value    Pr > |t|

         Intercept           1.303416661 B      0.05651947      23.06      <.0001
         AREA      1        -0.205402130 B      0.01233266     -16.66      <.0001
         AREA      2        -0.262970183 B      0.01307262     -20.12      <.0001
         AREA      3         0.000000000 B       .                .          .
         MONTH     4         0.466285795 B      0.02148167      21.71      <.0001
         MONTH     8         0.191627916 B      0.01387395      13.81      <.0001
         MONTH     9         0.120053927 B      0.01830754       6.56      <.0001
         MONTH     10        0.053393017 B      0.01789550       2.98      0.0029
         MONTH     12        0.000000000 B       .                .          .
         VESSEL    AAAA      0.158393900 B      0.05417895       2.92      0.0035
         VESSEL    AAAB      0.235459860 B      0.05085523       4.63      <.0001
         VESSEL    AAAC      0.339530212 B      0.05079372       6.68      <.0001
```

VESSEL	AAAD	0.407471483 B	0.05063886	8.05	<.0001

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
VESSEL	AAAE	0.449098624 B	0.05152462	8.72	<.0001
VESSEL	AAAF	0.293344521 B	0.05151628	5.69	<.0001
VESSEL	AAAG	0.103498021 B	0.05172822	2.00	0.0455
VESSEL	AAAH	-0.089020892 B	0.05955789	-1.49	0.1351
VESSEL	OUTE	0.026275312 B	0.05826382	0.45	0.6520
VESSEL	OVTJ	-0.051298377 B	0.06252892	-0.82	0.4120
VESSEL	OWMO	0.057145012 B	0.06101801	0.94	0.3491
VESSEL	OXPZ	0.511592013 B	0.05612155	9.12	<.0001
VESSEL	OZIQ	0.000000000 B	.	.	.
YEAR	88	0.238141088 B	0.04242887	5.61	<.0001
YEAR	89	0.007008296 B	0.03327096	0.21	0.8332
YEAR	91	-0.136262045 B	0.02759012	-4.94	<.0001
YEAR	92	-0.084189094 B	0.02778208	-3.03	0.0025
YEAR	93	0.011883004 B	0.02857534	0.42	0.6775
YEAR	94	-0.129141429 B	0.02776784	-4.65	<.0001
YEAR	95	-0.131032148 B	0.02796938	-4.68	<.0001
YEAR	96	-0.161685229 B	0.02930314	-5.52	<.0001
YEAR	97	-0.163748694 B	0.02845225	-5.76	<.0001
YEAR	98	-0.000055311 B	0.03377611	-0.00	0.9987
YEAR	99	0.053119221 B	0.02871206	1.85	0.0644
YEAR	100	0.323543314 B	0.02902390	11.15	<.0001
YEAR	101	0.205130003 B	0.02863509	7.16	<.0001
YEAR	102	0.426457261 B	0.02914256	14.63	<.0001
YEAR	103	0.470128361 B	0.03237885	14.52	<.0001
YEAR	104	0.562029536 B	0.02950748	19.05	<.0001
YEAR	105	0.625870042 B	0.03088120	20.27	<.0001
YEAR	106	0.667880558 B	0.04600962	14.52	<.0001
YEAR	109	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 III: Output from a run of SAS PROC GLM to estimate a series of standardised annual CPUE values for the Canadian fleet fishing in SFA 1.

```
                                The SAS System     08:33 Wednesday, October 25, 2006   1
                                   The GLM Procedure
                              Class Level Information

Class       Levels  Values

YEAR            23  1981 1982 1985 1987 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999
                    2000 2001 2002 2003 2004 2005 2006 2090
MONTH            5  7 9 10 11 13
cvf             17  101058 101597 105795 125081 126453 134608 134993 138775 154641 17009 176085
                    176119 4037 4043 4046 811498 99158909
TCLASS           3  5 6 7
GEAR             2  2 91


                        Number of Observations Read         573
                        Number of Observations Used         573
                                The SAS System     08:33 Wednesday, October 25, 2006   2

                                   The GLM Procedure

Dependent Variable: LNCPUE

Weight: WFACTOR
                                          Sum of
       Source                     DF         Squares     Mean Square    F Value    Pr > F
       Model                      43     6480.629404      150.712312      53.91    <.0001
       Error                     529     1478.847025        2.795552
       Corrected Total           572     7959.476429

                  R-Square     Coeff Var      Root MSE    LNCPUE Mean
                  0.814203      27.36861      1.671990       6.109153

       Source                     DF       Type I SS     Mean Square    F Value    Pr > F

       MONTH                       4      824.372105      206.093026      73.72    <.0001
       cvf                        16     2945.313856      184.082116      65.85    <.0001
       YEAR                       22     2352.587608      106.935800      38.25    <.0001
       GEAR                        1      358.355835      358.355835     128.19    <.0001

       Source                     DF     Type III SS     Mean Square    F Value    Pr > F

       MONTH                       4      117.089503       29.272376      10.47    <.0001
       cvf                        16      990.351676       61.896980      22.14    <.0001
       YEAR                       22     1443.093046       65.595138      23.46    <.0001
       GEAR                        1      358.355835      358.355835     128.19    <.0001

                                                    Standard
          Parameter                  Estimate             Error    t Value    Pr > |t|

          Intercept             6.141260642 B      0.04803672     127.85      <.0001
          MONTH     7           0.111013842 B      0.03254993       3.41      0.0007
          MONTH     9           0.045755361 B      0.02660906       1.72      0.0861
          MONTH     10         -0.040371970 B      0.02921967      -1.38      0.1677
          MONTH     11         -0.110146936 B      0.03293321      -3.34      0.0009
          MONTH     13          0.000000000 B       .               .          .
          cvf       101058      0.166074057 B      0.04962586       3.35      0.0009
          cvf       101597      0.193356379 B      0.04397910       4.40      <.0001
          cvf       105795      0.385296631 B      0.08202688       4.70      <.0001
          cvf       125081     -0.271385310 B      0.30448808      -0.89      0.3732
```

cvf	126453	0.120594439	B	0.07979602	1.51	0.1313
cvf	134608	-0.109489584	B	0.05908317	-1.85	0.0644
cvf	134993	-0.206595960	B	0.02860745	-7.22	<.0001

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate		Standard Error	t Value	Pr > |t|
cvf	138775	0.323675765	B	0.29875654	1.08	0.2791
cvf	154641	-0.562002890	B	0.07691196	-7.31	<.0001
cvf	17009	-0.517879253	B	0.12712520	-4.07	<.0001
cvf	176085	0.095569116	B	0.03604525	2.65	0.0083
cvf	176119	0.051416332	B	0.06618465	0.78	0.4376
cvf	4037	-0.750146135	B	0.15580313	-4.81	<.0001
cvf	4043	-0.441195527	B	0.06780538	-6.51	<.0001
cvf	4046	-0.320546876	B	0.04205092	-7.62	<.0001
cvf	811498	-0.250878392	B	0.24608601	-1.02	0.3084
cvf	99158909	0.000000000	B	.	.	.
YEAR	1981	0.213897550	B	0.11858385	1.80	0.0718
YEAR	1982	0.228914941	B	0.18853124	1.21	0.2252
YEAR	1985	-0.883964295	B	0.38791658	-2.28	0.0231
YEAR	1987	-0.040234971	B	0.14648169	-0.27	0.7837
YEAR	1988	-0.064666352	B	0.09415406	-0.69	0.4925
YEAR	1989	-0.113446012	B	0.05611897	-2.02	0.0437
YEAR	1991	-0.170636129	B	0.05101140	-3.35	0.0009
YEAR	1992	-0.042744111	B	0.05206832	-0.82	0.4121
YEAR	1993	-0.015608620	B	0.05226796	-0.30	0.7653
YEAR	1994	-0.355916968	B	0.05190248	-6.86	<.0001
YEAR	1995	-0.249140596	B	0.05867048	-4.25	<.0001
YEAR	1996	-0.404248636	B	0.05685542	-7.11	<.0001
YEAR	1997	-0.047763403	B	0.12423283	-0.38	0.7008
YEAR	1998	-0.275448423	B	0.09680868	-2.85	0.0046
YEAR	1999	-0.101483593	B	0.06843259	-1.48	0.1387
YEAR	2000	0.161535620	B	0.08836074	1.83	0.0681
YEAR	2001	0.253433957	B	0.07104314	3.57	0.0004
YEAR	2002	0.413739694	B	0.06094325	6.79	<.0001
YEAR	2003	0.523791386	B	0.06483398	8.08	<.0001
YEAR	2004	0.237107188	B	0.05897966	4.02	<.0001
YEAR	2005	0.290940105	B	0.06511615	4.47	<.0001
YEAR	2006	-0.913612462	B	0.56607863	-1.61	0.1071
YEAR	2090	0.000000000	B	.	.	.
GEAR	2	0.384117293	B	0.03392661	11.32	<.0001
GEAR	91	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.