Northwest Atlantic Fisheries Organization

Serial No. N5586 **NAFO SCR Doc. 08/57**

NAFO/ICES *PANDALUS* ASSESSMENT GROUP—OCTOBER 2008

The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970–2008

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 this stock 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 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 increases in allowed takes have been accompanied by increased catches. The log-book recorded catches in 2005 and 2006, 154 600 tons, were the highest recorded. The Total Allowable Catch for the stock advised in 2007 for 2008 was 110 000 tons live-caught weight, a reduction from 130 000 t advised for 2004–07. A TAC for Greenland waters for 2008 was set at 127 300 tons. For the Canadian fishery in SFA1 a TAC was set at 18 417 tons for 2008, but Canadian catches in recent years have decreased from about 7000 tons in 2003–05 to about 2000 tons in 2007 in spite of much higher TACs. The 2008 total catch has been projected at about 131 600 tons. The fishery in Greenland is regulated by individual quotas, but quota drawdowns are partly based not on live-caught weight, but on traded weight, less than the logbook recorded catch by an allowance for crushed and broken shrimps.

Reported discard and by-catch of other species are alike low, but recent investigations have shown that by-catch is probably under-reported, even by on-board observers.

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 fishery. These were combined to give a single standard CPUE series as an index of the biomass densities available to the fishery. Standardised CPUE was variable, but on average moderately high, from 1976 through 1987, then fell to uniform lower levels until the mid 1990s. It has since increased markedly, reaching a

plateau in 2004–07 of about twice its 1997 value, but on a half-year's data the 2008 value for the aggregate index has decreased by over 10%.

According to logbook records, the early fishery was concentrated in NAFO Division 1B, but from the late 1980s the fishery spread southwards, and by 1996–98 Divisions 1C–1F were producing nearly 70% of the catches. However, these southern areas have since become less important and the fishery is now again concentrated in Division 1B—more so than at any time since the late 1980s. Even though CPUEs remain high, if the area that the stock is spread over is shrinking, then its biomass could also be decreasing. However, 2007–08 have seen a great increase in fishing effort and catches on some far northern grounds up to 75°N that were briefly popular in the late 1980s but have seen little fishing since.

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 (60°N) to about 74°N, with the highest densities in depths between 150 and 600 m (Fig. 1). Within this habitat area, there is little evidence of sub-structure. TACs have at some times in the past been allocated to subdivisions of the stock area, especially with a view to limiting catches in northern areas (north variously of 72°52'N, 71°00'N, or 68°00'N) but since 1993 the species has been assessed as a single stock, and since 2002 a single TAC has been enacted for NAFO SA 1.

A bottom-trawl fishery began in inshore areas in 1935. In 1970 a multinational offshore fishery started to develop and over the following 30 or more 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 agreements on fisheries between the European Union (EU) and Greenland, an initial quota of 1000 tons allocated to EU vessels in NAFO Subarea 1 in 2003 has been increased to 4000 tons in subsequent years. The EU quota is an offshore quota and in this document is treated as part of the Greenland offshore fishery.

Three types of licence are issued to Greenland vessels in Subarea 1. A fleet of about 10 deep-sea trawlers with on-board production licences must stay 3 n.mi. outside the baseline (but can fish to the baseline between 61°N and 65°N from 1 Nov. to 31 March) and are further excluded from 5 'shrimp boxes' extending up to 47 n.mi. west from the baseline; they fish from an offshore quota. A few smaller sea-going trawlers also holding on-board production licenses but fishing from a coastal quota may fish to the baseline (but must stay 3 n.mi. offshore of it between 61°N and 65°N in summer) and are excluded from 3 of the boxes (G.H. 2002). Also fishing from the coastal quota are vessels without production licences—generally, those under 75 GRT/120 GT—which may fish anywhere, thus having privileged access to the 'shrimp boxes' and to good grounds inside the baseline in Julianehåb Bay, Disko Bay, Vaigat, and fjords. No TAC was set for the small-vessel fleet until 1997; the coastal quota is now fixed by law at 43% of the Greenland TAC, and while (parts of) individual quotas may be sold or transferred between licence holders within fleet components, the coastal and offshore quotas are kept separate. Since 1986 logbook recording of fishing activity has been required for all vessels above 50 GRT, and since 1997 for all vessels, but logbook records before 1986 must be recognised as incomplete.

The inshore fleet of smaller trawlers generally ices its catch and lands it at shore stations for processing, and Greenland vessels with on-board production licences are required to land 25% of their catches. In earlier years, the true weight of packages produced on board was often greater than the nominal weight—which was also the invoiced weight and the weight recorded for the product in the logbook—and this practice of 'overpacking' led to systematic underreporting. Legislation has been modified and since 2004 logbook entries are required to correspond to live catch weight (G.H. 2003). Catch data from 2003 and earlier was corrected (Hvingel 2004) by 21–25% for overpacking. TAC advice is based on the perceived ability of the stock to withstand reported catches, so upward adjustment of historical catch reports has led to an increase in advised TACs.

However, the quota drawdown for shrimps landed at shore stations in Greenland by any fleet component is still less than the live weight by an allowance for crushed or broken shrimps, which are included in the landing, but not in the

sale (G.H. 1996). If TACs and quotas are based on analysis of live-caught weights, but quota drawdown and tactical fishery management are partly based on such traded weights—even if honestly reported—annual catches measured as live-caught weight are apt to exceed TACs and the stock is liable to be over-fished.

A licence holder who fishes out his quota for a year may apply to start fishing the following year's quota from 15 November, and licence holders with quotas unfished at the end of the year may apply to fish the year's quota until 30 April in the following year. This provision can lead to accumulation of unfished quotas.

Canada fishes this stock where the edge of the West Greenland shelf bulges westward into the Canadian EEZ at the eastern edge of NAFO Div. 0A, between about 67°24'N and 68°40'N; 'Shrimp Fishing Area 1' (SFA1), consisting of NAFO Div. 0A east of 60°30'W, has been defined by Canada since 1994. Its least depth is 270 m; its greatest E-W extent of waters shallower than 600 m is about 24 n.mi. It is included in the annual Greenland research trawl survey. From 1996 to 2005 on average only about 9 vessels (2000–4000 GRT) have participated in the fishery in this area, slightly more in the most recent years. Catches are restricted by quota; a quota may be retroactively adjusted to cover an overrun, with a corresponding correction in a later year. Logbooks have been available since 1979.

Gear restrictions in place in Greenland are a cod-end mesh size of at least 40 mm stretched, and, for the Greenlandic fleet since 2000, sorting grids with 22-mm spaces between the bars to reduce finfish bycatch (G.H. 2001)[1]. The Canadian fleet fishing in SFA 1 uses cod-end mesh sizes ranging from 40 to 50 mm and grates with bar spacing from 22 to 28mm. Other measures to limit bycatch include an executive order of the Greenland Home Rule Government that a ship must move its fishing at least 5 n.mi. if bycatch exceeds a given proportion of the catch (G.H. 1995).

Material and Methods

Fleet Data

Logbook records were analysed to follow the development of the fleet and the fishery. Vessels were classified as 'offshore' or 'coastal' from available information, including current information on tonnage or the type of licence held, but mostly relying on the mapping of fishing positions, which were classified into statistical areas (Fig. 4). 'Coastal' vessels fish mostly in Areas 1 (Disko Bay), 2 (Vaigat), (Disko Bay mouth) and 13 (Julianehåb Bay), and in Area 7 (the Holsteinsborg Deep) they fish east of about 54°W in to the coast and fjords. 'Offshore' vessels do not fish in Areas 1, 2, or 13, but fish in Areas 4 and 6 north and west of Store Hellefiske Banke and in Area 7 they fish west of about 54°W. Both fleets fish in Areas 8–12, but this region is more important for the offshore fleet than for the coastal fleet.

The number of vessels providing logbook data for the West Greenland fishery was used to track fleet size, and the distribution of catches between vessels was assessed by an 'effective' fleet size calculated using Simpson's (1949) diversity index $D = 1 \Big/ \sum_i p_i^2$ where p_i is the proportion of the total catch taken by the i^{th} vessel. If this index is much lower than the nominal fleet size, it indicates large differences in annual catch between different vessels, while if it is close to the nominal fleet size, all ships are catching about the same amount. Nominal and effective fleet sizes were calculated for the offshore and coastal fleets separately and for the total fleet.

[1] dispensation from the requirement for sorting grids on trawls may be granted for vessels under 150 GRT for safety reasons.

Catch Data

Sources for catch data comprised: STATLANT 21A (sum of 'N Prawn' and 'Shrimps (NS)'); weekly and annual summaries of quota drawdowns ('kvotetræk') from the Greenlandic Fishery and Licence Control (GFLK); logbooks from vessels fishing in Greenlandic waters; and the Canadian Atlantic 'Quota Reports' from the website of the Canadian Department of Fisheries and Oceans (Kingsley 2007, 2008a). These sources are all (on-line) electronic databases, not printed documents, and are therefore labile; audit trails, if they exist, are not easily accessible. For years up to 1998, the catch series for the Greenland fishery was taken from existing SCR Documents, incorporating a correction for earlier overpacking (Kingsley 2007). For 1999 to 2001, STATLANT 21A data fetched in July 2007 was corrected for overpacking using the correction factors of SCR 03/74 (Hvingel 2003). For 2002 and 2003, Greenland logbooks were used as the source of catch data, again using correction factors for overpacking. This catch series for 1999 to 2003 was close to the values used in SCR 04/75 (Hvingel 2004). For years from 2004 on, Greenland logbooks were used without correction; for 2004 and 2005 these catch levels were 8–10% higher than the quota drawdown values used for the assessment in 2006.

For analysing CPUE data and standardising CPUE series, the following catch correction measures were used:

- the coastal fleet of small vessels, which land iced raw shrimps for processing by shore stations, was assumed not to have changed its practices as a result of the 2004 change in the laws, and no correction was applied;

- for the sea-going fleet, for which summary statistics were easily available as 'large' 'small' and 'unsorted', a correction of 15% was applied to reported catches of 'large' shrimp before 2004 and of 42% to catches of 'small' and 'unsorted'.

Up to 2006, no catch corrections had been used in standardising CPU series, and in 2007 an overall average catch correction had been applied to all catches from both fleets (Kingsley 2008c).

Logbook records were analysed to follow the development of the fleet and the fishery.

The Canadian fishery in SFA1 has 100% observer coverage (Siferd, pers. comm.), and catch data for this fishery was fetched in October 2008 from the DFO Commercial Quota Reports web-pages. Observer logbook data on catch and effort was provided by DFO staff. Information on the Canadian enacted TAC for SFA1 in 2008 was provided by the DFO statistical office.

Effort Data

Unstandardised logbook effort in trawl hours was corrected using 1.6 as a multiplier for records of trawl times with twin trawls to give corrected logbook effort. Unstandardised logbook CPUE was obtained by dividing corrected logbook catch by total corrected unstandardised logbook effort, and an unstandardised statistical effort by dividing total statistical catch by mean unstandardised logbook CPUE. Standardised statistical effort was calculated by dividing total statistical catch by standardised CPUE (see below).

CPUE Analyses

Catch and effort data from Greenlandic vessels above 50 GRT fishing in Subarea 1 and Canadian vessels fishing in SFA1 were used in multiplicative models to calculate indices of standardised CPUE. Four separate index series covering four fleets were derived (Hvingel *et al*., 2000).

All four models included the following effects: (1) a vessel effect (its fishing power, and the skill of its men), (2) a month effect (seasonal fishability of the shrimp and the fishing grounds) , (3) an area effect and (4) a year effect (overall year-to-year changes in CPUE). The main criterion for including a vessel was three years of participation in

the fishery covered by the index. Statistical areas were defined *ad hoc* based on distinct fishing grounds (Fig. 1), but Area 0 was not included in the analyses. The multiplicative model was represented in logarithmic form as:

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

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 year effects have been used as standardised annual CPUE indices in assessment models. These linear models in log. space were fitted using SAS Proc GLM (SAS Institute 1988). Estimates of the vessel, month and area effects from a first run of the main effects model (Model 1) were compared. To reduce the number of empty cells in the models, classes of effect variables were combined if a pairwise contrast had an F statistic less than one. However, posterior grouping on the basis of similar effects causes uncertainty to be underestimated. For further details on model construction and analysis see Hvingel *et al.* (2000).

The 'KGH index' was 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 Areas 3, 4, 6 and 7 (Fig. 1) for the years 1976–1990 was incorporated in the index. During this period this small fleet had a near-monopoly of the fishery and enjoyed fishing conditions somewhat different from those in subsequent years when the fishery became more populous. 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 areas 4, 6 and 7 combined. This analysis was not repeated and results from Hvingel (2004) were incorporated into the present analysis.

The 'Offshore' index covers the most recent 21 years of the offshore production fishery in NAFO Div. 1A to 1F. 48 vessels were included providing data since 1987, grouped into 27 groups of 1–4 vessels with similar estimated effects. Statistical areas 3–12 were included in the analysis; areas 7, 8, 9, and 10 were grouped. The month effect was reduced to 7 levels by grouping adjacent months with similar indices.

Checks of keyed data files against logbooks for 2007–08 showed that double-trawl hauls were often keyed as single trawl, but the reverse error was less frequent. Double-trawling vessels in the present offshore fleet use double trawls in over 80% of hauls. Therefore, for ships with much double-trawling activity, only double-trawl data was used. This reverses previous practice, according to which only single-trawl data was used. For 2007 and 2008, double- and single-trawl data was completely checked and corrected. There is no information on double trawling before 1995, so if a ship was using double trawls in 1995 and after, its data for 1994 and before, if any, was not used in the CPUE analyses.

A 'Coastal' index was based on vessels below 80 GRT or 210 GT, which have privileged access to the inshore grounds. Some larger vessels holding coastal quotas and, according to their logbook records, fishing only in coastal areas were included in this analysis. 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, but is also active in some inshore areas further south, especially areas 7 and 11–13. Areas 1–3, 7 and 13 were included in the anlaysis. Comprehensive data were available since 1988; 32 vessels were included, in 14 groups. October, November and December were grouped together.

Data from the Canadian fishery in SF1 was available for 1981 through 2006. However, there was no data from 1986, and before then the fishery was prosecuted by few vessels, most having only one or two years in the fishery, and none continuing in the fishery after 1986. So a standardised CPU index series for SFA1 as a whole was only calculated for 1987–2007. 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. Vessels with reports from fewer than 3 years in the fishery were rejected, and the 22 retained were nested within tonnage class. They were grouped, by examining pairwise contrasts, into 11 groups of up to 6 vessels.

One unified series of standardised CPUE, covering 1976–2008, 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.

Distribution of the Fishery

To aid in interpreting the time trajectory of CPUE estimates, the distribution of the fishery and its change with time were also examined. Catch and effort were allocated to the same statistical areas as those used for the GLM standardisation of CPUE and summed up by year and area, and also by year and NAFO Division. The distribution of catch and effort between areas or Divisions was plotted, and was also summarised by Simpson's diversity index to calculate an 'effective' number of statistical areas or Divisions being fished.

Biological Sampling

There is at the moment no programme for systematic sampling from the fishery for obtaining length, sex or weight distribution or for examining the relationships between these biological variables.

Results and Discussion

Evolution of the fishery: TACs, effort and catches,

Logbook data available since 1975 gives a picture of the evolution of the fishery. The first logbook data shows a small fishery comprising 1 or 2 vessels taking small catches in a restricted area, increasing to a fleet of the 7 sister trawlers of the KGH fleet. Nominal and effective fleet sizes were nearly the same, the fleet being homogeneous (Fig. 1a). After 1984 more vessels entered the fishery and the offshore fleet became larger and more heterogeneous, reaching a peak in the late 1980s. Since then a progressive rationalisation has forced a reduction in nominal fleet numbers, and the fleet has also returned close to its initial level of homogeneity.

The early logbook records from the coastal fleet, in the early 1990s, also show a small, homogeneous fleet, but this is an artefact of the small interval between the 80-ton upper limit for entry into the coastal fishery and the 50-ton lower limit for logbooks (Fig. 1b). When the latter was removed in 1997 and all trawlers had to report, the nominal size of the coastal fleet, as shown by logbooks, quadrupled from 24 to 94. However, the small ships were catching so little shrimp that the effective size of the coastal fleet only doubled, from 16 to 33, and the effective size of the total shrimp fleet changed little (Fig. 1c). Rationalisation and modernisation have driven the nominal size of the coastal fleet down by little less than 2/3 since 1997, but its effective size has decreased by only 1/3, as many of the smallest vessels have left the fishery and the fleet has become less diverse.

Since the inception of the fishery, it has seen continued increases in catches and TACs (Fig. 2). 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 1). Measures by the Greenland Home Rule Government to reduce effort, as well as improved fishing opportunities elsewhere for the Canadian shrimp fleet and the disappearance of a strong 1985 year-class (Garcia 2007), then introduced a period of lower catches lasting to the early 2000s. Canadian catches, in particular, were low in the mid- to late 90s. Catches have increased very rapidly since 2000, by about 50% by 2006. However, the logbook-recorded catches for the first 6 months of 2007, fetched in August 2007, were about 15% less than those for the same period in 2006, and for the first 6 months of 2008 are lower again. Enacted TACs have been high in recent years, and Canada has regularly set TACs for SFA1 that have been several time higher than catches. Management of the fishery in Greenland is bedevilled by mixed regulation, partly based on weights caught, and partly on weights traded.

From 1975, when the offshore fishery was well established, through 1984 annual unstandardised effort increased slightly 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 1991–92. 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 imposition in 1997 of logbook recording on vessels below 50 tons, until then exempt.

The trajectory of the standardised effort time series agrees with that of the unstandardised (Table 2, Fig. 3). After 1992, when it reached its highest value, standardised effort decreased steadily—overall by about 35%—to a minimum in 1998–2000. Since then it has been increasing again.

Spatial and seasonal distribution

During the period of logbook recordings (since 1975) the relative importance of the different fishing grounds has varied a lot (Fig. 5). At first, the fishery concentrated on the wide shelf west and southwest of Disko Bay (Div. 1B/Area 6; Fig. 5a), but the effective number of areas fished increased steadily up to the early 1990s (Fig. 6) as the fishery extended first into southwestern Disko Bay (Areas 3 and 4) and the Holsteinsborg Deep (Area 7), with short-lived excursions in the late 1980s and early ‘90s into northern areas (Area 0) and the outer margin of the shelf north of Canadian SFA1 (Area 5). From the end of the 1980s there was a significant expansion of the fishery southwards (Fig. 5b), and in the mid-1990s the effective number of areas being fished peaked at about 9.5. Since then, the fishery has contracted northwards and the effective number of areas fished has decreased as effort has become more concentrated (Fig. 6). Catches have also become more concentrated and the southern part of the distribution is contributing much less (Table 3, Table 4). In 1997 Areas 8–13 accounted for 65% of the catch and Areas 3, 6, and 7 for 20%; this is now reversed, and Areas 8–13 yielded 20% of the catch in 2007 and 17% in 2008, while Areas 3, 6, and 7 yielded 54% and 66%. More recently, effort and catches in Area 0 have increased, and rumours of high catch rates in 2008 near 74°N are current, but so far relate only to a small fishing ground. The distribution of the fishery from July 2007 to June 2008 (Fig. 4), when compared with the similar Figure for 2007, shows less fishing by both fleets in Areas 8 and south, no fishing, even by the coastal fleet, in Area 13, and a growing use of a northern ground near 74°N. An increasing concentration of the stock and the fishery would be consistent with a decreasing biomass index from research trawl survey while catch rates in the commercial fishery remain high, and this agrees with data since 2003.

The results of analyses for the current year must be viewed in the light of a somewhat seasonal distribution of the fishery, in that access to the most northerly grounds is restricted by sea-ice in the early part of the year. Therefore, the concentration of the fishery for the current year, based on a half year’s data, is exaggerated (Fig. 6), but the trajectory of similar indices calculated throughout on half-years’ data also shows a contracting fishery.

It has been suggested that the southward shift of the fishery in the early and mid-1990s could have been promoted by the development of gear that could fish effectively on difficult bottoms, but this would not explain the recent decline of the southern areas. Besides, a southward shift of the stock distribution in the early 1990s was also recorded by research trawl surveys (Carlsson and Kanneworff 1997; Rätz 1997).

The fishery is active all year, but more so in summer and fall. A strongly seasonal pattern prevalent as recently as 10 years ago, with summer monthly catches 2–3 times the winter minimum, appears to have given way to a more uniform seasonal distribution, with summer maxima only 25–50% higher than the winter minima (Table 5).

By-catch and discard

The logbook-reported at-sea discard of shrimp, mostly for quality reasons by production trawlers, has remained less than 1% by weight of total catch throughout the period 1975–2007 (Table 6, Table 7). However, these statistics do not include shrimp discarded for quality reasons from land processing stations ('vragrejer'). Placing observers on offshore vessels in 1991 may have improved the reporting of discard—hence an apparent increase—while an improved market for smaller shrimp may have offset a corresponding effect of observers on the reported discard of shrimp.

Bycatch of fish—especially pre-recruits—in small-mesh shrimp trawls has long been a serious problem, partly solved by the development of sorting grids that deflect fish, but not shrimp, out of the trawl. In the most recent years registered annual discards of fish have been below 1% of total shrimp catch, but fish discard reports are based on visual estimates of weight, not on physical weighing, and errors are likely. An EU project[2] to verify the quantity of bycatch and the accuracy with which it is reported—by both captain and observer—found from observations, including the weighing of bycatch, by a scientific assistant of 166 hauls on 7 vessels in NAFO Divs 1B–1E in 2006–07, that reports by captain and observer tended to agree on the bycatch weight, but not necessarily at the correct value, that the presence of the scientific assistant probably affected the estimates made by the captain and the observer, and that the weighed bycatches were on average larger—at 1.2–3.2% of the shrimp catch—than logbook reports on average indicate (Sünksen 2007). Catches of fish in the Canadian offshore fishery ranged up to well over 30% of the shrimp catch from the mid-1980s to the mid-1990s, but have since decreased to stable levels below 5%.

From 1995 to 2007 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*, and it is difficult to use the reporting of *montagui* to infer changes either in the targeting strategy of the fishery or in 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 appear to have stayed high, reaching a maximum in 2007 (Table 6).

Catch per unit of effort

Log-book data for selected ships from four fleets were analysed using SAS PROC GLM (see Appendices 1–3) to give standardised series and unified by fitting a separate model. 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. From 1988 to 2003 the CPUE indices from the Greenland coastal and the Greenland offshore fleets have remained closely in step. However, since 2004 they have diverged more than in previous years. CPUE in the Canadian fishery in SFA1 has always varied more from year to year and has never stayed closely in step with

[2] 'CEDER: Catch, Effort and Discard Monitoring in Real Time'

the Greenland fleets, although over time its overall trend has been similar and it too has increased between the 1990s and the present.

The overall combined index (Fig. 7) 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 1996. Since then, the unified CPUE index increased markedly and sustainedly for 9 years, reaching a plateau in 2004–2007, to turn downward on a half-year's data in 2008. The standardisation method used accounts for the increase in efficiency from renewal of the fleet but does not account for technological improvements to existing vessels. Examination of records of motor power changes in the GFLK fleet database showed very few real changes. Hvingel *et al*. (2000) considered the possible effects that upgrading ships, crews, or electronics might have on CPUE series, which are always liable to be over-optimistic in respect of the historical trend of stock biomass.

A louder alarm signal is sounded by the apparently contracting distribution area of the stock. CPUE does not truly measure biomass, it only measures density in fished areas; and if the fished areas are contracting it is difficult not to be concerned that the stock biomass might also be on its way down. Between the 1995–99 average and that for 2005–2008 the effective number of NAFO Divisions providing catches for the Greenland fleet has decreased to below 60% of its peak value, so that although densities in the fished areas remain high, the extent of the fishery, and therefore the likely biomass, is reduced. The same is true when the distribution by statistical areas is analysed in the same way. This reduction in the 'effective number of NAFO Divisions' does not translate proportionally into a reduction in the fished area, but it exceeds the increase in the CPUE over the same period. A decreasing area of distribution of the stock is consistent with changes in the research survey estimate of fishable biomass, which since 2003 has continually decreased, overall by 52% from its then value. Indices of location and distribution for the survey biomass show a contracting and more northerly distribution of the stock (Kingsley 2008b).

Catch rates never reflected the high survey biomass estimates of 2003–04. The survey estimates have high serial correlation, so must be credible. So perhaps the high survey biomass reflected an extension of the stock distribution area rather than increases in density. However, when the survey data is analysed, no index of how widely the stock is distributed is calculated; this would perhaps be a useful addition to the presentation of the survey data.

Acknowledgements

Mads Rossing Lund of Grønlands Fiskeri- og Licenskontrol helped in obtaining logbook data for the Greenland fleets. Tim Siferd of the Canadian Department of Fisheries and Oceans, Central and Arctic Region, Winnipeg, updated for me the data for the Canadian fishery in SFA1 for 2006 and sent also that for 2007; I thank David Orr and Pat. J. Veitch, of the Science Branch, Canadian Department of Fisheries and Oceans, Atlantic Region, for past help in obtaining and interpreting data on the Canadian fishery for earlier years; Jennifer Buie told me about the TAC for Canadian SFA1 for 2008.

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Table 1a. Catch limits, 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. (B_{msy}=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	0.96
1977	-	-	36000	42578	8580	51158	457	51615	73.1	-	73	0.93	699	-	706	0.90
1978	-	1000	41000	33835	8360	42195	122	42317	84.2	-	84	0.98	501	-	503	0.71
1979	-	2000	31500	32852	8250	41102	1732	42834	72.4	-	72	1.09	568	-	592	0.64
1980	-	2500	32000	44916	8250	53166	2726	55892	80.0	11.6	92	1.18	665	235	610	0.77
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	8.1	89	0.94	644	256	609	0.93
1983	34625	5000	39625	42553	8250	50803	5413	56216	89.0	26.1	115	1.11	571	208	488	0.82
1984	34925	5000	39925	42414	8250	50664	2142	52806	85.0	-	*85*	1.12	596	-	*621*	0.77
1985	42120	6120	48240	54889	8250	63139	3069	66208	129.1	23.6	153	1.31	489	130	433	0.82
1986	42120	6120	48240	65623	8250	73873	2995	76868	133.4	-	*133*	1.46	554	-	*576*	0.86
1987	40120	6120	46240	64222	7613	71836	6095	77931	137.1	17.7	155	1.25	524	344	503	0.97
1988	40120	6120	46240	56479	11256	67735	5881	73616	152.9	14.9	168	1.76	443	395	439	0.78
1989	45245	7520	52765	58890	14546	73436	7235	80671	179.6	19.7	199	2.18	409	367	405	0.65

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

Table 1b. Catch, effort and CPUE statistics for the shrimp fishery on the West Greenland shelf, 1990-2008.

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 Std.
				Offshore	Inshore	Total	Offshore		Unstd. ('000 hr)			Std. (index)	Unstd. (kg/hr)			(1976=1)
1990	45245	7520	52765	62800	14993	77793	6177	83970	209.6	14.3	224	2.42	371	433	375	0.57
1991	46225	8500	54725	66818	17884	84701	6788	91489	230.8	19.6	250	2.61	367	346	365	0.57
1992	44200	8500	52700	75341	22653	97994	7493	105487	234.2	16.6	251	2.7	418	451	421	0.63
1993	40600	8500	49100	65894	19627	85522	5491	91013	206.1	12.2	218	2.46	415	450	417	0.62
1994	42300	8500	50800	68109	19930	88039	4766	92805	209.8	15.3	225	2.52	420	312	412	0.62
1995	39500	8500	48000	66955	18072	85027	2361	87388	184.7	7.3	192	2.16	460	322	455	0.70
1996	63922	8500	72422	62368	19095	81463	2632	84095	164.6	9	174	2.06	495	293	484	0.73
1997	64600	8500	74800	62743	14868	77611	517	78128	184.9	1.3	186	1.95	420	412	420	0.70
1998	60729	7650	68379	69156	10406	79562	933	80495	152.7	2.6	155	1.77	521	353	518	0.81
1999	73500	9350	82850	71203	18948	90152	2046	92198	164.7	5.1	170	1.77	547	398	543	0.92
2000	77675	9350	87025	73013	23365	96378	1590	97968	156.2	2.6	159	1.71	617	613	617	1.00
2001	92950	9350	102300	79291	20010	99301	3625	102926	158.3	6	164	1.87	627	602	626	0.94
2002	91150	12040	103190	107195	21729	128925	6247	135172	173.3	9	182	2.07	744	695	741	1.13
2003	101000	14167	115167	104237	18799	123036	7137	130173	124.4	8.2	133	1.87	989	873	982	1.21
2004	135352	14167	149519	121640	20686	142326	7021	149347	130.0	12.3	142.3	1.92	1095	570	1049	1.36
2005	134000	18452	152452	128054	21924	149978	6921	156899	129.5	9.3	138.8	1.74	1158	741	1130	1.42
2006	134000	18380	152380	125498	25035	150533	4127	154660	126.1	4.7	130.8	1.79	1194	884	1182	1.37
2007	134000	18417	152417	114099	25532	139631	1945	141576	114.0	2.2	116.2	1.38	1225	872	1218	1.40
2008#	127300	18417	145717			*126221*	*5430*	*131651*	*111.8*				*1129*			1.22

*1981-1995 TAC for offshore only; #projected; for SA1 from Jan–June, for Can. SFA1 from average of previous 5 years.

Table 2. 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.

	KGH		Offshore		Coastal		Canada SFA1		Combined	
Year	mean	se	mean	se	mean	se	mean	se	median	i.q.r
1976	1.66	0.153							1.000	0.360
1977	1.556	0.095							0.895	0.213
1978	1.23	0.074							0.701	0.136
1979	1.113	0.066							0.633	0.112
1980	1.34	0.082							0.769	0.162
1981	1.265	0.072							0.723	0.137
1982	1.61	0.099							0.931	0.229
1983	1.423	0.085							0.817	0.176
1984	1.338	0.078							0.765	0.154
1985	1.432	0.082							0.820	0.172
1986	1.49	0.085							0.855	0.184
1987	1.787	0.106	1.614	0.042			0.898	0.278	0.944	0.062
1988	1.465	0.086	1.161	0.024	1.173	0.050	0.976	0.144	0.686	0.038
1989	1.086	0.071	1.051	0.020	0.890	0.028	0.954	0.090	0.607	0.033
1990	1		1.000		1.000		1.000		0.572	0.032
1991			0.980	0.017	0.975	0.028	0.839	0.078	0.575	0.030
1992			1.071	0.020	1.070	0.030	0.894	0.084	0.629	0.034
1993			1.048	0.019	1.113	0.031	0.972	0.088	0.620	0.033
1994			1.057	0.020	0.999	0.027	0.679	0.060	0.616	0.034
1995			1.210	0.023	1.013	0.028	0.795	0.072	0.695	0.038
1996			1.267	0.025	1.064	0.031	0.667	0.063	0.727	0.039
1997			1.220	0.026	1.079	0.031	0.710	0.096	0.704	0.039
1998			1.400	0.032	1.296	0.041	0.617	0.073	0.812	0.047
1999			1.595	0.038	1.415	0.040	0.856	0.092	0.918	0.054
2000			1.679	0.045	1.742	0.049	1.120	0.134	0.996	0.062
2001			1.600	0.042	1.594	0.044	1.127	0.112	0.942	0.058
2002			1.911	0.046	1.979	0.056	1.402	0.131	1.132	0.067
2003			2.069	0.051	2.009	0.058	1.686	0.165	1.212	0.073
2004			2.361	0.059	2.117	0.059	1.056	0.098	1.358	0.081
2005			2.504	0.061	2.061	0.058	1.111	0.112	1.419	0.085
2006			2.360	0.058	2.250	0.066	1.367	0.146	1.375	0.082
2007			2.342	0.062	2.549	0.076	1.290	0.150	1.399	0.087
2008			1.987	0.068	2.329	0.078			1.218	0.088

Table 3. Annual catch, effort and CPUE of the shrimp fishery on the West Greenland shelf by NAFO Divisions. Data from logbooks, weighted up to annual 'agreed' catch.

Year	Agreed Catch ('000 tons)							Corrected, Unstandardised Effort ('000 hr)							Unstandardised CPUE (agreed 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	44.6	2	0	0	0	-	0	70.5	3.6	0	0	0	-	-	632	551	-	-	-
1976	0.4	0	54.7	6.3	0	0	0	-	0.1	70.1	8	0.1	0.8	1.1	-	-	780	785	-	-	40
1977	0.5	0.2	47.8	3.1	0.1	0	0	-	0.5	67.8	4.4	0.5	0	0	-	357	705	691	253	-	-
1978	0.1	0.5	40.9	0.5	0.2	0	0	-	1.4	80.7	1.3	0.8	0	0	-	382	507	416	259	-	-
1979	1.7	4.8	35.7	0.5	0	0	0	-	6.7	64.1	1.5	0.1	0	0	-	719	557	348	112	-	-
1980	2.7	14.6	35	3.3	0.3	0	0	11.6	21.2	53.3	4.9	0.5	0	0	235	690	655	668	596	-	-
1981	5.3	5.7	37.5	5.3	0	0	0	16.6	11.2	66.4	10.4	0.1	0	0	318	511	564	510	409	-	-
1982	2.1	0.8	43.2	8.2	0	0	0	8.1	1.7	65.7	13.5	0.1	0	0	256	472	657	604	388	-	-
1983	5.4	0.5	40.5	9.4	0.5	0	0	26.1	0.9	69.5	17.8	0.9	0	0	208	559	582	528	531	-	614
1984	2.1	1.2	30.4	17	2.1	0	0	-	2.7	51.1	28.4	2.7	0	0.1	-	431	595	598	785	-	47
1985	3.1	8.1	35.5	14.9	4.7	0	0	23.6	28.7	66.2	25.6	8.7	0	0	130	282	536	580	540	-	-
1986	3	26.3	32.4	9.2	6	0	0	-	54.2	55.2	14.1	9.6	0.1	0.1	-	485	586	649	624	273	-
1987	6.1	19.4	43.7	7.3	1.3	0	0	17.7	54.4	67.9	10.7	4.2	0	0	344	357	644	685	324	-	-
1988	5.9	12.4	47.5	7.1	0.5	0	0.1	14.9	40.9	94.3	14.7	2	0	1	395	302	504	486	268	-	153
1989	7.2	16.3	33.8	12.9	10	0	0.5	19.7	47.3	77.7	30.5	19.8	0	4.2	367	343	435	422	507	-	111

Table 3. (cont'd)

Year	Agreed Catch ('000 tons)							Corrected, Unstandardised Effort ('000 hr)							Unstandardised CPUE (agreed kg/hr)						
	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F
1990	6.2	12.2	30	22.7	12.4	0	0.5	14.3	42.3	77.5	56.1	30.8	0	2.8	433	288	387	405	403	-	165
1991	6.8	12.6	32.9	18.8	19.6	0.6	0.2	19.6	37	90	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	0.6	16.6	49.3	76.2	48	51.7	7.8	1.3	451	330	431	415	452	642	497
1993	5.5	7.6	36.3	15.8	18.1	4.5	3.2	12.2	22.9	82	41.3	44.3	8	7.6	450	331	442	383	410	559	425
1994	4.8	7.3	33.7	15.9	19.9	7	4.2	15.3	23.3	84.1	40.9	42.7	9.6	9.3	312	313	401	390	467	736	450
1995	2.4	6.9	27.2	15.5	22	8.6	4.9	7.3	20.9	69.2	33.8	40.8	12.3	7.9	322	330	393	458	539	696	624
1996	2.6	5.4	22.4	16.8	23.3	8.3	5.3	9	18.4	51	35	39.3	11.8	9.1	293	293	439	481	594	700	579
1997	0.5	7.3	20.2	11.5	22.6	8.5	7.6	1.3	43.7	53.7	24	39.2	11.6	12.6	412	167	376	477	576	730	605
1998	0.9	4.5	22.6	13.5	21.1	8.7	9	2.6	20	48.9	25.4	34.2	10.6	13.5	353	226	463	532	618	817	671
1999	2	8.8	28.5	14.6	19.1	8.3	10.9	5.1	34.2	58.9	22.5	27.1	9.2	12.9	398	259	484	650	704	902	839
2000	1.6	14.8	29.2	15	19	7	11.5	2.6	36.2	51.7	20.3	26.2	7.7	14.1	613	409	564	737	727	909	810
2001	3.6	14.4	27.4	17.1	20.8	8	11.6	6	41	49.2	21.1	27.4	7.7	11.8	602	351	557	810	760	1029	980
2002	6.2	15.2	43.5	26.5	25	8.5	10.3	9	41.6	58.7	27.5	28.2	7	10.4	695	365	741	963	888	1216	989
2003	7.1	13.9	42.4	24.8	23.1	8	10.8	8.2	32.6	41.6	17.2	17.5	5.3	10.1	873	427	1018	1440	1324	1512	1061
2004	7.0	13.8	55.0	33.6	24.6	5.7	9.6	12.3	33.4	51.2	18.1	13.3	2.8	11.2	570	413	1075	1853	1857	2019	856
2005	6.9	11.3	73.0	33.6	18.0	5.4	8.7	9.3	23.1	58.6	16.5	10.6	5.2	15.5	741	488	1244	2038	1700	1038	565
2006	4.1	13.5	79.6	23.3	19.0	9.6	5.4	4.7	21.5	60.6	12.3	11.2	10.0	10.6	884	631	1313	1899	1700	967	510
2007	1.9	26.0	83.3	8.9	11.8	8.5	1.1	2.2	27.2	63.3	5.6	8.6	7.0	2.3	872	955	1316	1602	1381	1218	464
2008*	5.4	14.3	88.2	9.7	6.4	7.5	0.1		19.5	73.8	6.8	4.9	6.8	0.1		736	1195	1425	1300	1115	974

* projected.

Table 4a. Distribution (%; columns sum to 100) of catches 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	05–08
1A	4.7	9.2	23.4	12.8	8.1	12.1	11.5
1B	91.8	72.1	56.1	38.3	29.1	33.7	55.6
1C	3.3	17.4	13.9	21.5	17.2	20.0	14.0
1D	0.2	1.3	6.4	21.5	26.1	19.0	10.3
1E	0.0	0.0	0.0	4.0	10.2	6.2	5.4
1F	0.0	0.0	0.2	2.1	9.3	9.0	3.0
Diversity	1.2	1.8	2.5	3.9	4.8	4.6	2.8

Table 4b. 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	05–08
1A	4.2	9.3	30.5	15.9	16.7	24.9	19.2
1B	91.9	71.4	49.9	37.7	32.9	34.0	51.5
1C	3.4	18.1	12.6	21.9	16.2	14.1	8.9
1D	0.5	1.1	6.0	20.0	21.0	15.1	7.7
1E	0.1	0.0	0.0	2.4	6.5	4.1	6.0
1F	0.1	0.0	0.9	2.1	6.7	7.8	6.7
Diversity	1.2	1.8	2.8	3.9	4.6	4.4	3.1

[1] unstandardised trawl time

Table 5. Shrimp catch on the West Greenland shelf by month 1976-2008, summed from vessel logs and weighted up to total catch.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	5778	736	0	0	154	10861	10457	11588	11398	8369	1985	89
1977	3062	3145	2229	2780	3736	5565	5972	5052	4321	6459	5682	3612
1978	971	366	152	777	5829	6620	6134	6348	4506	3601	3529	3483
1979	2428	540	5245	6444	6184	5252	4298	3904	2352	1563	3007	1617
1980	4651	5383	4976	5892	7072	7453	6656	5226	5499	2508	0	576
1981	3564	3555	2964	4279	7157	4890	7118	7121	4476	3171	3431	2103
1982	3422	709	1	2441	8342	7738	6784	7803	4738	6907	4239	1168
1983	37	247	577	2029	7655	7838	9260	6855	5952	6785	5625	3357
1984	45	494	4426	7258	7881	8490	7800	3765	2408	4429	4310	1498
1985	2109	3513	5362	3419	5318	7221	6889	9117	6051	8733	6047	2429
1986	3337	3152	3553	5311	4768	9021	8382	7412	9571	14932	4401	3029
1987	2979	1731	4748	6167	7616	8168	9707	10340	7869	10724	4970	2911
1988	2318	2913	3589	7443	7636	7663	8835	8384	9110	7529	5412	2785
1989	2513	3029	4344	7873	6499	10254	13429	9699	6996	7883	4749	3403
1990	4097	4286	4952	8453	9011	8972	8997	8225	7393	7087	7957	4540
1991	4103	3653	4056	3834	6416	9439	11591	9941	8654	10243	11233	8326
1992	4695	3591	6037	6724	8463	11196	11442	10880	11384	13591	10274	7210
1993	2639	3164	4357	5950	7670	7991	8703	9659	10350	12584	11009	6937
1994	4321	3905	6566	8553	7342	7165	9656	9408	10678	11705	7942	5565
1995	3851	5268	7792	10378	8138	7761	8575	8931	8398	8010	6283	4004
1996	4028	6409	7885	9144	8873	8793	8842	9446	8570	6118	3302	2684
1997	3634	5995	6273	6562	7664	8185	9514	8061	7882	7277	5035	2047
1998	8625	6420	5896	9980	10438	10505	10308	5015	5366	3549	2634	1758
1999	5035	5648	7382	8133	9390	8547	11074	8738	8348	8203	6625	5075
2000	4440	6528	7491	9121	9738	11435	11580	8573	7934	6922	8377	5830
2001	4287	5471	6248	5763	8624	11195	12545	12011	9930	10981	8163	7708
2002	8815	5971	7985	11485	12324	12234	15668	14696	12415	11495	12711	9373
2003	8561	7984	10616	11832	12708	11228	10886	11542	14117	11901	10915	7881
2004	8018	8596	8875	12341	14081	13973	12736	10106	15341	14217	12758	11191
2005	10695	8782	12726	14836	15192	15181	15354	16471	13959	12719	10420	10564
2006	12563	11713	13939	10923	14195	10949	15465	15614	15014	12933	12157	9195
2007	5417	8660	10391	13376	13298	13476	16829	14512	13981	11228	9937	10471
2008	8989	7386	8478	12421	13432	11303	–	–	–	–	–	–

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
1976	0	0	0	0	0
1977	0	0	23	0	0
1978	0	0	27	0.1	0
1979	0	0	151	0.4	0
1980	0	0	186	0.3	0
1981	0	0	725	1.5	0
1982	0	0	788	1.5	0
1983	0	0	964	1.9	0
1984	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	5
1995	476	0.6	2700	3.2	562
1996	324	0.4	2712	3.3	773
1997	310	0.4	2327	3	422
1998	314	0.4	2183	2.7	1253
1999	197	0.2	7	0	4
2000	268	0.3	685	0.7	305
2001	382	0.4	1122	1.1	882
2002	649	0.5	1274	1	225
2003	638	0.5	1291	1	967
2004	724	0.5	992	0.7	789
2005	753	0.5	982	0.7	511
2006	850	0.6	1157	0.8	1419
2007	728	0.5	2047	1.5	1966
2008*	678	0.5	1061	0.8	160

* 2008: projected from part-year's data

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

	Fish Catch	Shrimp	Ratio (%)
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
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
2003	196	5439	3.6
2004	352	7155	4.9
2005	228	6077	3.8
2006	175	4127	4.2
2007	35	1945	1.8

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

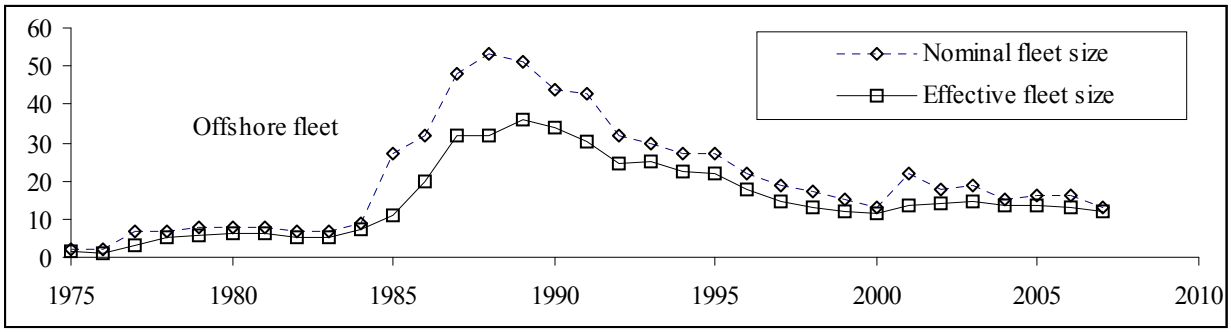

Fig. 1a. Nominal and effective sizes of the offshore trawler fleet in the West Greenland shrimp fishery, 1975–2007, from logbook records.

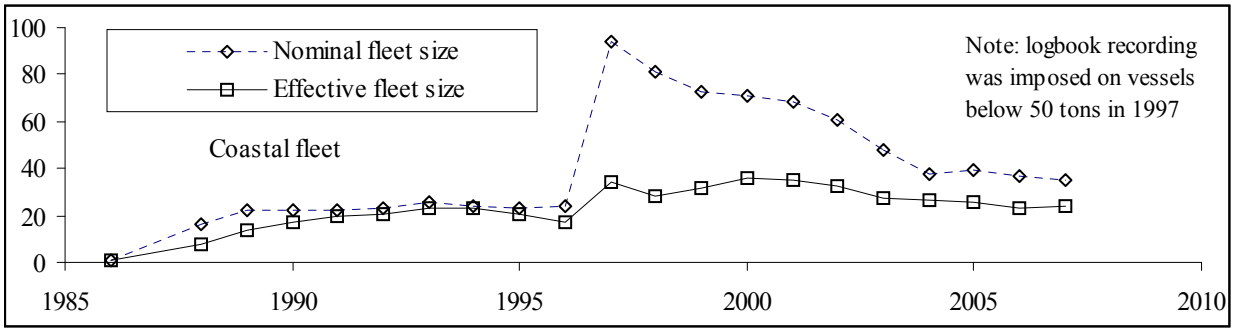

Fig. 1b. Nominal and effective sizes of the coastal trawler fleet in the West Greenland shrimp fishery, 1975–2007, from logbook records.

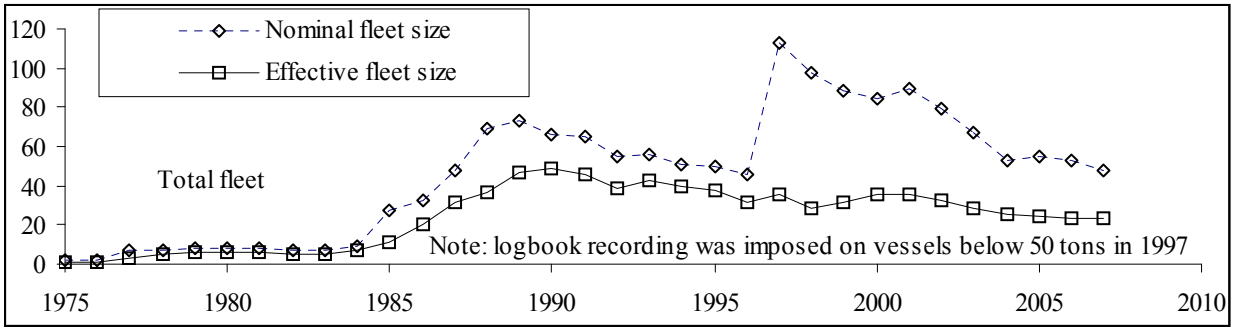

Fig. 1c. Nominal and effective sizes of the trawler fleet in the West Greenland shrimp fishery, 1975–2007, from logbook records.

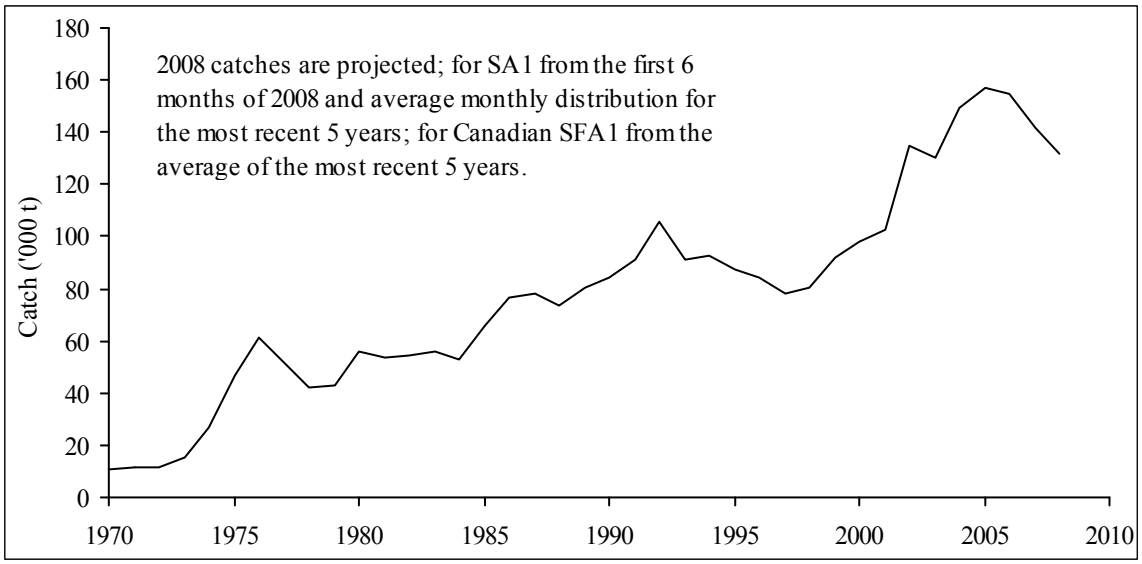

Fig. 2. Catches in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970-2008; 2008 value projected from half-year's data.

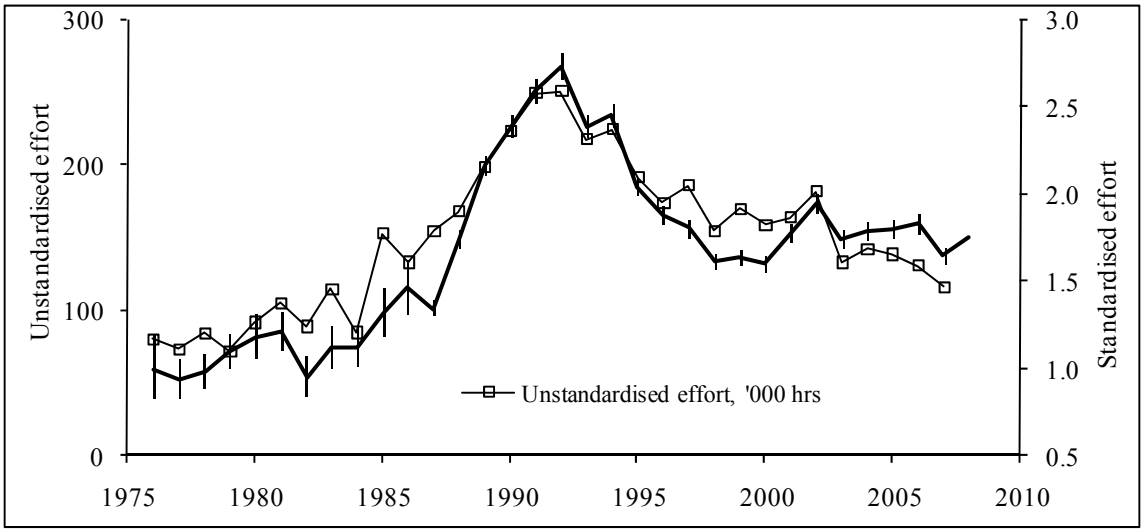

Fig. 3. Fishing effort applied in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970–2008.

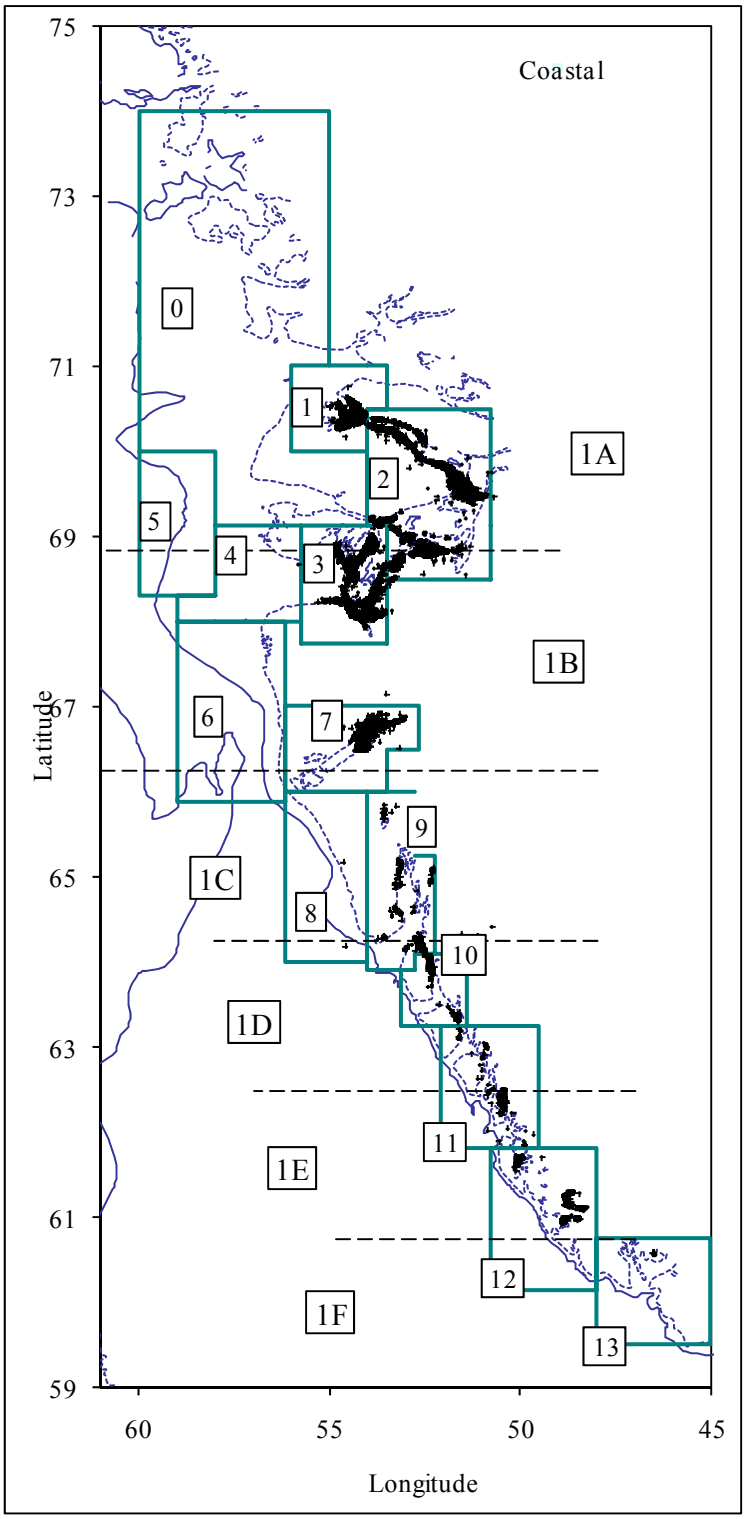

Fig. 4a. Distribution of fishing for Northern Shrimp by the Greenland coastal fleet in NAFO Subarea 1 from July 2007 through June 2008, with NAFO Divisions and statistical areas.

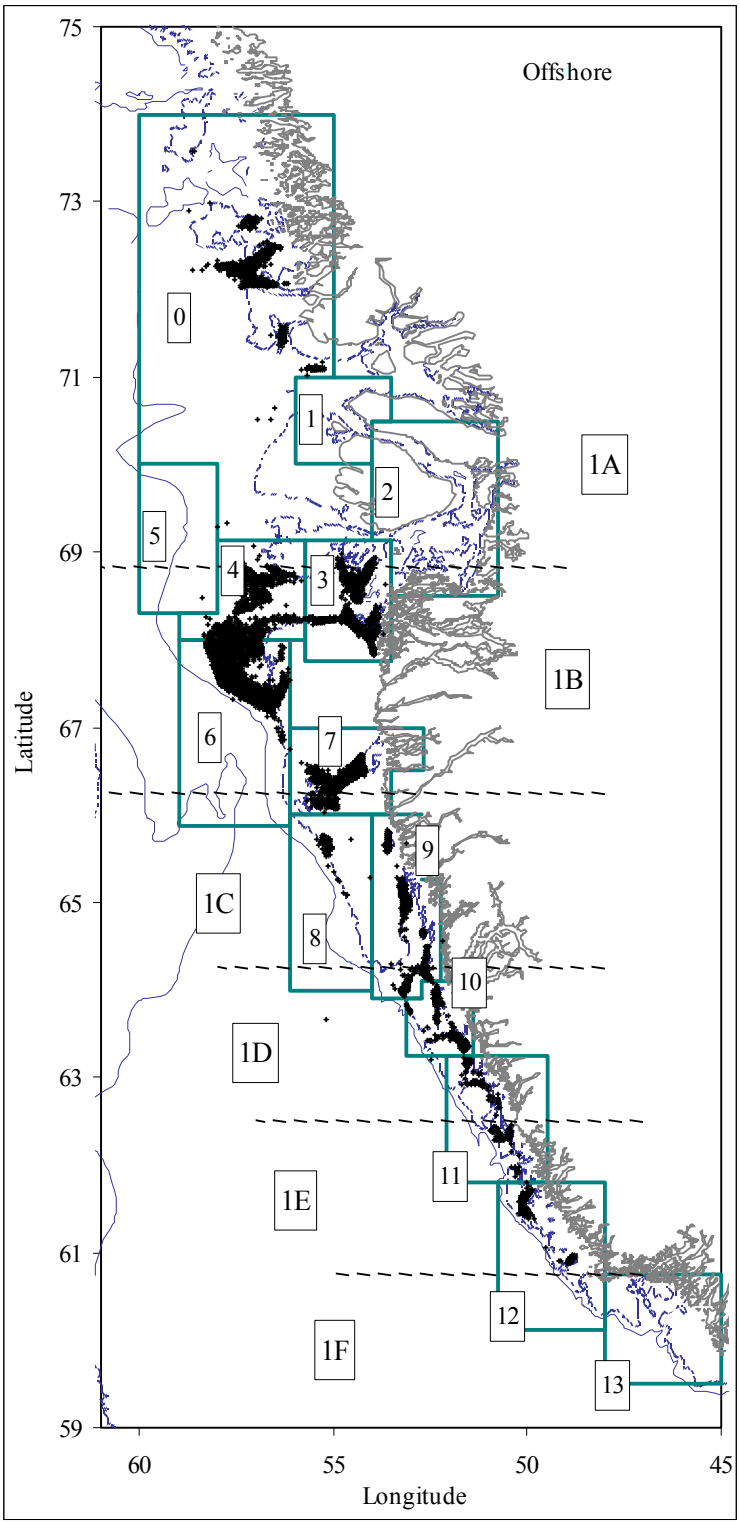

Fig. 4b. Distribution of fishing for Northern Shrimp by the offshore fleet in NAFO Subarea 1 from July 2007 through June 2008, with statistical areas and NAFO Divisions.

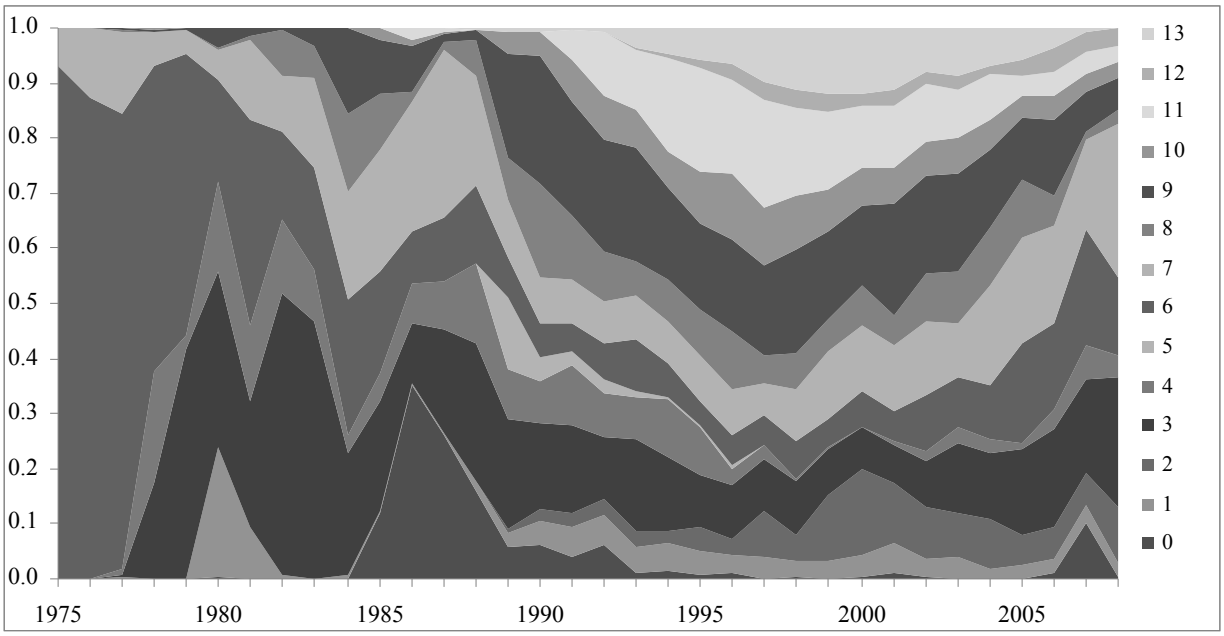

Fig. 5a. Distribution of the logbook-recorded catch of northern shrimp in the West Greenland fishery between statistical areas. (The light band that starts in the top left-hand corner is Area 7; the black band near the bottom is Area 3, that near the top is Area 9.)

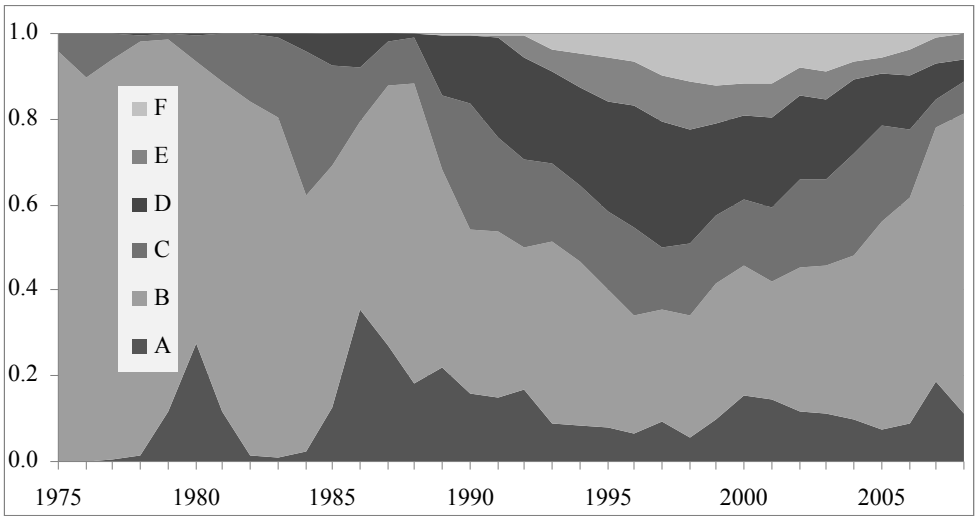

Fig. 5b. Distribution of the logbook-recorded catch of northern shrimp in the West Greenland fishery between NAFO Divisions in Subarea1.

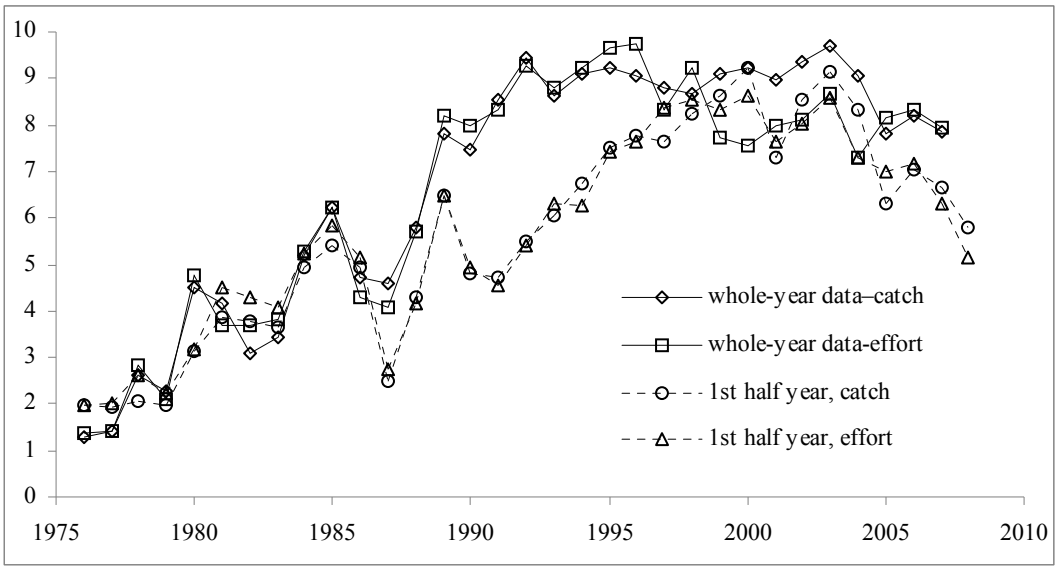

Fig. 6. Diversity indices for the distribution of logbook records of the West Greenland fishery between statistical areas, 1975–2008.

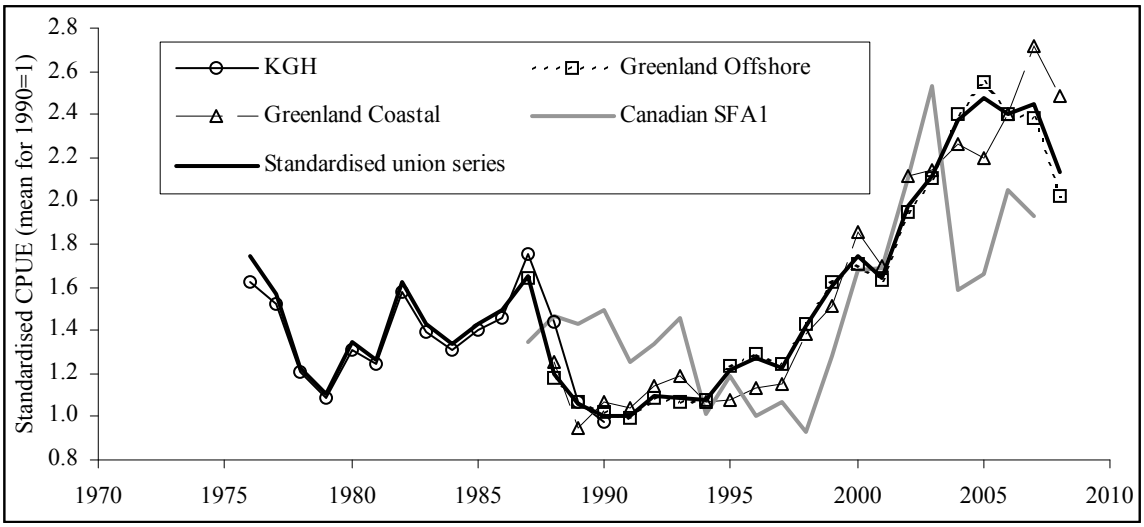

Fig. 7. Standardised CPUE in the West Greenland shrimp fishery, 1976–2008; standardised series from 4 fleets and a standardised union series.

Appendix I: A standardised CPUE series for the Greenland Offshore fleet.

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Class Level Information

Class	Levels	Values
VESSEL	27	hh02 hh05 hh06 hh07 hh10 hh11 hh13 hh16 hh20 hh22 hh23 hh24 hh26 hh27 hh28 hh29 hh30 hh32 hh35 hh36 hh40 hh41 hh43 hh45 hh46 hh47 hh48
year	22	1987 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2090
MONTH	7	1 2 4 5 7 8 11
AREA	7	3 4 5 6 10 11 12

Number of Observations Read 12619

Number of Observations Used 12619

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	59	128076.0005	2170.7797	728.91	<.0001
Error	12559	37402.2621	2.9781		
Corrected Total	12618	165478.2627			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.773975	72.20554	1.725724	2.390016

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESSEL	26	112552.7355	4328.9514	1453.58	<.0001
MONTH	6	2016.9600	336.1600	112.88	<.0001
AREA	6	2946.1675	491.0279	164.88	<.0001
year	21	10560.1374	502.8637	168.85	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	26	18566.75541	714.10598	239.78	<.0001
MONTH	6	1980.89023	330.14837	110.86	<.0001

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	6	831.78827	138.63138	46.55	<.0001
year	21	10560.13744	502.86369	168.85	<.0001

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
hh02 v hh05	1	139.1287125	139.1287125	46.72	<.0001
hh05 v hh06	1	14.3532913	14.3532913	4.82	0.0282
hh06 v hh07	1	18.2112366	18.2112366	6.12	0.0134
hh07 v hh10	1	8.9249370	8.9249370	3.00	0.0835
hh10 v hh11	1	4.1041783	4.1041783	1.38	0.2404
hh11 v hh13	1	4.3681328	4.3681328	1.47	0.2259
hh13 v hh16	1	9.1431662	9.1431662	3.07	0.0798
hh16 v hh20	1	19.9797913	19.9797913	6.71	0.0096
hh20 v hh22	1	24.0370037	24.0370037	8.07	0.0045
hh22 v hh23	1	10.1456550	10.1456550	3.41	0.0650
hh23 v hh24	1	6.8575058	6.8575058	2.30	0.1292
hh24 v hh26	1	16.0193204	16.0193204	5.38	0.0204
hh26 v hh27	1	8.9506082	8.9506082	3.01	0.0830
hh27 v hh28	1	11.8774898	11.8774898	3.99	0.0458
hh28 v hh29	1	3.9736446	3.9736446	1.33	0.2481
hh29 v hh30	1	21.5209230	21.5209230	7.23	0.0072
hh30 v hh32	1	3.2027229	3.2027229	1.08	0.2997
hh32 v hh35	1	17.4425338	17.4425338	5.86	0.0155
hh35 v hh36	1	16.3116755	16.3116755	5.48	0.0193
hh36 v hh40	1	12.0335718	12.0335718	4.04	0.0444
hh40 v hh41	1	3.2689658	3.2689658	1.10	0.2948

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
hh41 v hh43	1	7.5530395	7.5530395	2.54	0.1113
hh43 v hh45	1	13.8361012	13.8361012	4.65	0.0311
hh45 v hh46	1	24.9968001	24.9968001	8.39	0.0038
hh46 v hh47	1	2.9797865	2.9797865	1.00	0.3172
hh47 v hh48	1	3.8871460	3.8871460	1.31	0.2533
m01 v m02	1	51.8164215	51.8164215	17.40	<.0001
m02 v m04	1	51.0942272	51.0942272	17.16	<.0001
m04 v m05	1	215.7346411	215.7346411	72.44	<.0001
m05 v m07	1	987.7219052	987.7219052	331.66	<.0001
m07 v m08	1	319.3318502	319.3318502	107.23	<.0001
m08 v m11	1	94.1452913	94.1452913	31.61	<.0001
m11 v m01	1	35.0895701	35.0895701	11.78	0.0006
a03 v a04	1	258.7514027	258.7514027	86.88	<.0001
a04 v a05	1	228.3874116	228.3874116	76.69	<.0001
a04 v a06	1	15.3345773	15.3345773	5.15	0.0233
a06 v a10	1	53.5984937	53.5984937	18.00	<.0001
a10 v a11	1	62.0308100	62.0308100	20.83	<.0001
a11 v a12	1	20.1220682	20.1220682	6.76	0.0094

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		2.857604109 B	0.04191937	68.17	<.0001
VESSEL	hh02	-1.604228592 B	0.03690909	-43.46	<.0001
VESSEL	hh05	-1.396186004 B	0.03314341	-42.13	<.0001
VESSEL	hh06	-1.310105251 B	0.04418053	-29.65	<.0001

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
VESSEL	hh07	-1.202394169 B	0.03770281	-31.89	<.0001
VESSEL	hh10	-1.152148059 B	0.02958160	-38.95	<.0001
VESSEL	hh11	-1.117587790 B	0.03813540	-29.31	<.0001
VESSEL	hh13	-1.080116921 B	0.02888494	-37.39	<.0001
VESSEL	hh16	-1.048028972 B	0.02945175	-35.58	<.0001
VESSEL	hh20	-1.008687766 B	0.02839407	-35.52	<.0001
VESSEL	hh22	-0.953740004 B	0.03157088	-30.21	<.0001
VESSEL	hh23	-0.905438949 B	0.03315460	-27.31	<.0001
VESSEL	hh24	-0.853425481 B	0.03810439	-22.40	<.0001
VESSEL	hh26	-0.783057593 B	0.02816801	-27.80	<.0001
VESSEL	hh27	-0.727148263 B	0.04022794	-18.08	<.0001
VESSEL	hh28	-0.633645475 B	0.04580712	-13.83	<.0001
VESSEL	hh29	-0.586324686 B	0.03173999	-18.47	<.0001
VESSEL	hh30	-0.503929382 B	0.03412341	-14.77	<.0001
VESSEL	hh32	-0.466933540 B	0.03695538	-12.64	<.0001
VESSEL	hh35	-0.397900808 B	0.02589667	-15.36	<.0001
VESSEL	hh36	-0.347688689 B	0.03055910	-11.38	<.0001
VESSEL	hh40	-0.298238956 B	0.02791493	-10.68	<.0001
VESSEL	hh41	-0.266086614 B	0.03611241	-7.37	<.0001
VESSEL	hh43	-0.210520548 B	0.03116882	-6.75	<.0001
VESSEL	hh45	-0.151486037 B	0.02895294	-5.23	<.0001
VESSEL	hh46	-0.069377505 B	0.03195117	-2.17	0.0299
VESSEL	hh47	-0.037376466 B	0.03271555	-1.14	0.2533
VESSEL	hh48	0.000000000 B	.	.	
MONTH	1	-0.039943246 B	0.01163659	-3.43	0.0006
MONTH	2	0.026966554 B	0.01528404	1.76	0.0777

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
MONTH	4	0.090228314 B	0.01078389	8.37	<.0001
MONTH	5	-0.013868664 B	0.01197351	-1.16	0.2468
MONTH	7	0.203054541 B	0.01010137	20.10	<.0001
MONTH	8	0.070397311 B	0.01252069	5.62	<.0001
MONTH	11	0.000000000 B	.	.	.
AREA	3	0.046607314 B	0.03150682	1.48	0.1391
AREA	4	-0.115708362 B	0.03062820	-3.78	0.0002
AREA	5	-0.318498667 B	0.03565767	-8.93	<.0001
AREA	6	-0.082579638 B	0.02980928	-2.77	0.0056
AREA	10	-0.127414966 B	0.02857844	-4.46	<.0001
AREA	11	-0.076026550 B	0.02924828	-2.60	0.0094
AREA	12	0.000000000 B	.	.	.
year	1987	0.478426845 B	0.02590760	18.47	<.0001
year	1988	0.149280923 B	0.02068953	7.22	<.0001
year	1989	0.049344061 B	0.01915238	2.58	0.0100
year	1991	-0.020020087 B	0.01762529	-1.14	0.2560
year	1992	0.069036349 B	0.01826276	3.78	0.0002
year	1993	0.046701327 B	0.01824653	2.56	0.0105
year	1994	0.055416425 B	0.01845919	3.00	0.0027
year	1995	0.190472475 B	0.01877019	10.15	<.0001
year	1996	0.236385103 B	0.01987489	11.89	<.0001
year	1997	0.198826107 B	0.02102033	9.46	<.0001
year	1998	0.336534574 B	0.02265234	14.86	<.0001
year	1999	0.467178327 B	0.02351622	19.87	<.0001
year	2000	0.518050391 B	0.02616274	19.80	<.0001
year	2001	0.470281137 B	0.02560474	18.37	<.0001

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no month-area interaction included no summation after grouping

Group Area 7, 8, 9, w. 10

Group Mar. w. Apr., June w. July, Sept. & Oct. w. Nov.; Dec. w. Jan.

The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
year	2002	0.647502585 B	0.02359397	27.44	<.0001
year	2003	0.727139510 B	0.02417503	30.08	<.0001
year	2004	0.859143480 B	0.02451644	35.04	<.0001
year	2005	0.917833942 B	0.02420630	37.92	<.0001
year	2006	0.858489901 B	0.02422246	35.44	<.0001
year	2007	0.850881525 B	0.02609255	32.61	<.0001
year	2008	0.686808408 B	0.03363148	20.42	<.0001
year	2090	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: A standardised CPUE series for the Greenland Coastal fleet.

Greenland coastal fleet: areas 1--3, 7, 13 12:35 Friday, October 17, 2008 44

Oct. and Nov. combined with Dec.

The GLM Procedure

Class Level Information

Class	Levels	Values
VESSEL	14	cc01 cc02 cc05 cc07 cc10 cc12 cc15 cc16 cc20 cc21 cc24 cc27 cc30 cc32
year	21	1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2090
AREA	5	1 2 3 7 13
MONTH	10	1 2 3 4 5 6 7 8 9 12

Number of Observations Read 7965

Number of Observations Used 7965

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Oct. and Nov. combined with Dec.

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	46	31119.61335	676.51333	201.40	<.0001
Error	7918	26597.08179	3.35907		
Corrected Total	7964	57716.69514			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.539179	100.3836	1.832775	1.825772

Source	DF	Type I SS	Mean Square	F Value	Pr > F
AREA	4	3732.66343	933.16586	277.81	<.0001
MONTH	9	2705.28380	300.58709	89.49	<.0001
VESSEL	13	5143.83676	395.67975	117.79	<.0001
year	20	19537.82935	976.89147	290.82	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	4	3001.02074	750.25518	223.35	<.0001
MONTH	9	1953.94492	217.10499	64.63	<.0001
VESSEL	13	4386.63172	337.43321	100.45	<.0001

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The GLM Procedure

Dependent Variable: LNCPUE

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	19537.82935	976.89147	290.82	<.0001

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
cc01 v cc02	1	5.447672	5.447672	1.62	0.2029
cc02 v cc05	1	4.941019	4.941019	1.47	0.2252
cc05 v cc07	1	50.042555	50.042555	14.90	0.0001
cc07 v cc10	1	22.290785	22.290785	6.64	0.0100
cc10 v cc12	1	3.776635	3.776635	1.12	0.2890
cc12 v cc15	1	64.268395	64.268395	19.13	<.0001
cc15 v cc16	1	6.272726	6.272726	1.87	0.1718
cc16 v cc20	1	7.298682	7.298682	2.17	0.1405
cc20 v cc21	1	7.491903	7.491903	2.23	0.1354
cc21 v cc24	1	16.736537	16.736537	4.98	0.0256
cc24 v cc27	1	9.000187	9.000187	2.68	0.1017
cc27 v cc30	1	21.191515	21.191515	6.31	0.0120
cc30 v cc32	1	36.250638	36.250638	10.79	0.0010
a01 v a02	1	59.184714	59.184714	17.62	<.0001
a02 v a03	1	1210.790479	1210.790479	360.45	<.0001
a03 v a07	1	415.740153	415.740153	123.77	<.0001
a07 v a13	1	1297.874681	1297.874681	386.38	<.0001
m01 v m02	1	9.672331	9.672331	2.88	0.0898
m02 v m03	1	110.901293	110.901293	33.02	<.0001
m03 v m04	1	245.642974	245.642974	73.13	<.0001
m04 v m05	1	223.125284	223.125284	66.42	<.0001
m05 v m06	1	12.328062	12.328062	3.67	0.0554
m06 v m07	1	11.303529	11.303529	3.37	0.0666

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The GLM Procedure

Dependent Variable: LNCPUE

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
m07 v m08	1	45.549484	45.549484	13.56	0.0002
m08 v m09	1	59.897146	59.897146	17.83	<.0001
m09 v m12	1	40.494395	40.494395	12.06	0.0005
m12 v m01	1	51.886197	51.886197	15.45	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		1.894424027 B	0.03151149	60.12	<.0001
AREA	1	-0.341466223 B	0.01654647	-20.64	<.0001
AREA	2	-0.400671848 B	0.01561860	-25.65	<.0001
AREA	3	-0.157421106 B	0.01466153	-10.74	<.0001
AREA	7	-0.311364553 B	0.01584025	-19.66	<.0001
AREA	13	0.000000000 B	.	.	.
MONTH	1	-0.075485244 B	0.01920637	-3.93	<.0001
MONTH	2	-0.033624047 B	0.02105980	-1.60	0.1104
MONTH	3	0.108548609 B	0.01960317	5.54	<.0001
MONTH	4	0.301859468 B	0.01747366	17.28	<.0001
MONTH	5	0.144376719 B	0.01529040	9.44	<.0001
MONTH	6	0.178436964 B	0.01561604	11.43	<.0001
MONTH	7	0.212242667 B	0.01600820	13.26	<.0001
MONTH	8	0.140676939 B	0.01658947	8.48	<.0001
MONTH	9	0.056643654 B	0.01631410	3.47	0.0005
MONTH	12	0.000000000 B	.	.	.
VESSEL	cc01	-0.777352529 B	0.04144834	-18.75	<.0001
VESSEL	cc02	-0.689540350 B	0.06104165	-11.30	<.0001
VESSEL	cc05	-0.614862229 B	0.02834949	-21.69	<.0001

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The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
VESSEL	cc07	-0.503096982 B	0.02558190	-19.67	<.0001
VESSEL	cc10	-0.430945852 B	0.02769440	-15.56	<.0001
VESSEL	cc12	-0.404290660 B	0.02194669	-18.42	<.0001
VESSEL	cc15	-0.324614819 B	0.02193416	-14.80	<.0001
VESSEL	cc16	-0.293460940 B	0.02599806	-11.29	<.0001
VESSEL	cc20	-0.262236368 B	0.02028199	-12.93	<.0001
VESSEL	cc21	-0.227621430 B	0.02763665	-8.24	<.0001
VESSEL	cc24	-0.174939348 B	0.02074194	-8.43	<.0001
VESSEL	cc27	-0.145289938 B	0.02286345	-6.35	<.0001
VESSEL	cc30	-0.084837495 B	0.02582494	-3.29	0.0010
VESSEL	cc32	0.000000000 B	.	.	.
year	1988	0.159989531 B	0.04148994	3.86	0.0001
year	1989	-0.116490001 B	0.03106350	-3.75	0.0002
year	1991	-0.025247418 B	0.02797277	-0.90	0.3668
year	1992	0.067756932 B	0.02804789	2.42	0.0157
year	1993	0.106924378 B	0.02784394	3.84	0.0001
year	1994	-0.001310795 B	0.02714870	-0.05	0.9615
year	1995	0.013111105 B	0.02754129	0.48	0.6340
year	1996	0.061988244 B	0.02864341	2.16	0.0305
year	1997	0.075920454 B	0.02813005	2.70	0.0070
year	1998	0.259316577 B	0.03118902	8.31	<.0001
year	1999	0.346842058 B	0.02773287	12.51	<.0001
year	2000	0.555010120 B	0.02800040	19.82	<.0001
year	2001	0.466431570 B	0.02748183	16.97	<.0001
year	2002	0.682588435 B	0.02766894	24.67	<.0001
year	2003	0.697573741 B	0.02841834	24.55	<.0001
year	2004	0.749979885 B	0.02745629	27.32	<.0001

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The GLM Procedure

Dependent Variable: LNCPUE

Parameter		Estimate	Standard Error	t Value	Pr > |t|
year	2005	0.723183014 B	0.02772165	26.09	<.0001
year	2006	0.810893661 B	0.02872601	28.23	<.0001
year	2007	0.935711085 B	0.02921209	32.03	<.0001
year	2008	0.845649277 B	0.03275758	25.82	<.0001
year	2090	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: A standardised CPUE series for the Canadian fleet fishing for shrimps in SFA1

Canadian data for SFA1, nested within tonnage class

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Oct. and Nov. combined with Dec.

The GLM Procedure

Class Level Information

Class	Levels	Values
YEAR	21	1987 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2090
MONTH	6	5 6 7 8 9 12
vessel	11	nn01 nn02 nn04 nn06 nn08 nn10 nn11 nn14 nn15 nn21 nn22
TCLASS	3	5 6 7
GEAR	2	2 91

Number of Observations Read 616

Number of Observations Used 616

Canadian data for SFA1, nested within tonnage class 12:35 Friday, October 17, 2008 2
Oct. and Nov. combined with Dec.

The GLM Procedure

Dependent Variable: log_catch

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	37	1249.244585	33.763367	271.28	<.0001
Error	578	71.937959	0.124460		
Corrected Total	615	1321.182544			

R-Square	Coeff Var	Root MSE	log_catch Mean
0.945550	3.213654	0.352789	10.97782

Source	DF	Type I SS	Mean Square	F Value	Pr > F
log_effort	1	1095.301295	1095.301295	8800.42	<.0001
MONTH	5	15.271375	3.054275	24.54	<.0001
TCLASS	2	36.753837	18.376919	147.65	<.0001
vessel(TCLASS)	8	40.288521	5.036065	40.46	<.0001
YEAR	20	47.391240	2.369562	19.04	<.0001
GEAR	1	14.238318	14.238318	114.40	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
log_effort	1	845.4058710	845.4058710	6792.58	<.0001
MONTH	5	5.1434667	1.0286933	8.27	<.0001
TCLASS	2	8.7830815	4.3915407	35.28	<.0001
vessel(TCLASS)	8	7.5568433	0.9446054	7.59	<.0001

Canadian data for SFA1, nested within tonnage class 12:35 Friday, October 17, 2008 3
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The GLM Procedure

Dependent Variable: log_catch

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	20	30.0973031	1.5048652	12.09	<.0001
GEAR	1	14.2383181	14.2383181	114.40	<.0001

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
nn01 v nn02	1	0.25708939	0.25708939	2.07	0.1512
nn04 v nn06	1	0.88255914	0.88255914	7.09	0.0080
nn06 v nn08	1	0.13126107	0.13126107	1.05	0.3049
nn08 v nn10	1	1.08535228	1.08535228	8.72	0.0033
nn10 v nn11	1	0.16364050	0.16364050	1.31	0.2520
nn14 v nn15	1	0.39375906	0.39375906	3.16	0.0758
nn15 v nn21	1	0.55260179	0.55260179	4.44	0.0355
nn21 v nn22	1	0.33384120	0.33384120	2.68	0.1020
m05 v m06	1	3.78525261	3.78525261	30.41	<.0001
m06 v m07	1	0.29567456	0.29567456	2.38	0.1238
m07 v m08	1	0.90037260	0.90037260	7.23	0.0074
m08 v m09	1	0.41023284	0.41023284	3.30	0.0700
m09 v m12	1	0.43344954	0.43344954	3.48	0.0625

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		5.974469426 B	0.12400304	48.18	<.0001
log_effort		1.083602751	0.01314779	82.42	<.0001
MONTH	5	-0.822562060 B	0.18379765	-4.48	<.0001
MONTH	6	0.258450472 B	0.08402937	3.08	0.0022
MONTH	7	0.125045813 B	0.04650623	2.69	0.0074

Canadian data for SFA1, nested within tonnage class 12:35 Friday, October 17, 2008 4
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The GLM Procedure

Dependent Variable: log_catch

Parameter		Estimate	Standard Error	t Value	Pr > |t|
MONTH	8	-0.004112405 B	0.04086668	-0.10	0.9199
MONTH	9	0.073633910 B	0.03945697	1.87	0.0625
MONTH	12	0.000000000 B	.	.	.
TCLASS	5	-0.684401180 B	0.11365410	-6.02	<.0001
TCLASS	6	-0.014834311 B	0.17776534	-0.08	0.9335
TCLASS	7	0.000000000 B	.	.	.
vessel(TCLASS) nn01	5	-0.194933026 B	0.13563085	-1.44	0.1512
vessel(TCLASS) nn02	5	0.000000000 B	.	.	.
vessel(TCLASS) nn04	6	-0.709931815 B	0.18195859	-3.90	0.0001
vessel(TCLASS) nn06	6	-0.485941619 B	0.16945565	-2.87	0.0043
vessel(TCLASS) nn08	6	-0.426576744 B	0.16925270	-2.52	0.0120
vessel(TCLASS) nn10	6	-0.203581840 B	0.17754513	-1.15	0.2520
vessel(TCLASS) nn11	6	0.000000000 B	.	.	.
vessel(TCLASS) nn14	7	-0.347845681 B	0.08943900	-3.89	0.0001
vessel(TCLASS) nn15	7	-0.240216943 B	0.08760695	-2.74	0.0063
vessel(TCLASS) nn21	7	-0.132810282 B	0.08109179	-1.64	0.1020
vessel(TCLASS) nn22	7	0.000000000 B	.	.	.
YEAR	1987	-0.107578327 B	0.26936173	-0.40	0.6898
YEAR	1988	-0.024016327 B	0.13769076	-0.17	0.8616
YEAR	1989	-0.047353768 B	0.09029874	-0.52	0.6002
YEAR	1991	-0.175661393 B	0.08902637	-1.97	0.0490
YEAR	1992	-0.112445252 B	0.08989933	-1.25	0.2115
YEAR	1993	-0.028002520 B	0.08693433	-0.32	0.7475
YEAR	1994	-0.387457729 B	0.08445158	-4.59	<.0001
YEAR	1995	-0.229191952 B	0.08706055	-2.63	0.0087
YEAR	1996	-0.404381059 B	0.08997320	-4.49	<.0001
YEAR	1997	-0.342130793 B	0.12700657	-2.69	0.0073
YEAR	1998	-0.482538746 B	0.11247959	-4.29	<.0001

Canadian data for SFA1, nested within tonnage class 12:35 Friday, October 17, 2008 5

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The GLM Procedure

Dependent Variable: log_catch

Parameter		Estimate	Standard Error	t Value	Pr > |t|
YEAR	1999	-0.155789500 B	0.10199561	-1.53	0.1272
YEAR	2000	0.113405551 B	0.11312426	1.00	0.3165
YEAR	2001	0.119175893 B	0.09475332	1.26	0.2090
YEAR	2002	0.337617784 B	0.08937207	3.78	0.0002
YEAR	2003	0.522424392 B	0.09338860	5.59	<.0001
YEAR	2004	0.054849280 B	0.08903387	0.62	0.5381
YEAR	2005	0.105206628 B	0.09565462	1.10	0.2719
YEAR	2006	0.312559547 B	0.10151722	3.08	0.0022
YEAR	2007	0.254717796 B	0.10964843	2.32	0.0205
YEAR	2090	0.000000000 B	.	.	.
GEAR	2	0.451219627 B	0.04218653	10.70	<.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.