TO BE CITED WITHOUT PRIOR
REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N6109 **NAFO SCR Doc. 12/048**

NAFO/ICES *PANDALUS* ASSESSMENT GROUP—OCTOBER 2012

The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970–2012

by

Nanette Hammeken Arboe

Greenland Institute of Natural Resources

Box 570, 3900 Nuuk, Greenland

Abstract

The 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 SFA1). 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. Increases in allowed takes were subsequently accompanied by increased catches. The logbook recorded catches in 2005 and 2006, around 157 000 tons, were the highest recorded. In 2009 and 2010 the catches were near 135 000 tons decreasing to 124 000 tons in 2011. The Total Allowable Catch (TAC) for the stock advised for 2008–10 was 110 000 tons live-caught weight, a reduction from 130 000 tons advised for 2004–07. The advised TAC for 2011 was 120 000 tons.

Consequent to a change in assessment method, the advised TAC was reduced to 90 000 tons for 2012; a joint TAC for 2012 for Subarea 1 and Div. 0A was set by the Greenland Government at 105 000 tons; of this, 3325 tons were set aside for Canada resulting in an enacted TAC for Greenland of 101 675 tons. Canada set a TAC of 16 921 t for its fishery in SFA1 for 2012. Canadian catches in recent years have decreased from about 7000 tons in 2003–05 to 2000 tons in 2007, with no fishery at all in 2008 and insignificant catches in 2009. In 2010 the Canadian catch was about 6 000 tons and in 2011 about 1 300 tons. The 2012 Greenland catch has been projected at 110 000 tons; there appears to be little or no fishing in Canadian SFA1. The fishery in Greenland is regulated by individual quotas. Quota drawdowns have until recently been 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.

The distribution of fishery catches of *P. borealis* by depth has changed greatly over the most recent 20 years. Between 1991–94 and 2003–06 the median catch depth decreased by 100 m, or 30%.

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 2004–08 of about twice its 1997 value. CPUE in 2009 and 2010 was 10% to 15% less than in 2008, but in 2011 went back up to the 2004–08 plateau. In 2012, CPUE on part-year data has decreased to its level in 2009–10.

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. Since 2005 the catches taken in Division 1B has averaged 50% of the total catch. Since 1990 the proportion of the catch taken in Division 1A has been less than 15%. The proportion af the total catch taken in Division 1A has been rising since 2006 constituting between 35% and 40% of total catch in the years 2009-2011. This is especially due to increased fishing in statistical area 2 (Disko Bay area), statistical area 3 (Disko Bay mouth) and statistical area 0. Even though CPUEs remain high, if the area that the stock is spread over is shrinking, then its biomass could also be decreasing.

Introduction

The Northern shrimp (*Pandalus borealis*) occurs on the continental shelf off West Greenland in NAFO Div. 0A and in Div. 1A-1F. The species is distributed from Cape Farewell (60°N) to about 74°N, with the highest densities in depths between 150 and 550 m (Fig. 4).

A bottom-trawl fishery began in inshore areas in 1935. In 1970 a multinational offshore fishery started to develop and over the following years landings increased, to approximately 153 000 tons in 2006 (Table 1, Fig. 2). Catch restrictions were first imposed in 1977 and the fishery has since been managed by Total Allowable Catch (TAC). 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. 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 (Fig. 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, 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. Coastal quotas were at one time restricted to vessels under 75 GRT/120 GT, but there are now a few trawler of several hundred tons that fish on coastal quotas. No TAC was set for the coastal fleet until 1997; the coastal quota is now fixed by law at 43% of the Greenland TAC. A system of Individual Transferable Quotas (ITQs) was introduced in the Greenlandic fishery in 1991. The coastal and offshore quotas were kept separate until 2009, when a transfer of quotas between the coastal and the offshore fleet was first allowed. 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 are incomplete.

The coastal fleet 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. Since 2004 logbook entries have been 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.

Management of the fishery in Greenland has been bedevilled by mixed regulation, partly based on weights caught, and partly on weights traded. Even after elimination of overpacking the quota drawdown for shrimps landed at and sold to shore stations in Greenland by any fleet component remained less than the live weight by an allowance for crushed or broken shrimps, which were included in the landing but not in the sale (G.H. 1996). The stock assessment, the advice, and the enacted TACs and quotas were then based on analysis of live-caught weights, but quota drawdowns and tactical fishery management were partly based on such, smaller, traded weights, so annual catches measured as live-caught weight were apt to exceed TACs. Another regulatory change from 1 January 2011 requires quotas to be drawn down by the amount caught, without allowances for shrimps landed in poor condition. However, many catches, especially those taken in shallower waters, contain some admixture of *Pandalus montagui*. These catches are usually not identified, especially by vessels fishing bulk shrimps for landing in Greenland, but the proportion of *montagui* is estimated by sampling the catch at

the point of sale and the quota drawdown is restricted to its estimated weight of *borealis.* Logbook records can in this way still come to exceed quotas.

A licence holder who fishes out his quota 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 them until 30 April in the following year. These concessions 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. In 2006 there were 7, and in 2007 there were 5. In 2008 there was no fishery and in 2009 only one vessel fished, and that one didn't catch much. In 2010 there were 5 vessels fishing; they caught about 5½ Kt between them. In 2011 an unknown number of vessels caught around 1330 tons. Catches are nominally subject to individual quotas; a quota can be retroactively adjusted to cover an overrun, with a corresponding correction in a later year. Logbooks have been available since 1979.

Greenland and Canada have not agreed a formula for sharing the allowable catch on the stock. For the fishing year 2012 the Greenland Government initiated a practice of deciding on a TAC for the entire stock and setting aside a part of that TAC to allow for the Canadian interest, the proportion being reckoned on the basis of habitat area, recent catches, and recent survey estimates of stock biomass in the respective EEZs. The EU quota is now also deducted from the TAC before dividing the remainder between the coastal (43%) and the offshore (57%) fleets.

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. 2011). Dispensation from the requirement for sorting grids on trawls was granted to all vessels under 75 GRT/120 GT from 2001 to 2010. Sorting-grid technology has greatly improved and since April 2012 all vessels are using sorting grids. 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 in the shrimp fishery 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 5% of the catch (G.H. 2011). In 2011 a suite of new Technical Conservation measures to protect bottom habitats was implemented. It included a requirement to use rotating rockhopper gear on all shrimp trawls, so that foot gear will roll over bottom obstructions rather than digging into the bottom, and a requirement to use toggle chains of 72 mm or longer, to keep trawl netting off the bottom. It also defined a closed area of approximately 650 n.mi.^{2} (between 64°10'N and 65°15'N, going from the shore to 3 n.mi. outside the baseline) in which are found high concentrations of sponge and coral beds, as well as a requirement to report live coral catches of > 60 kg and live sponge catches of > 800 kg to the Licencing Authority and to move a minimum of 2 n.mi. in a direction away from any place at which such catches are taken. In addition the authorities can close areas

which can be viewed as vulnerable marine areas. There is also a definition of 'new fishing areas' in West Greenland as areas lying North of 74°N (G.H. 2011).

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 the type of licence held or tonnage, 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), 3 (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 (Fig. 4).

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 (Fig. 1).

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, Kingsley and Hammeken Arboe 2012). 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 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 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 CPUE series, and in 2007 an overall average catch correction had been applied to all catches from both fleets.

The Canadian fishery in SFA1 has 100% observer coverage (Siferd, pers. comm.), and catch data for this fishery was fetched in September 2012 from the DFO Commercial Quota Reports web pages and from Siferd (pers. comm.). Information on the Canadian enacted TAC for SFA1 in 2012 was available on the DFO Commercial Quota Reports web pages.

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. 4), but Area 0 was not included in the analyses. The multiplicative model was represented in logarithmic form as:

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

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 Den Kongelige Grønlandske Handel (KGH—the Royal Greenland Trading Company). This fishery only covered Div 1A and part of Div. 1B and data from Areas 3, 4, 6 and 7 (Fig. 4) 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 26 years of the offshore production fishery in NAFO Div. 1A to 1F. 50 vessels were included providing data since 1987, grouped into 23 groups of 1–5 vessels with similar estimated effects. Statistical areas 3–12 were included in the analysis; areas 7 and 8 were grouped. The month effect was reduced to 8 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 earlier practice up to 2009, according to which only single-trawl data was used. Since 2007 double- and single-trawl data has been 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. 4, but is also active in some inshore areas further south, especially in area 7 and in previous years in areas 11–13. Areas 1–3, 7 and 13 were included in the anlaysis. Comprehensive data were available since 1988; 35 vessels were included, in 17 groups of 1-4 vessels. January and February were grouped together.

Data from the Canadian fishery in SFA 1 was available for 1981 through 2007. 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. There was no fishing reported in 2008, and no data from the little fishing in 2009. 2010 and 2011 data was made available, but not in a form that allowed vessels fishing in 2010—of which there were only 5—and in 2011 to be matched with vessels fishing in earlier years. An updated CPU series fully corrected for fleet composition could therefore not be computed, but a series using only tonnage class, instead of vessel identity, to correct for changes in fleet composition was computed for 1987–2007 and 2010, with 2008, 2009 and 2011 as missing years. The annual values for 1987–2007 had a correlation of 98% with the values calculated in 2008 and standardised on vessel, but there remains some doubt whether standardising on tonnage class alone would give a statistically valid index for 2010 if the ships fishing in that year were all, or mostly, different from those that

fished in earlier years—it has been impossible, for example, to retain only vessels with 3 or more years in the fishery. 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.

One unified series of standardised CPUE, covering 1976–2012, 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 calculated 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.

Distribution by depth

The distribution of logbook-recorded catches of *P. borealis* by depth was analysed in 2011 for the period 1991–2010, in 5 4-year periods, both overall and separately for the offshore and coastal fleets (Kingsley 2011).

Biological Sampling

There is at the moment no programme for sampling from the fishery for obtaining data on length, sex or weight of individual shrimps.

Pandalus montagui in the West Greenland fishery

Aesop shrimp *P. montagui* occurs off West Greenland and is caught, sometimes in large quantitities, by the fishery. Most *montagui* is caught in mixed catches, but mixed catches are very often not identified in logbooks, especially by the fleet fishing iced bulk shrimps. Logbook records therefore presumably underestimate catches of *montagui*. A separate document describing the results of analyses of log-book records of catches of montagui was presented in 2011 (Kingsley 2011).

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 sizes of this homogeneous fleet were nearly the same (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 (Fig. 1b). 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 (Fig. 1b).

The early logbook records from the coastal fleet, in the early 1990s, also show a small, homogeneous fleet, but this is artificial: vessels had to be under 80 tons to be in the coastal fishery, but below 50 tons didn't have to complete logbooks, so coastal vessels submitting logbooks were all much the same size (Fig. 1c). After 1997 all trawlers had to report, so the nominal size of the coastal fleet, as shown by logbooks, quadrupled from 24 to 94. However, the small ships were catching so few shrimps 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 (Fig. 1c).

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 increased very rapidly after 2000, by about 50% by 2005, and high TACs were enacted, and large catches taken, in 2004–2008.

Canada sets autonomous TACs for SFA1 that range up to 4000% of the estimated survey biomass in the area and in 1991–2010 averaged 154% of it. In those 20 years, catches in SFA1 did not exceed 90% of the TAC and averaged 31% of it. The catches therefore appear, overall, to be *de facto* unregulated; they average near to 50% of the estimated survey biomass in the area. However, there have been other examples of unregulated fisheries for *P. borealis*, and in any case SFA1 is such a small proportion of the total distribution area that an unregulated fishery there seems unlikely to threaten the continued

existence of the stock, given that this is not a highly migratory species. In 1991–2010 Canadian catches averaged 1.2% of the estimated survey biomass in the entire stock distribution area.

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 to about 120 000 hr 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 (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, but it appears to have decreased sharply in the first part of 2012.

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. 5), 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. 5), and in the mid-1990s the effective number of statistical areas being fished peaked at about 9.5 (Fig. 6). Since then, the fishery has contracted northwards and the effective number of areas fished has decreased as effort has become more concentrated (Fig. 6, Table 4b). Catch has also become more concentrated and the southern areas (NAFO Divs. 1C–1F) accounted for less than 25% of total catch in 2005–09, and barely over 15% in 2010–2012 (Table 3, Table 4a). During the 1980s 80% of the catch was taken in NAFO Divisions 1A and 1B. This pattern changed from the beginning of the 1990s to mid-2000s, where between 50% and 63% of the catch was taken in NAFO Divisions 1C–1F. From 2005-2009, 75 % of the catches has been taken in NAFO Divisions 1A–1B and since 2010 nearly 85 % of the catches has been taken in NAFO Divisions 1A-1B (Table 4a). The proportion of the catch taken in Division 1A has been around 10% since the beginning of the fishery except for the period 1985-89, where there was a northward expansion of the fishery (Table 4a). In recent years up to 40% of the catch has been taken in Division 1A (Fig. 5b). This is especially due to increased fishing in statistical area 2 (Disko Bay area Fig. 7b), statistical area 3 (Disko Bay mouth Fig. 7c) and statistical area 0. In recent years Area 0 has yielded between 6 and 17% of the catch (Fig. 5a). The rise in catches taken in the Disko Bay Area (Statistical areas 1,2 and 3, Fig. 7a) is consistent with results from the survey, in which the proportion of survey biomass in the inshore area has been high since 2005 (Kingsley et al. 2012). The distribution pattern for fishing effort follows the distribution of the catch (Table 4b, Fig. 4). An increasing concentration of the stock and the fishery would be consistent with a decreasing biomass index from the 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 always 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).

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 using unchanged gear (Carlsson and Kanneworff 1997; Rätz 1997). The distribution of the survey biomass has moved north since 1997 and the distribution of the survey biomass has contracted since 2003 (Kingsley et al. 2012), which is consistent with the distribution of the catches taken by the fishery (Fig. 5, Fig. 6).

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).

Depth distribution

The depth distribution of catches has shifted significantly over the most recent 20 years. In 1991–1994 the median depth for all catches was 347 m, and catches extended down to 547 m (99^{th} percentile). 12 years later, in 2003–2006, the median catch was taken 100 m shallower at 246.5 m. The median catch depth for the offshore and the coastal fleets changed by almost exactly the same 100 m. In the most recent 4 years, 2007–2010, the median catch depth for the offshore fleet has increased again, nearly back to where it was in 1999–2002, but the depth profile for catches in the coastal fleet has stayed exactly the same as in 2003–2006. The movement of the stock into shallower water does not seem to be continuing, but to have reached a plateau (Kingsley 2011).

By-catch and discard

The logbook-reported at-sea discard of shrimps, mostly for quality reasons by production trawlers, has remained less than 1% by weight of total catch throughout 1975–2010 (Table 6). However, these statistics do not include shrimps 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 shrimps may have offset a corresponding effect of observers on the reported discard of shrimps.

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 shrimps, out of the trawl through escape openings. In the most recent years registered annual discards of fish have been below 1.5 % of total shrimp catch, but fish discard reports are based on visual estimates of weight, not on

physical weighing, and errors are likely (Table 6, Table 7). An EU project[1] 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% (Table 7). No data on Canadian bycatch has been made available for 2009–2011.

Pandalus montagui

The Aesop, or striped pink, shrimp *Pandalus montagui* is in general not highly sought after by the Greenland fishery, and few vessels catch much of it. Its presence lowers the price paid for bulk shrimps and can exclude catches from markets for the highest-quality products. But it does seem that some vessels, sometimes, make protracted series of catches, some large, with unusually high proportions of *montagui*. The offshore fleet records catches of *montagui*, estimated by sampling from the on-board holding tank, in logbooks. The coastal fleet fishing bulk shrimps for processing on shore does not record *P. montagui* in its logbooks; weights of *borealis* and *montagui* are reckoned from catch samples taken at the point of sale. Logbook records of *montagui* catches are therefore an underestimate, while logbook records of *borealis* catches are an overestimate. Neither fleet expects that catches of *montagui* will be withdrawn from its quotas on *borealis*, so quota drawdowns in the coastal fleet, which does not record montagui in logbooks, can be less than the logbook-recorded catches of bulk shrimps.

From 1995 to 2012 logbook reports have included overall annual catches of *P. montagui* in the range of about 100 to 4 200 tons (Table 6); for 27 vessels recording catches of P. montagui in 2001-2010, the (under-) reported catch of montagui averaged under 1% of the catch of borealis (Kingsley 2011). In 2011 the catch of montagui was 2% of the catch of borealis which rose to 4% in 2012 (on part years data) (Table 6). There were indications of increased biomass of *P. montagui* in the mid- and late 1990s (Kanneworff, 2003), but survey estimates of biomass have been low since the turn of the century (Siegstad and Hammeken Arboe 2011). The effect of the fishery for *borealis* on the stock of *montagui* has not been evaluated and is of some concern.

Catch per unit of effort

Logbook 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

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

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. After 2004 they diverged more than in previous years (Table 2, Fig. 8), but since 2008 they seem to have returned to closer agreement. In 2009–10 they agreed that catch rates were lower, but in 2011, they both had higher catch rates. In 2012, on part-year's data, they both fell to the same level as in 2009–10.

CPUE in the Canadian fishery in SFA1 has always varied more from year to year and has never stayed closely in step with the Greenland fleets, although over time its overall trend has been similar. (Table 2, Fig. 7). The Canadian CPUE index for 2010 is based on few ships, and the data provided for 2010 does not allow matching ships to those fishing earlier in the record, so that while the analysis indicates a great increase in CPUE in Canadian SFA1 between 2007 and 2010, the dislocation in the data makes it difficult to have much confidence in this index. No index was calculated for 2011.

The overall combined index (Table 2, 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 2004–2008, to turn downward in 2009, and to decrease yet further in 2010. In 2011, the combined index increased by 10% over its 2010 value to stand at the fifth highest value ever. In 2012 the combined index decreased reaching the level seen in 2009-2010.

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 in motor power. 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.

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 1995–99 and 2005–2009 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. And this contraction of the fishery appears to have continued in 2010, 2011 and 2012 (Fig. 6). This reduction in the 'effective number of areas' does not translate directly 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 decreased, overall by 50% from its then value (Kingsley et al. 2012). Catch rates in the fishery in recent years have been high although decreasing since 2009, but we hear from fishermen that high catch rates are coming from concentrations of shrimps that are restricted, sparse and local, so they might well not be a reflection of an abundant stock.

In conclusion, the state of the fishery in 2012 appears similar to that of 2011, only more so: catch rates have remained high, but the fishery has continued to contract.

Acknowledgements

Mads Rossing Lund of Grønlands Fiskeri- og Licenskontrol helped in obtaining logbook data for the Greenland fleets and with many insights into the conduct of the fishery. Tim Siferd of the Canadian Department of Fisheries and Oceans, Central and Arctic Region, Winnipeg, updated the data for the Canadian fishery in SFA1 for 2012.

References

CARLSSON, D. M., and P. KANNEWORFF. 1997. Offshore stratified-random trawl survey for shrimp (*Pandalus borealis*) in NAFO Subarea 0 & 1, in 1997. NAFO SCR Doc. 97/101, Ser. No. N2958.

GARCIA, E.G. 2007. The Northern Shrimp (*Pandalus borealis*) offshore fishery in the northeast Atlantic. Adv. Mar. Biol. 52:147–266.

G.H. 1996. Hjemmestyrets bekendtgørelse nr. 39 af 30. december 1996 om kontrol med kystnært fiskeri efter rejer. http://www.nanoq.gl/gh.gl-love/dk/1996/bkg/bkg_nr_39-1996_dk.htm

G.H. 2002. Hjemmestyrets bekendtgørelse nr. 23 af 29. august 2002 om geografisk adgang til rejefiskeri på Grønlands fiskeriterritorium. http://www.nanoq.gl/gh.gl-love/dk/2002/bkg/bkg_nr_29-2002_dk.htm

G.H. 2003. Hjemmestyrets bekendtgørelse nr. 25 af 29. december 2003 om beregningsmetoder ved rapportering af visse fangster. http://www.nanoq.gl/gh.gl-love/dk/2003/bkg/bkg_nr_25-2003_dk.htm

G.H. 2010 Selvstyrets bekendtgørelse nr. 20 af 16. december 2010 om kontrol med kystnært fiskeri efter rejer http://www.lovgivning.gl/gh.gl-love/dk/2010/bkg/bkg_nr_20-2010_dk.htm

G.H. 2010 Selvstyrets bekendtgørelse nr. 18 af 9. december 2010 om kontrol med havgående fiskeri http://www.lovgivning.gl/gh.gl-love/dk/2010/bkg/bkg_nr_18-2010_dk.htm

G. H. 2011 Selvstyrets bekendtgørelse nr. 14 af 6. december 2011 om fiskeriets bifangster

http://www.lovgivning.gl/gh.gl-love/dk/2011/bkg/bkg_nr_14-2011_dk.htm

G.H 2011 Selvstyrets bekendtgørelse nr. 12 af 17. november 2011 om tekniske bevaringsforanstaltninger i fiskeriet http://www.lovgivning.gl/gh.gl-love/dk/2011/bkg/bkg_nr_12-2011_dk.htm

G.H. 2011 Inatsisartutlov nr. 8 af 22. november 2011 om ændring af Landstinglov om fiskeri (Ændringer om ejerskab og kvoteloftbegrænsninger). http://www.lovgivning.gl/gh.gl-love/dk/2011/ltl/L_08-2011_fiskeri/L_08-2011_dk.htm

G.H. 2012 Selvstyrets bekendtgørelse nr. 1 af 2. februar 2012 om licens og kvoter til fiskeri. http://www.lovgivning.gl/gh.gl-love/dk/2012/bkg/bkg_nr_01-2012_dk.htm

HVINGEL, C. 2003. Correction of reported past catches of Northern Shrimp within the Greenland EEZ to conform to a revision of reporting practices. NAFO SCR Doc. 03/74, Ser. No. N4913. 3 pp.

HVINGEL, C. 2004. The fishery for Northern Shrimp *(Pandalus borealis*) off West Greenland, 1970–2004. NAFO SCR Doc. 04/75, Ser. No. 4914. 24 pp.

HVINGEL, C., H. LASSEN and D.G. PARSONS. 2000. A biomass index for northern shrimp (*Pandalus borealis*) in Davis Strait based on multiplicative modelling of commercial catch-per-unit-effort data (1976–1997). J. Northw. Atl. Fish. Sci. 26: 25–31.

KANNEWORFF, P. 2003. Occurrence of *Pandalus montagui* in trawl survey samples from NAFO Subarea 0+1. NAFO SCR Doc. 03/70, Ser. No. N4909.

KINGSLEY, M.C.S. 2007. Catches of Northern Shrimp (*Pandalus borealis*) off West Greenland, 1999–2006. NAFO SCR Doc. 07/66, Ser. No. N5451. 4 pp.

KINGSLEY, M.C.S. 2011. The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970–2011. NAFO SCR Doc. 11/052, Ser. No. N5977. 43 pp.

KINGSLEY, M.C.S. 2011. *Pandalus montagui* in the West Greenland shrimp fishery, 2001–2010. NAFO SCR Doc. 11/057, Ser. No. N5982. 5 pp.

KINGSLEY, M.C.S. and N. HAMMEKEN ARBOE. 2012. Catch Table Update for the West Greenland Shrimp Fishery. NAFO SCR Doc. 12/045, Ser. No. N6106. 6 pp.

KINGSLEY, M.C.S., H. SIEGSTAD and K. WIELAND. 2012. The West Greenland trawl survey for *Pandalus borealis*, 2012, with reference to earlier results. NAFO SCR Doc. 12/044, Ser. No. N6099. 44 pp.

RÄTZ, H.-J. 1997. Biomass indices and geographical distribution patterns of survey catches for shrimp (*Pandalus borealis*) off West and East Greenland, 1982–96. NAFO SCR Doc. 97/96, Ser. No. N2953.

SAS Institute. 1988. SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute Inc., 1988. 1028 pp.

SIMPSON, E.H. 1949. Measurement of diversity. Nature 163:688.

SIEGSTAD, H. and N. HAMMEKEN ARBOE. 2011. Occurence of *Pandalus montagui* in Trawl Survey Samples from NAFO Subareas 0 & 1. NAFO SCR Doc. 11/070, Ser. No. N5996. 13pp.

SÜNKSEN, K. 2007. Discarded by-catch in shrimp fisheries in Greenlandic offshore waters 2006–2007. NAFO SCR Doc. 07/88, Ser. No. 5474. 12 pp.

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	Std. Total
				Offshore	Inshore	Total	Offshore		Unstd. ('000 hr)			Std. (index)	Unstd. (kg/hr)			(1976=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	762	-	766	1.00
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	11.6	92	1.18	665	235	610	0.77
1981	35000	5000	40000	40295	8250	48545	5284	53829	88.2	16.6	105	1.21	551	318	514	0.73
1982	34800	5000	39800	43979	8250	52229	2064	54293	81.1	8.1	89	0.95	644	256	609	0.93
1983	34625	5000	39625	42553	8250	50803	5413	56216	89	26.1	115	1.11	571	208	488	0.82
1984	34925	5000	39925	42414	8250	50664	2142	52806	85	-	*85*	1.12	596	-	*621*	0.77
1985	42120	6120	48240	54889	8250	63139	3069	66208	129.1	23.6	153	1.30	489	130	433	0.83
1986	42120	6120	48240	65623	8250	73873	2995	76868	133.4	-	*133*	1.45	554	-	*576*	0.86
1987	40120	6120	46240	64222	7613	71836	6095	77931	137.1	17.7	155	1.32	524	344	503	0.96
1988	40120	6120	46240	56479	11256	67735	5881	73616	152.9	14.9	168	1.73	443	395	439	0.69
1989	45245	7520	52765	58890	14546	73436	7235	80671	179.6	19.7	199	2.18	409	367	405	0.60

* 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, 1990–2011.

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	2.38	371	433	375	0.57
1991	46225	8500	54725	66818	17884	84701	6788	91489	230.8	19.6	250	2.49	367	346	365	0.60
1992	44200	8500	52700	75341	22653	97994	7493	105487	234.2	16.6	251	2.60	418	451	421	0.66
1993	40600	8500	49100	65894	19627	85522	5491	91013	206.1	12.2	218	2.33	415	450	417	0.64
1994	42300	8500	50800	68109	19930	88039	4766	92805	209.8	15.3	225	2.38	420	312	412	0.63
1995	39500	8500	48000	66955	18072	85027	2361	87388	184.7	7.3	192	2.03	460	322	455	0.70
1996	63922	8500	72422	62368	19095	81463	2632	84095	164.6	9	174	1.86	495	293	484	0.74
1997	64600	8500	74800	62743	14868	77611	517	78128	184.9	1.3	186	1.78	420	412	420	0.72
1998	60729	7650	68379	69156	10406	79562	933	80495	152.7	2.6	155	1.59	521	353	518	0.82
1999	73500	9350	82850	71203	18948	90152	2046	92198	164.7	5.1	170	1.62	547	398	543	0.92
2000	77675	9350	87025	73013	23365	96378	1590	97968	156.2	2.6	159	1.57	617	613	617	1.01
2001	92950	9350	102300	79291	20010	99301	3625	102926	158.3	6	164	1.73	627	602	626	0.97
2002	91150	12040	103190	107195	21729	128925	6247	135172	173.3	9	182	1.91	744	695	741	1.15
2003	101000	14167	115167	104237	18799	123036	7137	130173	124.4	8.2	133	1.72	989	873	982	1.23
2004	135352	14167	149519	121627	20684	142311	7021	149332	130.0	12.3	142.3	1.78	1095	570	1049	1.37
2005	134000	18452	152452	128051	21927	149978	6921	156899	129.4	9.3	138.8	1.79	1159	741	1131	1.43
2006	134000	18380	152380	127712	25476	153188	4127	157315	126.1	4.7	130.8	1.83	1215	884	1203	1.40
2007	134000	18417	152417	116240	26005	142245	1945	144190	114.0	2.2	116.2	1.63	1248	872	1241	1.44
2008	127300	18417	145717	116649	37240	153889	0	153889	119.1	-	119.1	1.67	1292	-	1292	1.50
2009	114570	18417	132987	95361	39668	135029	429	135458	119.1	-	119.1	1.71	1134	-	-	1.29
2010	114570	18417	132987	92617	35491	128108	5882	133990	118.5	5.1	123.5	1.77	1081	1161	1085	1.23
2011	124000	18417	142417	77220	45435	122655	1296	123951	107.7	2.6	110.2	1.45	1139	507	1124	1.39
2012#	101675	12750	114425	69062	40938	110000	0	110000	101.7	-	101.7	1.39	1081	-	-	1.29

* 1981-1995 TAC for offshore only; # Projections based on information received from GFLK and DFO.

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	0.368
1977	1.556	0.095							0.903	0.209
1978	1.23	0.074							0.706	0.136
1979	1.113	0.066							0.637	0.115
1980	1.34	0.082							0.773	0.160
1981	1.265	0.072							0.726	0.138
1982	1.61	0.099							0.934	0.231
1983	1.423	0.085							0.822	0.178
1984	1.338	0.078							0.770	0.153
1985	1.432	0.082							0.827	0.172
1986	1.49	0.085							0.860	0.185
1987	1.787	0.106	1.627	0.047			0.916	0.235	0.962	0.067
1988	1.465	0.086	1.161	0.027	1.183	0.049	1.107	0.145	0.694	0.042
1989	1.086	0.071	1.034	0.021	0.892	0.027	0.933	0.079	0.604	0.035
1990	1		1.000		1.000		1.000		0.574	0.034
1991			1.013	0.019	0.977	0.027	0.794	0.067	0.598	0.033
1992			1.117	0.022	1.068	0.030	0.973	0.085	0.659	0.037
1993			1.063	0.021	1.120	0.031	1.001	0.087	0.636	0.036
1994			1.080	0.021	1.004	0.027	0.677	0.057	0.634	0.035
1995			1.215	0.025	1.016	0.028	0.788	0.069	0.702	0.041
1996			1.277	0.027	1.064	0.030	0.682	0.062	0.738	0.043
1997			1.229	0.028	1.081	0.030	0.774	0.105	0.715	0.043
1998			1.401	0.034	1.306	0.040	0.675	0.080	0.823	0.052
1999			1.592	0.040	1.406	0.038	0.938	0.100	0.924	0.057
2000			1.692	0.045	1.739	0.048	1.268	0.151	1.014	0.065
2001			1.624	0.045	1.625	0.044	1.232	0.120	0.971	0.061
2002			1.921	0.048	1.998	0.054	1.543	0.137	1.153	0.072
2003			2.079	0.054	2.022	0.056	1.934	0.180	1.234	0.078
2004			2.358	0.061	2.115	0.057	1.182	0.099	1.369	0.087
2005			2.503	0.064	2.056	0.056	1.255	0.114	1.428	0.090
2006			2.381	0.061	2.225	0.062	1.584	0.157	1.399	0.088
2007			2.388	0.066	2.506	0.071	1.415	0.162	1.438	0.094
2008			2.509	0.069	2.530	0.069	_	_	1.500	0.097
2009			2.153	0.065	2.165	0.060	_	_	1.288	0.086
2010			2.088	0.064	1.999	0.056	_	_	1.234	0.084
2011			2.352	0.076	2.258	0.064	_	_	1.391	0.098
2012			2.183	0.080	2.074	0.064	_	_	1.288	0.098

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
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	1074	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	2039	1700	1039	565
2006	4.1	13.8	81.0	23.7	19.3	9.8	5.5	4.7	21.5	60.6	12.3	11.2	10.0	10.6	884	642	1336	1932	1730	984	519
2007	1.9	26.5	84.8	9.1	12.0	8.7	1.1	2.2	27.2	63.3	5.6	8.6	7.0	2.3	872	973	1340	1635	1406	1241	473
2008	0.0	42.3	96.1	6.7	4.4	4.4	0.1	-	36.3	71.4	4.3	3.1	3.9	0.1	-	1165	1345	1562	1410	1119	1170
2009	0.4	48.1	71.9	5.0	6.5	3.6	0.0	-	46.5	63.1	3.6	3.8	2.1	0.0	-	1034	1140	1377	1702	1738	-
2010	5.9	50.8	63.4	6.2	6.6	1.1	0.0	5.1	55.2	56.5	3.2	3.1	0.5	0.0	1161	922	1122	1928	2132	2123	-
2011	1.3	46.9	54.2	7.9	10.9	2.7	0.0	2.6	56.4	41.6	3.7	5.0	1.0	0.0	507	832	1303	2127	2176	2852	-
2012*	0.0	26.0	58.0	6.3	12.1	7.5	0.0	0.0	35.7	50.7	3.3	5.6	3.1	0.0	-	730	1142	1925	2176	2467	111

*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						
	80–84	85–89	90–94	95–99	00–04	05–09	10–12
1A	9.2	23.4	12.8	8.1	12.1	19.4	35.9
1B	72.1	56.1	38.3	29.1	33.7	55.4	48.1
1C	17.4	13.9	21.5	17.2	20.0	10.6	5.7
1D	1.3	6.4	21.5	26.1	19.0	8.2	7.8
1E	0.0	0.0	4.0	10.2	6.2	4.3	2.6
1F	0.0	0.2	2.1	9.3	9.0	2.1	0.0
Diversity	1.8	2.5	3.9	4.8	4.6	2.7	2.7

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						
	80–84	85–89	90–94	95–99	00–04	05–09	10–12
1A	9.3	30.5	15.9	16.7	24.9	25.4	46.7
1B	71.4	49.9	37.7	32.9	34.0	52.2	45.0
1C	18.1	12.6	21.9	16.2	14.1	7.0	3.1
1D	1.1	6.0	20.0	21.0	15.1	6.1	4.0
1E	0.0	0.0	2.4	6.5	4.1	4.6	1.1
1F	0.0	0.9	2.1	6.7	7.8	4.7	0.0
Diversity	1.8	2.8	3.9	4.6	4.4	2.9	2.4

[1] unstandardised trawl time

Table 5. Shrimp catch on the West Greenland shelf by month 1976–2009, 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	8439	9047	9341	12989	14820	13653	13819	10277	14989	16225	13358	12374
2005	10695	8782	12726	14837	15193	14476	15471	15462	12932	14715	10523	11085
2006	12785	11920	14185	11116	14357	11210	15659	15494	14215	13701	13049	9625
2007	5517	8820	10584	13624	13544	13717	16336	15295	13644	12295	10121	10693
2008	8989	7386	9007	12488	13827	15429	18407	15311	14414	12982	13608	12039
2009	10997	8128	4321	9183	12422	12699	14629	16719	12678	12928	11959	8576
2010	8327	7264	8294	9463	11250	13962	15349	14446	12272	12560	10714	10173
2011	9465	8862	11831	10877	10480	10265	12517	9526	8866	10195	11471	8317
2012*	9393	8605	5818	10064	10761	9981	9170	-	-	-	-	-

* Greenland and EU only, uncorrected logbook-reported catches.

Table 6. Discards of shrimp and fish, and landed catch reported[1] 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	762	0.5	1044	0.7	831
2005	753	0.5	982	0.7	512
2006	865	0.6	1178	0.8	1444
2007	741	0.5	2085	1.5	2003
2008	860	0.6	1116	0.7	89
2009	710	0.5	1321	1.0	53
2010	739	0.6	1426	1.1	1168
2011	720	0.6	1109	0.9	2324
2012*	542	0.5	562	0.5	4222

[1]the coastal fleet does not report *P. montagui* separately in logbooks. Information on how much *montagui* that fleet catches is captured at the point of sale, but is only recorded on sales slips.

* 2012: projected from part-year's data

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

Year	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	184 8	7360	25.1
1990	135 4	5663	23.9
1991	249 6	6849	36.4
1992	245 7	7480	32.8
1993	142 6	5275	27
1994	149 8	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
2008	No fishing		
2009	Little fishing, no information		
2010	No information		
2011	No information		
2012	-	-	-

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

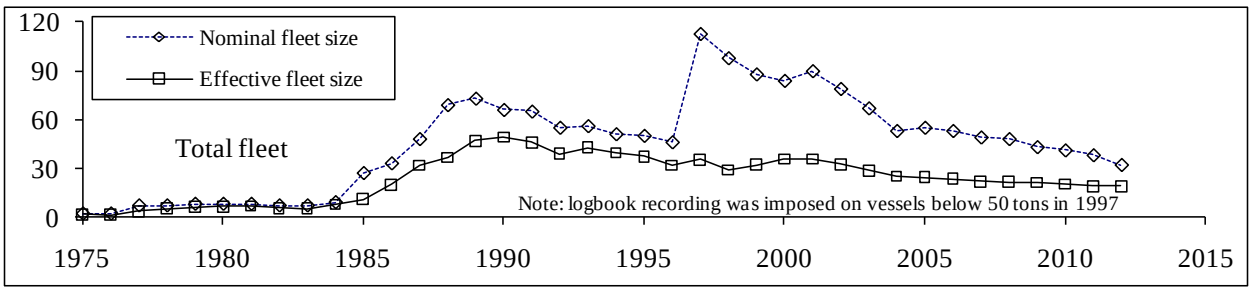

Fig. 1a. Nominal and effective sizes of the trawler fleet in the West Greenland shrimp fishery, 1975–2011, from logbook records.

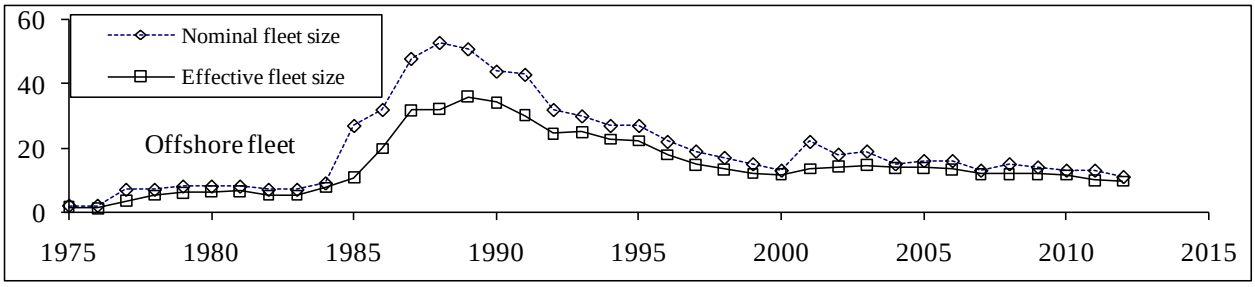

Fig. 1b. Nominal and effective sizes of the offshore trawler fleet in the West Greenland shrimp fishery, 1975–2011, from logbook records.

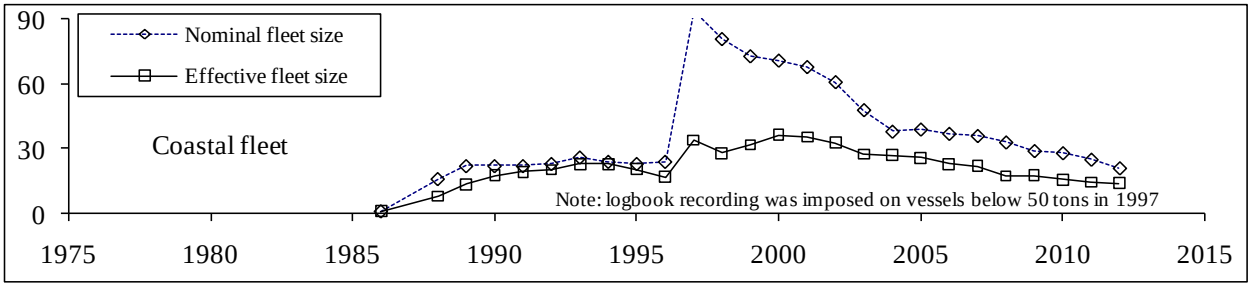

Fig. 1c. Nominal and effective sizes of the coastal trawler fleet in the West Greenland shrimp fishery, 1986–2011, from logbook records.

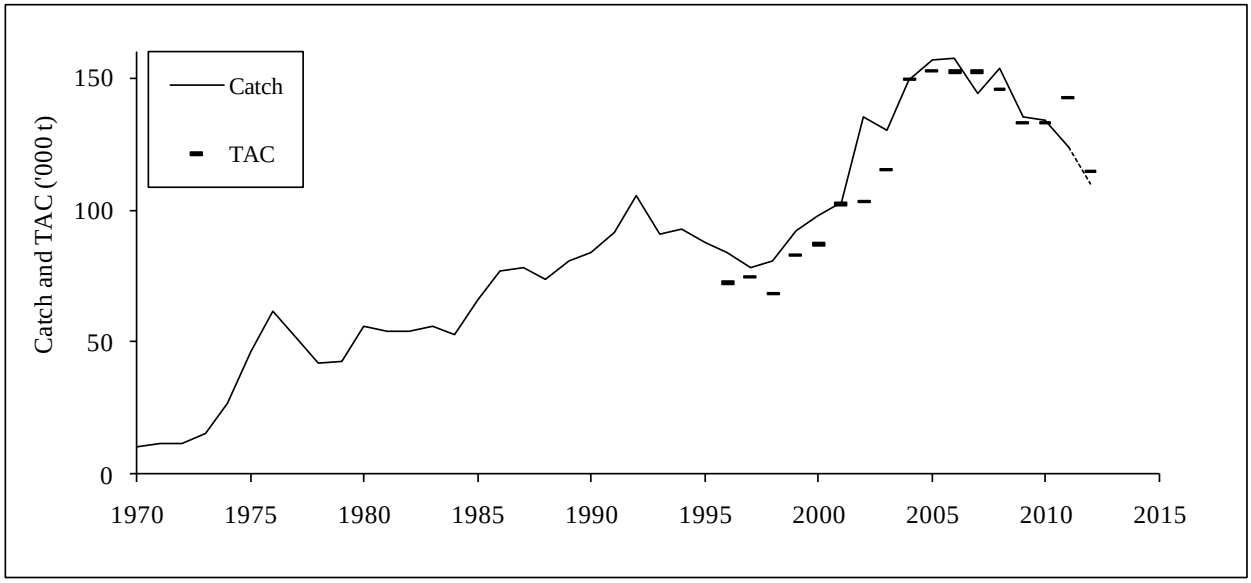

Fig. 2. Catches in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970–2011; 2012 catch estimate is based on forecasts from GFLK and DFO.

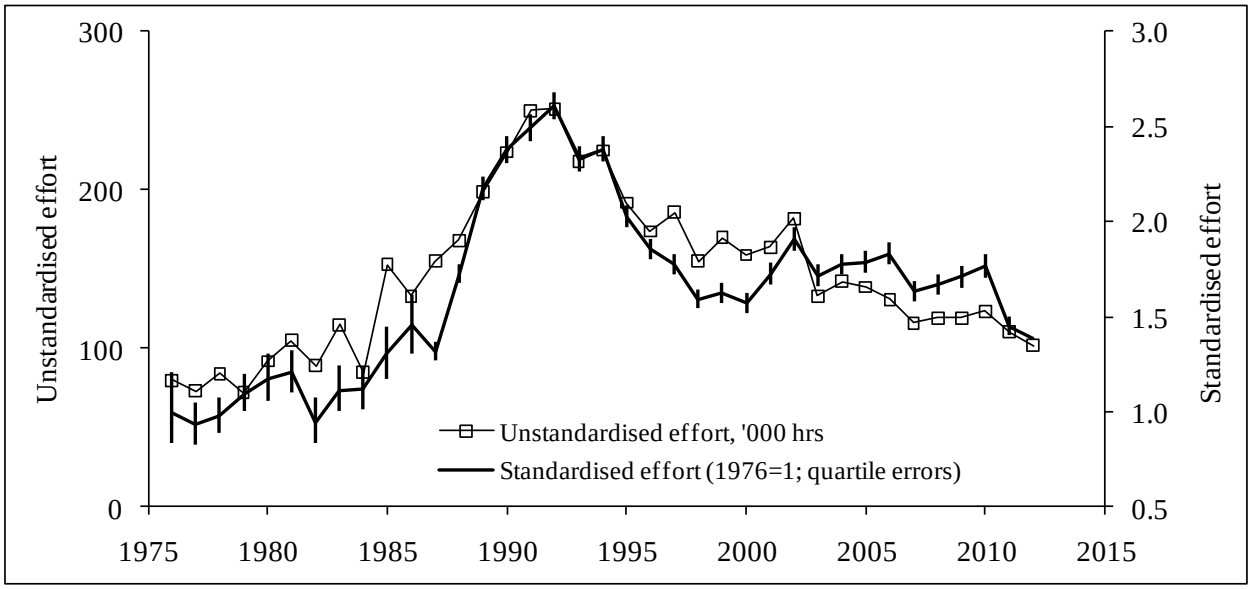

Fig. 3. Fishing effort applied in the shrimp fishery in NAFO Subarea 1 and Canadian SFA 1, 1970–2012.

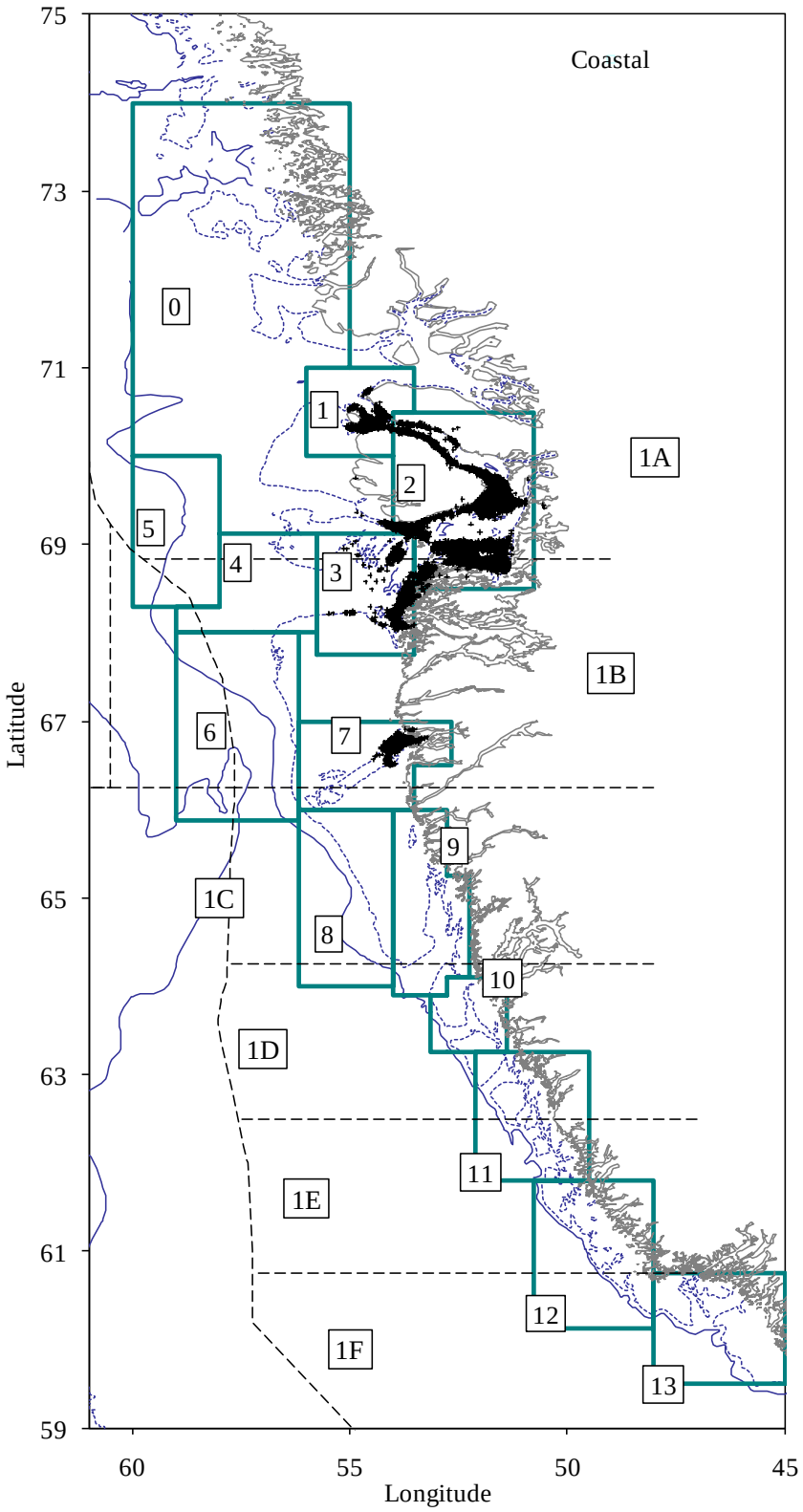

Fig. 4a. Positions of 12 165 hauls by the Greenland coastal fleet fishing for Northern Shrimp in NAFO Subarea 1 from July 2011 through June 2012.

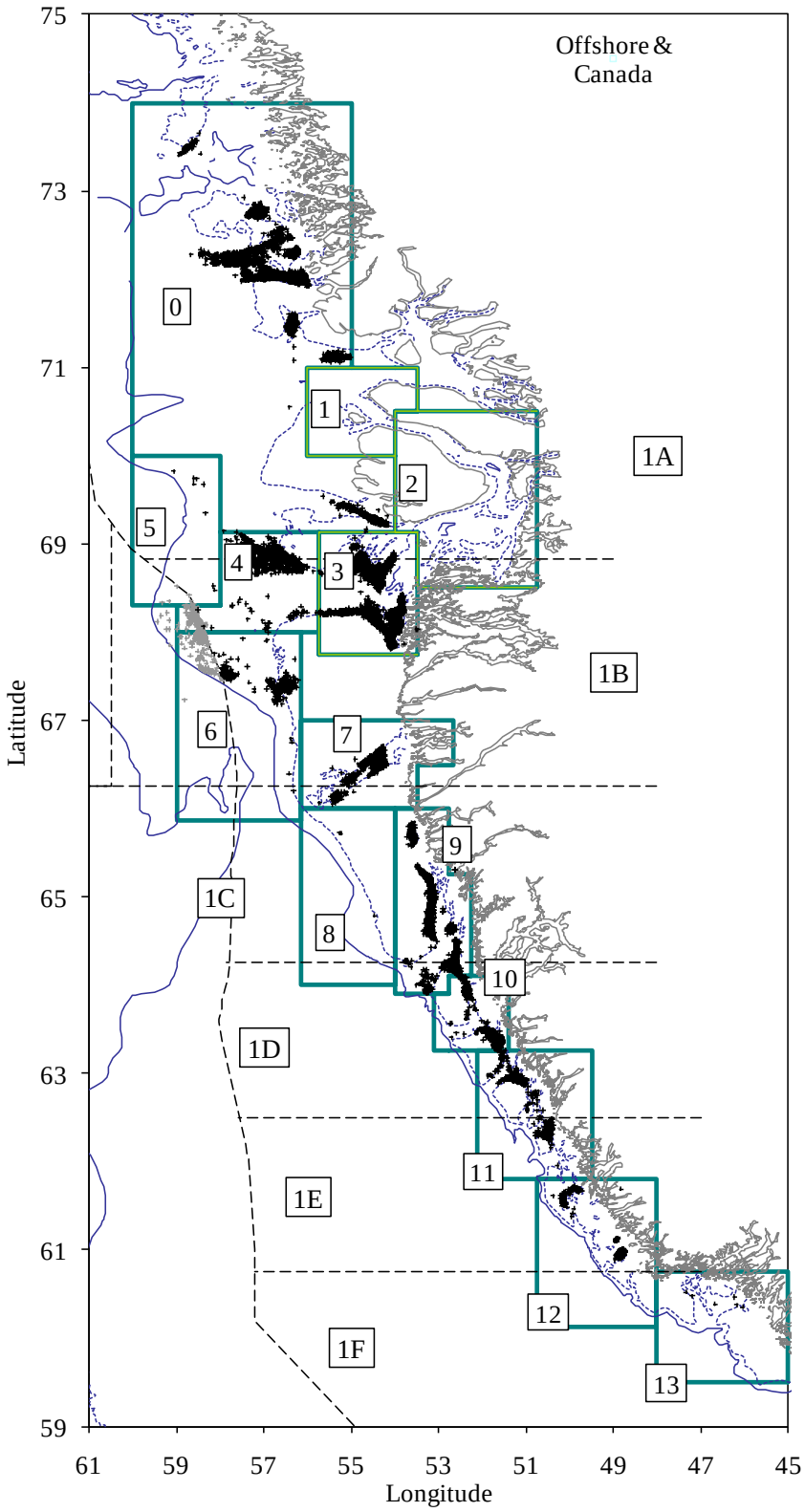

Fig. 4b. Positions of 11 435 hauls by the Greenland offshore fleet fishing for Northern Shrimp in NAFO Subarea 1 from July 2011 through June 2012 and of 369 hauls by the Canadian fleet fishing in SFA1 in 2011.

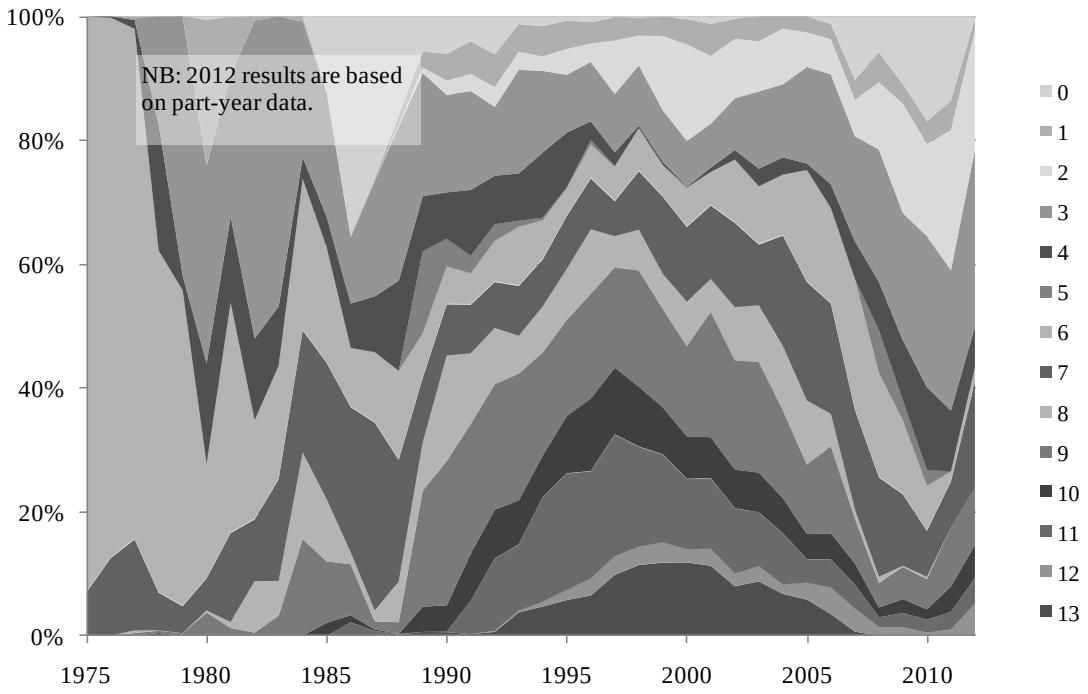

Fig. 5a. Distribution of the logbook-recorded catch of northern shrimp in the West Greenland fishery between statistical areas. (The light band that starts broad on the left-hand side is Area 6; the light band at the top is Area 0, the dark wedge at the very bottom from 1992 to 2007 is Area 13.)

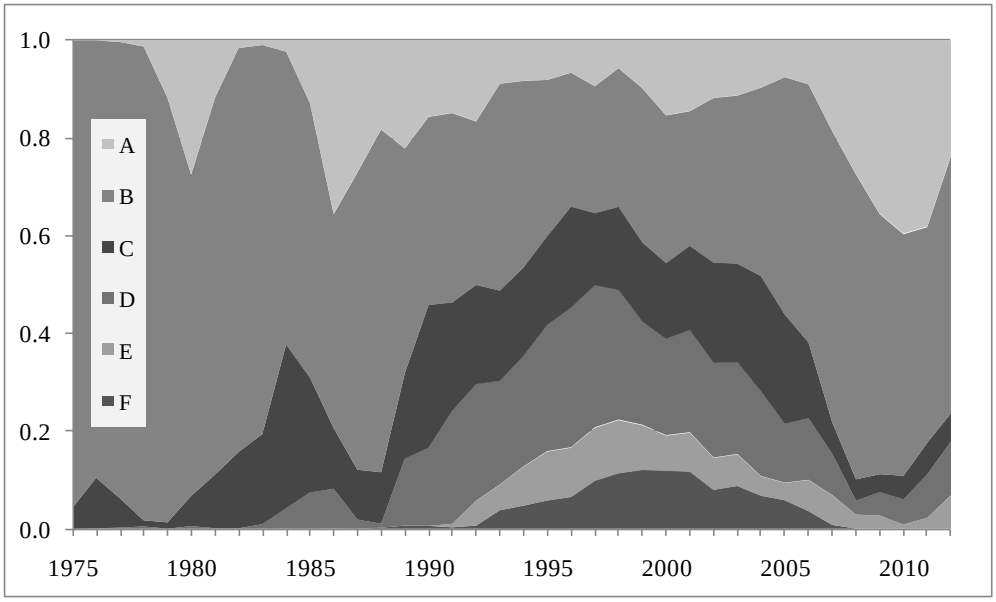

Fig. 5b. Distribution of the logbook-recorded catch of northern shrimp in the West Greenland fishery between NAFO Divisions in Subarea1. (2012 results are from part-year's data).

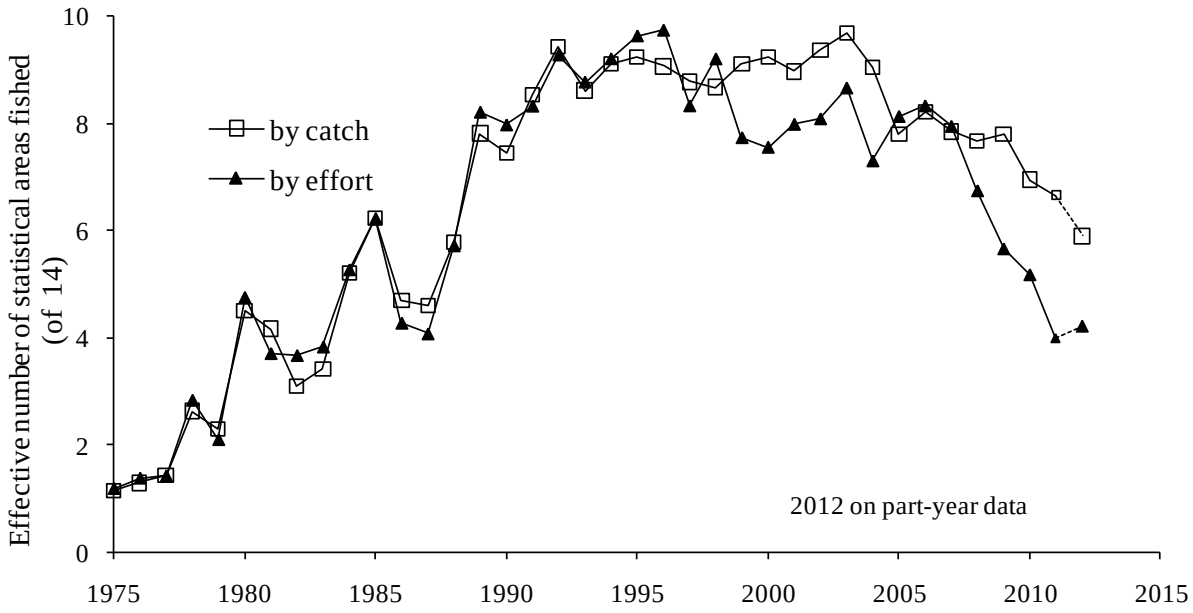

Fig. 6. Diversity indices for the distribution of logbook records of the West Greenland fishery between statistical areas, 1975–2012.

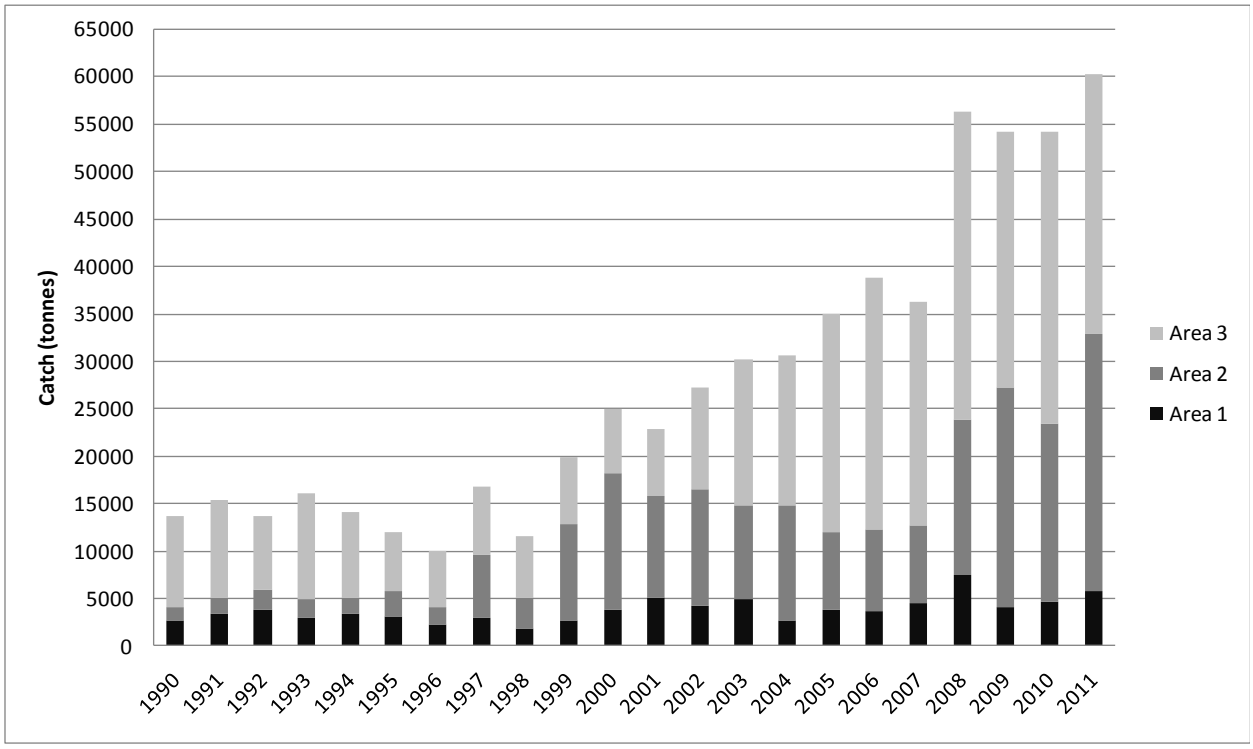

Fig. 7a. Distribution of catches of Northern Shrimp 1990–2011 in the Disko Bay Area (statistical areas 1, 2 and 3).

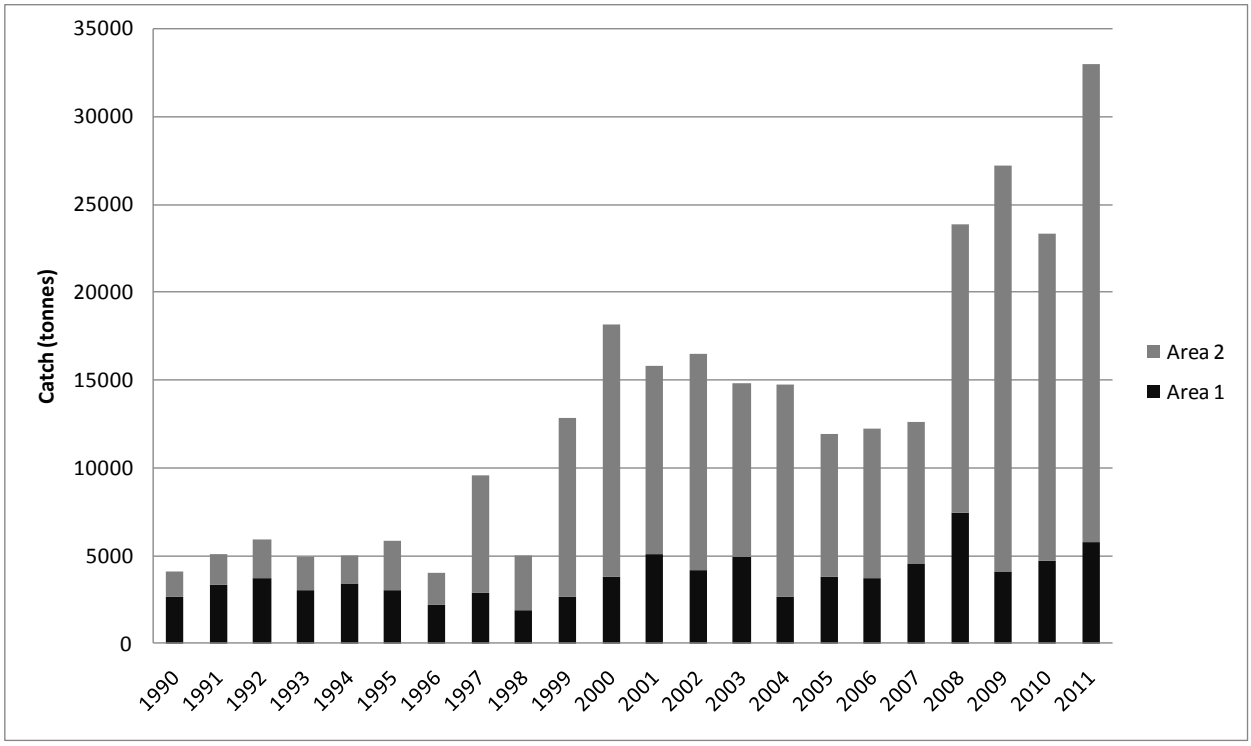

Fig. 7b. Distribution of catches of Northern Shrimp 1990–2011 in Vaigat and Disko Bay (statistical areas 1 and 2).

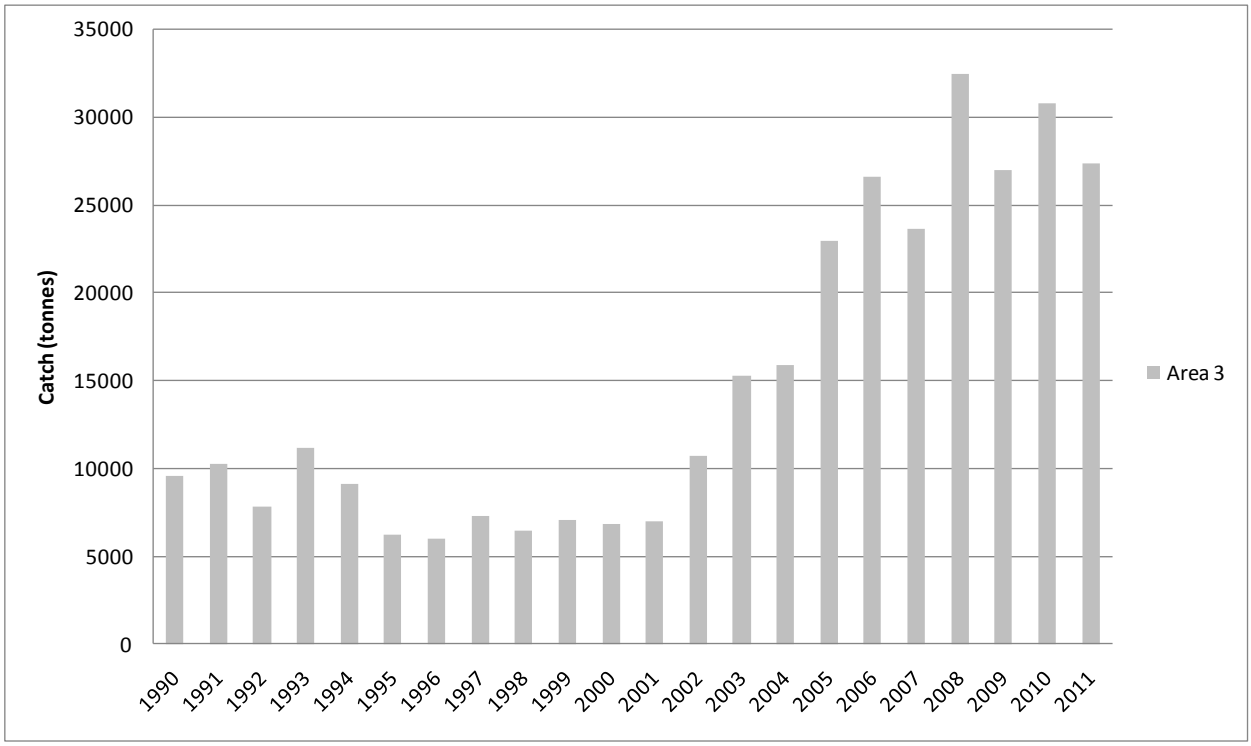

Fig. 7c. Catches of Northern Shrimp 1990–2011 in the mouth of Disko Bay (statistical area 3).

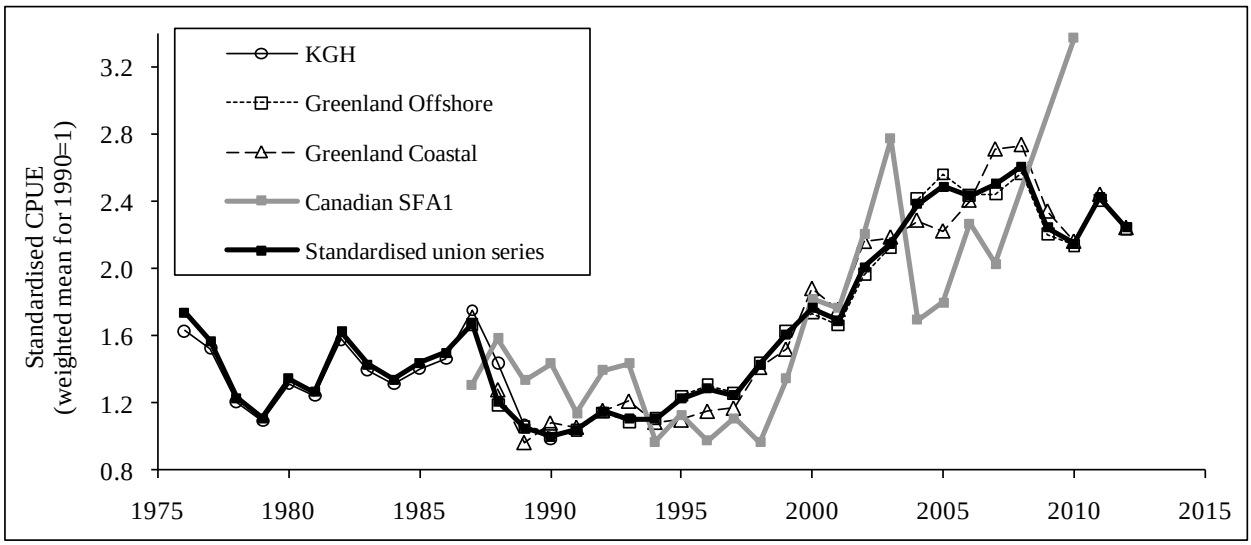

Fig. 8. Standardised CPUE in the West Greenland shrimp fishery, 1976–2012; standardised series from 4 fleets and a standardised union series.

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

The GLM Procedure

Class Level Information

Class	Levels	Values
VESSEL	23	hh02 hh05 hh06 hh07 hh11 hh16 hh18 hh20 hh22 hh23 hh24 hh26 hh28 hh31 hh33 hh38 hh39 hh41 hh43 hh45 hh47 hh48 hh50
Year	26	1987 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2090
MONTH	8	1 2 4 5 7 8 11 12
AREA	9	3 4 5 6 8 9 10 11 12
HOLD	2	1 2

Number of Observations Read	7704
Number of Observations Used	7704

The GLM Procedure

No month-area interaction included no summation after grouping
Group Area 7 with Area 9
Group March w. April; June w. July and September w. October w. November

Dependent Variable: LNCPUE

Weight: hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	62	156852.2385	2529.8748	666.67	<.0001
Error	7641	28996.0153	3.7948		
Corrected Total	7703	185848.2538			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.843980	78.00234	1.948023	2.497390

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESSEL	22	135738.5858	6169.9357	1625.90	<.0001
MONTH	7	2303.2136	329.0305	86.71	<.0001
AREA	8	4703.3724	587.9216	154.93	<.0001
year	25	14107.0667	564.2827	148.70	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	22	22090.61812	1004.11901	264.60	<.0001
MONTH	7	2296.15773	328.02253	86.44	<.0001
AREA	8	1110.58350	138.82294	36.58	<.0001
year	25	14107.06667	564.28267	148.70	<.0001

The GLM Procedure
No month-area interaction included no summation after grouping
Group Area 7 with Area 9
Group March w. April; June w. July and September w. October w. November
Dependent Variable: LNCPUE

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
hh02 v hh05	1	153.882196	153.882196	40.55	<.0001
hh05 v hh06	1	8.1105	8.1105	2.14	0.1438
hh06 v hh07	1	16.958859	16.958859	4.47	0.0345
hh07 v hh11	1	23.332188	23.332188	6.15	0.0132
hh11 v hh16	1	104.906071	104.906071	27.64	<.0001
hh16 v hh18	1	9.657648	9.657648	2.54	0.1107
hh18 v hh20	1	4.141845	4.141845	1.09	0.2962
hh20 v hh22	1	7.537149	7.537149	1.99	0.1588
hh22 v hh23	1	8.541929	8.541929	2.25	0.1336
hh23 v hh24	1	7.12765	7.12765	1.88	0.1706
hh24 v hh26	1	21.676635	21.676635	5.71	0.0169
hh26 v hh28	1	38.234427	38.234427	10.08	0.0015
hh28 v hh31	1	89.545417	89.545417	23.6	<.0001
hh31 v hh33	1	46.824089	46.824089	12.34	0.0004
hh33 v hh38	1	56.765542	56.765542	14.96	0.0001
hh38 v hh39	1	26.417131	26.417131	6.96	0.0083
hh39 v hh41	1	4.464194	4.464194	1.18	0.2781
hh41 v hh43	1	7.017876	7.017876	1.85	0.1739
hh43 v hh45	1	8.218434	8.218434	2.17	0.1412
hh45 v hh47	1	42.986412	42.986412	11.33	0.0008
hh47 v hh48	1	28.254375	28.254375	7.45	0.0064
hh48 v hh50	1	11.038178	11.038178	2.91	0.0881
m01 v m02	1	53.25158	53.25158	14.03	0.0002
m02 v m04	1	105.948196	105.948196	27.92	<.0001
m04 v m05	1	285.026455	285.026455	75.11	<.0001
m05 v m06	1	1166.309261	1166.309261	307.34	<.0001
m06 v m08	1	387.427905	387.427905	102.09	<.0001
m08 v m11	1	56.856545	56.856545	14.98	0.0001
m11 v m12	1	48.801457	48.801457	12.86	0.0003
a03 v a04	1	582.191623	582.191623	153.42	<.0001
a04 v a05	1	93.217281	93.217281	24.56	<.0001
a04 v a06	1	249.891628	249.891628	65.85	<.0001
a06 v a09	1	53.648114	53.648114	14.14	0.0002
a08 v a09	1	6.776239	6.776239	1.79	0.1815
a09 v a10	1	11.405317	11.405317	3.01	0.083
a10 v a11	1	17.90474	17.90474	4.72	0.0299
a11 v a12	1	48.900416	48.900416	12.89	0.0003

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		2.833080305 B	0.03982394	71.14	<.0001
VESSEL	hh02	-1.567335822 B	0.03475648	-45.09	<.0001
VESSEL	hh05	-1.348540429 B	0.02956799	-45.61	<.0001
VESSEL	hh06	-1.283865562 B	0.04427819	-29	<.0001
VESSEL	hh07	-1.179993377 B	0.03594984	-32.82	<.0001
VESSEL	hh11	-1.100190523 B	0.02387754	-46.08	<.0001
VESSEL	hh16	-1.016762064 B	0.02182996	-46.58	<.0001
VESSEL	hh18	-0.987406556 B	0.02502262	-39.46	<.0001
VESSEL	hh20	-0.963767837 B	0.02596534	-37.12	<.0001
VESSEL	hh22	-0.928732319 B	0.02748929	-33.79	<.0001
VESSEL	hh23	-0.884481277 B	0.03003262	-29.45	<.0001
VESSEL	hh24	-0.831472329 B	0.03689867	-22.53	<.0001
VESSEL	hh26	-0.749953820 B	0.02272041	-33.01	<.0001
VESSEL	hh28	-0.678005524 B	0.02702707	-25.09	<.0001
VESSEL	hh31	-0.565564165 B	0.0234053	-24.16	<.0001
VESSEL	hh33	-0.466261425 B	0.02942089	-15.85	<.0001
VESSEL	hh38	-0.368722545 B	0.0193054	-19.1	<.0001
VESSEL	hh39	-0.312513190 B	0.02474525	-12.63	<.0001
VESSEL	hh41	-0.284694878 B	0.02345146	-12.14	<.0001
VESSEL	hh43	-0.245414216 B	0.02805199	-8.75	<.0001
VESSEL	hh45	-0.199341658 B	0.02537529	-7.86	<.0001
VESSEL	hh47	-0.112725348 B	0.02193177	-5.14	<.0001
VESSEL	hh48	-0.042931827 B	0.02517241	-1.71	0.0881
VESSEL	hh50	0.000000000 B	.	.	.
MONTH	1	-0.027707977 B	0.01903205	-1.46	0.1455
MONTH	2	0.044581581 B	0.01890713	2.36	0.0184
MONTH	4	0.128358480 B	0.01542152	8.32	<.0001
MONTH	5	0.017400003 B	0.01641973	1.06	0.2893
MONTH	7	0.234825594 B	0.0150192	15.64	<.0001
MONTH	8	0.102809012 B	0.01693662	6.07	<.0001
MONTH	11	0.053089730 B	0.01480431	3.59	0.0003
MONTH	12	0.000000000 B	.	.	.
AREA	3	0.015381028 B	0.03188584	0.48	0.6296
AREA	4	-0.195959247 B	0.03085512	-6.35	<.0001
AREA	5	-0.304504521 B	0.03508934	-8.68	<.0001
AREA	6	-0.125067975 B	0.03018299	-4.14	<.0001
AREA	8	-0.178014354 B	0.03022388	-5.89	<.0001
AREA	9	-0.162622957 B	0.02917041	-5.57	<.0001
AREA	10	-0.139917944 B	0.03055773	-4.58	<.0001
AREA	11	-0.106296910 B	0.02961136	-3.59	0.0003
AREA	12	0.000000000 B	.	.	.

Parameter		Estimate	Error	t Value	Pr > |t|
year	1987	0.486646213 B	0.02876818	16.92	<.0001
year	1988	0.149061429 B	0.02263403	6.59	<.0001
year	1989	0.033254512 B	0.02047731	1.62	0.1044
year	1991	0.013131101 B	0.0187681	0.7	0.4842
year	1992	0.110869767 B	0.01943138	5.71	<.0001
year	1993	0.060626912 B	0.019355	3.13	0.0017
year	1994	0.077210715 B	0.01943704	3.97	<.0001
year	1995	0.194371702 B	0.02005731	9.69	<.0001
year	1996	0.244434444 B	0.02112398	11.57	<.0001
year	1997	0.205954971 B	0.02222168	9.27	<.0001
year	1998	0.337484614 B	0.02392489	14.11	<.0001
year	1999	0.465261269 B	0.02474271	18.8	<.0001
year	2000	0.525805562 B	0.02623045	20.05	<.0001
year	2001	0.484976207 B	0.02730897	17.76	<.0001
year	2002	0.652639392 B	0.02492718	26.18	<.0001
year	2003	0.731664962 B	0.02557464	28.61	<.0001
year	2004	0.857997380 B	0.02570513	33.38	<.0001
year	2005	0.917474893 B	0.02527116	36.31	<.0001
year	2006	0.867488172 B	0.02529418	34.3	<.0001
year	2007	0.870366780 B	0.02741153	31.75	<.0001
year	2008	0.919840643 B	0.02707564	33.97	<.0001
year	2009	0.766912326 B	0.02980522	25.73	<.0001
year	2010	0.736118812 B	0.03014713	24.42	<.0001
year	2011	0.855292058 B	0.0319044	26.81	<.0001
year	2012	0.780834566 B	0.03595387	21.72	<.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.

The GLM Procedure

Class Level Information

Class	Levels	Values
VESSEL	17	cc02 cc05 cc08 cc10 cc12 cc13 cc16 cc18 cc21 cc22 cc26 cc29 cc31 cc32 cc33 cc34 cc35
Year	25	1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2090
AREA	5	1 2 3 7 13
MONTH	11	2 3 4 5 6 7 8 9 10 11 12

Number of Observations Read	9814
Number of Observations Used	9814

The GLM Procedure

Greenland coastal fleet: areas 1-3, 7, 13
No month-area interaction included no summation after grouping
Group January w. February

Dependent Variable: LNCPUE

Weight: Hauls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	54	45637.92004	845.14667	264.46	<.0001
Error	9759	31187.69124	3.19579		
Corrected Total	9813	76825.61128			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.594046	92.69029	1.787677	1.928656

Source	DF	Type I SS	Mean Square	F Value	Pr > F
AREA	4	3846.12282	961.53070	300.87	<.0001
MONTH	10	2899.05282	289.90528	90.71	<.0001
VESSEL	16	14840.86075	927.55380	290.24	<.0001
Year	24	24051.88365	1002.16182	313.59	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	4	3080.23849	770.05962	240.96	<.0001
MONTH	10	2170.22459	217.02246	67.91	<.0001
VESSEL	16	7373.21466	460.82592	144.20	<.0001
Year	24	24051.88365	1002.16182	313.59	<.0001

The GLM Procedure
Greenland coastal fleet: areas 1-3, 7, 13
No month-area interaction included no summation after grouping
Group January w. February
Dependent Variable: LNCPUE
Weight: Hauls

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
cc02 v cc05	1	40.50652	40.50652	12.67	0.0004
cc05 v cc08	1	64.088901	64.088901	20.05	<.0001
cc08 v cc10	1	16.864705	16.864705	5.28	0.0216
cc10 v cc12	1	16.107021	16.107021	5.04	0.0248
cc12 v cc13	1	11.500929	11.500929	3.6	0.0579
cc13 v cc16	1	8.220963	8.220963	2.57	0.1088
cc16 v cc18	1	39.309853	39.309853	12.3	0.0005
cc18 v cc21	1	11.993659	11.993659	3.75	0.0527
cc21 v cc22	1	17.685717	17.685717	5.53	0.0187
cc22 v cc26	1	7.269704	7.269704	2.27	0.1315
cc26 v cc29	1	9.149305	9.149305	2.86	0.0907
cc29 v cc31	1	36.002286	36.002286	11.27	0.0008
cc31 v cc32	1	5.178299	5.178299	1.62	0.2031
cc32 v cc33	1	28.618898	28.618898	8.96	0.0028
cc33 v cc34	1	4.491304	4.491304	1.41	0.2359
cc34 v cc35	1	93.613449	93.613449	29.29	<.0001
m07 v m08	1	218.305071	218.305071	68.31	<.0001
m08 v m09	1	228.939362	228.939362	71.64	<.0001
m09 v m10	1	221.129404	221.129404	69.19	<.0001
m10 v m11	1	12.630033	12.630033	3.95	0.0468
m11 v m12	1	25.216904	25.216904	7.89	0.005
m12 v m02	1	61.215757	61.215757	19.16	<.0001
m02 v m03	1	98.073632	98.073632	30.69	<.0001
m03 v m04	1	28.255578	28.255578	8.84	0.003
m04 v m05	1	3.797843	3.797843	1.19	0.2757
m05 v m06	1	4.288243	4.288243	1.34	0.2467
a01 v a02	1	37.253902	37.253902	11.66	0.0006
a02 v a03	1	1175.941564	1175.941564	367.97	<.0001
a03 v a07	1	495.196238	495.196238	154.95	<.0001
a07 v a13	1	1485.952153	1485.952153	464.97	<.0001

The GLM Procedure
Greenland coastal fleet: areas 1-3, 7, 13
No month-area interaction included no summation after grouping
Group January w. February
Dependent Variable: LNCPUE
Weight: Hauls

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		2.299198009 B	0.03952945	58.16	<.0001
AREA	1	-0.330491491 B	0.01527012	-21.64	<.0001
AREA	2	-0.373072613 B	0.01416248	-26.34	<.0001
AREA	3	-0.160921589 B	0.01345399	-11.96	<.0001
AREA	7	-0.316152467 B	0.01466166	-21.56	<.0001
AREA	13	0.000000000 B	.	.	.
MONTH	2	-0.028509418 B	0.01872425	-1.52	0.1279
MONTH	3	0.120432589 B	0.02146783	5.61	<.0001
MONTH	4	0.287374613 B	0.02009512	14.3	<.0001
MONTH	5	0.147426728 B	0.01894048	7.78	<.0001
MONTH	6	0.178446177 B	0.01909048	9.35	<.0001
MONTH	7	0.223667642 B	0.01927356	11.6	<.0001
MONTH	8	0.150339493 B	0.01958694	7.68	<.0001
MONTH	9	0.054548770 B	0.01964726	2.78	0.0055
MONTH	10	0.004335995 B	0.01927351	0.22	0.822
MONTH	11	0.022676400 B	0.01957597	1.16	0.2467
MONTH	12	0.000000000 B	.	.	.
VESSEL	cc02	-1.175039201 B	0.04203769	-27.95	<.0001
VESSEL	cc05	-1.044612089 B	0.03492091	-29.91	<.0001
VESSEL	cc08	-0.929035129 B	0.03184445	-29.17	<.0001
VESSEL	cc10	-0.870356277 B	0.03402223	-25.58	<.0001
VESSEL	cc12	-0.816147105 B	0.03079814	-26.5	<.0001
VESSEL	cc13	-0.772632089 B	0.03428961	-22.53	<.0001
VESSEL	cc16	-0.736782649 B	0.03003109	-24.53	<.0001
VESSEL	cc18	-0.679731431 B	0.03030129	-22.43	<.0001
VESSEL	cc21	-0.649499101 B	0.02964191	-21.91	<.0001
VESSEL	cc22	-0.603051634 B	0.03261751	-18.49	<.0001
VESSEL	cc26	-0.574192659 B	0.02909519	-19.73	<.0001
VESSEL	cc29	-0.543191142 B	0.03180857	-17.08	<.0001
VESSEL	cc31	-0.465439546 B	0.03198751	-14.55	<.0001
VESSEL	cc32	-0.426397659 B	0.03819592	-11.16	<.0001
VESSEL	cc33	-0.293651370 B	0.0444731	-6.6	<.0001
VESSEL	cc34	-0.235330220 B	0.0434808	-5.41	<.0001
VESSEL	cc35	0.000000000 B	.	.	.

Parameter		Estimate	Error	t Value	Pr > |t|
year	1988	0.167839114 B	0.04045747	4.15	<.0001
year	1989	-0.113831662 B	0.03027728	-3.76	0.0002
year	1991	-0.023562931 B	0.02725518	-0.86	0.3873
year	1992	0.066146607 B	0.02731322	2.42	0.0155
year	1993	0.113171269 B	0.02710537	4.18	<.0001
year	1994	0.003773787 B	0.02643265	0.14	0.8865
year	1995	0.015814286 B	0.02679523	0.59	0.5551
year	1996	0.062449500 B	0.02787698	2.24	0.0251
year	1997	0.078289995 B	0.02730194	2.87	0.0041
year	1998	0.266955144 B	0.03011989	8.86	<.0001
year	1999	0.340433002 B	0.02683737	12.69	<.0001
year	2000	0.553511651 B	0.02706117	20.45	<.0001
year	2001	0.485293780 B	0.02663305	18.22	<.0001
year	2002	0.692386671 B	0.02682445	25.81	<.0001
year	2003	0.704330918 B	0.02750435	25.61	<.0001
year	2004	0.749097614 B	0.02658897	28.17	<.0001
year	2005	0.720655124 B	0.02684719	26.84	<.0001
year	2006	0.799866357 B	0.02766872	28.91	<.0001
year	2007	0.918884893 B	0.02778827	33.07	<.0001
year	2008	0.928411390 B	0.0267973	34.65	<.0001
year	2009	0.772407507 B	0.027432	28.16	<.0001
year	2010	0.692883207 B	0.02769001	25.02	<.0001
year	2011	0.814334417 B	0.027827	29.26	<.0001
year	2012	0.729649796 B	0.03058292	23.86	<.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

The GLM Procedure

Class Level Information

Class	Levels	Values
YEAR	22	1987 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2010 2090
MONTH	5	5 7 8 9 12
TCLASS	3	5 6 7
GEAR	2	2 91

Number of Observations Read	709
Number of Observations Used	709

Dependent Variable: log_catch

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	1442.379101	49.737210	355.14	<.0001
Error	679	95.092681	0.140048		
Corrected Total	708	1537.471782			

R-Square	Coeff Var	Root MSE	log_catch Mean
0.938150	3.409277	0.374230	10.97682

Source	DF	Type I SS	Mean Square	F Value	Pr > F
log_effort	1	1266.569125	1266.569125	9043.81	<.0001
MONTH	4	17.293420	4.323355	30.87	<.0001
TCLASS	2	37.704864	18.852432	134.61	<.0001
YEAR	21	102.151374	4.864351	34.73	<.0001
GEAR	1	18.660317	18.660317	133.24	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
log_effort	1	1025.583670	1025.583670	7323.08	<.0001
MONTH	4	6.637093	1.659273	11.85	<.0001
TCLASS	2	11.154190	5.577095	39.82	<.0001
YEAR	21	57.633059	2.744431	19.60	<.0001
GEAR	1	18.660317	18.660317	133.24	<.0001

20:18 Monday, September 26, 2011 27

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
m05 v m07	1	4.39171845	4.39171845	31.36	<.0001
m07 v m08	1	2.23666217	2.23666217	15.97	<.0001
m08 v m09	1	0.47386506	0.47386506	3.38	0.0663
m09 v m12	1	0.47803087	0.47803087	3.41	0.0651
t5 v t6	1	1.59050801	1.59050801	11.36	0.0008
t6 v t7	1	7.78879338	7.78879338	55.62	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		5.703086736	B	0.09079314	62.81	<.0001
log_effort		1.082870435		0.01265405	85.57	<.0001
MONTH	5	-0.911863407	B	0.19244782	-4.74	<.0001
MONTH	7	0.172749502	B	0.04188228	4.12	<.0001
MONTH	8	-0.006882083	B	0.04007919	-0.17	0.8637
MONTH	9	0.072521716	B	0.03925353	1.85	0.0651
MONTH	12	0.000000000	B	.	.	.
TCLASS	5	-0.459315013	B	0.06727712	-6.83	<.0001
TCLASS	6	-0.237861693	B	0.03189540	-7.46	<.0001
TCLASS	7	0.000000000	B	.	.	.
YEAR	1987	-0.087927511	B	0.22838408	-0.38	0.7004
YEAR	1988	0.101939773	B	0.12338272	0.83	0.4090
YEAR	1989	-0.069155454	B	0.08141391	-0.85	0.3959
YEAR	1991	-0.230409952	B	0.08108148	-2.84	0.0046
YEAR	1992	-0.027574301	B	0.08397859	-0.33	0.7427
YEAR	1993	0.000692891	B	0.08378182	0.01	0.9934
YEAR	1994	-0.390811082	B	0.08078640	-4.84	<.0001
YEAR	1995	-0.238324242	B	0.08421882	-2.83	0.0048
YEAR	1996	-0.383007430	B	0.08687190	-4.41	<.0001
YEAR	1997	-0.255624021	B	0.12685065	-2.02	0.0443
YEAR	1998	-0.392929461	B	0.11240013	-3.50	0.0005
YEAR	1999	-0.063922684	B	0.10113092	-0.63	0.5275
YEAR	2000	0.237493433	B	0.11223889	2.12	0.0347
YEAR	2001	0.208813928	B	0.09269272	2.25	0.0246
YEAR	2002	0.433574986	B	0.08518699	5.09	<.0001
YEAR	2003	0.659608286	B	0.08914388	7.40	<.0001
YEAR	2004	0.167336122	B	0.08035341	2.08	0.0377
YEAR	2005	0.227032825	B	0.08713737	2.61	0.0094
YEAR	2006	0.459808307	B	0.09430783	4.88	<.0001
YEAR	2007	0.347047972	B	0.10856317	3.20	0.0015
YEAR	2010	0.856159839	B	0.09864764	8.68	<.0001
YEAR	2090	0.000000000	B	.	.	.
GEAR	2	0.445161391	B	0.03856529	11.54	<.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.