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The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970–2019

by

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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. 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.

Catch 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. Since then catches has decreased to a recent low level in 2015 at 72 256 tons. In the following years, both TACs and catches increased, and the total catches was 94 878 tons in 2018.

The enacted TAC for Greenland in 2019 is set at 103 383 tons and a TAC of 1 617 tons were set for Canada, by the Greenland Self-government. The projected catch for 2019 is set at 100 000 tons. The enacted TAC for Canada in 2019 was 14 875 tons, but no fishery has been conducted so far.

The overall combined index fluctuated without trend by a factor of 1½ between 1976 and 1987. It then dropped precipitously to the lowest levels in the series in 1989–91, 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. From 2009 to 2013, the standardised CPUE index decreased and was in 2013, 72% of the 2008 value. In the following year's catch rate continuously increased to a high level in 2017, however a little less in 2018, but was comparable to the high value observed in 2008.

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, which moved northwards, is now concentrated in Division 1B and 1A where more than 80% of the catches have been conducted since 2007.

Introduction—the Fishery

The West Greenland stock of Northern shrimp (*Pandalus borealis*) is distributed on the continental shelf off West Greenland between about 60°N and about 74°N; densities are highest in water between 150 and 550 m deep (Fig. 4). On the West Greenland shelf, the Greenland EEZ comprises NAFO Subarea 1 (Divs 1A–1F), and the Canadian EEZ is a westward bulge of the shelf across the mid-line at the eastern edge of Div. 0A, between about 67°24'N and 68°40'N. 'Shrimp Fishing Area 1' (SFA1), consisting of 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.

A bottom-trawl fishery began in Greenland inshore areas in 1935. In 1970 a multinational offshore fishery started to develop and landings increased, to approximately 153 000 tons in 2006 (Table 1, Fig. 2). Catches were first restricted in 1977 and the fishery has since been managed by Total Allowable Catch (TAC). TACs have at sometimes been allocated to subdivisions of the stock area in Greenland waters, 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 Subarea 1. In NAFO Subarea 1 the fishery was limited to Greenlandic vessels from 1981 through 2002, but quotas have since been allocated to EU vessels under fisheries agreements with Greenland.

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. (The EU quota is also fished offshore and for the assessment is treated as part of the Greenland offshore fishery). 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 are mostly restricted to vessels under 75 GRT/120 GT, but there are trawlers of several hundred tons that fish on coastal quotas. The coastal fleet generally ices its catch and lands it at shore stations for processing, and Greenland vessels with on-board production licences are also required to land 25% of their catches. The total coastal quota is fixed by law at 43% of the Greenland TAC. Individual Transferable Quotas (ITQs) were introduced in the Greenlandic fishery in 1991. Transfer of quotas between the coastal and the offshore fleet has been allowed since 2009. Vessels above 50 GRT have been required to keep fishery logbooks since 1986, and all vessels since 1997.

In earlier years, the true weight of packages produced on board was often greater than the nominal weight, which was the weight both invoiced and recorded in the logbook. This practice of 'overpacking' led to systematic underreporting. Since 2004 logbook entries have been required to correspond to live catch weight (G.H. 2003), and earlier catch data was corrected (Hvingel 2004) by 21–25%. 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.

The tactical management of the Greenland fishery has been partly based on weights caught, and partly on weights traded. Even after elimination of overpacking the quota draw down for shrimps sold to shore stations in Greenland by any fleet component remained less than the live weight by an allowance for crushed or broken shrimps, included in the landing but not in the sale (G.H. 1996). The stock assessment, the advice, and the enacted TACs and quotas were based on analysis of live-caught weights, but quota draw downs and tactical fishery management were partly based on such, smaller, traded weights, so annual catches, recorded in log-books as live-caught weight, were apt to exceed TACs. From 1 January 2011 quotas are required to be drawn down by the amount caught, without allowances for shrimps landed in poor condition (G.H. 2010). However, many catches, especially those taken in shallower waters, contain some admixture of *Pandalus montagui*.

Hitherto, catches of *P. montagui* have often not been distinguished in logbooks from *borealis*, especially by vessels fishing bulk shrimps for landing in Greenland, the proportion of *montagui* being estimated by sampling the catch at the point of sale. Quota draw downs were then restricted to the estimated weight of *borealis* and logbook records could in this way still come to exceed quotas. However, *P. montagui* is now among the species protected by by-catch regulations (G.H. 2011) and logbooks should record at least estimated catches of this species (G.H. 2010).

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 (G.H. 2012).

Gear restrictions in Greenland include a cod-end mesh size of at least 40 mm stretched and sorting grids with 22-mm bar spacing to reduce fin-fish bycatch (G.H. 2011). Owing to improvements in sorting grids, it is no longer necessary to exempt small vessels, for safety reasons, from being required to use them. Other measures to limit bycatch include a requirement to move at least 5 n.mi. if bycatch exceeds 5% of the catch (G.H. 2011).

Regulations now in force in Greenland to protect bottom habitats (G.H. 2011) include the use of rolling rockhopper ground gear, and toggle chains of 72 mm or longer to keep trawl netting off the bottom. Waters between 64°10'N and 65°15'N from the shore to 3 n.mi. outside the baseline (comprising about 650 n.mi.^{2}), an area in which there are high concentrations of sponge and coral beds, have been closed to shrimp trawling. Vessels are required to report live coral catches of 60 kg or more and live sponge catches of 800 kg or more to the Licensing Authority and to move a minimum of 2 n.mi. from any place at which such catches are taken before continuing to fish. In addition, the authorities have powers to close areas which can be considered 'vulnerable marine areas'. 'New fishing areas' in West Greenland have been defined as lying North of 74°N and special regulations are in force for protecting vulnerable habitats there.

The fishery in SFA 1 is restricted to Canadian vessels. From 1996 to 2007 on average about 8 vessels (range 5–12) participated. Since then, the number of ships has varied, with 0 to 2 ships fishing in 2008-2009 and 2012-2013, 7 ships fishing in 2010 and 10 ships fishing in 2011. 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 from the Canadian fishery in SFA1 have been available from 1979 to 2011 and aggregated catch data from 2010 - 2018.

For the Canadian fishery in SFA 1 observer log-books record all catches, including non-target species, in detail, as well as technical details of each set. Minimum mesh sizes ranging from 24 to 52 mm have been used, but 89% of catches have been taken with 40–46 mm mesh; 63% with 42, 43 or 45 mm. Since 1993, grates with bar spacing from 19 to 55 mm have been used, but 83% of catches (with bar spacing recorded) have been taken with bar spacing's of 22 or 28 mm, and 93% with spacing's in that range.

There is no procedure or formula agreed between the two range states, Greenland and Canada, for setting or sharing a TAC on the stock. Instead they set TACs independently. The Greenland Government has instituted a practice of deciding on a TAC for the entire stock and setting aside a part of that TAC (3.1%) to allow for the Canadian interest, the proportion being reckoned based on habitat area, recent catches, and recent survey estimates of stock biomass in the respective EEZs. The EU quota is also deducted from the Greenland TAC before dividing the remainder between the coastal fleet (43%) and the offshore fleet (57%) quotas.

Material and Methods

Fleet Data

Logbook records were analysed to follow the recent development of the fleet and the fishery. Two Greenland fleets were defined. Vessels were classified as 'offshore' or 'coastal' from information including licence type and tonnage, but mostly relying on the mapping of fishing positions (Fig. 4). Coastal vessels fish mostly in statistical

Areas 1 (Disko Bay), 2 (Vaigat), 3 (Disko Bay mouth) and 13 (Julianehåb Bay), and in statistical Area 7 (the Holsteinsborg Deep), they fish east of about 54°W into the coast and fjords (Fig. 4a). Offshore vessels do not have permission to fish in statistical Areas 1, 2 and part of statistical Area 13, but fish in statistical Areas 4 and 6 north and west of Store Hellefiske Banke. In statistical Area 7 they fish west of about 54°W. Only the offshore fleet fishes in statistical Area 0 and -1 (Fig. 4b). Both fleets fish in statistical Areas 8–12, but the offshore fleet more than 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 (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, Hammeken Arboe 2013) as well as the private version distributed by Wojciech Walkusz, DFO. 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, and a comprehensive data record based on observer logbooks was provided in August 2013 by T. Siferd. However, from 2011 no data from the Canadian fishery in SFA1 have been available.

CPUE Analyses

Catch and effort data from logbooks are 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.

CPUE was analysed separately for four different fleets (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 statistical 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. 6 of the 7 vessels were grouped;. months were reduced to 10 levels and statistical Areas 4, 6 and 7 were combined. This analysis was not repeated and results from Hvingel (2004) were incorporated into the present analysis.

Catch and effort data from Greenlandic vessels above 50 GRT fishing in Subarea 1 was used in calculating CPUE indices for the more recent fishery. Corrected unstandardised effort was calculated by adding 60% to trawl times with twin trawls and a series of unstandardised CPUE was obtained by dividing corrected logbook catch by total corrected unstandardised effort. Standardised series of annual CPUE indices were obtained by analysing catch and effort data with multiplicative models that 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. Statistical Areas were defined *ad hoc* based on distinct fishing grounds (Fig. 4). The multiplicative model was linearised as:

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

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 the area effect; S_j is the month effect; V_k is the vessel effect; Y_i is the year effect; the residuals ε_{mjki} are assumed to be distributed $N(0,\sigma^2/n)$ where n is the number of observations in the cell and σ^2 is the residual variance. The model was fitted with SAS Proc GLM (SAS Institute 1988). Vessel effects were sorted by value, month and area effects were kept in their natural order, and then to reduce the number of empty cells in the model neighboring classes of effect variables were combined if a pairwise contrast of their effects had an F statistic less than one; however, we note that such posterior grouping of class variables on the basis of similar effect values causes uncertainty and lead to be underestimated. The posterior grouping of class variables were dropped in 2019, as the effect on the year effect were negligible. The year effects were then used as standardised annual CPUE indices in assessment models. They are assumed (on the basis of the central limit theorem) to be (approximately) normally distributed.

The offshore fleet has recently been active north of 69°12'5 to 76° N and beyond, so two statistical Area 0 and Area -1 has been defined (Fig. 4) and in 2013 and 2016 respectively, was for the first time included in the GLM calculation of year effect on CPUE (for all years).

The 'Offshore' index covers the most recent 28 years of the offshore production fishery in NAFO Div. 1A to 1F. 50 vessels were included providing data since 1987. All statistical Areas – 1, 0 and 3–13 have been included in the analysis as well as the months of fishing.

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 statistical Areas 1, 2 and 3 in Fig. 4, but is also active in some inshore areas further south, especially in statistical Area 7 and in previous years in statistical Areas 11–13. Statistical Areas 1–3, 7 and 13 were included in the analysis.

A consolidated file of data on 61 624 hauls from the Canadian fishery in SFA 1 was available for 1979 through 2012. No data were available for 2013. It included data from 79 vessels, using 56 types of gear with 189 combinations of mesh sizes. Data was selected to include hauls between half an hour and six hours long, using gear types 17 or 66 (standard single or double shrimp trawls), and with no or insignificant gear damage. Ships were deleted that had less than two effective years in the fishery, and years were deleted with less than two effective ships. The resulting data file comprised 34 124 hauls by 27 vessels in years 1980–82, 89–96, 1998–2007 and 2010–11. Years before 1987 and months before May were then also removed. Catch and trawl-time were summed over year, month, vessel and gear characteristics. Vessels were grouped by combining pairs with contrast F-statistics less than one; the same was done for pairs of consecutive months (Appendix III). Grate bar spacing and mesh sizes were omitted from the final GLM model, which included year, month, tonnage class, vessel group within tonnage class, and gear (Appendix III). The GLM model fitted was:

$$\ln\left(C_{ymtvg}\right) = \ln\left(E_{ymtvg}\right) + A_{yC} + B_m + C_t + D_{vt} + G_g + \varepsilon_{ymtvg}$$

where C_{ymtvg} was tons caught in year y and month m by vessel group v in tonnage class t using gear g trawling for a total of E_{ymtvg} hours. Year effects A_{yC} were then considered annual indices provided by the Canadian fleet of stock size difference from the reference year 1990 in log. space; the B_m, C_t, D_{vt} and G_g were assumed to be nuisance variables by which year-to-year variation in the composition and behaviour of the fishing fleet alter the relationship between effort and catch. The residuals ε_{ymtvg} were assumed independently distributed with equal variances.

One unified series of standardised CPUE, covering 1976–2018, was derived by combining these three index series, considered for each year to be a set of independent estimates of how much the biomass differed from its size in the reference year, set to be 1990. For each year, the values from the several series were combined with weighting. Their reported uncertainties could be considered to comprise three factors: for each series, the overall size of the uncertainties reflects how much data there was, how well the model fitted, and generally how well the data was arranged to estimate differences from the reference year, while within the series, each value reflected how suitably the data was arranged to estimate it, in particular, relative to the values for the other years. However, neither severally nor collectively did they betoken the importance of the fleet in the fishery nor how well, relative to other fleets, its catch rates should consequently be supposed to follow changes in *total* stock size. An additional weighting was therefore applied in combining the year-effects series, so

$$A_{yf} \sim N\left(\overline{A}_y, \sigma_{yf}^2\right) \text{ where } \sigma_{yf}^2 = \hat{\sigma}_{yf}^2 \Big/ w_f$$

the A_{yf}—GLM-estimated year effects for fleet f—being considered to be Normally distributed about a series of overall year effects $\overline{A}_y$ with individual error variances σ_{yf}^2 whose relative sizes were calculated from the individual error variances estimated by the GLM— $\hat{\sigma}_{yf}^2$ —and weights w_f assigned on the basis of the area fished by fleet f. The weights w_f for the KGH, Greenland offshore and Greenland coastal fleets were assigned as 0.376, 0.434, and 0.191. The year effects were fitted using Bayesian methods on the OpenBUGS platform and were given uninformative uniform prior distributions.

Until 2017, A Canadian CPUE index was included in the combine CPUE index. In 2018 is was decided to remove the index from the combine index, while it since 2012 have been difficult to obtain logbook data and catch/effort

and CPUE information from the Canadian fishery in SFA1. Because Canadian catches in SFA1 is very low, removing this index from the combine CPUE index, have no influence on the perception of the trajectory of CPUE over time.

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.

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 statistical 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 by depth of catches of *P. borealis* recorded in Greenland logbooks was analysed in 2011 for the period 1991–2010, in 5-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. Most *montagui* is caught in mixed catches, but mixed catches have in the past often—even usually—not been identified in logbooks, especially by the fleet fishing iced bulk shrimps. Logbook records have therefore presumably underestimated catches of *montagui* (Kingsley 2011), but the recording of montagui reported has improved in recent years (Nedergaard pers. comm.).

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. 1).

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). Rationalization and modernization have driven the nominal size of the coastal fleet down by 85 % since 1997, but its effective

size has decreased by only 2/3, 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). Greenland Home Rule Government implementet some measures 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), and introduced a period of lower catches lasting to the early 2000s. Canadian catches, in particular, were low in the mid- to late 90s. After 2000 survey estimates of stock size (Burmeister et al. 2014) and catches increased very rapidly, by about 50% by 2005, and high TACs were enacted, and large catches taken, in 2004–2008 (Fig. 2). Fishable biomass peaked from 2003 to 2005 followed by a decline a low value in 2014 (Burmeister and Rigét 2017, 2018, 2019) and corresponding decline in TACs and catches (Fig. 2). Since 2015, catches slightly increased and so has the biomass.

Canada sets autonomous TACs for SFA1 that in 1991–2010 averaged 154% of the estimated survey biomass in that area (Burmeister et al. 2014). In those 20 years, catches in SFA1 did not exceed 90% of the TAC and averaged 31% of it (Table 1). The catches therefore appear, overall, to be *de facto* unregulated; they average near to 50% of the estimated survey biomass. However, 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 1991–2018 Canadian catches averaged approx. 1.2% of the estimated survey biomass in the entire stock distribution area (Burmeister et al., 2019).

From 1975, when the offshore fishery was well established, through 1984 annual unstandardised effort increased slightly from about 75 000 hr to about 100 000 hr (Table 1, 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 low about 80 000 hr in 2015 because of management measures, reduced activity in Div. 0A (Table 1) and a generally increased fishing efficiency. Over the past years unstandardised effort steadily increased to about 100 000 hr. in line with enhanced catches and TAC.

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. The standardised effort increased by 20% from 2000 to 2002, followed by continuous decline by approximately 3% a year until 2015. Over the past three years, standardized effort has slightly increasing still at a lower level compared to the period before 2015. This might be caused by the fact, that three offshore trawlers has been fishing in the Barents Sea for two to three month in 2015 – 2017 and replacement of trawlers in both 2018 and 2019.

Spatial and seasonal distribution

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 (Table 3, Table 4a, Fig. 5a). However, these southern areas have since become less important and the fishery, which moved northwards, is now concentrated in Division 1B and 1A where more than 80% of the catches have been conducted since 2007. Number of statistical Areas fished increased steadily up to the early 1990s (Fig. 6), remained quite stable until 2003, dropped to fewer fished statistical areas in 2004 and 2005, remained stable again until 2015, then followed by an increase in number of fished areas (Fig. 6). Effort has since 2005, become more concentrated in the north (Fig. 6, table 4b).

Since 2010, 35 to 40% of the catches have been taken in Division 1A alone (Fig. 5b). This is especially due to increased fishing in statistical Area 2 and Area 3 from 2009 to 2017 (Disko Bay and Disko Bay mouth (Fig. 8, Fig. 7a, Fig. 5b). Where the majority of catches were based on fishery in statistical Area 0, Area 2 and Area 3, in the years 2009 to 2012, statistical Area 7 has since become more important and over the past five years

produced 20% of the fishery (Fig. 5a). Area 0 (Offshore between 69°12'5 N and 74° N), has in recent years yielded between 10 and 17% of the total catches and a smaller part, less of 2% has been harvest in Melville Bay (area -1) (Fig. 8). In general and for the past 14 years, 83% of the total catches has been harvest in the north of 66°N. This is consistent with results from the survey, in which the proportion of survey biomass in the northern Areas has been high since 2003 (Fig. 2b in Burmeister and Rigét 2019). Over the most recent three years, catches seems to spreading over a lightly large area, than in 2005 – 2015.

Fishing activity happen during all months a year, but with some variation the amount of catch taken during summer and wintertime. The most recent 8 years, appears to have a more uniform seasonal distribution, where catches are somewhat divide equally between annual quarters (Table 5).

Depth distribution

The depth distribution of catches has shifted significantly over the most recent 20 years. In 1991–1994 the median depth by weight for all catches was 347 m, and catches extended down to 547 m (99th percentile). 12 years later, in 2003–2006, the median catch was taken 80 m shallower at 254 m. The median depth for the offshore and the coastal fleets changed by almost exactly the same 100 m. In 2007–2010 the median depth distribution for the offshore fleet increased again, nearly back to where it was in 1999–2002, but the depth distributions for catches in the coastal fleet stayed exactly the same as in 2003–2006 (Fig. 10a, Fig. 10b and Fig. 10c). In the following years depth distributions of catches was continuous increasing and has in the most previous years (2015-2018) been 312 m, almost comparable to observations from the late 90'ties.

By-catch and discard

The logbook-reported at-sea discard of shrimps (*Pandalus borealis*), mostly for quality reasons by production trawlers, has remained less than 1% by weight of total catch throughout 1975–2019 (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 juvenile—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% 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[1] to verify the quantity of bycatch and the accuracy reported by both captain and observer was initiated in the mid 00'ties. It was found from observations, including the weighing of bycatch of 166 hauls on 7 vessels covering fishery in in NAFO Divs 1B–1E, that reports by captain and observer tended to agree on the bycatch weight. However, not necessarily at the correct value, but the presence of the scientific assistant probably affected the estimates made by the captain and the observer. This resulted in an improvement of the registration of bycatch, and were on average larger—at 1.2–3.2% of the shrimp catch—than logbook reports on average indicate (Sünksen 2007).

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 stock of females and older males combined. From 1988 to 2015 the CPUE indices from the Greenland coastal and the Greenland offshore fleets have remained closely in step except for a few years. (Table 2, Fig. 9). From 2004 to 2008 the

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

catch rate of the offshore fleet reached the high levels, but declined to the most recent low in 2013. In the succeeding years CPUE steadily increasing to a record high value in 2017, but dropped little in 2018 to a level comparable to high values in 2005 and 2008. The catch rate for the inshore fleet reached its highest level in 2007 to 2008, and decreased correspondingly to the offshore fleet. The trajectory of the catch rate have been inverse between the offshore and inshore fleet. While offshore catch rate since 2014 continuously increased, indices declined for the inshore fleet (Fig. 9).

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, but no CPUE data has been available since 2011 (Table 2).

The overall combined index (Table 2, Fig. 9) fluctuated without trend by a factor of 1½ between 1976 and 1987. It then dropped precipitously to the lowest levels in the series in 1989–91, 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. From 2009 to 2013, the standardised CPUE index decreased and was in 2013, 72 % of the 2008 value. In the following year's catch rate continuously increased to a peak value in 2017, but slightly drop in 2018, but still comparable to the relatively high value observed in 2008.

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. Nonetheless, some vessels, sometimes, have made 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 has not recorded *P. montagui* in its logbooks; weights of *borealis* and *montagui* have been reckoned from catch samples taken at the point of sale. Logbook records of *montagui* catches have in the past been an underestimate, while logbook records of *borealis* catches have been an overestimate.

From 1995 logbook reports included overall annual catches of *P. montagui* in the range of about 100 tons to a 2014 peak of 4944 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 3% in 2012 and in 2013 further increased to 5%, but by-catch of *montagui* have since dropped to less than 1% in 2017 (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 (Rigét and Burmeister 2017, Rigét and Burmeister 2018). The effect of the fishery for *borealis* on the stock of *montagui* has not been evaluated and was of some concern. Since 2012 *P. montagui* has been included among the species for which a moving rule is in force for reducing bycatch, and efforts are being made to have fleets fishing in Greenland waters record catches of these shrimps better (G.H. 2011).

Based on the logbooks from five offshore fleets a standardized CPUE index series (2001-2019) was derived using GLM including the factors year, area, month and fleet weighted with the number of hauls (Fig. 11A). Throughout the period, the CPUE index has fluctuated with an increasing tendency in the period after 2010 to 2016 compared to previous years, dropped significantly in 2017 and has continued the decline.

In order to construct a time series comprising the coastal fleet, a standardized LPUE index series (2008-2018) based on sale notes was initiated. A GLM model including the factors year, month and fleet was performed (Fig. 11B). In the period 2008 to 2010 LPUE were considerably lower than in the period 2013 to 2018). During the recent 4 years LPUE has been stable.

Correspondingly, to last year, a stochastic surplus production model (SPiCT) was applied to the West Greenland stock of *Pandalus montagui* (Rigét and Burmeister, 2017). Input data composed of catch and commercial CPUE index derived from five offshore vessels and survey biomass excluding hauls below 150 m during the period 2001 to 2018. The SPiCT model was only able to converge when fixing key parameters such as n = 2 (symmetric Schaefer production curve) and the ratios of error terms to a known value of 1. However, the model did not lead to reliable results as the uncertainties were extreme large, likely because of the large fluctuations in catch and index values and that the time series is relative short.

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Table 1a. *P. borealis* in W. Greenland: Catch limits, effort, catch and CPUE, SA 1 up to 73°30'N, 1970–1989.

Year	TAC (t)			Catch (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)			(1990=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	0.49	762	-	766	1.48
1977	-	-	36000	42578	8580	51158	457	51615	73.1	-	73	0.44	699	-	706	1.39
1978	-	1000	41000	33835	8360	42195	122	42317	84.2	-	84	0.46	501	-	503	1.10
1979	-	2000	31500	32852	8250	41102	1732	42834	72.4	-	72	0.51	568	-	592	0.99
1980	-	2500	32000	44916	8250	53166	2726	55892	80	11.6	92	0.56	665	235	610	1.20
1981	35000	5000	40000	40295	8250	48545	5284	53829	88.2	16.6	105	0.57	551	318	514	1.13
1982	34800	5000	39800	43979	8250	52229	2064	54293	81.1	8.1	89	0.45	644	256	609	1.43
1983	34625	5000	39625	42553	8250	50803	5413	56216	89	26.1	115	0.53	571	208	488	1.27
1984	34925	5000	39925	42414	8250	50664	2142	52806	85	-	*85*	0.53	596	-	*621*	1.19
1985	42120	6120	48240	54888	8250	63138	3069	66207	129.1	23.6	153	0.62	489	130	433	1.28
1986	42120	6120	48240	65019	8250	73269	2995	76264	133.4	-	*133*	0.68	554	-	*576*	1.33
1987	40120	6120	46240	64161	7613	71774	6095	77869	137.1	17.7	155	0.61	524	344	503	1.53
1988	40120	6120	46240	56479	11256	67735	5881	73616	152.9	14.9	168	0.76	443	395	439	1.15
1989	45245	7520	52765	58890	14546	73436	7235	80671	179.6	19.7	199	0.91	409	367	405	1.05

* in 1981–1995 quotas applied to the offshore area only

Table 1b. *P. borealis* in W. Greenland: Catch limits, effort, catch, and CPUE, SA 1 up to 76'N, 1990–2019. (2019 is only preliminary data from January the 1. to June the 30).

Year	TAC (t)			Catch (t)					Effort				CPUE			
	SA 1*	Div. 0A	Total	SA 1			Div. 0A	Total	SA 1	Div. 0A	Total	Total Std.	SA 1	Div. 0A	Total	Total Std.
				Offshore	Inshore	Total	Offshore		Unstd. ('000 hr)			(1990=1)	Unstd. (kg/hr)			(1990=1)
1990	45245	7520	52765	62800	14993	77793	6177	83970	210	14	224	1.00	371	433	375	1.00
1991	46225	8500	54725	66817	17884	84701	6788	91489	231	20	250	1.04	367	346	365	1.05
1992	44200	8500	52700	75341	22653	97994	7493	105487	234	17	251	1.12	418	451	421	1.12
1993	40600	8500	49100	65894	19627	85522	5491	91013	206	12	218	0.97	415	450	417	1.12
1994	42300	8500	50800	68109	19930	88039	4766	92805	210	15	225	0.99	420	312	412	1.12
1995	39500	8500	48000	66955	18072	85027	2361	87388	185	7	192	0.85	460	322	455	1.23
1996	63922	8500	72422	62368	19095	81463	2632	84095	165	9	174	0.78	495	293	484	1.29
1997	64600	8500	74800	62743	14868	77611	517	78128	185	1	186	0.74	420	412	420	1.25
1998	60729	7650	68379	69156	10406	79562	933	80495	153	3	155	0.66	521	353	518	1.45
1999	73500	9350	82850	71203	18948	90152	2046	92198	165	5	170	0.68	547	398	543	1.62
2000	77675	9350	87025	73013	23365	96378	1590	97968	156	3	159	0.65	617	613	617	1.79
2001	92950	9350	102300	79291	20010	99301	3625	102926	158	6	164	0.71	627	602	626	1.72
2002	91150	12040	103190	107195	21729	128925	6247	135172	173	9	182	0.78	744	695	741	2.06
2003	101000	14167	115167	104237	18799	123036	7137	130173	142	8	150	0.70	869	846	868	2.22
2004	135352	14167	149519	121658	20653	142311	7021	149332	149	12	161	0.73	958	569	928	2.44
2005	134000	18452	152452	128068	21910	149978	6921	156899	151	9	160	0.74	994	744	980	2.52
2006	134000	18380	152380	127747	25441	153188	4127	157315	149	5	153	0.75	1030	884	1026	2.50
2007	134000	18417	152417	116674	25571	142245	1945	144190	138	2	141	0.66	1028	872	1026	2.59
2008	127300	18417	145717	119797	34092	153889	0	153889	145	-	145	0.68	1064	-	1064	2.71
2009	114570	15583	130153	97051	37978	135029	429	135458	144	-	144	0.67	937	-	-	2.39
2010	114570	15583	130153	94596	33513	128109	5561	133670	145	7	151	0.68	886	839	884	2.33
2011	124000	15583	139583	78437	44222	122659	1274	123933	132	3	135	0.60	932	399	919	2.45
2012	101675	12750	114425	76090	39875	115965	5	115970	135	0	135	0.61	862	56	862	2.26
2013	89263	11333	100596	65797	29582	95379	2	95381	117	0	117	0.57	817	120	817	2.00
2014	86316	11333	97649	60768	27997	88765	0	88765	105	-	105	0.49	842	-	842	2.15
2015	74061	8500	82561	49246	23008	72254	2	72256	83	0	83	0.38	868	34	868	2.26
2016	85801	10625	96426	56593	27763	84356	1163	85519	96	3	96	0.43	879	421	891	2.39
2017	88957	12750	101707	63037	26332	89369	3001	92370	90	7	90	0.41	991	452	1024	2.69
2018	99998	14875	114873	68942	24247	93189	1689	94878	99	2	99	0.45	937	845	954	2.50
2019#	105000	14875	119875	40239	12680	52919	0	52919	53	-	53	0.26	992	-	992	2.44

* 1981-1995 TAC for offshore only.

Projections based on information received from GFLK and DFO.

Table 2. *P. borealis* in W. Greenland, SA 1 up to 76°N': Standardised (1990=1) CPUE series for 4 fleets and a combined standardized CPUE series. * relative i.q.r.: the interquartile range divided by the median. ****2019 is only preliminary data***

	KGH		**Offshore**		**Coastal**		**Canada SFA1**		**Combined**	
Year	median	rel. iqr	median	rel. iqr	median	rel. iqr	median	rel. iqr	median	rel. iqr
1976	1.660	0.124							1.487	0.204
1977	1.556	0.082							1.384	0.153
1978	1.230	0.082							1.098	0.152
1979	1.113	0.080							0.992	0.148
1980	1.340	0.082							1.200	0.151
1981	1.266	0.077							1.126	0.139
1982	1.611	0.083							1.427	0.149
1983	1.423	0.081							1.261	0.148
1984	1.338	0.079							1.189	0.144
1985	1.432	0.077							1.271	0.142
1986	1.490	0.077							1.326	0.151
1987	1.787	0.080	1.532	0.028			—	—	1.515	0.057
1988	1.465	0.079	1.148	0.025	1.177	0.054	—	—	1.156	0.053
1989	1.086	0.088	1.080	0.024	0.888	0.040	1.114	0.110	1.048	0.051
1990	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000
1991			1.055	0.022	0.977	0.036	0.795	0.095	1.045	0.051
1992			1.128	0.022	1.070	0.036	0.861	0.103	1.121	0.052
1993			1.110	0.023	1.125	0.036	0.935	0.098	1.116	0.054
1994			1.139	0.023	1.007	0.035	0.652	0.095	1.121	0.053
1995			1.274	0.024	1.020	0.036	0.765	0.102	1.231	0.054
1996			1.330	0.026	1.068	0.037	0.616	0.100	1.286	0.054
1997			1.286	0.027	1.090	0.036	—	—	1.254	0.056
1998			1.469	0.029	1.320	0.040	0.609	0.135	1.449	0.061
1999			1.664	0.031	1.419	0.036	0.880	0.129	1.620	0.058
2000			1.762	0.033	1.764	0.036	1.067	0.137	1.789	0.063
2001			1.699	0.034	1.658	0.035	1.106	0.116	1.716	0.061
2002			2.026	0.032	2.034	0.035	1.318	0.107	2.060	0.058
2003			2.232	0.032	2.056	0.036	1.579	0.113	2.220	0.060
2004			2.507	0.032	2.149	0.035	1.180	0.107	2.442	0.060
2005			2.647	0.032	2.064	0.036	1.261	0.117	2.519	0.058
2006			2.555	0.032	2.200	0.037	1.443	0.141	2.495	0.059
2007			2.574	0.033	2.486	0.037	1.388	0.141	2.587	0.061
2008			2.723	0.034	2.521	0.036	—	—	2.713	0.059
2009			2.447	0.036	2.142	0.036	—	—	2.394	0.063
2010			2.443	0.036	1.959	0.037	2.055	0.182	2.330	0.061
2011			2.493	0.037	2.230	0.037	0.250	0.305	2.453	0.061
2012			2.280	0.037	2.051	0.037	—	—	2.257	0.062
2013			1.954	0.037	1.986	0.040	—	—	1.999	0.063
2014			2.103	0.038	2.161	0.041	—	—	2.154	0.064
2015			2.215	0.040	2.233	0.043	—	—	2.259	0.065
2016			2.431	0.040	2.167	0.041	—	—	2.394	0.068
2017			2.911	0.039	2.049	0.042	—	—	2.688	0.068
2018			2.717	0.038	1.903	0.041	—	—	2.503	0.064
2019			2.757	0.051	1.775	0.048	—	—	2.442	0.073

Table 3a. *P. borealis* in W. Greenland: 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

Table 3b. *P. borealis* in W. Greenland: 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
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	8.4	32.6	46.8	23.3	22.7	5.9	10.2	842	427	905	1065	1017	1345	1064
2004	7.0	13.8	55.0	33.6	24.6	5.7	9.6	12.3	33.4	59.7	24.2	17.0	3.1	11.2	569	413	921	1391	1449	1850	856
2005	6.9	11.3	73.0	33.6	18.0	5.4	8.7	9.3	23.2	71.2	22.8	12.9	5.2	15.5	744	486	1025	1470	1399	1031	565
2006	4.1	13.8	81.0	23.7	19.3	9.8	5.5	4.7	21.9	73.5	17.4	15.1	10.3	10.6	884	631	1102	1366	1284	952	519
2007	1.9	26.5	84.8	9.1	12.0	8.7	1.1	2.2	32.3	78.1	7.1	10.5	8.0	2.3	872	821	1085	1294	1144	1081	473
2008	0.0	42.3	96.1	6.7	4.4	4.4	0.1	0.0	42.7	88.1	5.7	3.7	4.5	0.1	-	991	1090	1189	1179	977	1170
2009	0.4	48.1	71.9	5.0	6.5	3.6	0.0	0.1	54.8	77.7	4.6	4.6	2.5	0.0	-	877	926	1084	1391	1463	-
2010	5.6	50.9	63.4	6.2	6.6	1.1	0.0	6.6	64.7	70.5	4.7	4.1	0.6	0.0	839	786	899	1319	1620	1852	-
2011	1.3	46.9	54.2	7.9	10.9	2.7	0.0	3.2	65.8	52.3	5.2	7.0	1.3	0.0	399	713	1036	1531	1548	2085	-
2012	0.0	45.7	45.3	6.3	12.0	6.4	0.3	0.1	67.1	51.6	4.6	7.6	3.4	0.2	56	680	878	1377	1576	1886	1539
2013	0.0	33.9	39.2	6.6	10.6	4.6	0.6	0.0	52.5	46.6	5.5	8.5	3.5	0.3	120	646	840	1214	1240	1314	2141
2014	0.0	37.9	38.3	4.0	6.2	1.6	0.7	0.0	55.4	39.3	3.8	5.3	1.3	0.3	-	685	973	1068	1181	1285	1971
2015	0.0	28.6	30.0	4.7	5.4	1.8	1.8	0.1	40.0	32.2	3.7	5.0	1.3	1.0	34	715	933	1269	1078	1372	1692
2016	1.2	32.6	36.6	5.9	5.7	2.2	1.2	2.8	44.0	41.1	4.6	4.5	1.1	0.5	421	741	891	1283	1253	2078	2382
2017	3.0	36.3	35.4	10.9	5.1	1.4	0.3	6.6	44.6	35.1	6.6	3.2	0.5	0.1	452	813	1007	1640	1581	2845	2833
2018	1.7	30.8	37.7	15.5	7.3	1.8	0.0	4.5	41.2	39.5	11.4	6.3	1.0	0.0	378	748	955	1364	1159	1765	300
2019*	0.0	8.6	31.2	7.0	4.8	1.4	0.0	0.0	12.6	31.7	4.9	3.3	0.8	0.0	-	681	983	1421	1429	1852	0

*Projected

Table 4a. *P. borealis* in W. Greenland; Distribution (%; columns sum to 100) of catches 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	10–14	15-19
1A	9.2	23.4	12.8	8.1	12.1	19.4	39.1	34.9
1B	72.1	56.1	38.3	29.1	33.7	55.4	43.6	43.6
1C	17.4	13.9	21.5	17.2	20.0	10.6	5.6	11.2
1D	1.3	6.4	21.5	26.1	19.0	8.2	8.4	7.2
1E	0.0	0.0	4.0	10.2	6.2	4.3	3.0	2.2
1F	0.0	0.2	2.1	9.3	9.0	2.1	0.3	0.8
Diversity	1.8	2.5	3.9	4.8	4.6	2.7	2.8	3.0

Table 4b. *P. borealis* in W. Greenland; Distribution (%; columns sum to 100) of fishing effort[1] 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	10–14	15-19
1A	15.9	30.5	15.9	16.7	23.8	24.1	48.3	44.8
1B	37.7	49.9	37.7	32.9	34.2	53.5	41.1	40.9
1C	21.9	12.6	21.9	16.2	15.0	7.9	3.7	7.3
1D	20.0	6.0	20.0	21.0	15.6	6.4	5.1	5.4
1E	2.4	0.0	2.4	6.5	4.0	4.2	1.6	1.1
1F	2.1	0.9	2.1	6.7	7.4	3.9	0.1	0.5
Diversity	3.9	2.8	3.9	4.6	4.4	2.8	2.5	2.7

[1]unstandardised single-trawl-equivalent time

Table 5. *P. borealis* in W. Greenland: Catch by month 1976–2018, 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	3388	3200	3607	5392	4757	9422	8665	6898	8119	14642	5217	2958
1987	3094	1798	4931	6404	7907	8627	10797	8590	8170	9368	5161	3023
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	14539	13469	10477	16044	15194	13265	11707
2005	10695	8782	12726	14837	15193	15076	15775	16301	13581	12903	10449	10579
2006	12785	11920	14185	11116	14430	11138	15719	15802	15251	13153	12505	9312
2007	5517	8820	10584	13624	13544	13726	17126	14775	14224	11436	10121	10693
2008	8989	7386	9007	12488	13827	15429	18407	15311	14414	12982	13608	12039
2009	10993	8126	4321	9183	12422	12698	14606	16683	12642	12892	12352	8540
2010	8277	7237	8289	9462	11250	13953	15135	14385	12147	12508	10697	10329
2011	10197	9253	11831	10877	10480	10265	12523	9615	8883	10221	11472	8317
2012	9399	8623	5839	10089	10780	10026	11486	11514	9169	9684	10728	8632
2013	8008	6725	8487	9366	8866	8539	7115	8764	7064	8112	7711	6621
2014	7224	7900	7734	10055	6767	7169	7623	7580	6893	6839	7435	5545
2015	6855	4863	3536	5629	6411	5804	5641	6516	6678	6759	7214	6347
2016	7758	7534	6949	7162	5630	5977	7431	7427	7371	7425	8418	6439
2017	8185	7670	3726	5370	7637	6613	8158	7838	8733	7957	10543	9941
2018	9729	6906	4930	6957	8176	9327	9383	8451	7827	8037	7971	7187
2019*	8842	8332	8085	10541	9679	7439	0	0	0	0	0	0

Table 6. *P. borealis* in W. Greenland: Discards, and landed catch reported[1] as *P. montagui,* in NAFO Subarea 1.

Year	P. borealis		P. montagui		P. borealis
	discard (tons)	discard (%)	landed (tons)	%-by catch	Catch
1975	0	0.00	0		
1976	0	0.00	0		
1977	0	0.00	0		
1978	0	0.00	0		
1979	0	0.00	0		
1980	0	0.00	0		
1981	0	0.00	0		
1982	0	0.00	0		
1983	0	0.00	0		
1984	0	0.00	0		
1985	151	0.24	0		
1986	110	0.15	0		
1987	189	0.25	0		
1988	216	0.31	0		
1989	196	0.27	0		
1990	265	0.34	0		49729
1991	406	0.48	0		52392
1992	335	0.34	0		56748
1993	251	0.29	0		54822
1994	332	0.38	5		56538
1995	476	0.56	563	1.0%	53633
1996	323	0.40	772	1.5%	51407
1997	310	0.40	422	0.7%	63913
1998	314	0.39	1253	2.3%	54356
1999	197	0.22	4	0.0%	70099
2000	268	0.28	305	0.4%	76350
2001	382	0.38	881	1.1%	81060
2002	648	0.50	225	0.2%	105473
2003	639	0.52	967	0.9%	100963
2004	762	0.54	831	0.6%	135213
2005	753	0.50	512	0.3%	147687
2006	865	0.56	1444	1.0%	150533
2007	741	0.52	2003	1.4%	139657
2008	860	0.56	89	0.1%	153889
2009	710	0.53	53	0.0%	135029
2010	739	0.58	1168	0.9%	128109
2011	720	0.59	2324	1.9%	122659
2012	587	0.51	3121	2.6%	115965
2013	491	0.52	4944	4.9%	95379
2014	443	0.50	1357	1.5%	88765
2015	325	0.45	2027	2.7%	72254
2016	329	0.39	3176	3.6%	84356
2017	405	0.45	664	0.7%	89369
2018	429	0.46	133	0.1%	93189
2019*	212	0.40	27	0.1%	52919

[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, and is recorded on sales slips.

* 2018: projected from part-year's data.

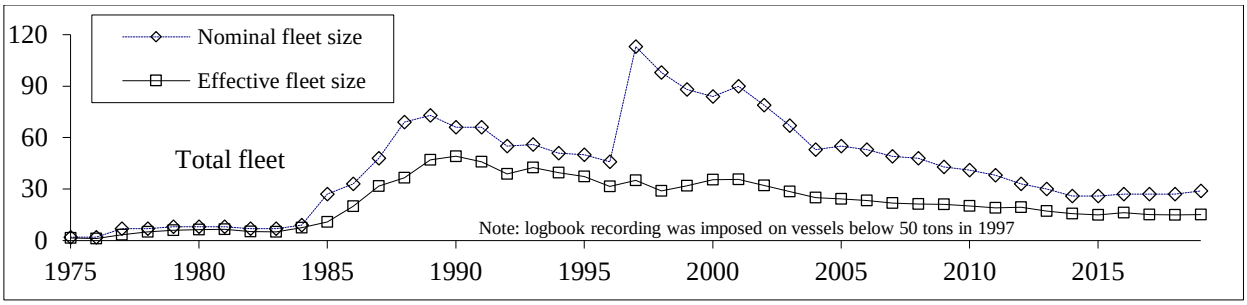

Figure 1a. *P. borealis* in W. Greenland: Nominal and effective sizes of the Greenland trawler fleet, 1975–2019, from logbook records.

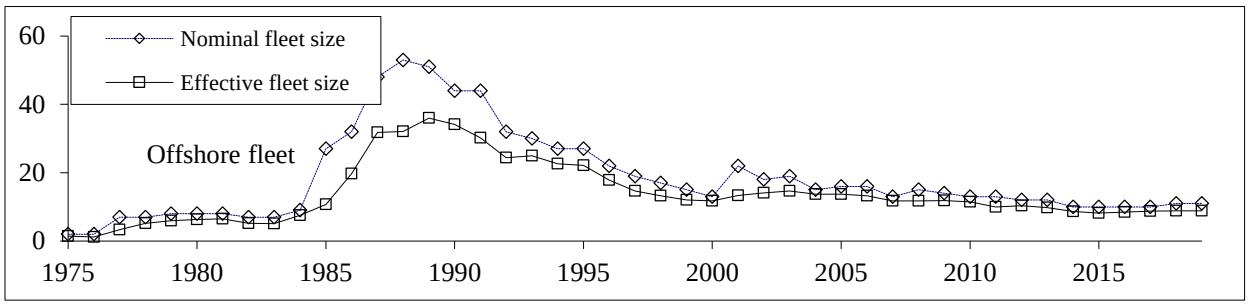

Figure 1b. *P. borealis* in W. Greenland: Nominal and effective sizes of the Greenland offshore trawler fleet, 1975–2019, from logbook records.

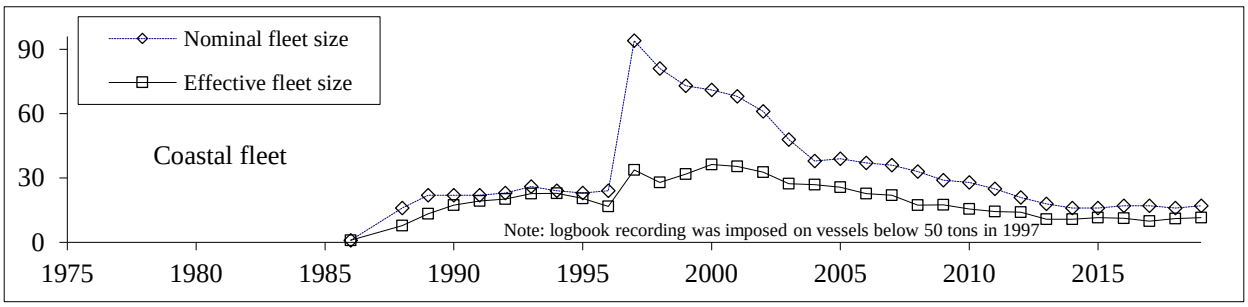

Figure 1c. *P. borealis* in W. Greenland: Nominal and effective sizes of the Greenland coastal trawler fleet, 1986–2019, from logbook records.

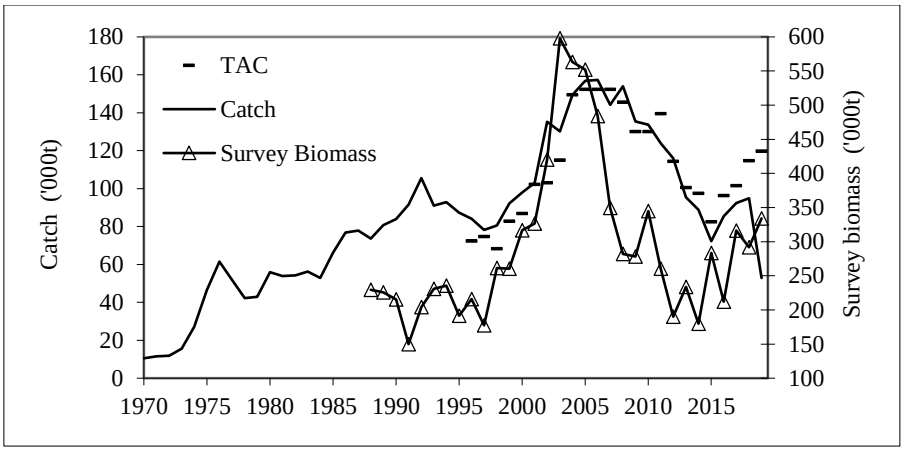

Figure 2 *P. borealis* in W. Greenland: Catches in NAFO Subarea 1 and Canadian SFA 1, 1970–2019; 2019 is projected catch.

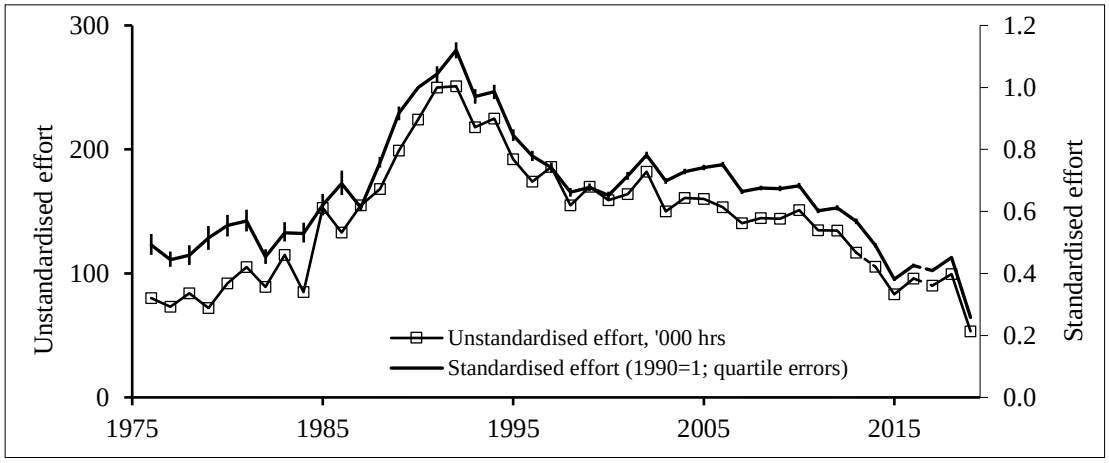

Figure 3 *P. borealis* in W. Greenland: Fishing effort applied in NAFO Subarea 1 and Canadian SFA 1, 1970–2019. 2019 is on part-year's data.

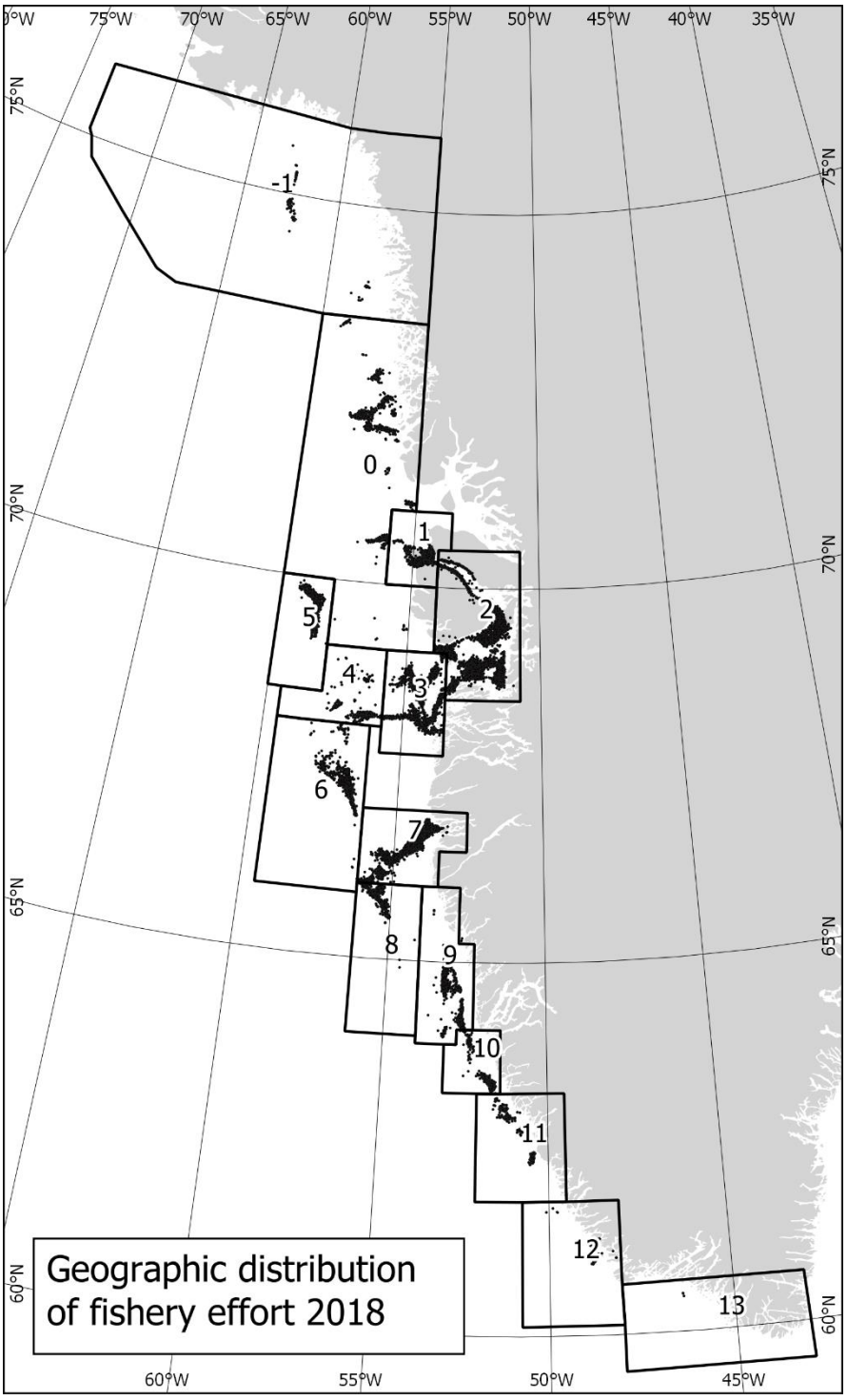

Figure 4a. *P. borealis* in W. Greenland: positions of 17 019 hauls by the Greenland coastal fleet in NAFO Subarea 1 up to 76°N from January the 1 to December the 31, 2018. Statistical Areas in green frames. 200 meter depth contour dotted purple line and 600 meter depth contour solid purple line.

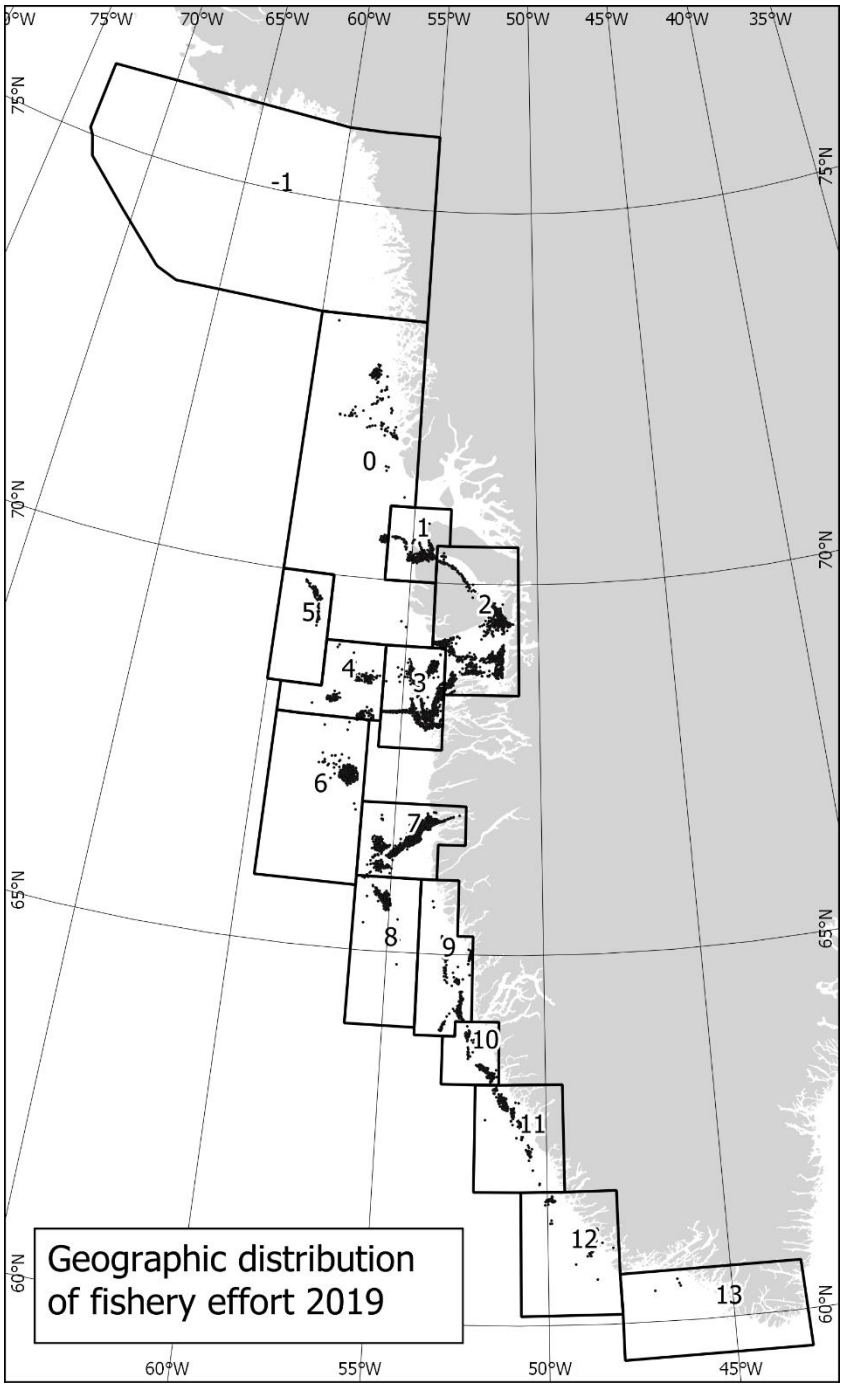

Figure 4b. *P. borealis* in W. Greenland: positions of 9 579 hauls by the Greenland offshore fleet in NAFO Subarea 1 up to 76°N from January the 1 through June 2019. Statistical Areas in green frames. 200 meter depth contour dotted purple line and 600 meter depth contour solid purple line.

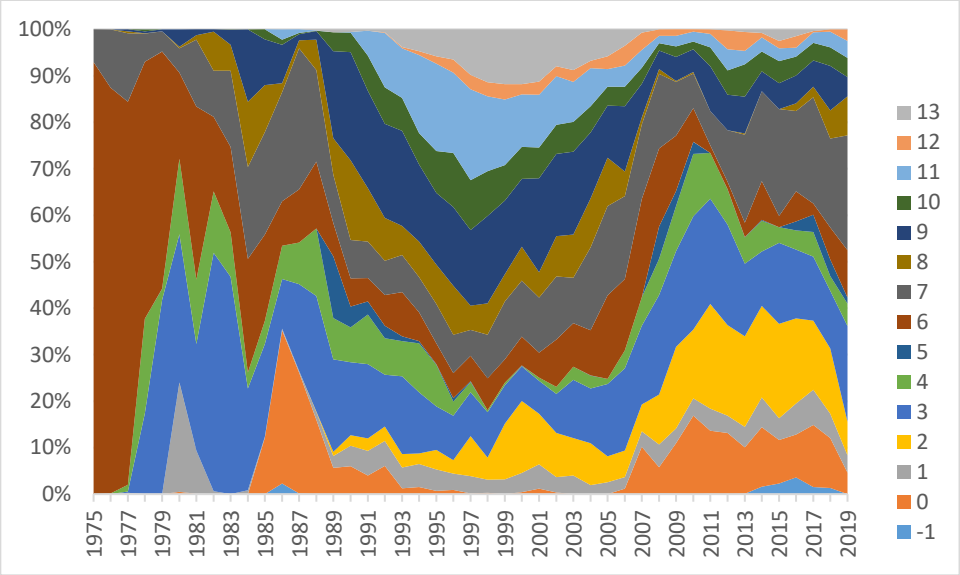

Figure 5a. *P. borealis* in W. Greenland: Distribution of the logbook-recorded catch between statistical Areas in Greenland waters, 1975-2019. (The light band that starts broad on the left-hand side is Area 6; the light band at the top is Area 0, the dark wedge at the very bottom from 1992 to 2007 is Area 13.)

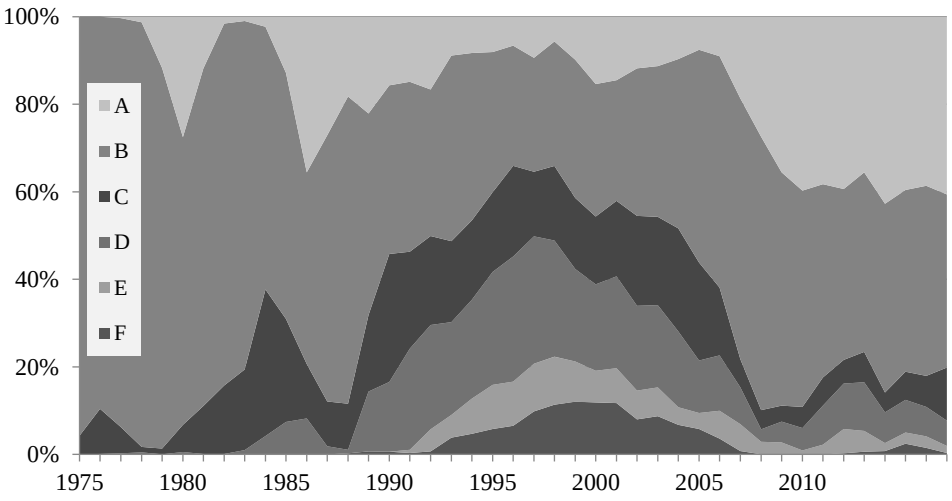

Figure 5b. *P. borealis* in W. Greenland: Distribution of the logbook-recorded catch between NAFO Divisions in Subarea 1 up to 76° N, 1975-2019.

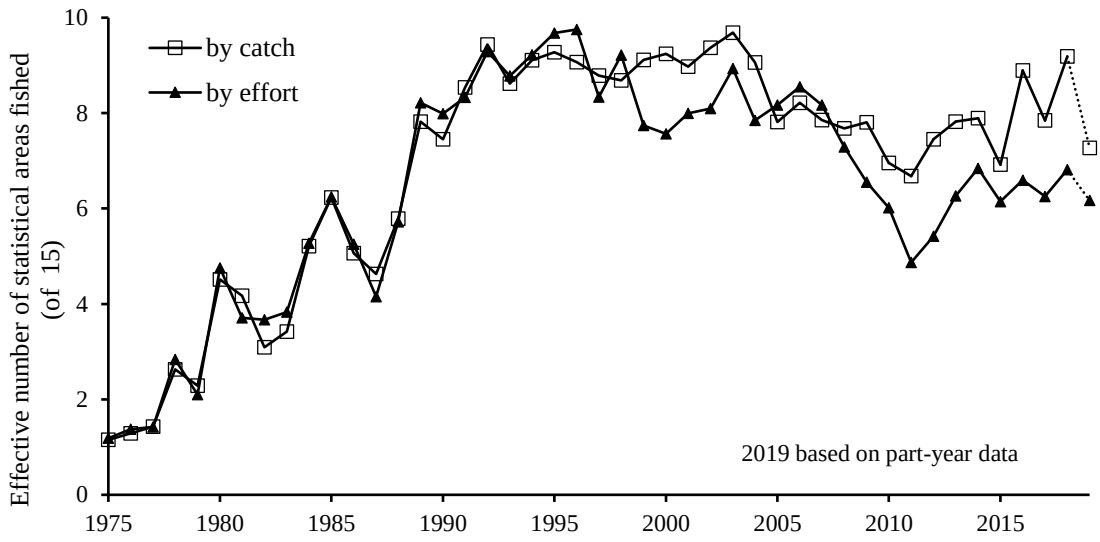

Figure 6a. *P. borealis* in W. Greenland: diversity indices for the distribution of logbook-recorded catch between statistical Areas in Greenland waters, 1975–2019. 2019 is on part-year's data.

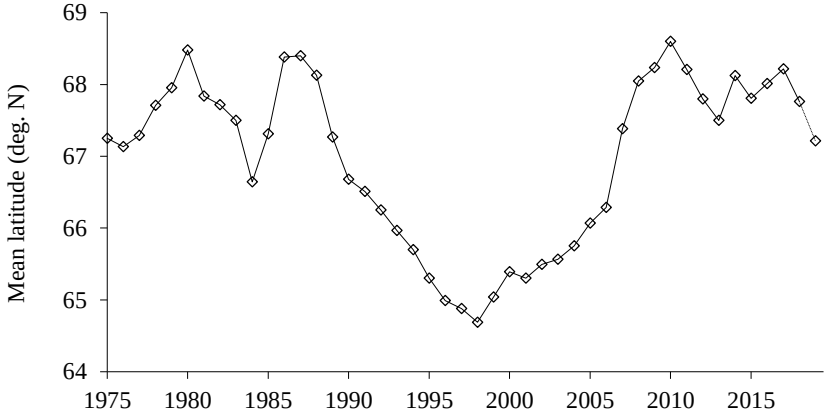

Figure 6b. *P. borealis* in W. Greenland: diversity indices for the distribution of logbook-recorded catch between statistical Areas in Greenland waters, 1975–2019. 2019 is on part-year's data.

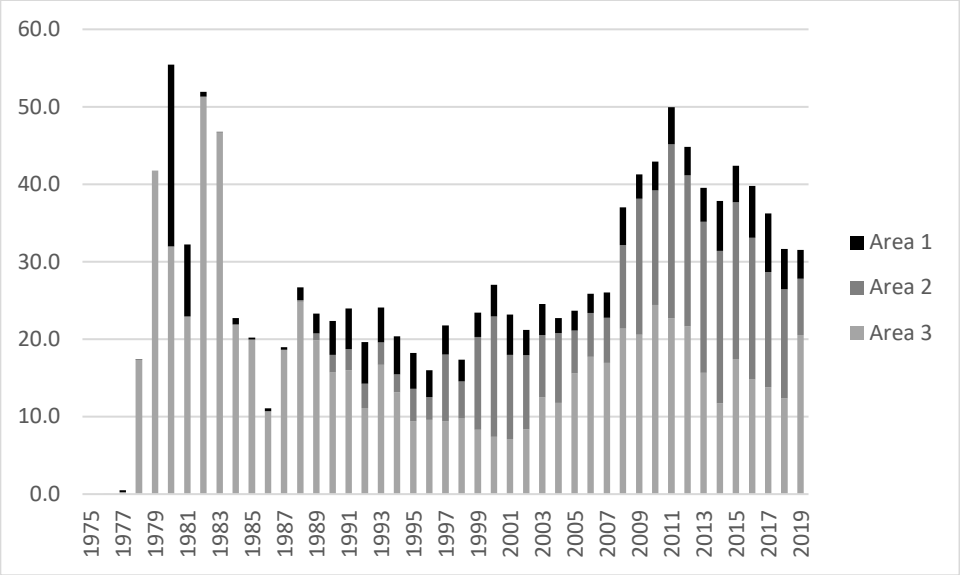

Figure 7a. *P. borealis* in W. Greenland: distribution of catches in the Disko Bay Area (statistical Areas 1, 2 and 3) 1990–2019. 2019 is on part-year's data.

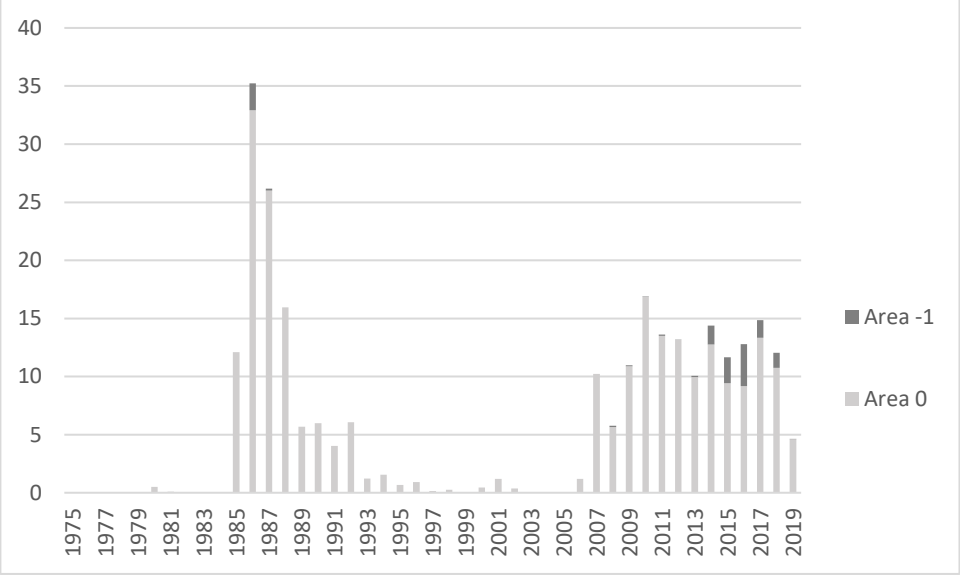

Figure 8. *P. borealis* in W. Greenland: catches taken in statistical area 0 and -1 as a percentage of total catches, 1990–2019. 2019 is on part-year's data.

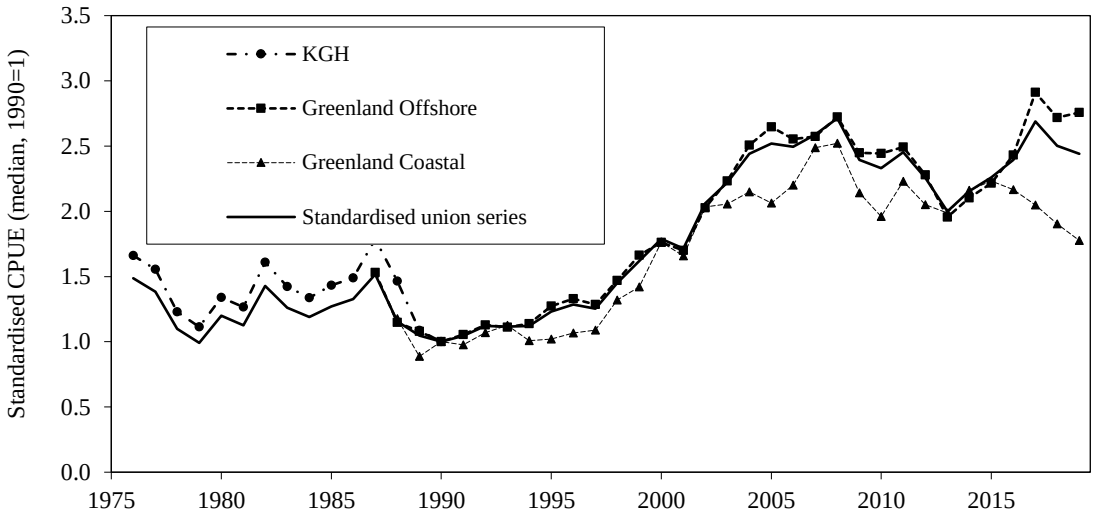

Figure 9. *P. borealis* in W. Greenland: standardized (1990=1) CPUE series from three fleets and a standardized union series 1976–2019. 2019 is on part-year's data.

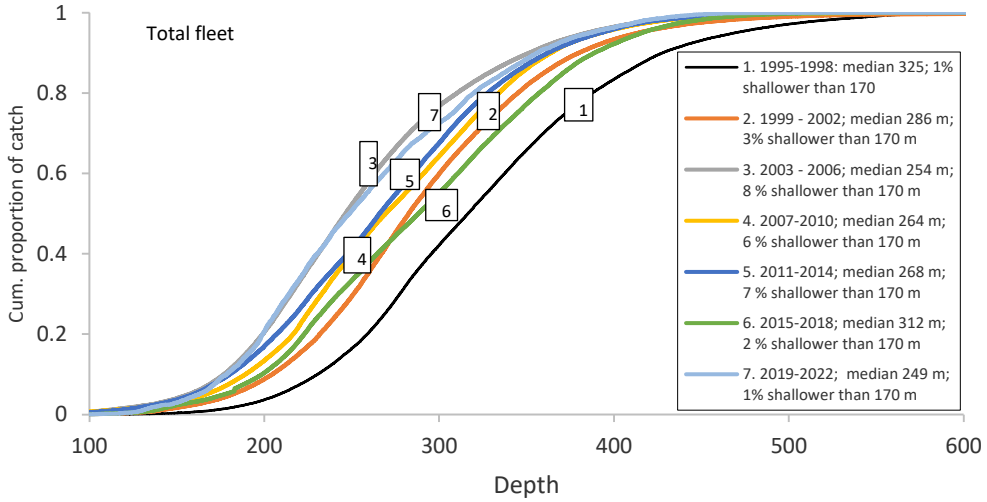

Figure 10a. *P. borealis* in W. Greenland: standardised (1990=1) CPUE series from all fleets and a standardised union series 1976–2019. 2019 is on part-year's data.

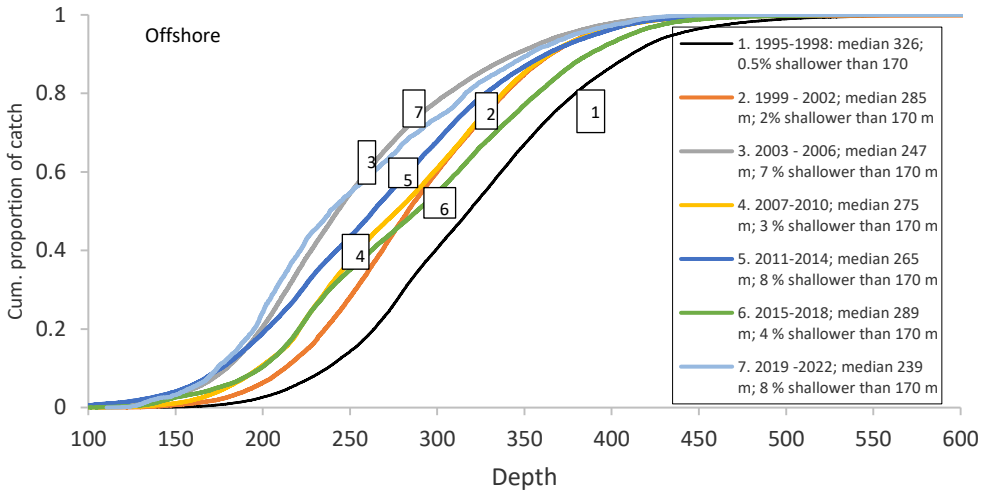

Figure 10b. *P. borealis* in W. Greenland: standardised (1990=1) CPUE series from offshore fleets and a standardised union series 1976–2019. 2019 is on part-year's data.

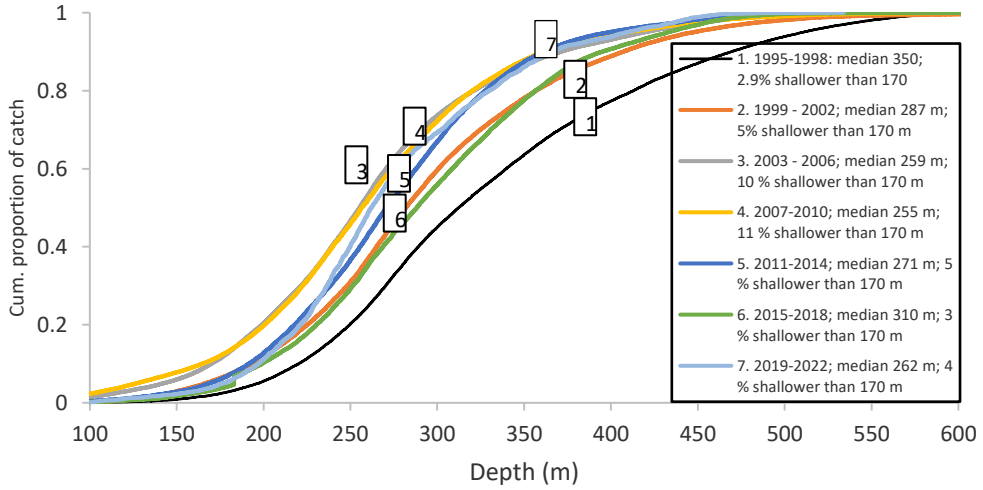

Figure 10c. *P. borealis* in W. Greenland: standardised (1990=1) CPUE series from coastal fleets and a standardised union series 1976–2019. 2019 is on part-year's data.

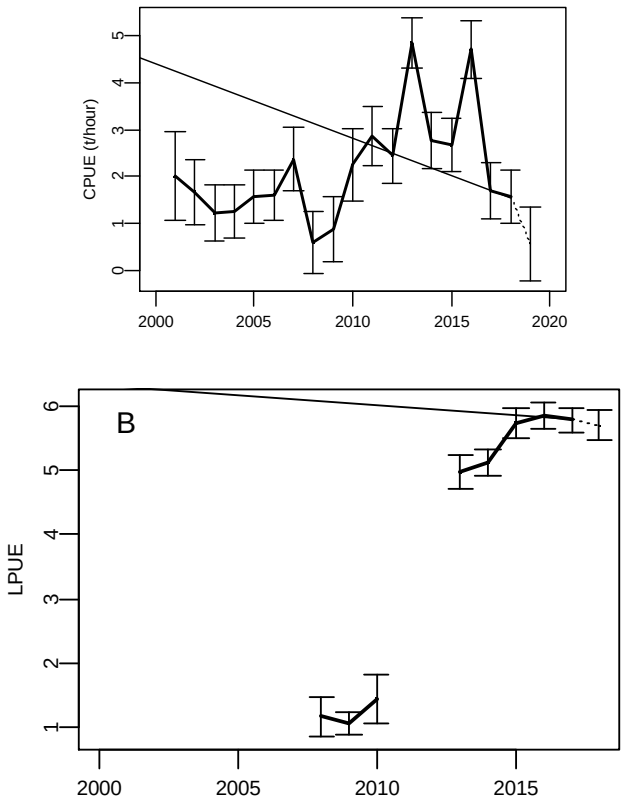

Figure 11. *P. montagui* in W. Greenland. A: standardized CPUE series from 5 offshore fleets 2008 - 2019. B: standardized LPUE series from sale notes 2008–2018. 2019 is on part-year's data. Error bars show 95% confidence limits

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

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
VESSEL	54	hh01 hh02 hh03 hh04 hh05 hh06 hh07 hh08 hh09 hh10 hh11 hh12 hh13 hh14 hh15 hh16 hh17 hh18 hh19 hh20 hh21 hh22 hh23 hh24 hh25 hh26 hh27 hh28 hh29 hh30 hh31 hh32 hh33 hh34 hh35 hh36 hh37 hh38 hh39 hh40 hh41 hh42 hh43 hh44 hh45 hh46 hh47 hh48 hh49 hh50 hh51 hh52 hh53 hh54
year	33	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 2013 2014 2015 2016 2017 2018 2019 2090
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
area	12	-1 0 3 4 5 6 7 8 9 10 11 12

Number of Observations Read 18240

Number of Observations Used 18240

_____

The SAS System

The GLM Procedure

Dependent Variable: LNCPUE

Weight: hauls

Source	DF	Sum of Squares		Mean Square	F Value	Pr > F
Model	107	132429.6846	1237.6606	385.68	<.0001	
Error	18132	58185.9636	3.2090			
Corrected Total		18239	190615.6482			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.694747	75.35516	1.791374	2.377241

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESSEL	53	111219.1895	2098.4753	653.93	<.0001
MONTH	11	2680.4832	243.6803	75.94	<.0001
area	11	5492.7692	499.3427	155.61	<.0001
year	32	13037.2426	407.4138	126.96	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	53	20362.29548	384.19425	119.72	<.0001
MONTH	11	1805.38051	164.12550	51.15	<.0001
area	11	4035.20736	366.83703	114.31	<.0001

year	32	13037.24258	407.41383	126.96	<.0001

Parameter	Estimate		Standard		
Error	t Value	Pr > |t|			
Intercept	2.020422141	B	0.08072256	25.03	<.0001
VESSEL hh01	-0.746162808	B	0.08874362	-8.41	<.0001
VESSEL hh02	-0.755279381	B	0.07936097	-9.52	<.0001
VESSEL hh03	-0.615206437	B	0.08048632	-7.64	<.0001
VESSEL hh04	-0.549828896	B	0.07974589	-6.89	<.0001
VESSEL hh05	-0.539554589	B	0.08031416	-6.72	<.0001
VESSEL hh06	-0.516944819	B	0.08183088	-6.32	<.0001
VESSEL hh07	-0.340749649	B	0.08054575	-4.23	<.0001
VESSEL hh08	-0.342974486	B	0.07666441	-4.47	<.0001
VESSEL hh09	-0.345983626	B	0.07852674	-4.41	<.0001
VESSEL hh10	-0.332188770	B	0.07708193	-4.31	<.0001
VESSEL hh11	-0.287223994	B	0.07616010	-3.77	0.0002
VESSEL hh12	-0.264178135	B	0.07734177	-3.42	0.0006
VESSEL hh13	-0.265367003	B	0.07850448	-3.38	0.0007
VESSEL hh14	-0.222837734	B	0.07743115	-2.88	0.0040
VESSEL hh15	-0.226726525	B	0.07672348	-2.96	0.0031
VESSEL hh16	-0.211793484	B	0.07785002	-2.72	0.0065

VESSEL hh17	-0.218055157	B	0.07730568	-2.82	0.0048
VESSEL hh18	-0.205804399	B	0.07709468	-2.67	0.0076
VESSEL hh19	-0.195550831	B	0.07637450	-2.56	0.0105
VESSEL hh20	-0.181151201	B	0.07487656	-2.42	0.0156
VESSEL hh21	-0.177597468	B	0.07782646	-2.28	0.0225
VESSEL hh22	-0.178404592	B	0.07758433	-2.30	0.0215
VESSEL hh23	-0.140186462	B	0.08619206	-1.63	0.1039
VESSEL hh24	-0.131032781	B	0.07792729	-1.68	0.0927
VESSEL hh25	-0.115101916	B	0.07684900	-1.50	0.1342
VESSEL hh26	-0.116791711	B	0.07571497	-1.54	0.1230
VESSEL hh27	-0.042763265	B	0.07964293	-0.54	0.5913
VESSEL hh28	-0.042200303	B	0.07676530	-0.55	0.5825
VESSEL hh29	-0.008901513	B	0.07541256	-0.12	0.9060
VESSEL hh30	-0.002344889	B	0.07592810	-0.03	0.9754
VESSEL hh31	0.017594739	B	0.07431422	0.24	0.8128
VESSEL hh32	0.037239447	B	0.07960608	0.47	0.6399
VESSEL hh33	0.051306462	B	0.07701937	0.67	0.5053
VESSEL hh34	0.061417282	B	0.07879925	0.78	0.4357
VESSEL hh35	0.053524338	B	0.07446644	0.72	0.4723
VESSEL hh36	0.073855238	B	0.12777301	0.58	0.5633
VESSEL hh37	0.105611941	B	0.07694660	1.37	0.1699

VESSEL hh38	0.138967524	B	0.08071148	1.72	0.0851
VESSEL hh39	0.123917685	B	0.07418615	1.67	0.0949
VESSEL hh40	0.217781622	B	0.07666024	2.84	0.0045
VESSEL hh41	0.227720028	B	0.08336832	2.73	0.0063
VESSEL hh42	0.249413412	B	0.07576418	3.29	0.0010
VESSEL hh43	0.234773193	B	0.07432912	3.16	0.0016
VESSEL hh44	0.240891151	B	0.07529812	3.20	0.0014
VESSEL hh45	0.240882129	B	0.07423640	3.24	0.0012
VESSEL hh46	0.277782818	B	0.07422292	3.74	0.0002
VESSEL hh47	0.389934804	B	0.07648473	5.10	<.0001
VESSEL hh48	0.380486070	B	0.07480132	5.09	<.0001
VESSEL hh49	0.382420704	B	0.07518673	5.09	<.0001
VESSEL hh50	0.385150696	B	0.07682897	5.01	<.0001
VESSEL hh51	0.007915717	B	0.13339254	0.06	0.9527
VESSEL hh52	-0.064536228	B	0.11042978	-0.58	0.5590
VESSEL hh53	0.213824496	B	0.08341427	2.56	0.0104
VESSEL hh54	0.000000000	B	.	.	.
MONTH 1	-0.028693884	B	0.01559932	-1.84	0.0659
MONTH 2	0.037075778	B	0.01565317	2.37	0.0179
MONTH 3	0.086395248	B	0.01496549	5.77	<.0001
MONTH 4	0.101358840	B	0.01419896	7.14	<.0001

MONTH 5	0.006699449	B	0.01374456	0.49	0.6260
MONTH 6	0.194194137	B	0.01392836	13.94	<.0001
MONTH 7	0.191339946	B	0.01375175	13.91	<.0001
MONTH 8	0.079037018	B	0.01375809	5.74	<.0001
MONTH 9	0.060009451	B	0.01384684	4.33	<.0001
MONTH 10	0.052886960	B	0.01396149	3.79	0.0002
MONTH 11	0.046675715	B	0.01405930	3.32	0.0009
MONTH 12	0.000000000	B	.	.	.
area -1	-1.101796142	B	0.04566823	-24.13	<.0001
area 0	-0.369598596	B	0.02767957	-13.35	<.0001
area 3	0.005457484	B	0.02831065	0.19	0.8471
area 4	-0.234428120	B	0.02724777	-8.60	<.0001
area 5	-0.328507199	B	0.03088974	-10.63	<.0001
area 6	-0.130419957	B	0.02675940	-4.87	<.0001
area 7	-0.163469019	B	0.02676026	-6.11	<.0001
area 8	-0.163015642	B	0.02683956	-6.07	<.0001
area 9	-0.158524853	B	0.02608950	-6.08	<.0001
area 10	-0.129154454	B	0.02703148	-4.78	<.0001
area 11	-0.093753942	B	0.02626826	-3.57	0.0004
area 12	0.000000000	B	.	.	.
year 1987	0.426577083	B	0.02105667	20.26	<.0001

year 1988	0.138806147	B	0.01845124	7.52	<.0001
year 1989	0.076636448	B	0.01772113	4.32	<.0001
year 1991	0.053231746	B	0.01628397	3.27	0.0011
year 1992	0.119559573	B	0.01667605	7.17	<.0001
year 1993	0.104336267	B	0.01714711	6.08	<.0001
year 1994	0.129794909	B	0.01726264	7.52	<.0001
year 1995	0.240786816	B	0.01789874	13.45	<.0001
year 1996	0.284000958	B	0.01910785	14.86	<.0001
year 1997	0.249775064	B	0.02029353	12.31	<.0001
year 1998	0.383570672	B	0.02188876	17.52	<.0001
year 1999	0.507833021	B	0.02280908	22.26	<.0001
year 2000	0.565022787	B	0.02449709	23.06	<.0001
year 2001	0.529139288	B	0.02556607	20.70	<.0001
year 2002	0.703888560	B	0.02376981	29.61	<.0001
year 2003	0.790577609	B	0.02417823	32.70	<.0001
year 2004	0.921767712	B	0.02429114	37.95	<.0001
year 2005	0.985744226	B	0.02414438	40.83	<.0001
year 2006	0.932922121	B	0.02421825	38.52	<.0001
year 2007	0.953999342	B	0.02522358	37.82	<.0001
year 2008	1.000421339	B	0.02536160	39.45	<.0001
year 2009	0.897717064	B	0.02712594	33.09	<.0001

year 2010	0.887832382	B	0.02681356	33.11	<.0001
year 2011	0.898923895	B	0.02774543	32.40	<.0001
year 2012	0.807309796	B	0.02766129	29.19	<.0001
year 2013	0.646965639	B	0.02810093	23.02	<.0001
year 2014	0.728394286	B	0.02864727	25.43	<.0001
year 2015	0.784744512	B	0.03030028	25.90	<.0001
year 2016	0.886972378	B	0.02990644	29.66	<.0001
year 2017	1.077140508	B	0.02924592	36.83	<.0001
year 2018	0.997166282	B	0.02862879	34.83	<.0001
year 2019	1.033125297	B	0.03924729	26.32	<.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 41 cc01 cc02 cc03 cc04 cc05 cc06 cc07 cc08 cc09 cc10 cc11 cc12 cc13 cc14 cc15 cc16 cc17 cc18 cc19 cc20 cc21 cc22 cc23 cc24 cc25 cc26 cc27 cc28 cc29 cc30 cc31 cc32 cc33 cc34 cc35 cc36 cc37 cc38 cc39 cc41 cc42
year 32 1988 1989 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2090
area 2 1 2
MONTH 12 1 2 3 4 5 6 7 8 9 10 11 12

Number of Observations Read 6465
Number of Observations Used 6465

The SAS System

The GLM Procedure

Dependent Variable: LNCPUE

Weight: Hauls

Source DF Sum of Squares Mean Square F Value Pr > F
Model 83 31380.46895 378.07794 187.65 <.0001
Error 6381 12856.58078 2.01482
Corrected Total 6464 44237.04973

R-Square Coeff Var Root MSE LNCPUE Mean
0.709371 72.50471 1.419444 1.957727

Source DF Type I SS Mean Square F Value Pr > F
area 1 313.21674 313.21674 155.46 <.0001
MONTH 11 2537.54879 230.68625 114.49 <.0001
VESSEL 40 18496.38664 462.40967 229.50 <.0001
year 31 10033.31678 323.65538 160.64 <.0001

Source DF Type III SS Mean Square F Value Pr > F
area 1 136.26734 136.26734 67.63 <.0001
MONTH 11 1417.45240 128.85931 63.96 <.0001
VESSEL 40 6791.87805 169.79695 84.27 <.0001
year 31 10033.31678 323.65538 160.64 <.0001

Parameter Estimate Standard
Error t Value Pr > |t|
Intercept 0.531985707 B 0.05596282 9.51 <.0001
area 1 0.077187953 B 0.00938582 8.22 <.0001
area 2 0.000000000 B . . .
MONTH 1 0.013658586 B 0.02244275 0.61 0.5428
MONTH 2 0.042283589 B 0.02703716 1.56 0.1179
MONTH 3 0.242767580 B 0.02770159 8.76 <.0001
MONTH 4 0.306871197 B 0.02150152 14.27 <.0001
MONTH 5 0.217875539 B 0.01876701 11.61 <.0001
MONTH 6 0.253359098 B 0.01877221 13.50 <.0001
MONTH 7 0.259642724 B 0.01922903 13.50 <.0001
MONTH 8 0.194848031 B 0.01923320 10.13 <.0001
MONTH 9 0.103627772 B 0.01897179 5.46 <.0001
MONTH 10 0.062313072 B 0.01844620 3.38 0.0007
MONTH 11 0.049097681 B 0.01875516 2.62 0.0089
MONTH 12 0.000000000 B . . .
VESSEL cc01 0.566863273 B 0.07692561 7.37 <.0001

VESSEL cc02 0.568221546 B 0.06434655 8.83 <.0001
VESSEL cc03 0.642563716 B 0.05624358 11.42 <.0001
VESSEL cc04 0.534610798 B 0.05339044 10.01 <.0001
VESSEL cc05 0.509336723 B 0.05282106 9.64 <.0001
VESSEL cc06 0.640922670 B 0.05901912 10.86 <.0001
VESSEL cc07 0.539148702 B 0.08092346 6.66 <.0001
VESSEL cc08 0.494491670 B 0.08042289 6.15 <.0001
VESSEL cc09 0.760935249 B 0.05547706 13.72 <.0001
VESSEL cc10 0.504842204 B 0.07714617 6.54 <.0001
VESSEL cc11 0.695875254 B 0.05096195 13.65 <.0001
VESSEL cc12 0.747810140 B 0.05025106 14.88 <.0001
VESSEL cc13 0.811656276 B 0.04909817 16.53 <.0001
VESSEL cc14 0.834003580 B 0.05914846 14.10 <.0001
VESSEL cc15 0.846312408 B 0.04965691 17.04 <.0001
VESSEL cc16 0.795298706 B 0.05173470 15.37 <.0001
VESSEL cc17 0.844330980 B 0.04857668 17.38 <.0001
VESSEL cc18 0.995490619 B 0.05182847 19.21 <.0001
VESSEL cc19 0.933153921 B 0.05095543 18.31 <.0001
VESSEL cc20 0.942356122 B 0.05060356 18.62 <.0001
VESSEL cc21 0.808642820 B 0.05359836 15.09 <.0001
VESSEL cc22 0.996595435 B 0.05021865 19.85 <.0001
VESSEL cc23 0.932591556 B 0.04841294 19.26 <.0001
VESSEL cc24 0.930922184 B 0.04868780 19.12 <.0001
VESSEL cc25 0.755335010 B 0.05510091 13.71 <.0001
VESSEL cc26 1.045748535 B 0.04991840 20.95 <.0001
VESSEL cc27 0.859523568 B 0.05852422 14.69 <.0001
VESSEL cc28 1.007953624 B 0.05133295 19.64 <.0001
VESSEL cc29 0.986276385 B 0.05019917 19.65 <.0001
VESSEL cc30 1.038468007 B 0.41277786 2.52 0.0119
VESSEL cc31 1.147001537 B 0.05129288 22.36 <.0001
VESSEL cc32 1.117327062 B 0.05774299 19.35 <.0001
VESSEL cc33 1.181100271 B 0.05623342 21.00 <.0001
VESSEL cc34 1.254829481 B 0.06573749 19.09 <.0001
VESSEL cc35 1.721385587 B 0.05462805 31.51 <.0001
VESSEL cc36 0.632445296 B 0.05235890 12.08 <.0001
VESSEL cc37 0.389922532 B 0.07867433 4.96 <.0001
VESSEL cc38 1.577132239 B 0.05197072 30.35 <.0001

VESSEL cc39 0.946407733 B 0.05293890 17.88 <.0001
VESSEL cc41 0.446277640 B 0.06790712 6.57 <.0001
VESSEL cc42 0.000000000 B . . .
year 1988 0.149727191 B 0.06426580 2.33 0.0198
year 1989 0.005711268 B 0.04634847 0.12 0.9019
year 1991 -0.159391341 B 0.03409201 -4.68 <.0001
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year 2015 0.568709093 B 0.03504891 16.23 <.0001
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year 2018 0.386652824 B 0.03467375 11.15 <.0001
year 2019 0.291987394 B 0.04487811 6.51 <.0001
year 2090 0.000000000 B . . .