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The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2004

by

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Abstract

Northern shrimp (*Pandalus borealis*) occurs on the continental shelf off West Greenland in NAFO Divisions 0A and 1A–1F in depths between approximately 150–600 m. The stock is assessed as a single population and managed by catch control. Greenland and Canada exploit the stock in Subarea 1 and Div. 0A east of 60°W, respectively.

Following a maximum in 1992 of 105 000 tons catches decreased to around 80 000 tons in 1998 due to management measures. Since then stepwise increases of catch quotas have been followed by increased catches. The projected catch of 2004 is expected to be the highest ever amounting to about 141 000 tons. The inshore fishery (vessels below 80 GRT) accounts for around 15% of the total landings. Reported discard and by-catch is low.

A standardised CPUE series indicate an increasing trend of stock biomass since the early-1990s. The estimated 2004 median value is the highest of the time series. Standardised effort based on biomass indicated a decrease in harvest rate from 1992 to 2000 by about 35%. For 2003 and 2004 the indices indicate a harvest rate at the 2000 level.

The mean size of shrimp caught has declined since 1991. In spite of these changes, the proportions of female to male shrimp in the catches seem relatively stable since the mid-1990s. The length-frequency distribution of the 2001 catches shows a large peak of males around 20 mm carapace length. The female component is less prominent, however, with representation of all sizes normally present. Sparse sampling in 2002 does not indicate major changes from that. The 2003 and 2004 catch composition could not be evaluated due to incomplete sampling.

Introduction

Northern shrimp (*Pandalus borealis*) occurs on the continental shelf off West Greenland in NAFO Div. 0A and 1A–1F. The stock is continuously distributed from Cap Farewell to about 74°N, with highest concentrations in depths between 150 and 600 m (Fig. 1). There is no evidence of distinct sub-populations and since 1993 this stock is assessed as a single population (Anon., 1993).

The fishery for shrimp began in inshore areas in 1935. In 1970 the development of a multinational offshore fishery started and during the following 30-years landings increased, reaching approximately 130 000 tons in 2003. Since 1981 access to the stock was limited to Greenlandic vessels in Subarea 1 and Canadian vessels in Div. 0A east of 60°W. Catch restrictions were imposed in 1977 and since then the stock has been managed by a Total Allowable Catch (TAC).

Two Greenlandic fleet components exploit the stock in Subarea 1: an offshore fleet, which at present consists of 15 large factory trawlers (500-4000 GRT) and a small vessel fleet composed of about 60 vessels below 80 GRT. The offshore fleet component is restricted to offshore areas and by quotas. With a few exceptions vessels below 80 GRT were unrestricted by areas and quotas until 1997 when catch regulation was introduced also for this fleet component. Since 1986 logbooks have been mandatory for vessels above 50 GRT. Since 1997 logbooks are available for all vessels. An Internal Transferable Quota system (ITQ) was introduced as a management tool in 1991.

The Canadian fleet exploits the stock component in Div. 0A east of 60°W. Seventeen companies are currently licensed to fish in the area but in recent years only 6-7 vessels (2000-4000 GRT) have participated. Catches are restricted by quotas. Vessel logs are available since 1979.

The present paper updates time series of catch, effort, catch composition, standardised CPUE-indices and spatial distribution of the Greenlandic and Canadian trawl fishery for shrimp off West Greenland.

Materials and Methods

Total catches were estimated from vessel logs and weekly reporting to Greenlandic authorities, corrected for “over-packing” and converted to live weight (Hvingel, 2003). Logbook data were analysed to show the spatial and temporal distribution of the fishery. Unstandardised CPUE was calculated using a factor 1.6 as a multiplier for recorded effort by vessels using twin-trawl. Unstandardised effort was calculated by dividing total catch with mean CPUE. Standardised effort was calculated by dividing total catch by the standardised CPUE-index (see below).

CPUE data from Greenlandic vessels above 50 GRT fishing in Subarea 1 and Canadian vessels fishing in Div. 0A east of 60°W were used in multiplicative models to calculate standardised annual catch rate indices. Four separate indices covering four different fleets were derived (Hvingel *et al.*, 2000). These indices were then combined in a single series representing the total area. Annual CPUE indices for the total area cannot be derived from a single GLM (General Linear Model) run including all fleets as they had no or too little overlap either in time or in space and thus such a model will not be able to estimate the relative fishing power of the individual vessels.

The four indices included the following variables: (1) individual vessel fishing power, (2) seasonal availability of shrimp, (3) spatial availability of shrimp and (4) annual mean CPUE. The calculations were done using the SAS statistical software (Anon., 1988). The main criterion for including an individual vessel in either of the multiplicative models was three years of participation in the fishery covered by the index. Hauls by twin-trawls (two complete trawls towed simultaneously) were excluded from the analysis. The area definition used is based on distinct fishing grounds (Fig. 1). The multiplicative model was represented in logarithmic form either as:

$$\text{Model 1} \quad \ln(\text{CPUE}_{mjk}) = \ln(u) + \ln(A_m) + \ln(S_j) + \ln(V_k) + \ln(Y_i) + e_{mjk}$$

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

$$\text{Model 2} \quad \ln(\text{CPUE}_{mjk}) = \ln(u) + \ln(V_k) + \ln(Y_i) + \ln(A_m * S_j) + e_{mjk}$$

Where CPUE_{mjk} is the mean CPUE for vessel k , fishing in area m in month j during year i ($k = 1, \dots, n$; $m = 1, \dots, a$; $j = 1, \dots, s$; $i = 1, \dots, y$); $\ln(u)$ is overall mean $\ln(\text{CPUE})$; A_m is effect of the m^{th} 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; e_{mjk} is the error term assumed to be normally distributed $N(0, \sigma^2/n)$ where n is the number of observations in the cell. The standardised CPUE indices are the antilog of the year coefficient.

Parameter estimates of the vessel, month and area variable from a first run of the main effects model (model 1) were compared. Levels within each variable were combined in subsequent analyses if the parameter estimates did not differ by more than 5%. This was done to reduce the number of empty cells in the models. For further details on model construction and analyses see Hvingel *et al.* (2000).

The ‘1BCDEF index’ largely covers the NAFO Div. 1B to F (area 1A was not included due to misreporting from that particular area). 40 vessels were included providing data since 1987. These data were grouped into 10 areas (Area 4-13, Fig. 1). Based on the exploratory run of the main effects model (model 1) the vessel effect was collapsed

into 27 groups consisting of 1-3 vessels with similar fishing power. The month effect was reduced to 10 levels by grouping adjacent months with similar indices of relative shrimp availability. Areas 7 and 8 and area 9 and 10 were grouped.

The ‘KGH index’: The initial offshore fishery was executed by 7 sister trawlers (722 GRT) all operated by the Kongelige Grønlandske Handel (KGH). This early fishery only covered Div 1A and part of Div. 1B and data from Area 3, 4, 6 and 7 (Fig. 1) for the years 1976-1990 were considered for this index. The analyses for reducing variable levels showed that 6 of the seven vessels could be treated as a group in the subsequent analyses. The month variable could be reduced to 10 levels and area 4, 6 and 7 combined.

Data for the ‘0A index’ is available since 1981. The fishery in Div. 0A takes place in a very limited area (Fig. 1) thus no areal segregation was required for the 0A-index. Although the fishery takes place in June-December, the analysis was confined to July-November because effort was sparse in June and December, especially in recent years. Effort in 1997 was low and an unknown proportion was due to twin trawling thus 1997 was not included. The 29 levels of the vessel variable were reduced to 10 consisting of 1-7 individual vessels of similar fishing power. The months August-November were grouped into one level before subsequent analyses.

The ‘small vessel index’ is based on vessels below 80 GRT, which have exclusive rights for fishing in “inshore” areas. This fishery is almost exclusively confined to areas around Disko Island in Div. 1A and 1B. The areas included were those shown as areas 1, 2 and 3 in Fig. 1. Comprehensive data are available since 1988 and 27 vessels were used in the model. The fishery occurs from March/April to December. The vessel variable was reduced to 9 levels consisting of groupings of 1-5 vessels due to similarity of estimated fishing power. The month variable was reduced from 9 to 5 levels.

One unified time series of standardised CPUE, covering 1976-2002, was derived by aggregating the four available indices. 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 p^{th} fleet, μ_{pi} , was assumed to reflect an overall biomass series, Y_i , and a constant fleet coefficient, v_p , so that:

$$\mu_{pi} = v_p Y_i \exp(e_{pi}).$$

The error, e_{pi} , were considered to be distributed with mean zero and variance σ_{pi}^2 . I assumed that e_{pi} , had variances inversely proportional to the area of fishing ground, a_p , covered by fleet p . The factor, a_p , was taken to be the area of sea bottom between 150-600 m. Hence, σ_{pi}^2 was calculated by:

$$\sigma_{pi}^2 = \frac{cv_{pi}^2}{a_p}$$

Where cv_{pi} is the annual fleet specific coefficient of variation as calculated in the GLM run. The area weighting factor, a_p , for the 1BCD, KGH, 0A and Small vessel indices was estimated to 0.46, 0.36, 0.05 and 0.13, respectively.

Annual size compositions of shrimp catches were obtained from samples taken before processing by fisheries observers onboard offshore vessels. Onboard the vessel or later in the laboratory samples were sorted by sexual characteristics (McCrary, 1971) and measured to the nearest 0.1 mm (Greenland) and 0.5 mm (Canada) carapace length. The data were pooled in 0.5 mm length groups and adjusted by the weight of the catch to the number caught in the set. Numbers from all sets for the month were totalled and adjusted by weight to the monthly catch by NAFO Division. The numbers from all months and areas were totalled and adjusted by weight to the total or projected catch of the year.

Results and Discussion

Spatial and seasonal distribution

The fishery has been conducted on the continental shelf of Greenland between 59 and 74°N, mainly between 150 and 600 m depth (Fig. 1). However, during the period of logbook recordings (since 1975) a substantial change in

the relative importance of the different areas is indicated. Since the mid-1970s until the early-1980s the vast majority of the annual fishing effort were allocated to Div. 1A and 1B. Div. 1C and 0A received some attention but almost no effort was spent in Div. 1D, 1E and 1F (Table 1). Since then the fishery has gradually expanded southward to include also these three southern-most Divisions in Subarea 1. Incomplete logbook coverage of the small vessel component causes underestimation of the fishery in Div. 1A and 1F until 1997. Alternating quota restrictions in offshore areas of Div. 1A may also have biased data for this area.

The southward expansion/displacement of the offshore fishery 1987-1998 is summarised by a decreasing mean latitude of effort allocation as shown in Fig. 2. Indications of biomass distribution from the German groundfish survey (Rätz, 1997) and the Greenlandic trawl survey (Carlsson and Kannevorff, 1997) may suggest that the fishery was tracking a southward shift in shrimp biomass. However, development of improved trawling gear for accessing the more difficult trawling grounds in the southern areas may also have been an important factor. Since then the distributional pattern of the fishery has stabilised. The preliminary data for 2004 do not suggest any significant changes in the distribution of the fishery in Subarea 1 and Div. 0A as compared to that of year 2003 (Fig. 3).

The fishery takes place in all months (Table 2). In general the monthly amount of shrimp caught tracks a dome shaped curve over the year with a maximum in midsummer (June-July). In some years (1991-1994) a second maximum occur in October. In Div. 0A the fishery usually begins in late June - early July and continues into late November. However, most of the catch and effort occurs in August-October.

Catch

Catches of shrimp taken in the Greenland Exclusive Economic Zone (EEZ) have until 2003 been reported without accounting for “over-packing” – the quantum of surplus weight in a certain packaging (e.g. in 5 kg cartons) – or the difference between the product weight and live weight. January 1st 2004 this practice was changed by the enforcement of new legislation to ensure that total removals by fishing are reported in units of live weight. The catch data previous to this date has been revised to account also for unreported catch (Hvingel, 2003).

In conjunction with the development of the offshore shrimp fishery total annual catch has increased from about 10000 tons in the early-1970s to more than 105 000 tons in 1992 (Fig. 4A, Table 3). Government restrictions to reduce effort and fishing opportunities elsewhere for the Canadian fleet then made catches decrease to about 80000 tons in 1998. Since then increased annual quotas (Table 3) has been accompanied by increased catches. The projected catch of 2004 is expected to be about 141 000 tons (projected from Oct. to the end of the year).

Since the beginning of the 1970s catches in the inshore areas have been fluctuating between 8 000 and 23 000 tons (Table 3). Limited access for vessels above 80 GRT was the only management related restraint on inshore catch levels until 1997 when ITQ's were enforced also for the small vessel fleet. Subsequently catches decreased substantially while a major reorganisation of the fleet took place. During most of the nineties the inshore fishery had accounted for 19-24% of the total catches, but in 1998 only 13% (10 500 tons) were taken inshore. By 1999 catches were back up around 20 000 tons. However, while the catches of the offshore fishery kept increasing the catches of inshore fishery has remained stable. Thus for the recent three years the inshore fleets' share of total catches has declined to 15%.

The Canadian catches in Div. 0A east of 60°W have fluctuated between 1 700 and 5 400 tons during 1979-1983 after which they increased from 2 100 tons in 1984 to the highest recorded level of around 6-7 000 tons in the late-1980s-early-1990s (Table 3). Catches thereafter declined to around 1 000 tons in 1998 coincident with the increased fishing opportunities off Labrador. During the mid-1990s-early-2000s catches in Div. 0A have accounted for less than 4% of the total catches off West Greenland. The 2004 catches are expected to be about 6 000 tons i.e. 4% of total catches.

By-catch and discard

The reported discard of shrimp has remained less than 1% (weight) of total catch throughout the period 1975-2004 (Table 4). The discard of fish has shown a slightly increasing trend from about 1 to 3% of total catch in the years 1987-1998. The introduction of observers on all offshore vessels in 1991 has most likely contributed to this

development by the increasing incentive to report discard. An improved market for smaller shrimp may have offset the corresponding effect of observers on the reported discard of shrimp. In the most recent years registered annual discard of fish have been around 1% of total catch. Sorting grids with 22mm grid space are mandatory for stern trawlers.

From 1995 to 2003 vessels have reported annual catches of *P. montagui* in the range of about 100 to 1 000 tons (Table 4). Landings of *P. montagui* are allowed to include up to 70% *P. borealis*. As *P. montagui* can be landed outside the quota it has therefore been possible to "hide" catches of *P. borealis* within these landings. Hence, it is difficult to use the emergence and disappearance of *P. montagui* in the catches to infer changes in targeting strategy of the fishery or as an indication of increased availability of this species. However there have been indications of increased biomass of *P. montagui* during the mid-1990s (Kannevorff, 2003).

Effort

Since 1975, when the offshore fishery was well established, until 1984 annual unstandardised effort showed a slightly increasing trend from about 75 000 hr's to about 93 000 hr's (Fig. 4B). In the subsequent years a considerable enlargement of the offshore fleet took place and effort went up by almost a factor three reaching 250 000 hr's in 1991-1992. Hereafter unstandardised effort has decreased as a result of management measures, reduced activity in Div. 0A (Table 1) and a general increased fishing efficiency of the participating vessels. The increase in the overall unstandardised effort and in particular effort in Div. 1A from 1996 to 1997 (Table 1) is caused by the addition of logbooks from vessels below 50 tons to the database (introduction of new logbook system). In 2003 about 126 000 trawling hr's were registered and preliminary data suggest that the year 2003 figure will be at the same level.

The course of the standardised effort time series agrees trend wise with the unstandardised (Fig. 4B). Since 1992, when it reached its highest value, standardised effort has shown a continuous decrease until 2000 by about 35%. effort then increased marginally from 2000 to 2002. For 2003 and 2004 the indices is down again indicating a harvest rate at the 2000 level.

Catch-per-unit-effort

The unified standardised CPUE index is an aggregate of four individual indices (Table 5) derived by GLM (Appendix 1-4). All fleets included in the analysis mainly exploit shrimp greater than 16 mm cpl. The CPUE indices are therefore indicative of the older male and the female stock combined.

The overall combined index (Fig. 4C, Table 5) fluctuated without trend by a factor of 2 between 1976 and 1987. It then dropped precipitously to the lowest level of the time series in 1990-91. Since 1990 the index has shown an increasing trend. The revised 2003 median index value, using the complete set of data for the year, was slightly lower than the value reported in Hvingel (2003) based on partial data for the year. The estimated median value for 2004 is up by 18% compared to the 2003-median value and is the highest of the time series.

The standardisation method used accounts for the increase in efficiency from renewal of the fleet but does not account for the technological improvements, which result from upgrading of older vessels. However, the YEAR*VESSEL term had low importance in the individual models which suggested that this term could be ignored and the YEAR-effect therefore interpreted as a biomass indicator. Still, the standardised CPUE time series is expected to give a slightly optimistic view of the stock development (for further discussion of the CPUE index as a stock indicator, see Hvingel *et al.*, 2000).

Catch composition.

The mean shrimp size caught has declined during the 1990's. In Subarea 1 it declined by 3 mm cpl. from 1991 to 1999 corresponding to a mean individual weight reduction of about 30% (Fig. 5). Mean shrimp size caught in the Canadian fishery in Div. 0A showed a similar declining trend since 1981 (Fig. 5). In spite of these changes, the proportions of female to male shrimp in the catches seem relatively stable since the mid-1990s

The reduced size may be partly due to better market prices for small shrimp along with a thorough restructuring of the Greenlandic offshore fleet during this time period, leaving most vessels with enough quota to make 'high-grading' less profitable. However, the decline of shrimp size in the catches was temporarily reversed in year 2000 by the presence of a relative high proportion of female shrimp (table 6). The length frequency distribution of year 2000 shows a large peak of female shrimp at around 25 mm cpl. (Fig. 6).

The data of 2001 does not indicate an equally good catch quality. The length frequency distribution shows a dominant peak of male shrimp at around 20 mm cpl. (Fig. 6). The female component is less prominent, however, with representation of all sizes normally present in the catches.

For 2002 only three samples were available and therefore numbers on annual catch composition derived from these samples should be viewed with reservation. However, no major changes from the previous year were indicated. The 2003 and 2004 catch composition was not evaluated due to sparse sampling.

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References

- ANON. 1988. SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute Inc., 1988. 1028.
- ANON. 1991. Scientific Council Reports 1991. NAFO, Dartmouth, Canada, 1991. 166 p.
- ANON. 1993. Scientific Council Reports 1993. NAFO, Dartmouth, Canada 1993. 227 p.
- 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.*, No. 101, Serial No. N2958.
- KANNEWORFF, P. 2003. Occurrence of (*Pandalus montagui*) in trawl survey samples from NAFO Subarea 0+1. *NAFO SCR Doc.*, No. 70, Serial No. N4909.
- HVINGEL, C. 2003. The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2003. *NAFO SCR Doc.*, No. 75 Serial No. 4914.
- 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.*, No. 74 Serial No.4913.
- 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.
- MCCRARY, J. A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. *J. Fish. Res. Board Can.*, **28**: 98-100.
- 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.*, No. 96, Serial No. N2953.

Table 1. Annual catch, effort and CPUE of the shrimp fishery in Subarea 1 and Div. 0A by NAFO Divisions. Data was derived from vessel logs and weighted up to total catch of the year.

Year year	Catch ('000 tons)							Effort ('000 hr's)							CPUE (kg/hr)							
	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F	0A	1A	1B	1C	1D	1E	1F	
1975	0.0	0.0	44.6	2.0	0.0	0.0	0.0	-	0.0	70.5	3.6	0.0	0.0	0.0	-	-	632	551	-	-	-	-
1976	0.4	0.0	54.7	6.3	0.0	0.0	0.0	-	0.1	70.1	8.0	0.1	0.8	1.1	-	-	780	785	-	-	-	40
1977	0.5	0.2	47.8	3.1	0.1	0.0	0.0	-	0.5	67.8	4.4	0.5	0.0	0.0	-	357	705	691	253	-	-	
1978	0.1	0.5	40.9	0.5	0.2	0.0	0.0	-	1.4	80.7	1.3	0.8	0.0	0.0	-	382	507	416	259	-	-	
1979	1.7	4.8	35.7	0.5	0.0	0.0	0.0	7.3	6.7	64.1	1.5	0.1	0.0	0.0	236	719	557	348	112	-	-	
1980	2.7	14.6	35.0	3.3	0.3	0.0	0.0	7.6	21.2	53.3	4.9	0.5	0.0	0.0	358	690	655	668	596	-	-	
1981	5.3	5.7	37.5	5.3	0.0	0.0	0.0	17.7	11.2	66.4	10.4	0.1	0.0	0.0	299	511	564	510	409	-	-	
1982	2.1	0.8	43.2	8.2	0.0	0.0	0.0	6.2	1.7	65.7	13.5	0.1	0.0	0.0	335	472	657	604	388	-	-	
1983	5.4	0.5	40.5	9.4	0.5	0.0	0.0	19.1	0.9	69.5	17.8	0.9	0.0	0.0	284	559	582	528	531	-	614	
1984	2.1	1.2	30.4	17.0	2.1	0.0	0.0	7.7	2.7	51.1	28.4	2.7	0.0	0.1	280	431	595	598	785	-	47	
1985	3.1	8.2	35.3	14.9	4.7	0.0	0.0	9.9	29.0	64.8	25.4	8.8	0.0	0.0	309	282	545	586	541	-	-	
1986	3.0	26.6	32.1	9.1	6.1	0.0	0.0	6.7	54.8	54.1	13.9	9.8	0.1	0.1	445	485	593	655	624	273	-	
1987	6.1	19.7	43.7	7.3	1.1	0.0	0.0	12.4	55.2	67.1	10.5	3.4	0.0	0.0	491	357	651	695	343	-	-	
1988	5.9	12.6	47.4	7.1	0.5	0.0	0.1	12.6	41.6	92.3	14.1	1.8	0.0	1.0	468	302	514	502	282	-	153	
1989	7.2	16.6	34.0	12.8	9.5	0.0	0.5	18.5	48.4	77.9	29.7	16.6	0.0	4.3	391	344	437	431	572	-	111	
1990	6.2	12.3	30.2	22.6	12.2	0.0	0.5	15.2	42.7	78.1	54.3	29.1	0.0	2.8	405	288	387	417	419	-	165	
1991	6.8	12.7	33.0	18.8	19.4	0.6	0.2	20.5	37.2	90.3	51.9	47.6	0.7	1.3	330	341	365	362	408	824	191	
1992	7.5	16.4	32.9	20.0	23.2	4.9	0.6	17.6	49.5	76.3	48.1	51.1	7.5	1.3	425	330	431	415	455	661	498	
1993	5.5	7.6	36.2	15.8	18.1	4.5	3.2	13.6	23.0	82.0	41.3	44.3	8.0	7.6	404	331	442	383	410	559	425	
1994	4.8	7.3	33.6	15.9	19.9	7.0	4.2	16.3	23.4	84.0	40.9	42.7	9.6	9.3	292	313	401	390	467	736	450	
1995	2.4	7.0	27.2	15.4	22.0	8.5	4.9	7.2	21.1	69.2	33.6	40.7	12.0	7.9	329	331	393	459	540	706	625	
1996	2.6	5.4	22.4	16.8	23.3	8.2	5.3	8.7	18.6	51.2	34.7	39.0	11.5	9.2	303	293	439	484	596	711	579	
1997	0.5	7.4	20.2	11.4	22.5	8.4	7.7	1.2	44.3	53.6	23.9	39.1	11.5	12.7	443	167	377	478	575	732	605	
1998	0.9	4.5	22.6	13.5	21.1	8.7	9.0	3.1	20.1	48.8	25.4	34.2	10.6	13.5	300	226	463	532	618	817	671	
1999	2.0	9.1	28.3	14.6	19.0	8.3	10.8	4.0	34.4	58.3	22.5	27.0	9.2	12.9	507	263	485	650	704	902	839	
2000	1.8	14.8	28.7	14.8	18.8	6.9	11.3	2.4	36.3	50.8	20.1	25.9	7.6	14.0	743	409	565	737	727	909	810	
2001*	3.6	14.5	27.3	17.1	20.8	8.0	11.6	4.2	41.2	48.9	21.1	27.3	7.7	11.8	855	351	558	810	760	1029	980	
2002*	3.3	15.4	43.3	26.5	25.0	8.5	10.3	4.0	42.1	58.3	27.5	28.1	7.0	10.4	831	366	743	963	888	1216	989	
2003*	2.6	14.2	42.7	24.9	23.2	8.1	10.9	0.6	33.1	41.8	17.2	17.5	5.3	10.2	4669	427	1021	1447	1327	1510	1061	
2004**		12.7	45.9	33.1	27.4	6.9	9.1	-	32.7	47.2	18.5	15.2	3.4	10.2	-	387	972	1789	1799	2048	894	

*Preliminary.

**Projected.

Table 2. Shrimp catch in SA 1 by month 1987-2003, summed from vessel logs and weighted up to total catch.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	5793	740	0	0	131	10846	10454	11543	11238	8232	1960	87
1977	3063	3145	2232	2783	3723	5558	5955	4979	4139	6317	5666	3597
1978	975	369	156	778	5823	6617	6126	6331	4455	3563	3522	3481
1979	2429	542	5244	6444	6184	5250	4298	3905	2349	1566	3005	1619
1980	4650	4597	4873	5892	6384	6887	7926	5224	5493	2507	0	1459
1981	3563	3553	2965	4280	7156	5109	6780	6220	4563	3655	3783	2200
1982	3422	708	0	2443	8342	7736	6966	7659	4629	6731	4488	1170
1983	36	247	575	2031	7657	7810	8850	7216	5993	6943	5503	3355
1984	43	494	4425	7258	7824	8476	8275	3954	2124	4223	4295	1414
1985	2138	3562	5437	3467	5392	7610	7600	6439	6540	9396	6168	2462
1986	3375	3188	3591	5372	4739	9352	8916	7251	8778	14264	5096	2947
1987	2888	1704	4815	6253	7721	8201	10395	8938	8489	10581	4993	2952
1988	2354	2959	3644	7504	7528	7735	8969	8845	8662	7205	5462	2749
1989	2560	3087	4426	7889	6590	10494	13319	10159	7024	7480	4352	3291
1990	4130	4321	4993	8475	8956	8854	8777	8361	7555	6871	8098	4577
1991	4021	3599	4073	3851	6444	9455	11605	10152	8531	10268	11127	8361
1992	4643	3453	6057	6747	8491	11234	11820	11037	11308	13255	10208	7233
1993	2640	3164	4357	5950	7671	7990	8651	9633	10292	12596	11089	6980
1994	4321	3905	6567	8553	7342	7165	9606	9345	10830	11749	7857	5565
1995	3869	5293	7721	10228	8177	7806	8771	9265	8194	7948	6113	4002
1996	4060	6460	7948	9217	8944	8864	8889	9265	8367	6048	3327	2706
1997	3657	6035	6086	6514	7714	8237	9576	8117	7740	7325	5065	2061
1998	8626	6420	5896	9980	10438	10505	10306	5014	5356	3547	2649	1758
1999	5025	5643	7375	8133	9369	8564	11077	8744	8366	8198	6620	5078
2000	4396	6464	7418	9028	9643	11314	11601	8581	7838	6854	8295	5774
2001*	4281	5463	6239	5754	8611	11178	13486	11926	9280	10714	8152	7697
2002*	8814	5967	7983	11474	12310	11962	16464	13910	10166	11454	12332	9372
2003*	7025	6551	8704	9709	10428	9113	7714	7785	9794	8700	8645	6457
2004**	8020	8559	8748	12248	14002	12091	8397	1305				

*Preliminary.

Table 3. Total Allowable Catch (TAC), catch, effort and Catch per Unit of Effort (CPUE) of the shrimp fishery in NAFO SA 1 and Div. 0A 1970-2004. Catch are in tons, effort in '000 hr's (unstandardised) or as an index (standardised to 1 for 1976). CPUE is kg/hr (unstandardised) or index values (standardised to 1 for 1976).

Year	TAC			Catch (t)					Effort				CPUE				
	SA 1*	Div. 0A	Total	SA 1			Div. 0A		Total	SA 1	Div. 0A	Total	Total	SA 1	Div. 0A	Total	Total
				Offshore	Inshore	Total	Offshore	Total									
1970	no	no	no	1243	9272	10515	0	10515	-	-	-	-	-	-	-	-	
1971	no	no	no	1978	9615	11593	0	11593	-	-	-	-	-	-	-	-	
1972	no	no	no	3786	8076	11862	0	11862	-	-	-	-	-	-	-	-	
1973	no	no	no	6785	8745	15530	0	15530	-	-	-	-	-	-	-	-	
1974	no	no	no	15967	11070	27038	0	27038	-	-	-	-	-	-	-	-	
1975	no	no	no	36977	9570	46547	0	46547	74.2	-	74	-	628	-	628	-	
1976	no	no	no	52993	8030	61023	392	61415	80.1	-	80	1.00	762	-	766	1.00	
1977	-	-	36000	42578	8580	51158	457	51615	73.1	-	73	0.93	699	-	706	0.90	
1978	-	-	41000	33835	8360	42195	122	42317	84.2	-	84	0.98	501	-	503	0.70	
1979	-	-	31500	32852	8250	41102	1732	42834	72.4	7.3	80	1.10	568	236	537	0.64	
1980	-	-	32000	44916	8250	53166	2726	55892	80.0	7.6	88	1.18	665	358	638	0.77	
1981	35000	5000	40000	40295	8250	48545	5284	53829	88.2	17.7	106	1.18	551	299	509	0.74	
1982	34800	5000	39800	43979	8250	52229	2064	54293	81.1	6.2	87	0.94	644	335	622	0.94	
1983	34625	5000	39625	42553	8250	50803	5413	56216	89.0	19.1	108	1.12	571	284	520	0.81	
1984	34925	5000	39925	42414	8250	50664	2142	52806	85.0	7.7	93	1.12	596	280	570	0.76	
1985	42120	6120	48240	54889	8250	63139	3069	66208	128.0	9.9	138	1.33	493	309	480	0.81	
1986	42120	6120	48240	65623	8250	73873	2995	76868	132.8	6.7	140	1.54	556	445	551	0.81	
1987	40120	6120	46240	64222	7613	71836	6095	77931	136.1	12.4	149	1.22	528	491	525	1.04	
1988	40120	6120	46240	56479	11256	67735	5881	73616	150.7	12.6	163	1.74	449	468	451	0.69	
1989	45245	7520	52765	58890	14546	73436	7235	80671	176.9	18.5	195	2.15	415	391	413	0.61	
1990	45245	7520	52765	62800	14993	77793	6177	83970	207.0	15.2	222	2.38	376	405	378	0.57	
1991	46225	8500	54725	66818	17884	84701	6788	91489	229.1	20.5	250	2.57	370	330	366	0.58	
1992	44200	8500	52700	75341	22653	97994	7493	105487	233.7	17.6	251	2.73	419	425	420	0.63	
1993	40600	8500	49100	65894	19627	85522	5491	91013	206.1	13.6	220	2.39	415	404	414	0.62	
1994	42300	8500	50800	68109	19930	88039	4766	92805	209.8	16.3	226	2.50	420	292	410	0.61	
1995	39500	8500	48000	66955	18072	85027	2361	87388	184.6	7.2	192	2.19	461	329	456	0.65	
1996	63922	8500	72422	62368	19095	81463	2632	84095	164.2	8.7	173	2.08	496	303	487	0.66	
1997	64600	10200	74800	62743	14868	77611	517	78128	185.2	1.2	186	1.99	419	443	419	0.64	
1998	60729	7650	68379	69156	10406	79562	933	80495	152.7	3.1	156	1.82	521	300	517	0.72	
1999	71000	9350	80350	71197	18948	90145	2046	92191	164.4	4.0	168	1.88	548	507	547	0.80	
2000	71000	9350	80350	72291	23133	95424	1782	97206	154.6	2.4	157	1.80	617	743	619	0.88	
2001'	82000	9350	91350	79174	19981	99156	3625	102781	158.1	4.2	162	1.96	627	855	633	0.85	
2002'	91150	9850	101000	107271	21636	128906	3300	132206	173.3	4.0	177	2.09	744	831	746	1.03	
2003'	101000	14667	115667	105051	18794	123845	2617	126462	125.2	0.6	126	1.86	989	4669	1006	1.11	
2004**	135352	14667	150019	113400	21600	135000	6000	141000	127.2	-	-	1.75	1062	-	-	1.31	

* 1981-1995 The TAC's are for the offshore areas only.

' Preliminary.

** Projected.

Table 4. Time series of the four standardised CPUE indices included in the combined CPUE index for NAFO Subarea 1 + Div. 0A. Estimates based on data until September 2004.

Year	IBCD		KGH		Small ves.		0A		Combined		
	mean	se	mean	se	mean	se	mean	se	25%	median	75%
1976	-	-	1.66	0.15	-	-	-	-	0.84	1.00	1.19
1977	-	-	1.56	0.09	-	-	-	-	0.81	0.90	1.01
1978	-	-	1.23	0.07	-	-	-	-	0.64	0.70	0.77
1979	-	-	1.11	0.07	-	-	-	-	0.58	0.64	0.70
1980	-	-	1.34	0.08	-	-	-	-	0.70	0.77	0.85
1981	-	-	1.27	0.07	-	-	1.16	0.08	0.68	0.74	0.81
1982	-	-	1.61	0.10	-	-	1.36	0.11	0.84	0.94	1.06
1983	-	-	1.42	0.09	-	-	1.08	0.07	0.74	0.81	0.90
1984	-	-	1.34	0.08	-	-	1.00	0.09	0.70	0.76	0.84
1985	-	-	1.43	0.08	-	-	0.87	0.12	0.73	0.81	0.89
1986	-	-	1.49	0.09	-	-	0.88	0.07	0.74	0.81	0.90
1987	1.84	0.09	1.79	0.11	-	-	1.38	0.07	0.97	1.04	1.12
1988	1.16	0.03	1.47	0.09	1.29	0.06	1.22	0.07	0.67	0.69	0.71
1989	1.05	0.02	1.09	0.07	1.05	0.04	0.90	0.04	0.59	0.61	0.63
1990	1.00	-	1.00	-	1.00	-	1.00	-	0.57	0.57	0.57
1991	1.01	0.02	-	-	0.89	0.03	0.88	0.04	0.57	0.58	0.59
1992	1.09	0.02	-	-	0.94	0.03	1.01	0.05	0.61	0.63	0.65
1993	1.06	0.02	-	-	1.03	0.03	0.95	0.05	0.60	0.62	0.64
1994	1.07	0.02	-	-	0.88	0.03	0.74	0.04	0.59	0.61	0.62
1995	1.16	0.02	-	-	0.88	0.03	0.82	0.06	0.63	0.65	0.67
1996	1.20	0.03	-	-	0.87	0.03	0.76	0.04	0.64	0.66	0.68
1997	1.17	0.03	-	-	0.85	0.02	0.58	0.10	0.62	0.64	0.66
1998	1.28	0.03	-	-	1.00	0.03	0.68	0.07	0.69	0.72	0.74
1999	1.46	0.04	-	-	1.04	0.03	1.14	0.09	0.77	0.80	0.83
2000	1.50	0.05	-	-	1.37	0.04	1.28	0.12	0.84	0.88	0.92
2001	1.50	0.05	-	-	1.21	0.04	1.48	0.13	0.82	0.85	0.89
2002	1.78	0.05	-	-	1.51	0.05	1.81	0.13	0.98	1.03	1.08
2003	1.97	0.06	-	-	1.54	0.05	2.46	0.50	1.05	1.11	1.17
2004	2.46	0.09	-	-	1.63	0.06	-	-	1.22	1.31	1.41

Table 5. Annual discard of shrimp and fish in tons and percent of total shrimp catch, and landed by-catch of *P. montagui* (tons) as reported in vessel logs from Subarea 1 1975-2004.

Year	P. borealis		Fish		P. montagui landed (tons)
	discard (tons)	discard (%)	discard (tons)	discard (%)	
1975	0	0.0	0	0.0	0
1976	0	0.0	0	0.0	0
1977	0	0.0	23	0.0	0
1978	0	0.0	27	0.1	0
1979	0	0.0	151	0.4	0
1980	0	0.0	186	0.3	0
1981	0	0.0	725	1.5	0
1982	0	0.0	788	1.5	0
1983	0	0.0	964	1.9	0
1984	0	0.0	1311	2.6	0
1985	146	0.2	1511	2.4	0
1986	108	0.1	1620	2.2	0
1987	180	0.3	881	1.2	0
1988	196	0.3	1065	1.6	0
1989	190	0.3	1342	1.8	0
1990	262	0.3	1267	1.6	0
1991	407	0.5	2060	2.4	0
1992	327	0.3	2150	2.2	0
1993	250	0.3	1906	2.2	0
1994	331	0.4	2671	3.0	5
1995	478	0.6	2698	3.2	565
1996	323	0.4	2701	3.3	779
1997	312	0.4	2334	3.0	425
1998	314	0.4	2183	2.7	1253
1999	197	0.2	0	0.0	4
2000	265	0.3	678	0.7	302
2001*	382	0.4	1120	1.1	881
2002*	649	0.5	1274	1.0	225
2003*	643	0.5	1300	1.0	974
2004**	770	0.6	931	0.7	1016

*Preliminary

**Projected

Table 6. Composition of shrimp catches in NAFO SA 1 as derived from sub-samples weighted up to the total catch. Numbers caught were divided by standardised effort to produce abundance indices. (no sampling 2003-2004).

Mean size												
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Cpl (mm)	23.5	23.5	22.9	22.3	21.8	21.9	21.2	21.2	21.2	21.6	20.8	20.5
Weight (g)	9.4	9.6	9.5	9.0	9.1	8.4	7.8	8.0	7.4	8.0	6.7	7.3
Count (no/kg)	107	104	106	111	110	119	128	126	135	125	149	137

Proportion of total catch												
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Males	46%	33%	51%	56%	64%	64%	64%	66%	64%	55%	69%	77%
Primi	9%	3%	1%	11%	15%	9%	12%	8%	12%	15%	10%	8%
Multi	45%	63%	48%	33%	21%	27%	24%	26%	24%	30%	21%	15%
Females total	54%	67%	49%	44%	36%	36%	36%	34%	36%	45%	31%	23%

Number caught (millions)												
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Males	5109	4133	5563	6713	7284	7616	7769	8031	9503	7942	12504	16275
Primi	1006	427	117	1302	1689	1005	1460	1019	1772	2246	1781	1753
Multi	4918	7921	5332	3925	2394	3189	2883	3151	3522	4309	3753	3063
Females Total	5924	8348	5449	5227	4083	4194	4343	4170	5294	6555	5534	4817
Total	11034	12481	11012	11939	11367	11811	12112	12201	14798	14497	18037	21092

Abundance index												
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Males	1.00	0.76	1.16	1.36	1.69	1.87	2.00	2.24	2.58	2.21	3.47	4.18
Primi	1.00	0.40	0.12	1.33	1.99	1.25	1.91	1.44	2.44	3.17	2.51	2.29
Multi	1.00	1.51	1.16	0.82	0.58	0.81	0.77	0.91	0.99	1.24	1.08	0.82
Females total	1.00	1.32	0.98	0.91	0.82	0.89	0.96	1.00	1.24	1.57	1.33	1.07

Table 7. Information on biological samples taken in the Greenlandic fishery 2000-2004 (no sampling 2003-2004).

2000					
Month	Division	Number of samples	Sample weight	Numbers measured	Catch (kg)
2	1B	5	8	1006	17988
2	1C	4	4.79	877	10945
3	1C	5	12.03	875	15693
4	1B	4	9.15	1021	11481
4	1D	7	10.68	1979	21645
6	1C	1	3.27	557	1503
6	1D	7	16.9	2914	24445
7	1B	15	47.8	6886	51789
7	1C	10	33.64	4707	34410
8	1B	1	1.64	241	1556
9	1B	3	7.83	1120	6867
9	1C	5	23.19	2809	10713
9	1D	12	44.6	6712	29371
9	1E	3	9.44	1014	19931
10	1B	8	23.4	3054	28866
10	1E	4	14.66	2125	6296
11	1C	5	21.04	2962	15706
11	1D	8	28.78	4860	26574
Total		107	321	45719	335779

2001					
Month	Division	Number of samples	Sample weight	Numbers measured	Catch (kg)
1	1C	5	15.23	2521	30341
1	1D	4	12.46	1830	14669
1	1E	5	22.56	3623	15788
2	1C	1	2.87	466	10218
2	1D	2	11.21	1527	29388
4	1B	6	11.86	2149	32403
4	1C	5	12.58	1253	9741
4	1D	8	20.21	2909	26821
5	1B	13	24.88	3943	46090
5	1C	11	18.58	2811	61074
5	1D	14	25.17	3582	44358
6	1D	12	22.82	3256	57178
7	1B	1	4.04	861	790
7	1D	13	19.61	2602	45465
7	1E	8	10.73	1664	37916
8	1B	3	5.28	775	18942
8	1C	6	10.03	1755	34411
10	1B	3	6.22	1093	16142
10	1D	6	8.44	1761	9592
10	1E	2	3.52	537	2768
11	1B	3	4.57	743	6748
11	1C	3	4.56	684	13576
11	1D	3	5.2	713	13506
Total		137	283	43058	577925

2002					
Month	Division	Number of samples	Sample weight	Numbers measured	Catch (kg)
3	1D	7	9.01	1502	17881
3	1F	1	1.28	225	1805
Total		8	10	1727	19686

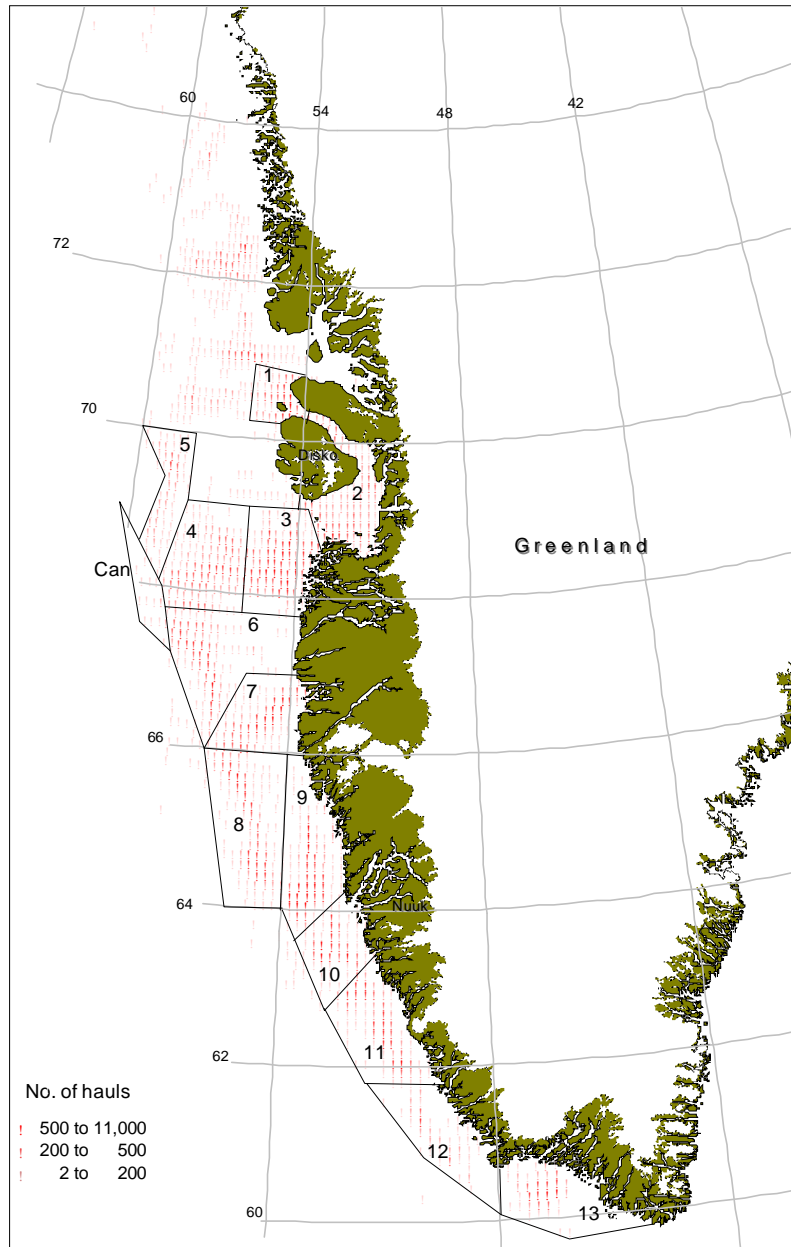


Fig. 1. Distribution of the shrimp fishery off West Greenland, based on logbook data 1975-2004. The boxed areas numbered 1-13 or labelled “Can”. (Canadian fishery area) are the area segregation used in the models for standardising the catch-per-unit-effort data (see text).

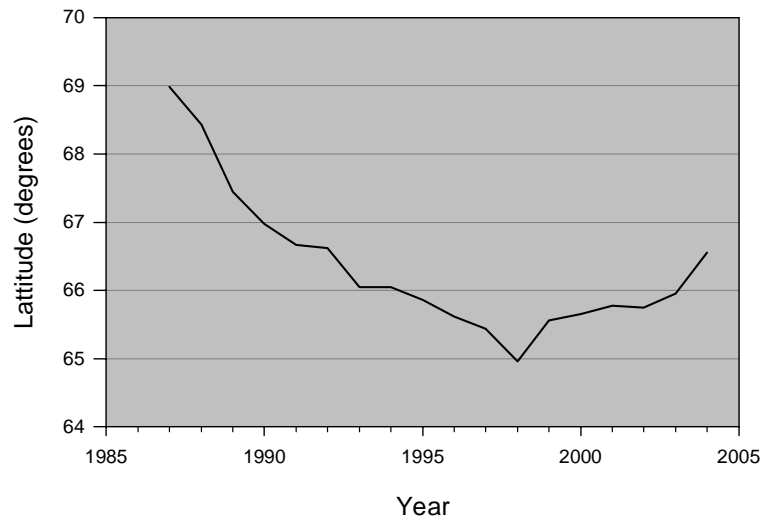


Fig. 2. Mean latitude ($^{\circ}$ N) of allocated effort by vessels fishing offshore in Subarea 1, 1987-2004.

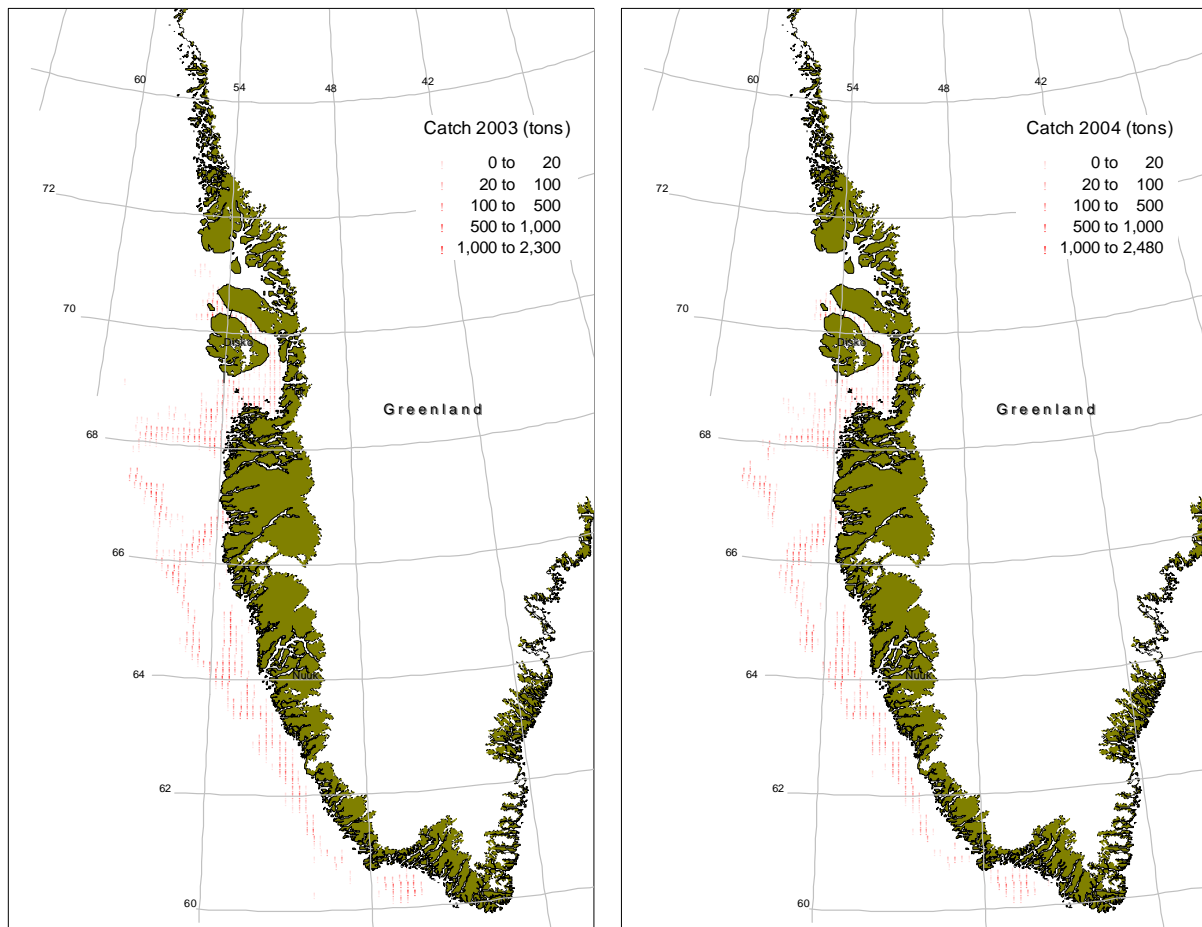


Fig. 3. Spatial distribution of the Greenlandic shrimp catches in Subarea 1, 2003 and 2004.

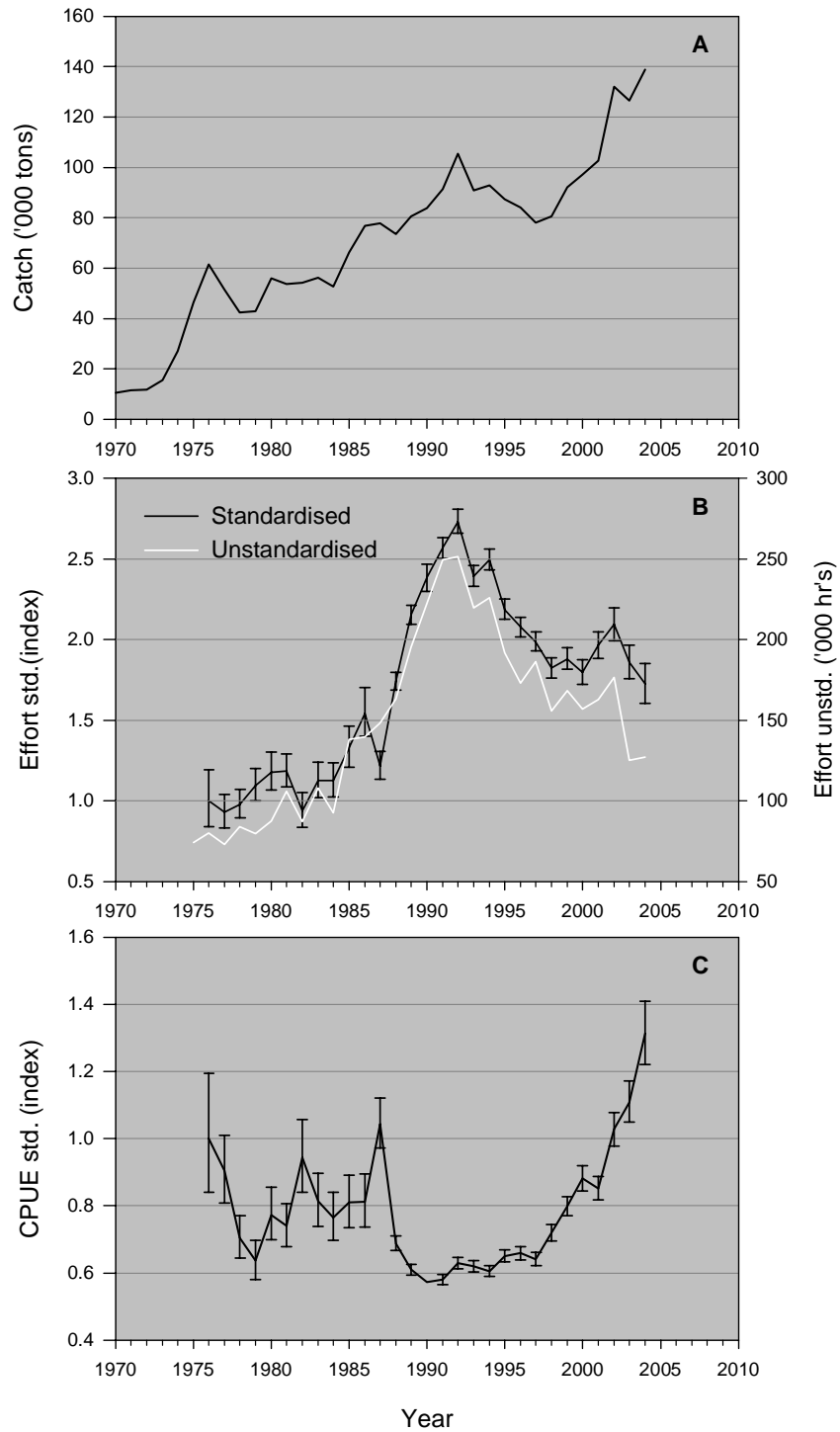


Fig. 4. Total catch (A), standardised and unstandardised effort (B) and standardised CPUE indices (C) of the shrimp fishery in NAFO SA 1 + Div. 0A east of 60°W. Estimates of std. effort and CPUE are medians with 25 and 75 percentile error bars and are based on data series until September 2004. Catch for 2004 are projected from September to the end of the year.

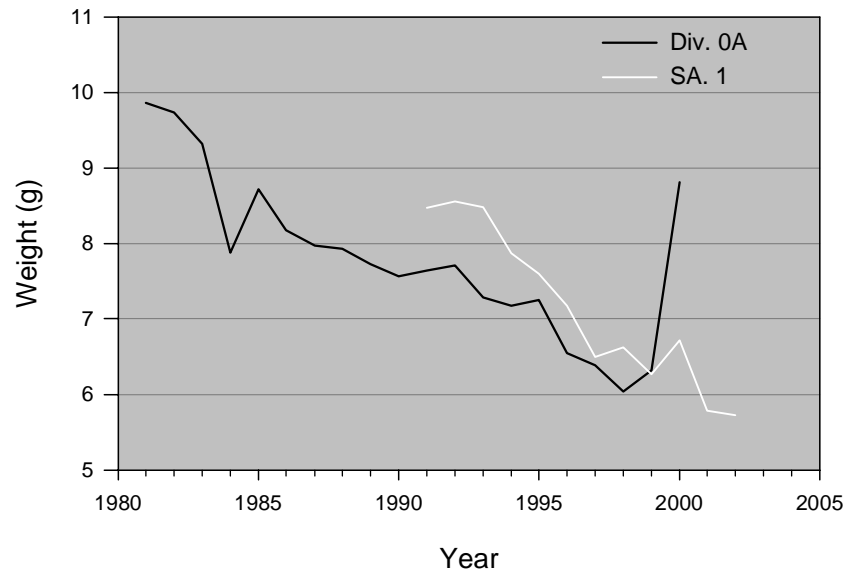


Fig. 5. Mean shrimp size (g) in catches in Subarea 1, 1991-2002, and Div. 0A, 1981-2000.

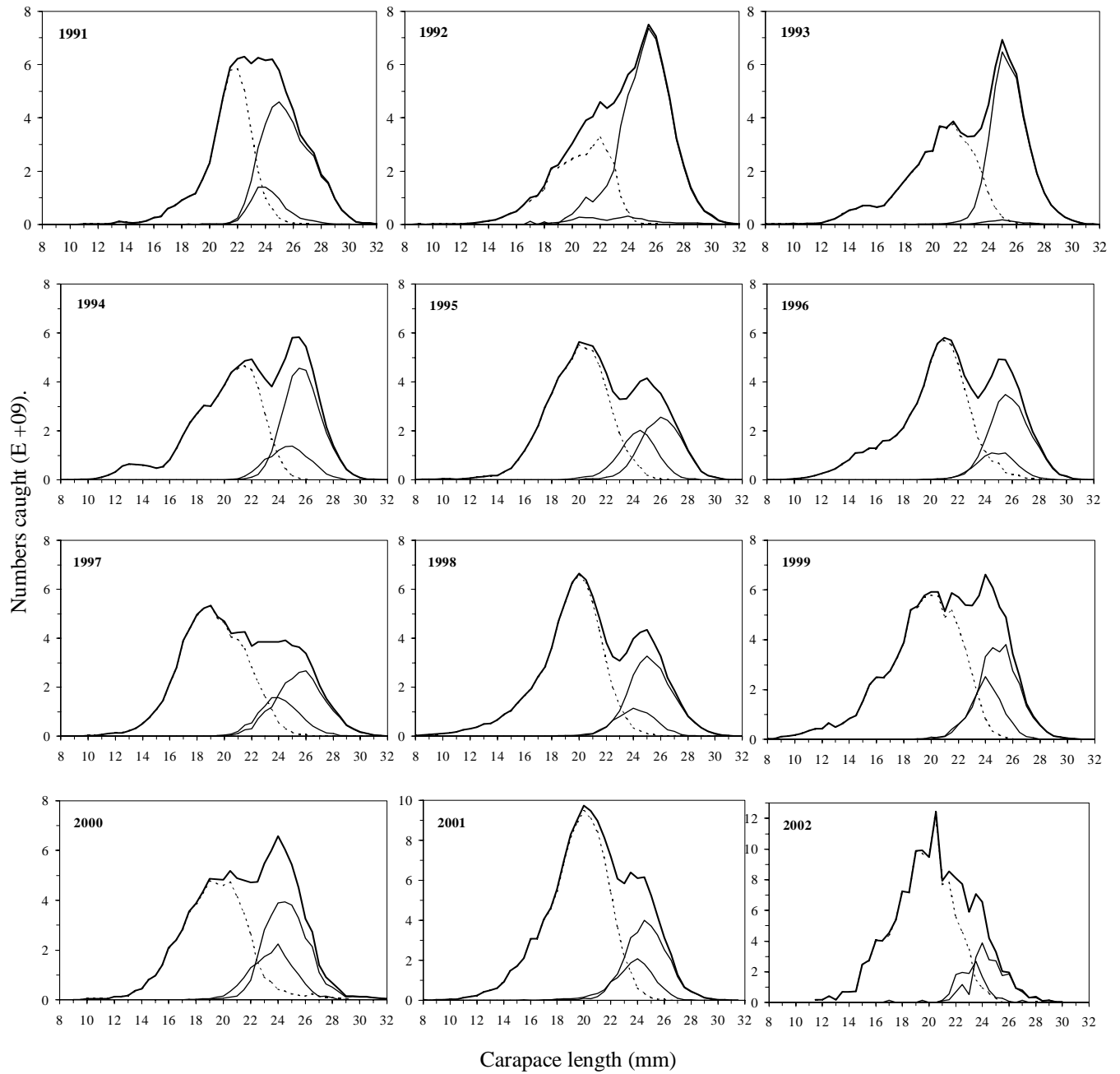


Fig. 6. Length frequency distributions of commercial shrimp catches in Subarea 1 and Div. 0A, 1991 - 2002. The distribution of male shrimp is shown by a dotted line, primiparous and multiparous each as a thin line where the primiparous is distinguished as the smallest component of the two. The sum, i.e. the total distribution, is shown by a bold line.

Appendix 1. Diagnostical output from GLM-run of 1BCDEF index.

		Class Level Information																	
Class	Level s	Values																	
VESSEL	27	AAAA	BBBB	CCCC	DDDD	EEEE	FFFF	GGGG	HHHH	IIII	JJJJ	OUIQ	OUKV	OVZM	OWLQ	OWUD			
YEAR	18	87	88	89	91	92	93	94	95	96	97	98	99	100	101	102	103	104	109
MONTH	10	1	2	3	4	6	7	8	9	10	12								
AREA	8	4	5	6	8	10	11	12	13										
		Number of Observations Read																	
		9394																	

Dependent Variable: LNCPUE
Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	117	53582.91667	457.97365	144.57	<.0001
Error	9276	29385.61661	3.16792		
Corrected Total	9393	82968.53328			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
VESSEL	26	43806.73533	1684.87444	531.86	<.0001
MONTH	9	1173.94478	130.43831	41.17	<.0001
AREA	7	1073.31064	153.33009	48.40	<.0001
YEAR	17	5891.40006	346.55294	109.39	<.0001
MONTH*AREA	58	1637.52586	28.23320	8.91	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
VESSEL	26	13014.93392	500.57438	158.01	<.0001
MONTH	9	510.89978	56.76664	17.92	<.0001
AREA	7	703.89880	100.55697	31.74	<.0001
YEAR	17	5726.44527	336.84972	106.33	<.0001
MONTH*AREA	58	1637.52586	28.23320	8.91	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	0.852345724	0.06655855	12.81	<.0001
VESSEL AAAA	0.603412912	0.03563505	16.93	<.0001
VESSEL BBBB	0.393842471	0.03787698	10.40	<.0001
VESSEL CCCC	0.436430428	0.03593373	12.15	<.0001
VESSEL DDDD	0.524142047	0.03582091	14.63	<.0001
VESSEL EEEE	1.127271877	0.03827467	29.45	<.0001
VESSEL FFFF	0.219728940	0.04084975	5.38	<.0001
VESSEL GGGG	0.955846737	0.03615020	26.44	<.0001
VESSEL HHHH	0.671586443	0.03792703	17.71	<.0001
VESSEL IIII	1.175920897	0.03514262	33.46	<.0001
VESSEL JJJJ	0.554584064	0.03652230	15.18	<.0001
VESSEL OUIQ	0.836692622	0.04605445	18.17	<.0001
VESSEL OUKV	1.208767330	0.03800571	31.80	<.0001
VESSEL OVZM	1.150769522	0.06687521	17.21	<.0001
VESSEL OWLQ	0.166504562	0.05538678	3.01	0.0027
VESSEL OWUD	0.479357855	0.04054319	11.82	<.0001
VESSEL BWVM	0.321251713	0.05008111	6.41	<.0001
VESSEL OYBZ	0.902376470	0.03982469	22.66	<.0001
VESSEL OYCY	0.844852870	0.05298596	15.94	<.0001
VESSEL OYFF	0.932550074	0.05231580	17.83	<.0001
VESSEL OYKK	0.740867612	0.03859220	19.20	<.0001
VESSEL OYPK	1.320627437	0.07068404	18.68	<.0001
VESSEL OYRK	0.785192850	0.03865289	20.31	<.0001
VESSEL OYRT	0.628238484	0.04359922	14.41	<.0001
VESSEL OZMA	1.027313831	0.05986368	17.16	<.0001
VESSEL OZWQ	1.430146178	0.05772209	24.78	<.0001
VESSEL OZWR	1.343636559	0.06943226	19.35	<.0001
VESSEL ZZZZ	0.000000000	.	.	.
MONTH 1	0.423467383	0.11547170	3.67	0.0002
MONTH 2	0.456661407	0.12918770	3.53	0.0004
MONTH 3	0.593925166	0.12579365	4.72	<.0001
MONTH 4	0.687387846	0.13652943	5.03	<.0001
MONTH 6	0.620309650	0.13325484	4.66	<.0001
MONTH 7	1.065813088	0.11335327	9.40	<.0001
MONTH 8	0.683925530	0.09727768	7.03	<.0001
MONTH 9	0.476201833	0.14358616	3.32	0.0009
MONTH 10	0.315978592	0.11378126	2.78	0.0055
MONTH 12	0.000000000	.	.	.

AREA	4	0.151396472	B	0.06112524	2.48	0.0133
AREA	5	0.702327734	B	0.09923610	7.08	<.0001
AREA	6	0.019136440	B	0.07076304	0.27	0.7868
AREA	8	0.182601545	B	0.06082480	3.00	0.0027
AREA	10	0.030848622	B	0.06032379	0.51	0.6091
AREA	11	0.160849370	B	0.06129784	2.62	0.0087
AREA	12	0.209881738	B	0.08262717	2.54	0.0111
AREA	13	0.000000000	B	.	.	.
YEAR	87	0.608916968	B	0.04748652	12.82	<.0001
YEAR	88	0.148269014	B	0.02393676	6.19	<.0001
YEAR	89	0.044516104	B	0.02064425	2.16	0.0311
YEAR	91	0.005083045	B	0.01889551	0.27	0.7879
YEAR	92	0.088587412	B	0.01965741	4.51	<.0001
YEAR	93	0.059950033	B	0.01955851	3.07	0.0022
YEAR	94	0.064452897	B	0.01956862	3.29	0.0010
YEAR	95	0.150377798	B	0.02041436	7.37	<.0001
YEAR	96	0.181962030	B	0.02201736	8.26	<.0001
YEAR	97	0.152838689	B	0.02344569	6.52	<.0001
YEAR	98	0.250646529	B	0.02511393	9.98	<.0001
YEAR	99	0.378533651	B	0.02515835	15.05	<.0001
YEAR	100	0.405524922	B	0.02982994	13.59	<.0001
YEAR	101	0.405041809	B	0.02972540	13.63	<.0001
YEAR	102	0.546459304	B	0.02966762	18.42	<.0001
YEAR	103	0.631650094	B	0.03172510	19.91	<.0001
YEAR	104	1.144867311	B	0.03441011	33.27	<.0001
YEAR	109	0.000000000	B	.	.	.
MONTH*AREA	1 4	-0.240338569	B	0.46114670	-0.52	0.6023
MONTH*AREA	1 6	-0.184179590	B	0.14494445	-1.27	0.2039
MONTH*AREA	1 8	-0.446666907	B	0.12164916	-3.67	0.0002
MONTH*AREA	1 10	-0.404264709	B	0.12001729	-3.37	0.0008
MONTH*AREA	1 11	-0.526629758	B	0.12395513	-4.25	<.0001
MONTH*AREA	1 12	-0.483480800	B	0.15873167	-3.05	0.0023
MONTH*AREA	1 13	0.000000000	B	.	.	.
MONTH*AREA	2 4	-4.485512381	B	1.78583389	-2.51	0.0120
MONTH*AREA	2 6	0.095131013	B	0.17286525	0.55	0.5821
MONTH*AREA	2 8	-0.483710596	B	0.13765833	-3.51	0.0004
MONTH*AREA	2 10	-0.318851883	B	0.13302715	-2.40	0.0166
MONTH*AREA	2 11	-0.437308901	B	0.13505648	-3.24	0.0012
MONTH*AREA	2 12	-0.374161845	B	0.15711543	-2.38	0.0173
MONTH*AREA	2 13	0.000000000	B	.	.	.
MONTH*AREA	3 6	-0.080045197	B	0.15669767	-0.51	0.6095
MONTH*AREA	3 8	-0.413207161	B	0.12983953	-3.18	0.0015
MONTH*AREA	3 10	-0.401535817	B	0.12949928	-3.10	0.0019
MONTH*AREA	3 11	-0.596199589	B	0.13143103	-4.54	<.0001
MONTH*AREA	3 12	-0.421237887	B	0.15413216	-2.73	0.0063
MONTH*AREA	3 13	0.000000000	B	.	.	.
MONTH*AREA	4 4	-0.273654429	B	0.23170649	-1.18	0.2376
MONTH*AREA	4 6	-0.281839127	B	0.14790885	-1.91	0.0567
MONTH*AREA	4 8	-0.684385384	B	0.13945357	-4.91	<.0001
MONTH*AREA	4 10	-0.511567011	B	0.14003727	-3.65	0.0003
MONTH*AREA	4 11	-0.612699706	B	0.14184557	-4.32	<.0001
MONTH*AREA	4 12	-0.395498922	B	0.16927444	-2.34	0.0195
MONTH*AREA	4 13	0.000000000	B	.	.	.
MONTH*AREA	6 4	-0.731449800	B	0.13861432	-5.28	<.0001
MONTH*AREA	6 5	-1.541318255	B	0.22333778	-6.90	<.0001
MONTH*AREA	6 6	-0.438941714	B	0.14152594	-3.10	0.0019
MONTH*AREA	6 8	-0.706187782	B	0.13613073	-5.19	<.0001
MONTH*AREA	6 10	-0.464969509	B	0.13576069	-3.42	0.0006
MONTH*AREA	6 11	-0.550442405	B	0.13710498	-4.01	<.0001
MONTH*AREA	6 12	-0.581040734	B	0.16716755	-3.48	0.0005
MONTH*AREA	6 13	0.000000000	B	.	.	.
MONTH*AREA	7 4	-1.102960061	B	0.12047576	-9.16	<.0001
MONTH*AREA	7 5	-1.752685779	B	0.14773890	-11.86	<.0001
MONTH*AREA	7 6	-0.701671389	B	0.12458616	-5.63	<.0001
MONTH*AREA	7 8	-0.953625313	B	0.11810127	-8.07	<.0001
MONTH*AREA	7 10	-0.879793564	B	0.11789557	-7.46	<.0001
MONTH*AREA	7 11	-0.758069679	B	0.12046263	-6.29	<.0001
MONTH*AREA	7 12	-0.570530804	B	0.15849426	-3.60	0.0003
MONTH*AREA	7 13	0.000000000	B	.	.	.
MONTH*AREA	8 4	-0.728625486	B	0.10444009	-6.98	<.0001
MONTH*AREA	8 5	-1.484755766	B	0.13280672	-11.18	<.0001
MONTH*AREA	8 6	-0.564083105	B	0.10968972	-5.14	<.0001
MONTH*AREA	8 8	-0.778079448	B	0.10411404	-7.47	<.0001
MONTH*AREA	8 10	-0.584729900	B	0.10426119	-5.61	<.0001
MONTH*AREA	8 11	-0.536534613	B	0.10492500	-5.11	<.0001
MONTH*AREA	8 12	-0.364672050	B	0.13281253	-2.75	0.0060
MONTH*AREA	8 13	0.000000000	B	.	.	.

MONTH*AREA 9 4	-0.442941637 B	0.14769380	-3.00	0.0027
MONTH*AREA 9 5	-1.233863993 B	0.16845007	-7.32	<.0001
MONTH*AREA 9 6	-0.524761551 B	0.15618192	-3.36	0.0008
MONTH*AREA 9 8	-0.669468898 B	0.14995842	-4.46	<.0001
MONTH*AREA 9 10	-0.522906937 B	0.15094725	-3.46	0.0005
MONTH*AREA 9 11	-0.378666673 B	0.14829969	-2.55	0.0107
MONTH*AREA 9 12	-0.318949573 B	0.17199441	-1.85	0.0637
MONTH*AREA 9 13	0.000000000 B	.	.	.
MONTH*AREA 10 4	-0.298450744 B	0.11853582	-2.52	0.0118
MONTH*AREA 10 5	-1.065550000 B	0.14458433	-7.37	<.0001
MONTH*AREA 10 6	-0.255523363 B	0.13450561	-1.90	0.0575
MONTH*AREA 10 8	-0.303334334 B	0.12310237	-2.46	0.0138
MONTH*AREA 10 10	-0.285556146 B	0.12537224	-2.28	0.0228
MONTH*AREA 10 11	-0.308428515 B	0.11933851	-2.58	0.0098
MONTH*AREA 10 12	-0.241788532 B	0.14560742	-1.66	0.0968
MONTH*AREA 10 13	0.000000000 B	.	.	.
MONTH*AREA 12 4	0.000000000 B	.	.	.
MONTH*AREA 12 5	0.000000000 B	.	.	.
MONTH*AREA 12 6	0.000000000 B	.	.	.
MONTH*AREA 12 8	0.000000000 B	.	.	.
MONTH*AREA 12 10	0.000000000 B	.	.	.
MONTH*AREA 12 11	0.000000000 B	.	.	.
MONTH*AREA 12 12	0.000000000 B	.	.	.
MONTH*AREA 12 13	0.000000000 B	.	.	.

Appendix 2. Diagnostical output from GLM-run of KGH index.

The GLM Procedure						
Class Level Information						
Class	Level s	Values				
VESS	2	32 33				
YR	15	76 77 78 79	80 81 82 83	84 85 86 87	88 89 90	
MO	10	1 2 4 6 7 8 9 10 11 12				
AREA	2	3 6				
Number of observations						1371
Dependent Variable: LNCPUE						
Weight: WEIGHT						
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	
Model	24	2959.662874	123.319286	54.70	<.0001	
Error	1346	3034.342633	2.254341			
Corrected Total	1370	5994.005506				
		R-Square	Coeff Var	Root MSE	LNCPUE Mean	
		0.493770	24.03387	1.501446	6.247210	
Source	DF	Type I SS	Mean Square	F Value	Pr > F	
VESS	1	265.265065	265.265065	117.67	<.0001	
MO	9	2028.491712	225.387968	99.98	<.0001	
YR	14	665.906096	47.564721	21.10	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F	
VESS	1	176.702927	176.702927	78.38	<.0001	
MO	9	1741.943810	193.549312	85.86	<.0001	
YR	14	665.906096	47.564721	21.10	<.0001	
Parameter	Estimate	Standard Error	t Value	Pr > t		
Intercept	5.519584121 B	0.05972433	92.42	<.0001		
VESS 32	0.162995969 B	0.01841047	8.85	<.0001		
VESS 33	0.000000000 B	.	.	.		
MO 1	0.315289464 B	0.05377667	5.86	<.0001		
MO 2	0.380992526 B	0.05721325	6.66	<.0001		
MO 4	0.707713228 B	0.04492019	15.75	<.0001		
MO 6	0.567510541 B	0.04043884	14.03	<.0001		
MO 7	0.465709628 B	0.04266259	10.92	<.0001		
MO 8	0.354247454 B	0.04281827	8.27	<.0001		
MO 9	0.150752249 B	0.04470863	3.37	0.0008		
MO 10	0.023991093 B	0.04412360	0.54	0.5867		
MO 11	0.097217900 B	0.04500646	2.16	0.0309		
MO 12	0.000000000 B	.	.	.		
YR 76	0.506924682 B	0.08804812	5.76	<.0001		
YR 77	0.442223706 B	0.05909604	7.48	<.0001		
YR 78	0.206741848 B	0.05869672	3.52	0.0004		
YR 79	0.107151428 B	0.05734955	1.87	0.0619		
YR 80	0.292689676 B	0.05909863	4.95	<.0001		
YR 81	0.235455267 B	0.05533503	4.26	<.0001		
YR 82	0.476527068 B	0.05941174	8.02	<.0001		
YR 83	0.352758060 B	0.05834257	6.05	<.0001		
YR 84	0.291241348 B	0.05675027	5.13	<.0001		
YR 85	0.359175071 B	0.05565256	6.45	<.0001		
YR 86	0.398675904 B	0.05561951	7.17	<.0001		
YR 87	0.580394317 B	0.05754350	10.09	<.0001		
YR 88	0.381897562 B	0.05674461	6.73	<.0001		
YR 89	0.082618304 B	0.06351394	1.30	0.1936		
YR 90	0.000000000 B	.	.	.		

Appendix 3. Diagnostical output from GLM-run of the OA index.

		Class Level Information																						
Class	Levels	Values																						
Year	23	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97	98	99	100	101	102	103	109
Month	2	7		13																				
Vessel	15	1	70	72	73	75	77	79	111	222	444	555	666	777	888	999								
		Number of Observations Read															615							

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	37	5253.000031	141.972974	39.90	<.0001
Error	572	2035.120935	3.557904		
Corrected Total	609	7288.120966			

	R-Square	Coeff Var	Root MSE	LNCPUE Mean
	0.720762	31.93887	1.886241	5.905784

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Month	1	507.761964	507.761964	142.71	<.0001
Vessel	14	3036.122984	216.865927	60.95	<.0001
Year	22	1709.115083	77.687049	21.84	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Month	1	192.229896	192.229896	54.03	<.0001
Vessel	14	1754.385422	125.313244	35.22	<.0001
Year	22	1709.115083	77.687049	21.84	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	5.578948385	0.04342391	128.48	<.0001
Month 7	0.200364381	0.02725883	7.35	<.0001
Month 13	0.000000000	.	.	.
Vessel 1	-0.460474772	0.10501521	-4.38	<.0001
Vessel 70	-0.116076653	0.08926579	-1.30	0.1940
Vessel 72	0.899292815	0.11523854	7.80	<.0001
Vessel 73	0.800827434	0.13153618	6.09	<.0001
Vessel 75	0.319286207	0.21983562	1.45	0.1469
Vessel 77	0.208166111	0.20923725	0.99	0.3202
Vessel 79	1.034897431	0.25404799	4.07	<.0001
Vessel 111	-0.242232579	0.05301378	-4.57	<.0001
Vessel 222	0.105097418	0.04453738	2.36	0.0186
Vessel 444	0.631637516	0.03987095	15.84	<.0001
Vessel 555	0.381585773	0.03498444	10.91	<.0001
Vessel 666	0.578662045	0.04035344	14.34	<.0001
Vessel 777	0.479747519	0.05946994	8.07	<.0001
Vessel 888	0.228408213	0.03585486	6.37	<.0001
Vessel 999	0.000000000	.	.	.
Year 81	0.144830656	0.06347900	2.28	0.0229
Year 82	0.308133522	0.07674681	4.01	<.0001
Year 83	0.079133453	0.05975543	1.32	0.1859
Year 84	-0.004587193	0.08332428	-0.06	0.9561
Year 85	-0.137942579	0.12808637	-1.08	0.2820
Year 86	-0.122448128	0.07652909	-1.60	0.1101
Year 87	0.323747396	0.05244991	6.17	<.0001
Year 88	0.202200864	0.05261636	3.84	0.0001
Year 89	-0.102708357	0.04665403	-2.20	0.0281
Year 91	-0.124612645	0.04653926	-2.68	0.0076
Year 92	0.012457653	0.04462878	0.28	0.7802
Year 93	-0.049632380	0.04795890	-1.03	0.3012
Year 94	-0.300232286	0.04647019	-6.46	<.0001
Year 95	-0.197075379	0.06733910	-2.93	0.0036
Year 96	-0.279237268	0.05449502	-5.12	<.0001
Year 97	-0.543724161	0.15515750	-3.50	0.0005
Year 98	-0.378661005	0.09075171	-4.17	<.0001
Year 99	0.135116354	0.07420120	1.82	0.0691
Year 100	0.248529424	0.09078934	2.74	0.0064
Year 101	0.390725055	0.08533368	4.58	<.0001
Year 102	0.592364862	0.06693563	8.85	<.0001
Year 103	0.939988682	0.18416047	5.10	<.0001
Year 109	0.000000000	.	.	.

Appendix 4. Diagnostics output from GLM-run of the small vessel index.

		Class Level Information										
Class	Levels	Values										
VESSEL	9	AAAA	BBBB	CCCC	DDDD	EEEE	FFFF	GGGG	HHHH	OUHK		
YEAR	17	88	89	91	92	93	94	95	96	97	98	99
AREA	3	1	2	3								
MONTH	4	4	5	8	11							

Number of Observations Read 3704

Dependent Variable: LNCPUE
Weight: HAULS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	9215.70484	317.78293	134.39	<.0001
Error	3674	8687.36590	2.36455		
Corrected Total	3703	17903.07074			

R-Square 0.514756 Coeff Var 93.05854 Root MSE 1.537710 LNCPUE Mean 1.652412

Source	DF	Type I SS	Mean Square	F Value	Pr > F
AREA	2	1205.139575	602.569787	254.83	<.0001
MONTH	3	2577.482019	859.160673	363.35	<.0001
VESSEL	8	1998.122694	249.765337	105.63	<.0001
YEAR	16	3434.960549	214.685034	90.79	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	2	1156.650828	578.325414	244.58	<.0001
MONTH	3	1244.150781	414.716927	175.39	<.0001
VESSEL	8	2040.377519	255.047190	107.86	<.0001
YEAR	16	3434.960549	214.685034	90.79	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	1.988291778	0.04018281	49.48	<.0001
AREA 1	-0.213157938	0.01267106	-16.82	<.0001
AREA 2	-0.280991813	0.01377384	-20.40	<.0001
AREA 3	0.000000000		.	
MONTH 4	0.492108477	0.02175001	22.63	<.0001
MONTH 5	0.188415384	0.01655788	11.38	<.0001
MONTH 8	0.131693147	0.01212867	10.86	<.0001
MONTH 11	0.000000000		.	
VESSEL AAAA	-0.295129654	0.03339934	-8.84	<.0001
VESSEL BBBB	-0.363164943	0.03420221	-10.62	<.0001
VESSEL CCCC	-0.743849790	0.04299952	-17.30	<.0001
VESSEL DDDD	-0.508063443	0.03809907	-13.34	<.0001
VESSEL EEEE	-0.564687462	0.03477196	-16.24	<.0001
VESSEL FFFF	-0.195429953	0.03468765	-5.63	<.0001
VESSEL GGGG	-0.456740405	0.03533255	-12.93	<.0001
VESSEL HHHH	-0.630546604	0.04752037	-13.27	<.0001
VESSEL OUHK	0.000000000		.	
YEAR 88	0.253114548	0.04271824	5.93	<.0001
YEAR 89	0.051192092	0.03324759	1.54	0.1237
YEAR 91	-0.119393439	0.02825736	-4.23	<.0001
YEAR 92	-0.065119691	0.02820667	-2.31	0.0210
YEAR 93	0.031411831	0.02890107	1.09	0.2772
YEAR 94	-0.126051509	0.02798545	-4.50	<.0001
YEAR 95	-0.123961499	0.02852465	-4.35	<.0001
YEAR 96	-0.143924065	0.02970258	-4.85	<.0001
YEAR 97	-0.162797817	0.02873803	-5.66	<.0001
YEAR 98	0.004088722	0.03399773	0.12	0.9043
YEAR 99	0.043159987	0.02904247	1.49	0.1373
YEAR 100	0.316742533	0.02964344	10.69	<.0001
YEAR 101	0.193660481	0.02918046	6.64	<.0001
YEAR 102	0.409254286	0.02975024	13.76	<.0001
YEAR 103	0.429249676	0.03258843	13.17	<.0001
YEAR 104	0.487574675	0.03874987	12.58	<.0001
YEAR 109	0.000000000		.	