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The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2002

by

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Abstract

Northern shrimp (*Pandalus borealis*) occurs off West Greenland in NAFO Divisions 0A and 1A–1F. The stock is assessed as a single population and managed by Total Allowable Catch (TAC). Greenland and Canada exploit the stock in Subarea 1 and Div. 0A, respectively. Following a southward expansion during the late-1980s to late-1990s the spatial distribution of the fishery seems to have stabilised. The distribution of the 2002 fishery is not expected to deviate significantly from that of 2001.

After reaching a maximum in 1992 of 87 000 tons catches have decreased somewhat to around 66 000 tons in 1998 due to management measures. Since then raises in catch quotas have been followed by an increase of catches. The projected catch of 2002 is expected to be the highest ever amounting to about 99 000 tons. The inshore fishery (vessels below 80 GRT) accounted for around 20% 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 2002 median value shows a 25% increase as compared that of the previous year and is the highest of the time series. Standardised effort based on biomass indicated a decrease in harvest rate from 1992 to the late-1990s by about 35%. However, when based on numbers only a 13% decrease was evident. For 2002 the indices indicate a harvest rate at the level of the previous four years.

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 cpl. The female component is less prominent, however, with representation of all sizes normally present. Sparse sampling from 2002 does not indicate major changes from the previous year.

Introduction

Northern shrimp (*Pandalus borealis*) occurs off West Greenland in NAFO Div. 0A and 1A–1F. The stock is continuously distributed from Cap Farewell to about 74°N in depths down to around 800 m (Fig. 1). The highest concentrations occur from 150-600 m. 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 85 000 tons in 2001. Since 1981 access to the stock was limited to Greenlandic vessels in Subarea 1 and Canadian vessels in Div. 0A. Catch restrictions were first 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 (1 500-3 000 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. Internal Transferable Quotas (ITQ) were introduced as a management tool in 1991.

The Canadian fleet exploits the stock component in Div. 0A. Seventeen companies are currently licensed to fish in the area but in recent years only 6-7 vessels (2 000-4 000 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. Catches from vessels smaller than 80 GRT were estimated and allocated to inshore/offshore areas, based on information from logbooks and sales slips. Logbook data were analysed to show the spatial distribution of the fishery and the overall distribution of catch, effort and catch rates by year, month and NAFO Division. 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 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 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:

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

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

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

Where $CPUE_{ijkl}$ is the mean CPUE for vessel k, fishing in area m in month j during year i (k = 1,...,n; m = 1,…,a; j = 1,…,s; i = 1,…,y); ln(u) is overall mean ln($CPUE$); 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_{mjki} 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 detail on model construction and analyses see Hvingel *et al.* (2000).

The '1BCDEF index' largely covers the NAFO Div. 1B to E (area 1A was not included due to misreportings from that particular area). 34 vessels were included providing data since 1987. These data were grouped into 9 areas (Area 4-12, Fig. 1). Based on the exploratory run of the main effects model (model 1) the vessel effect was collapsed into 18 groups consisting of 1-5 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 (see Table 1).

The 'KGH index': The initial offshore fishery was executed by 7 sister trawlers (800 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 (Table x).

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 in the index were those shown as areas 1, 2 and 3 in Fig. 1. Comprehensive data are available since 1988 and 26 vessels were used in the model. The fishery 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.

For this year's analyses the indices were revised as compared to the previous two years, and the following changes were made:

- 1BCDEF index: addition of two new vessels, inclusion of the three new areas 9-11 see Fig. X.
- Small vessel index: addition of 9 new vessels
- KGH index: No changes
- Div. 0A index: No changes

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.1.3, (www.mrc-bsu.cam.ac.uk/bugs; Gilks *et al.* 1994; Spiegelhalter *et al.* 2000). The individual CPUE series for the p^{th} fleet, m_{pi}, was assumed to reflect an overall biomass series, Y_i, and a constant fleet coefficient, v_p, so that $m_{pi} = v_p Y_i \exp(e_{pi})$. The error, e_{pi}, were considered to be distributed with mean zero and variance s_{pi}^2. we 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, s_{pi}^2 was calculated by:

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

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. Sex specific indices of abundance were calculated by dividing the numbers caught of each sex by the standardised effort.

Results and Discussion

Catch

In conjunction with the development of the offshore shrimp fishery total annual catch has increased from less than 10 000 tons in the early-1970s to more than 86 000 tons in 1992 (Fig. 2, Table 1). Since then, government restrictions to reduce effort and fishing opportunities elsewhere for the Canadian fleet have somewhat reduced landings which in 1998 amounted to about 66 000 tons. However, when measured in numbers caught the catch level of 1992 was maintained. Since then raises of the annual quotas (Table 1) has been accompanied by increased catches. The projected catch of 2002 is expected to be about 99 000 tons (projected from Nov. to the end of the year).

Since the beginning of the 1970s catches in the inshore areas have been fluctuating between 10 000-20 000 tons (Table 1). Limited access for vessels above 80 GRT was the only management related restraint on inshore catch levels until 1997 when ITQs 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 20-25% of the total catches, but in 1998 only 14% (9 500 tons) were taken by the small vessel fleet. By 1999 catches were back up around 20000 tons, which will also be the expected catch level of year 2002.

The Canadian catches in Div. 0A 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 to early-1990s (Table 1). 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 5% of the total catches off West Greenland. However, the 2002 catches are expected to be about 6 000 tons, i.e. about 6% of total catches.

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) of about 8 000 tons. 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.

By-catch and discard

The reported discard of shrimp has remained less than 1% (weight) of total catch throughout the period 1987-2002 (Table 5). 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 22 mm grid space are mandatory for stern trawlers.

From 1995 to 2002 vessels have reported annual catches of *P. montagui* in the range of about 100 to 1 000 tons (Table 5). 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 (Folmer, 1996).

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. 2B). 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 3) and a general increased fishing efficiency of the participating vessels. The increase in unstandardised effort from 1996 to 1997 is caused by the addition of logbooks from vessels below 50 tons to the database (introduction of new logbook system). In 2001 about 164 000 trawling hr's were registered and preliminary data suggest that the year 2001 figure will be around 137 000 hr's.

The development of the weight based standardised effort time series agrees with the trend of the unstandardised (Fig. 2B). Since 1992, when it reached its highest value, standardised effort has shown a continuous decrease until the late-1990s by a total of about 35%. A corresponding effort index based on number of individuals (Fig. 2B) showed a similar decreasing trend of the 1990's however the reduction was less i.e. about 13%. For 2002 the indices indicate a harvest rate at the level of the previous four years.

Catch-per-unit-effort

The unified standardised CPUE index in an aggregate of four individual indices developed through GLM (Table 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. 2C, Table 4) fluctuated without trend by a factor of 2 between 1976 and 1987. It then dropped precipitously to the lowest level of the time series. The marked spike in 1987 is likely the result of some very strong year-classes produced in the early-1980s (Anon., 1991). Since 1990 the index has shown an increasing trend. The revised 2001 median index value, using the complete set of data for the year, was more optimistic than the preliminary value reported in Hvingel (2001). The estimated median value for 2002 is up by 25% compared to the previous year 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 results from the upgrading of older vessels. The lack of importance of the YEAR*VESSEL term in the individual models suggests that this has minor influence on the use of the CPUE index as a biomass indicator. However, the standardised CPUE time series interpreted as a biomass index 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).

Spatial distribution of the fishery

The fishery has been conducted on the continental shelf of Greenland between 59 and 74°N, mainly between 200 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 1970's until the early 1980's the vast majority of the annual fishing effort were allocated to Div. 1and 1B. Div. 1C and 0A received some attention but almost no effort was spent in Div. 1D, 1E and 1F (Table 3). 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 since the late-1980s (Hvingel, 1996) is summarized by a decreasing mean latitude of effort allocation as shown in Fig. 3 and may be observed in more detail in Fig. 6. Indications of biomass distribution from the German ground fish survey (Rätz, 1997) and the Greenlandic trawl survey (Carlsson and Kanneworff, 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.

The preliminary data for 2002 do not suggest any significant changes in the distribution of the fishery in Subarea 1 and Div. 0A as compared to that of year 2001 (Fig. 6).

Catch composition.

The mean shrimp size caught has declined during the 1990s. In Subarea 1 it declined by 3 mm cpl. from 1991to 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. 7).

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. 7). The female component is less prominent, however, with representation of all sizes normally present in the catches. Thus, the standardised catch rates indicate a decrease in the abundance of females compared to 2000 (Fig. 4) while abundance indices of males indicate an increase.

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.

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Table 1. Total Allowable Catch (TAC), catch, effort and Catch per Unit of Effort (CPUE) of the shrimp fishery in NAFO SA 1 and Div. 0A 1970-2002. Catch are in tons, effort in '000 hr's (unstandardized) or as an index (standardized to 1 for1976). CPUE is given in kg/hr (unstandardized) or as an index (standardized).

Year	TAC (t)					Catch (t)					Effort				CPUE			
	Subarea 1			Div. 0A	Total	Subarea 1			Div. 0A	Total	SA 1	Div. 0A	Total	Total	SA 1	Div. 0A	Total	Total
	Offshore	Inshore*	Total	Offshore		Offshore	Inshore	Total	Offshore		Unstd. ('000 hr's)			Std. (index)	Unstd. (kg/hr)			Std. (index)
1970	no	no	no	no	no	130	8429	8559	0	8559	-	-	-	-	-	-	-	-
1971	no	no	no	no	no	696	8741	9437	0	9437	-	-	-	-	-	-	-	-
1972	no	no	no	no	no	2314	7342	9656	0	9656	-	-	-	-	-	-	-	-
1973	no	no	no	no	no	4692	7950	12642	0	12642	-	-	-	-	-	-	-	-
1974	no	no	no	no	no	11945	10064	22009	0	22009	-	-	-	-	-	-	-	-
1975	no	no	no	no	no	29190	8700	37890	0	37890	74.2	-	74	-	511	-	511	-
1976	no	no	no	no	no	42374	7300	49674	392	50066	80.1	-	80	1.00	620	-	625	1.00
1977	-	no	-	-	36000	33843	7800	41643	457	42100	73.0	-	73	0.93	571	-	577	0.90
1978	-	no	-	-	41000	26747	7600	34347	122	34469	84.1	-	84	0.97	408	-	410	0.71
1979	-	no	-	-	31500	25958	7500	33458	1732	35190	72.4	7.3	80	1.10	462	236	441	0.64
1980	-	no	-	-	32000	35778	7500	43278	2726	46004	80.0	7.6	88	1.19	541	358	525	0.77
1981	35000	no	35000	5000	40000	32016	7500	39516	5284	44800	88.2	17.7	106	1.21	448	299	423	0.74
1982	34800	no	34800	5000	39800	35015	7500	42515	2064	44579	81.1	6.2	87	0.94	524	335	511	0.95
1983	34625	no	34625	5000	39625	33854	7500	41354	5413	46767	89.0	19.1	108	1.16	464	284	433	0.81
1984	34925	no	34925	5000	39925	33741	7500	41241	2142	43383	85.0	7.7	93	1.13	485	280	468	0.76
1985	42120	no	42120	6120	48240	43896	7500	51396	3069	54465	109.4	9.9	119	1.34	470	309	457	0.81
1986	42120	no	42120	6120	48240	52634	7500	60134	2995	63129	129.2	6.7	136	1.54	466	445	465	0.82
1987	40120	no	40120	6120	46240	50720	6921	57641	6095	63736	136.6	12.4	149	1.22	422	491	428	1.04
1988	40120	no	40120	6120	46240	44159	10233	54392	5881	60273	150.1	12.6	163	1.75	362	468	371	0.69
1989	45245	no	45245	7520	52765	45198	13224	58422	7235	65657	176.4	18.5	195	2.27	331	391	337	0.58
1990	45245	no	45245	7520	52765	49554	13630	63184	6177	69361	206.3	15.2	222	2.27	306	405	313	0.61
1991	46225	no	46225	8500	54725	52834	16258	69092	6788	75880	228.7	20.5	249	2.59	302	330	304	0.58
1992	44200	no	44200	8500	52700	58664	20594	79258	7493	86751	232.9	17.6	250	2.73	340	425	346	0.63
1993	40600	no	40600	8500	49100	52280	17843	70123	5491	75614	206.1	13.6	220	2.41	340	404	344	0.63
1994	42300	no	42300	8500	50800	53693	18118	71811	4766	76577	209.6	16.3	226	2.50	343	292	339	0.61
1995	39500	no	39500	8500	48000	51900	16429	68329	2361	70690	186.9	7.2	194	2.14	366	329	364	0.66
1996	37890	26032	63922	8500	72422	49251	17359	66610	2632	69242	168.6	8.7	177	2.06	395	303	391	0.67
1997	38292	26308	64600	10200	74800	50475	13525	64000	517	64517	191.2	1.2	192	1.98	335	443	335	0.65
1998	36000	24729	60729	7650	68379	55687	9483	65170	933	66103	159.2	3.1	162	1.80	409	300	407	0.73
1999*	40109	30891	71000	9350	80350	56721	17264	73985	2046	76031	170.3	4.0	174	1.88	434	507	436	0.81
2000*	40109	30891	71000	9350	80350	57773	20564	78337	1782	79927	161.4	2.4	164	1.80	485	743	488	0.89
2001*	45609	36391	82000	9350	91350	63233	18165	81398	3625	85023	159.0	4.8	164	1.95	512	748	519	0.87
2002**	54600	36550	91150	12040	103190	75440	17560	93000	6000	99000	130.8	6.0	137	1.82	711	1003	724	1.09

* The TAC's are confined to vessels below 79 GRT. These vessels fish almost exclusively in inshore areas.

**Preliminary.

***Projected.

Table 2. Total shrimp catch in Subarea 1 by month 1987-2002. Numbers are summed from vessel logs and weighted up to total catch.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	1269	996	3948	5137	6348	6750	8703	7693	7217	9156	4096	2421
1988	1884	2357	2906	5982	6004	6327	7338	7594	7144	6060	4483	2194
1989	2036	2455	3520	6274	5241	8463	11092	8390	5739	6240	3601	2606
1990	3331	3493	4027	6841	7224	7141	7347	7281	6294	5815	6798	3768
1991	3258	2917	3300	3120	5220	7895	9749	8654	7161	8626	9193	6785
1992	3749	2786	4886	5442	6851	9062	9885	9278	9708	10930	8337	5837
1993	2158	2594	3561	4870	6282	6530	7201	8182	8780	10529	9216	5712
1994	3519	3176	5337	6972	5991	5851	7959	7963	8994	9787	6509	4521
1995	3105	4247	6175	8179	6600	6370	7185	7664	6685	6375	4907	3196
1996	3659	5324	6452	7484	7255	7195	7256	7707	6940	4985	2790	2196
1997	3342	5267	5051	5301	6277	6700	7807	6620	6305	5962	4205	1680
1998	7076	5258	4828	8168	8539	8598	8438	4125	4507	2928	2198	1440
1999*	4178	4622	6057	6655	7699	7022	9106	7256	7034	6806	5441	4157
2000*	3729	5408	6246	7504	7985	9351	9701	7197	6276	5478	6630	4615
2001*	3515	4485	5121	4724	7069	9176	11413	10005	7710	8795	6692	6318
2002*	7196	4848	6503	9369	10046	9608	12105	9353	1029			

*Preliminary.

Table 3. 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	Catch ('000 tons)							Effort ('000 hr's)							CPUE (kg/hr)						
year	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	36.3	1.6	0.0	0.0	0.0	-	0.0	70.5	3.6	0.0	0.0	0.0	-	-	514	448	-	-	-
1976	0.4	0.0	44.5	5.1	0.0	0.0	0.0	-	0.1	70.1	8.0	0.1	0.8	1.1	-	0	635	639	0	0	32
1977	0.5	0.1	38.8	2.5	0.2	0.0	0.0	-	0.5	67.6	4.4	0.5	0.0	0.0	-	290	574	567	365	-	-
1978	0.1	0.4	33.3	0.4	0.2	0.0	0.0	-	1.4	80.7	1.3	0.8	0.0	0.0	-	311	413	339	211	-	-
1979	1.7	3.9	29.1	0.4	0.0	0.0	0.0	7.3	6.7	64.1	1.5	0.1	0.0	0.0	236	585	454	283	91	-	-
1980	2.7	11.9	28.4	2.7	0.2	0.0	0.0	7.6	21.2	53.3	4.9	0.5	0.0	0.0	358	562	533	547	485	0	-
1981	5.3	4.7	30.5	4.3	0.0	0.0	0.0	17.7	11.2	66.4	10.4	0.1	0.0	0.0	299	416	459	415	333	-	-
1982	2.1	0.7	35.2	6.6	0.0	0.0	0.0	6.2	1.7	65.7	13.5	0.1	0.0	0.0	335	384	535	492	316	-	-
1983	5.4	0.4	32.9	7.6	0.4	0.0	0.0	19.1	0.9	69.5	17.8	0.9	0.0	0.0	284	455	474	430	432	0	500
1984	2.1	0.9	24.8	13.8	1.7	0.0	0.0	7.7	2.7	51.1	28.4	2.7	0.0	0.1	280	351	484	487	639	0	38
1985	3.1	5.0	29.9	12.6	3.8	0.0	0.0	9.9	15.8	62.2	24.3	7.1	0.0	0.0	309	318	481	519	544	-	-
1986	3.0	22.0	25.7	7.5	4.9	0.0	0.0	6.7	55.6	50.6	13.7	9.1	0.1	0.1	445	395	509	545	544	-	-
1987	6.1	16.2	35.0	5.8	0.7	0.0	0.0	12.4	56.5	67.1	10.2	2.8	0.0	0.0	491	287	521	567	250	0	-
1988	5.9	10.0	38.2	5.7	0.4	0.0	0.1	12.6	41.2	92.1	14.0	1.8	0.0	1.0	468	242	415	403	226	0	124
1989	7.2	13.2	27.1	10.2	7.6	0.0	0.4	18.5	48.1	77.7	29.7	16.6	0.0	4.3	391	275	348	343	457	0	89
1990	6.2	9.9	24.6	18.4	9.9	0.0	0.4	15.2	42.3	77.9	54.4	28.9	0.0	2.8	405	234	316	339	341	0	134
1991	6.8	10.3	26.9	15.3	15.9	0.5	0.2	20.5	37.2	90.1	51.8	47.6	0.7	1.3	330	276	298	296	335	671	158
1992	7.5	13.2	26.7	16.1	18.8	4.0	0.5	17.6	49.4	76.2	47.8	50.7	7.4	1.3	425	267	350	337	370	538	398
1993	5.5	6.2	29.7	12.9	14.9	3.7	2.6	13.6	22.9	82.0	41.2	44.3	8.1	7.6	404	272	363	314	336	456	349
1994	4.8	5.9	27.4	13.0	16.2	5.9	3.4	16.3	23.4	83.8	40.7	42.6	10.0	9.2	292	254	327	318	381	593	369
1995	2.4	5.6	21.8	12.5	17.7	6.9	3.9	7.2	21.1	69.8	34.1	41.6	12.4	7.9	329	265	312	365	425	552	501
1996	2.6	4.4	18.3	13.9	19.0	6.7	4.3	8.7	18.7	52.0	35.9	40.8	12.0	9.1	303	238	351	387	465	555	474
1997	0.5	6.1	16.8	9.3	18.6	6.9	6.3	1.2	44.1	55.7	24.8	42.1	11.8	12.7	443	138	302	377	441	579	498
1998	0.9	3.7	18.5	11.1	17.3	7.1	7.4	3.1	20.1	50.6	27.2	36.6	11.2	13.5	300	185	366	407	473	635	548
1999*	2.0	7.5	23.2	12.0	15.6	6.8	8.9	4.0	34.6	59.5	24.3	29.1	9.9	12.9	507	216	391	492	536	692	687
2000*	1.8	11.9	23.4	12.7	15.7	5.5	9.1	2.4	35.5	51.9	23.0	29.2	8.0	13.9	743	336	451	551	536	692	659
2001*	3.6	11.9	22.4	14.0	17.1	6.5	9.5	4.8	41.2	49.0	21.4	27.8	7.8	11.8	748	288	458	656	613	841	804
2002**	6.0	10.8	28.7	22.4	17.8	6.0	7.3	6.0	32.6	43.3	21.7	19.8	5.2	8.1	1003	332	663	1032	898	1148	905

*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 Spetember 2002.

	1BCD		KGH		Small ves.		0A		Combined		
Year	mean	se	mean	se	mean	se	mean	se	25%	median	75%
1976	-	-	1.66	0.15	-	-	-	-	0.84	1.00	1.19
1977	-	-	1.56	0.09	-	-	-	-	0.81	0.90	1.01
1978	-	-	1.23	0.07	-	-	-	-	0.65	0.71	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	-	-	1.15	0.08	0.68	0.74	0.81
1982	-	-	1.61	0.10	-	-	1.36	0.11	0.85	0.95	1.05
1983	-	-	1.42	0.09	-	-	1.08	0.07	0.73	0.81	0.89
1984	-	-	1.34	0.08	-	-	0.99	0.09	0.69	0.76	0.84
1985	-	-	1.43	0.08	-	-	0.86	0.12	0.73	0.81	0.89
1986	-	-	1.49	0.09	-	-	0.88	0.07	0.74	0.82	0.90
1987	1.83	0.09	1.79	0.11	-	-	1.38	0.07	1.00	1.04	1.09
1988	1.15	0.03	1.47	0.09	1.30	0.06	1.22	0.07	0.67	0.69	0.71
1989	1.04	0.02	1.09	0.07	1.06	0.04	0.90	0.04	0.58	0.58	0.58
1990	1.00	-	1.00	-	1.00	-	1.00	-	0.59	0.61	0.63
1991	1.01	0.02	-	-	0.89	0.03	0.88	0.04	0.57	0.58	0.60
1992	1.10	0.02	-	-	0.94	0.03	1.01	0.05	0.62	0.63	0.65
1993	1.07	0.02	-	-	1.03	0.03	0.95	0.05	0.61	0.63	0.64
1994	1.07	0.02	-	-	0.88	0.02	0.74	0.04	0.60	0.61	0.63
1995	1.17	0.02	-	-	0.88	0.03	0.82	0.06	0.64	0.66	0.68
1996	1.20	0.03	-	-	0.86	0.03	0.76	0.04	0.65	0.67	0.69
1997	1.16	0.03	-	-	0.85	0.03	0.58	0.10	0.63	0.65	0.67
1998	1.29	0.03	-	-	1.02	0.04	0.69	0.07	0.71	0.73	0.76
1999	1.45	0.04	-	-	1.04	0.03	1.15	0.09	0.79	0.81	0.83
2000	1.52	0.05	-	-	1.37	0.04	1.22	0.12	0.86	0.89	0.91
2001	1.54	0.05	-	-	1.20	0.04	1.31	0.15	0.84	0.87	0.90
2002	1.89	0.07	-	-	1.58	0.05	1.51	0.72	1.05	1.09	1.13

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 1987-2002.

Year	P. borealis		Fish		P. montagui
	discard (tons)	discard (%)	discard (tons)	discard (%)	landed (tons)
1987	150	0.3	693	1.2	0
1988	169	0.3	865	1.6	0
1989	166	0.3	1072	1.8	0
1990	218	0.3	1030	1.6	0
1991	333	0.5	1686	2.4	0
1992	265	0.3	1771	2.2	0
1993	205	0.3	1566	2.2	0
1994	271	0.4	2179	3.0	4
1995	390	0.6	2167	3.2	471
1996	268	0.4	2213	3.3	634
1997	254	0.4	1919	3.0	336
1998	257	0.4	1788	2.7	1026
1999*	161	0.2	1172	1.6	530
2000*	221	0.3	542	0.7	241
2001*	313	0.4	919	1.1	723
2002**	476	0.5	860	0.9	73

*Preliminary

**Projecdted

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.

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)	8.4	8.5	8.4	7.8	7.6	7.2	6.5	6.6	6.3	6.7	5.8	5.7
Count (no/kg)	119	118	119	128	132	140	154	151	160	149	174	175

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	4188	3388	4560	5502	5971	6243	6368	6583	7790	6509	10249	13340
Primi	825	350	96	1067	1384	824	1197	835	1452	1841	1460	1437
Multi	4031	6493	4370	3217	1962	2614	2363	2583	2887	3532	3076	2511
Females Total	4856	6843	4466	4284	3347	3438	3560	3418	4340	5373	4536	3948
Total	9044	10231	9026	9786	9317	9681	9928	10001	12129	11883	14785	17288

Abundance index

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Males	1.00	0.77	1.17	1.36	1.73	1.88	1.99	2.26	2.57	2.24	3.52	4.23
Primi	1.00	0.40	0.13	1.34	2.04	1.26	1.90	1.46	2.43	3.21	2.55	2.31
Multi	1.00	1.53	1.16	0.83	0.59	0.82	0.77	0.92	0.99	1.26	1.10	0.83
Females total	1.00	1.34	0.99	0.91	0.84	0.89	0.96	1.01	1.23	1.59	1.34	1.08

Table 7. Information on biological samples taken in the Greenlandic fishery 2000-2002

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

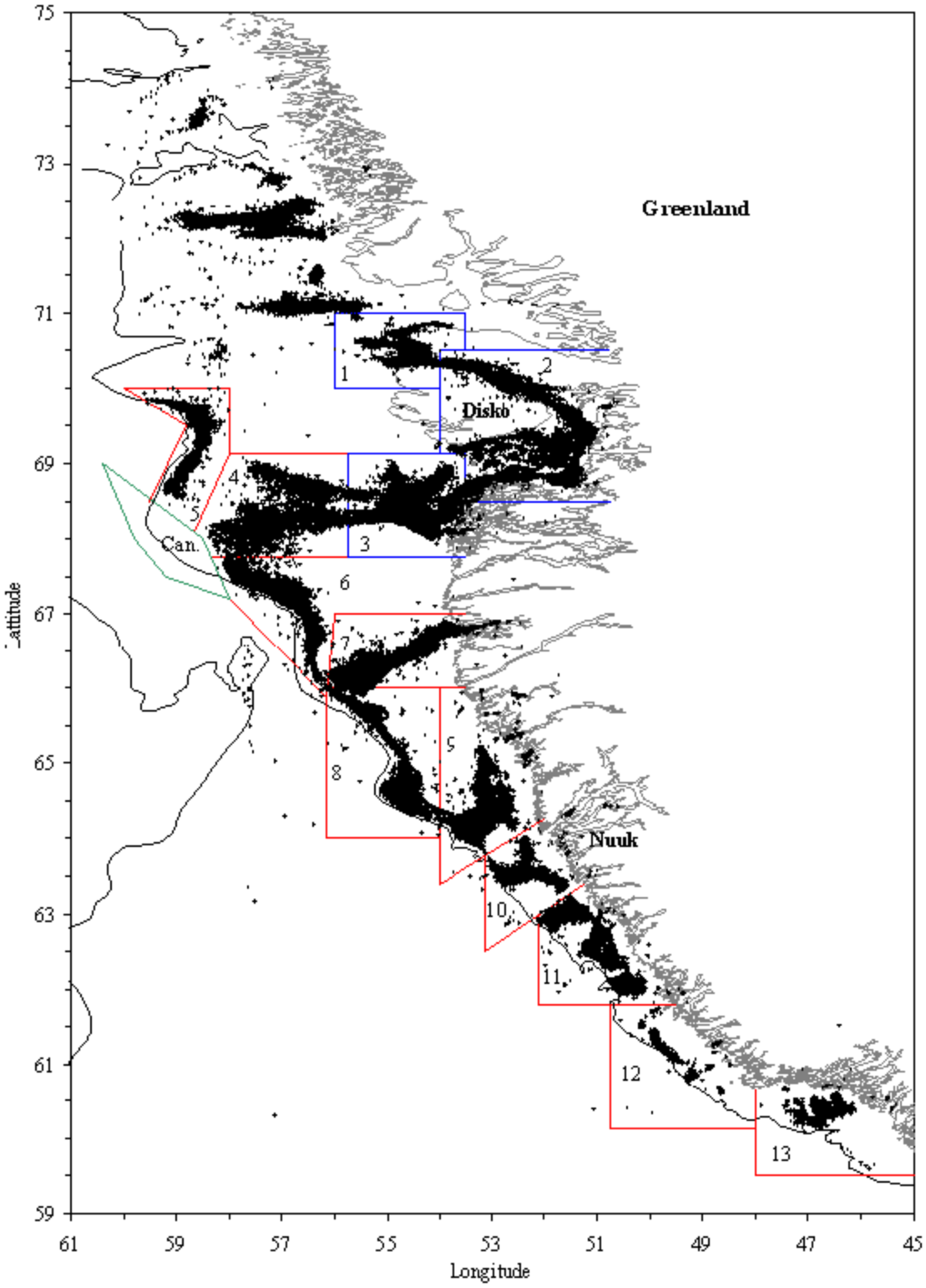

Fig. 1. Distribution of hauls by Greenlandic shrimp trawlers fishing off West Greenland, based on available logbooks 1975-2002. Dots represent individual hauls. 600 m depth contour is shown as the bold line. The boxed areas numbered 1-13 or labelled Can. (Canadian fishery area) are the area segregation used in the models for standardising the catch-per-unit-effort data (see text).

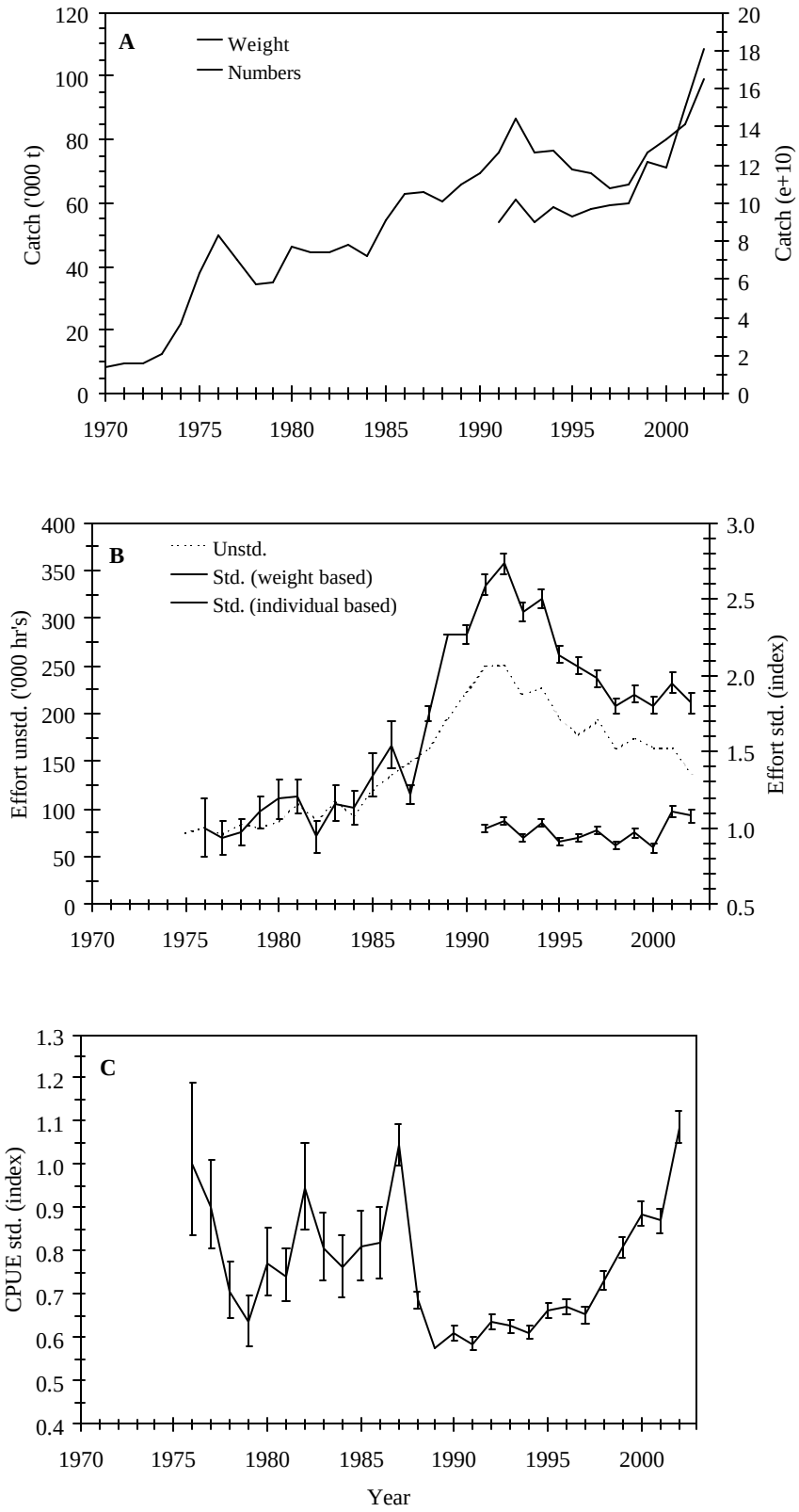

Fig. 2. Total catch (A), standardized and unstandardized effort (B) and standardized CPUE indices (C) of the shrimp fishery in NAFO SA 1 + Div. 0A. Estimates of std. effort and CPUE are medians with 25 and 75 percentile error bars and are based on data series until September 2002. Catch for 2002 are projected from November to the end of the year.

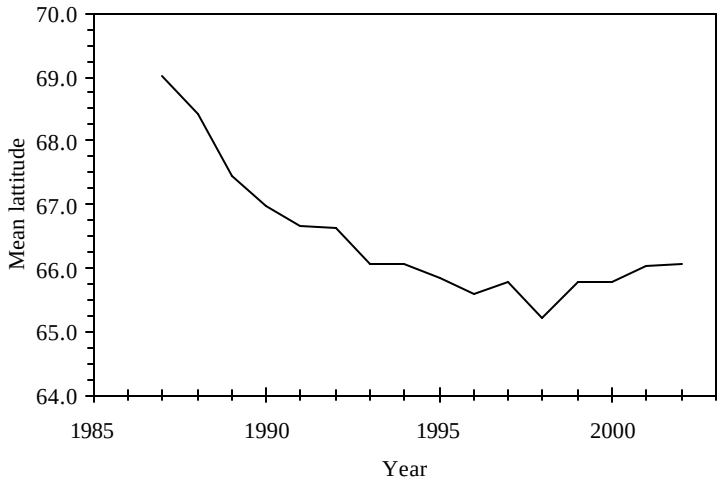

Fig. 3. Mean latitude (°N) of allocated effort by vessels fishing offshore in Subarea 1, 1987-2002.

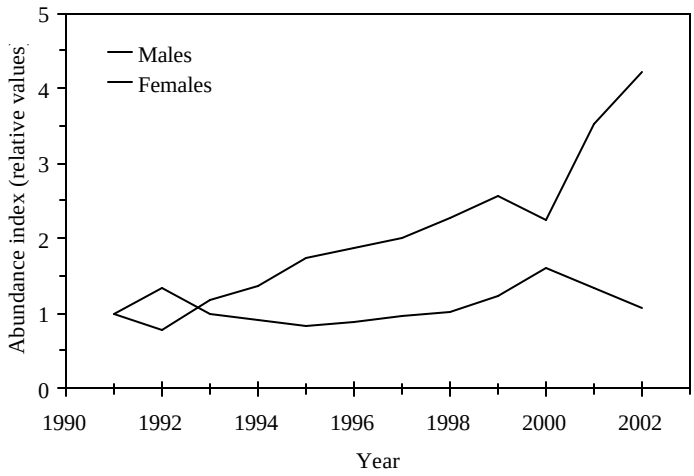

Fig. 4. Standardized CPUE indices of the male and female component of the West Greenland shrimp stock 1991-2002, both standardized to their value in 1991.

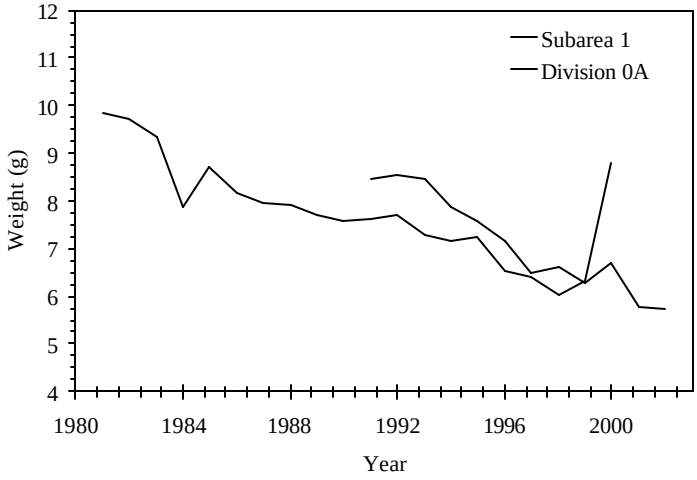

Fig. 5. Mean shrimp size (g) in catches in Subarea 1, 1991-2002, and Division 0A, 1981-2000.

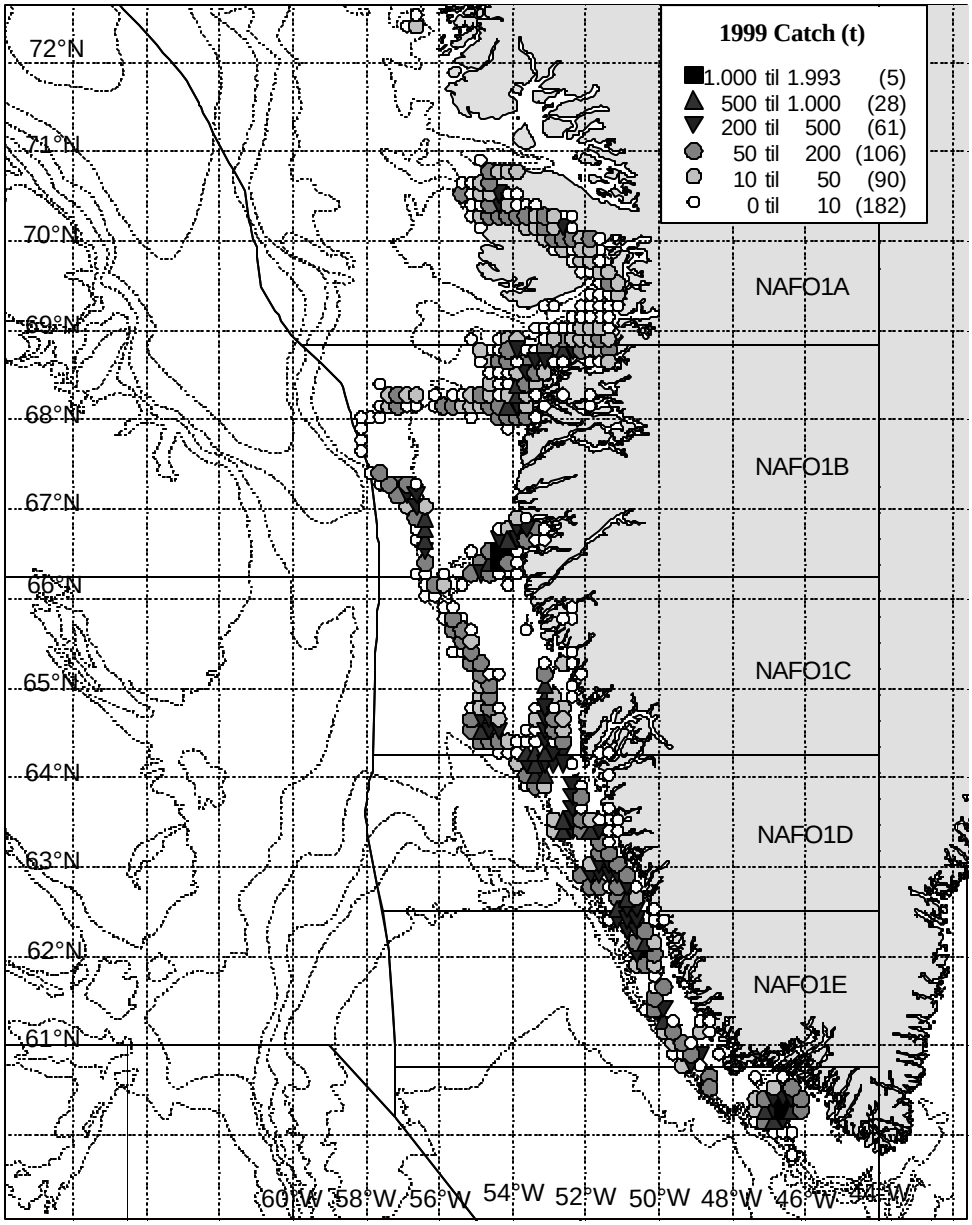

Fig. 6a. Spatial distribution of the Greenlandic shrimp catches in Subarea 1, 1999.

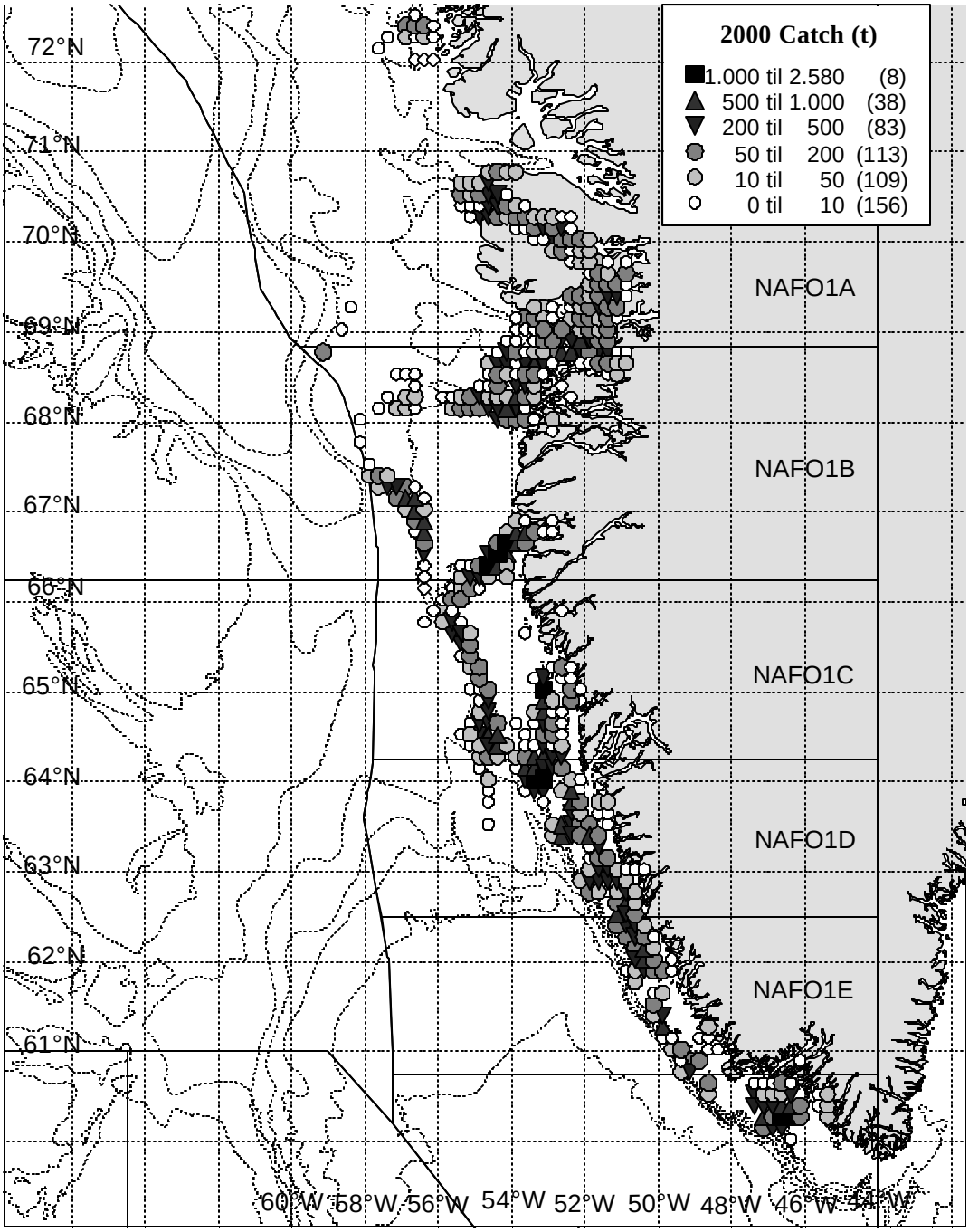

Fig. 6b. Spatial distribution of the Greenlandic shrimp catches in Subarea 1, 2000.

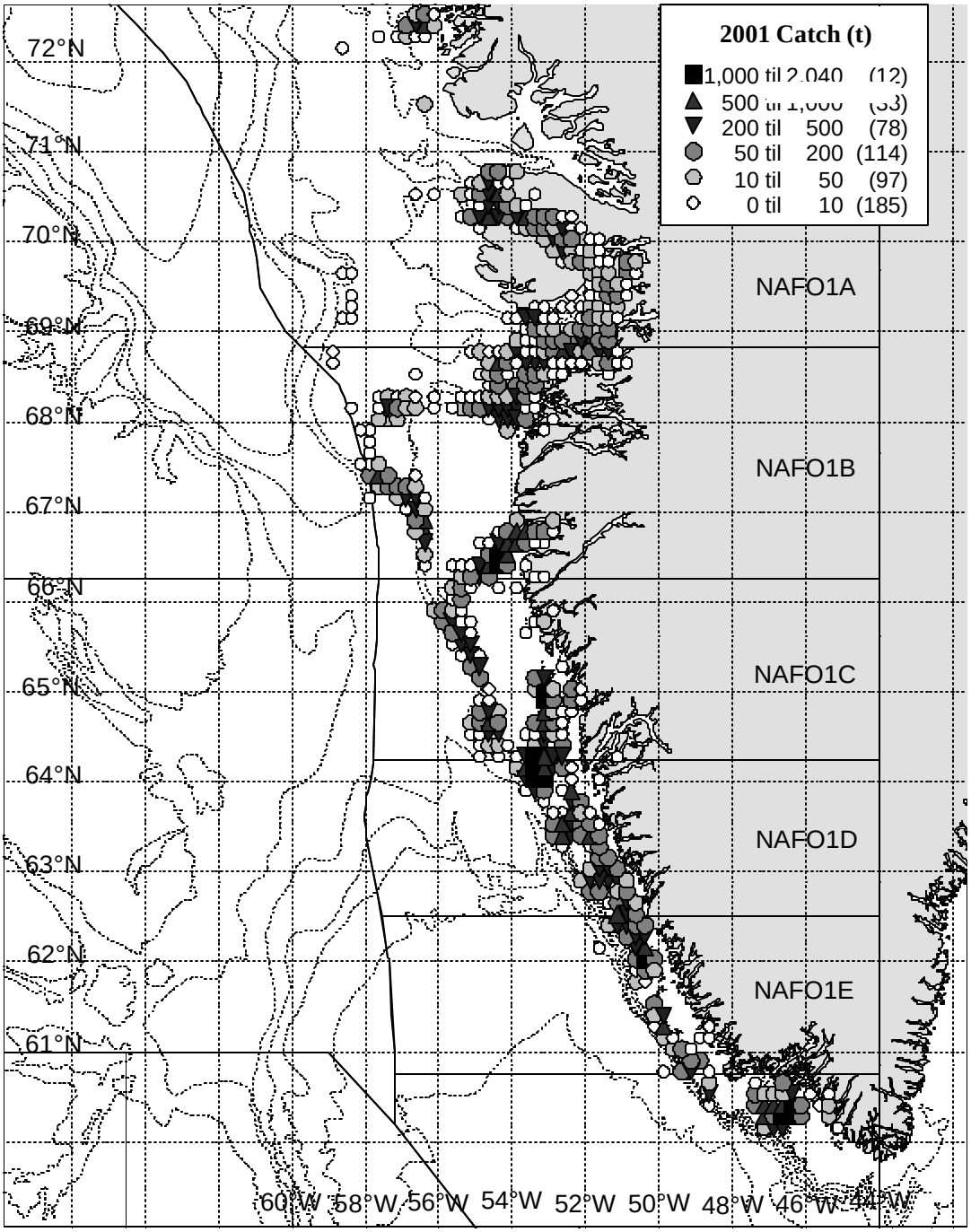

Fig. 6c. Spatial distribution of the Greenlandic shrimp catches in Subarea 1, 2001.

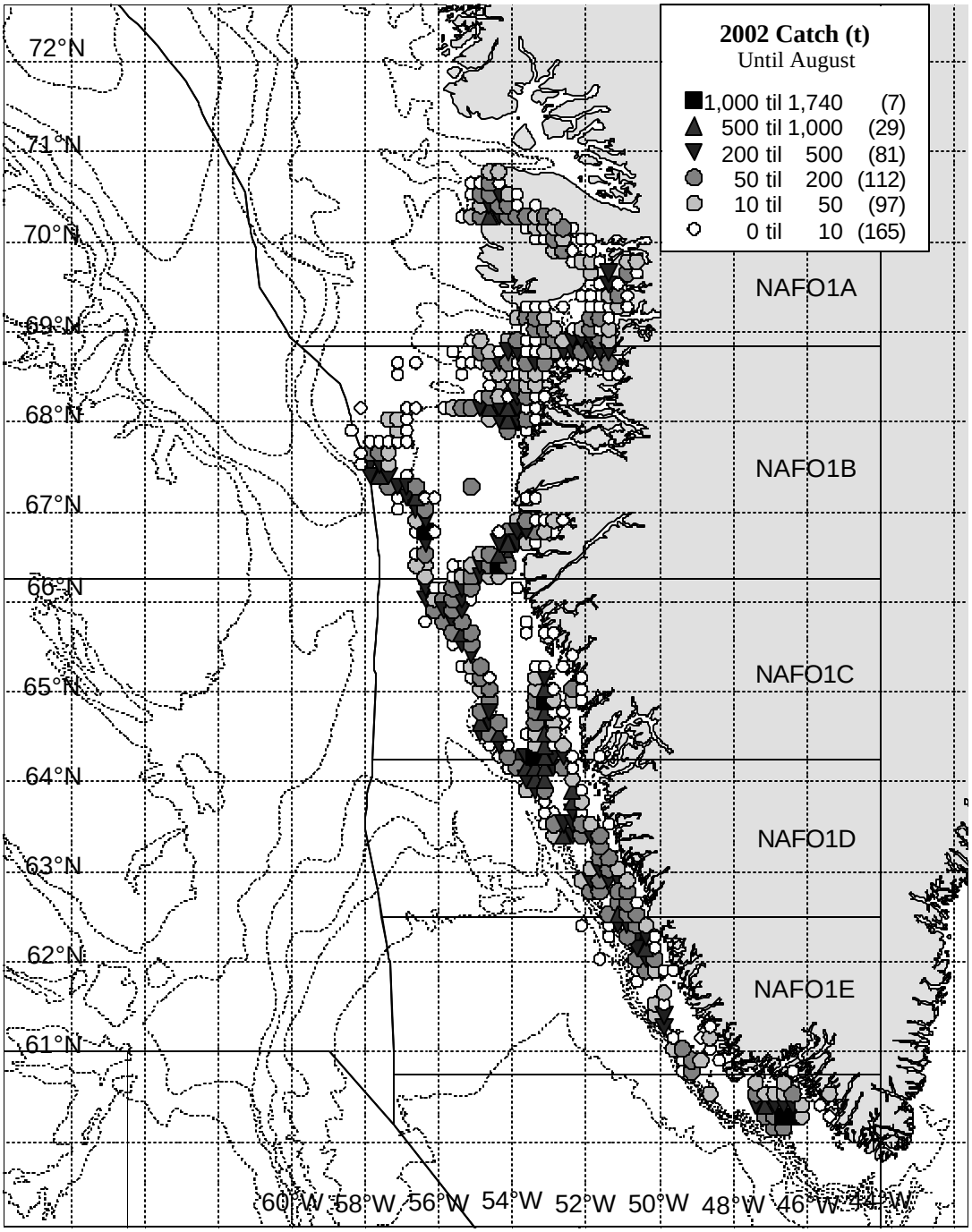

Fig. 6d. Spatial distribution of the Greenlandic shrimp catches in Subarea 1, 2002 until August.

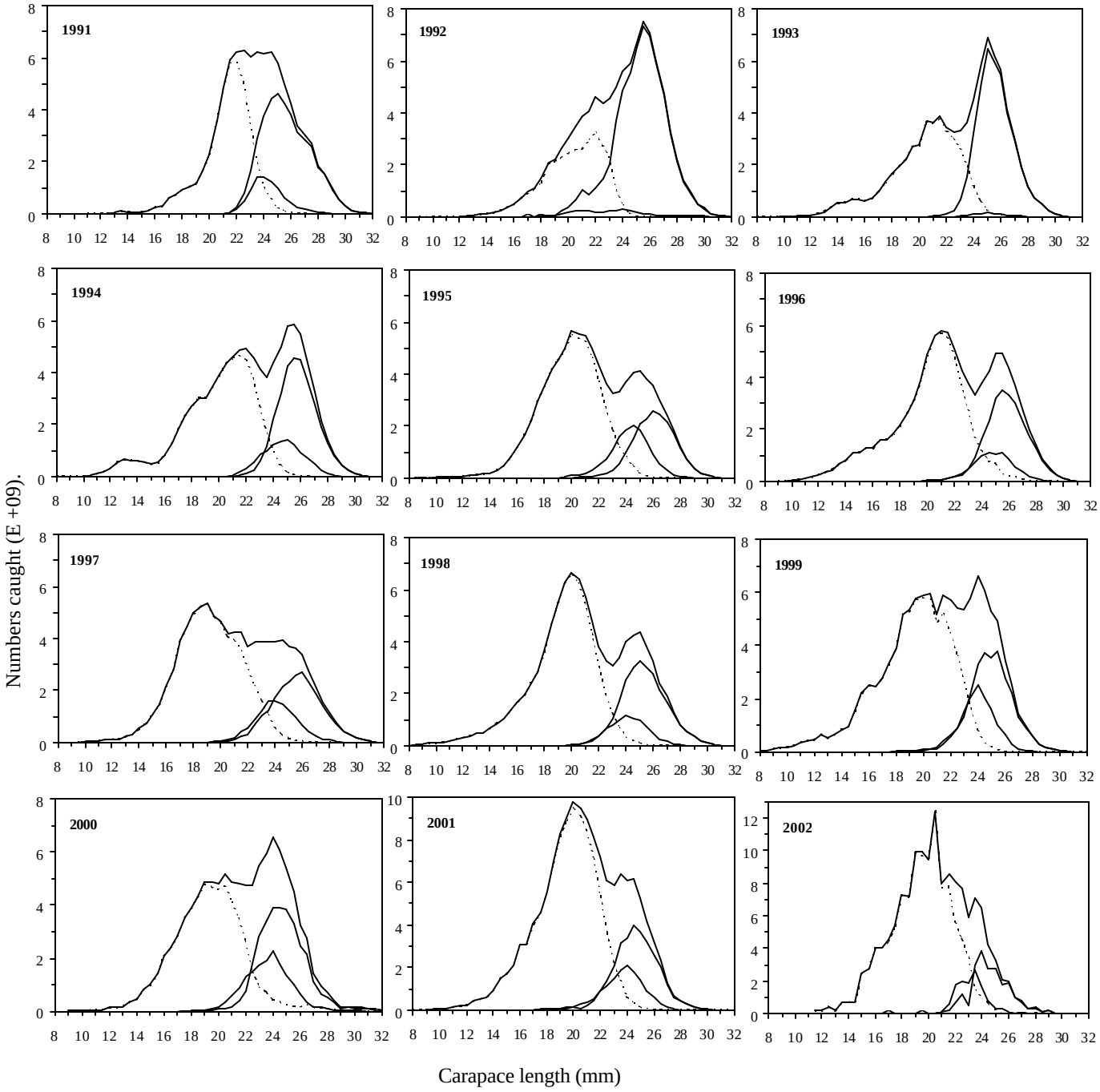

Fig. 7. Length frequency distributions of commercial shrimp catches in Subarea 1 and Div. 0A, 1991-2002. The distribution of male shrimp is shown by a dotted line, primiparous and multiparous each as a thin line where the primiparous is distinguis ed as the smallest component of the two. The sum, i.e. the total distribution, is shown by a bold line.