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Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 + Div. 1A Offshore + Div.1B-1F

by

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Abstract

The paper presents the background and the input parameters from research surveys and the commercial fishery to the assessment of the Greenland halibut stock component in NAFO Subarea 0 + Div. 1A offshore + Div.1B-1F. Catches peaked at 18,000 tons in 1992 but have been stable around 10,000 tons since then, but increased to 13,285 in 2001, primarily due to increased effort in Div. 0A. The catch composition has been stable in recent years. Survey trawlable biomass in Div. 1CD was in 2001 estimated at 77,500 tons, which is the highest in the five year survey series. Surveys in Div. 0A and 0B also showed an increase in biomass. In Div 0A biomass increased from 83,000 tons in 1999 to 97,500 tons in 2001, and in Div. 0B from 56,000 tons in 2000 to 69,000 tons in 2001. The biomass in a new survey in Div. 1AB was estimated at 63,000 tons. The recruitment of age one has been increasing during the latest years and the 2000 year-class was estimated as the largest in the time series, which dates back to 1988. A standardised CPUE index from Div. 1CD has showed a minor increase during 1999-2001 and CPUE was slightly above the average for the 1990-2001 period. An unstandardized CPUE from the single-trawl fishery in Div 0A showed a slight increase compared to 2000 and catch rates were at an average level for the period 1996-2001.

1. TAC, description of the fishery and nominal catches.

Between 1979 and 1994 a TAC has been set at 25,000 tons for SA 0+1, including Div. 1A inshore. In 1994 it was decided to make separate assessments for the inshore area in Div. 1A and for SA 0 + Div. 1A offshore + Div.1B-1F. From 1995-2001 the advised TAC for the latter area has been 11,000 tons. In 2000, there was set an additional TAC on 4,000 tons for Div. 0A+1A for 2001.

In the period 1982-1989 nominal catches of Greenland halibut in SA 0 + Div. 1A offshore + Div.1B-1F fluctuated between 300 and 4,500 tons. Catches increased from 2,200 tons in 1989 to 10,500 in 1990. Catches stayed at that level in 1991 but increased again in 1992 to 18,100, the highest in the time series. Since then catches have fluctuated between 8,300 and 11,400 tons. The catch amounted to 10,700 tons in 2000 and catches increased to 13,300 tons in 2001. The increase in catches from 1989 to 1990 was due to a new trawl fishery by Canada and Norway and increased effort by Russia and Faeroe Islands in Div. 0B, while the increase from 1991 to 1992 was caused by a further increase in effort by Russia in Div. 0B and an increase in fishing activity in SA 1. The increase in catches between 2000 and 2001 was due to an in increase in effort in Div. 1AB and especially Div. 0A.

In 1983 annual catches in Div. 0B were about 4,500 tons. Catches then dropped to a level of 1,000 tons or lower, where they remained until they increased from 907 tons in 1989 to 9,498 tons in 1990. Catches decreased in 1991 to 8,606 tons, to increase again in 1992 to 12,358 tons. Catches then decreased gradually to 3,233 tons in 1995 and fluctuated between 4,000 and 5,000 tons between 1996 and 1999. Catches increased to 5,438 in 2000 and further to 7,647 tons in 2001 including 127 tons from Cumberland Sound (Table 1). (SCR 02/46, SCR 02/50)

The increase in catches is due to an increased effort in Div. 0A where catches increased from a level about 300 ton, where they have stayed since 1996, to 2 625 tons in 2001. All catches in Div 0A were taken by either single or twin trawlers. The fishery was prosecuted by Canadian trawlers and trawlers from Faroe Islands, Poland, Lithuania and Estonia fishing on a Canadian license. (Poland has in Statlant 21A reported 445 tons taken in Div. 0A, but these catches are included in the Canadian).

Catches in Div. 0B amounted to 5,023 tons, including 127 tons taken on longlines in Cumberland Sound. Trawlers took 1,970 tons, longliners 787 tons while 2,138 tons was taken by gillnet. All catches were taken by Canadian vessels.

The catches in Subarea 1 (Div. offshore 1A Div. + 1B-1F) were below 1,600 tons during 1982-1990. In 1991 catches increased to 2,376 tons and were around 5,500 tons in the period 1992-1994, but decreased to around 4,500- 5,000 in the period 1995-1999. Catches increased slightly from 5,251 in 2000 to 5,638 in 2001. Almost all catches were taken offshore (Table 2).

Catches in Div 1AB amounted to 666 tons, which is an increase from the 151 tons taken in 2000. Trawlers from Faroe Islands, Russia and Greenland took 581 tons and 85 tons were taken by a longliner.

Catches in Div 1CD (almost exclusively Div. 1D) amounted to 4,972 tons of which 3981 were taken by trawlers from Greenland (SCS 02/16), Norway, Russia (SCS 02/4), EU/GER (SCS 02/9) and Faroe Islands, 768 tons was taken by a gillnetter and 223 tons were taken by longlines. The catches have been broken down by gear based on reportings to the Greenland authorities.

When catch data from research reports and STATLANT 21 catches have been conflicting the 21 A catches have been used.

2. Input data

2.1 Research trawl survey

Div. 1A-1D GHL-survey

Since 1997 Greenland has conducted stratified random bottom trawl surveys in September-October for Greenland halibut in NAFO Div. 1C-D at depth between 400 and 1500 m. In 2001 the survey area was expanded to include Div. 1A (to 74^{o} N) and Div. 1B. The survey was split in two. First part covering 1A and the northern part of Div. 1B took place in September-October, while the second part covering the southern part of Div 1B and 1C-1D took place in the beginning of November. In total 121 hauls were made (SCR 02/30). The total biomass and abundance was estimated at 140,439 tons and $2.354*10^{8}$. The biomass and abundance in Div. 1C-D was estimated at 77,554 tons and $80.814*10^{6}$ which is an statistically insignificant (95%) increase compared to 59,092 tons and $61.710*10^{6}$ specimens in 2001, and above the level seen since 1997 (56,000 – 70,000 tons). Two strata, which traditionally yield biomasses < 1000 were not covered in 2001. The biomass in Div. 1A and 1B was estimated at 50,485 tons and 12,400 tons, respectively. The highest densities were found at depths 800-1000 m in Div. 1D, and in the southern part of Div. 1A.

The length distribution in Div. 1A-B was dominated by modes at 8, 15, 25, 30 and broader mode at 36-42 cm. Fish < 30 cm were almost exclusively found at depths < 600 m. The over all length distribution in Div. 1C-D was dominated by a mode at 45 cm. The age distribution was dominated by a mode at age 6 as in 2000. In 1999 the mode was at age 7.

Div. 0A-0B GHL-survey

In 2001 Canada conducted two surveys covering Div. 0A and OB, respectively. The Div 0A survey took place in September and the Div. 0B survey in October (SCR 02/47). The surveys were conducted as stratified random bottom trawl surveys covering depths between 401 and 1500 m. The two surveys were conducted in conjunction with the two surveys in 1AD and used the same gear and vessel (SCR 02/47).

The biomass in Div. 0A was estimated at 97,628 tons in 2001 compared to 83,340 tons in a similar survey in 1999. The abundance was estimated at $142.7*10^{6}$ compared to $140.1*10^{6}$ in 1999. The survey coverage in 2001 was, however,

reduced slightly compared to 1999. It was estimated that the reduction in survey area corresponded to an underestimate of the biomass at about 13,000 tons (SCR 02/47). The length distribution was dominated by a mode at 43 cm and the age distribution by a mode at age 5.

The biomass in Div. 0B was estimated at 68,917 tons compared to 56,212 tons estimated from a similar survey in 2000 and the abundance was estimated at 85.9 $*10^6$ compared with $74.6*10^6$ in 2000. There was a slight reduction in the survey area in 2001 compared to 2000. It was estimated that the reduction corresponded to an underestimation of the biomass of about 3,000 tons. The length distribution was dominated by a mode at 45 cm and the age distribution by age 6.

The distribution of catches in the four surveys in 1A-D and 0A-B in number km^{-2} and kg km^{-2} are shown in Fig. 1 and 2.

The length distributions in the 1A-D surveys and 0A-B surveys are shown in Fig 3.

Greenland shrimp-survey

Since 1988 annual trawl surveys with a shrimp trawl have been conducted off West Greenland in July-September. The survey covers the area between 59°N and 72°30'N (Div. 1A-1F), from the 3-mile limit to the 600-m depth contour line. Estimated total trawlable biomass of Greenland halibut in the offshore areas (- Disko Bay) has fluctuated between 6,800 and 15,020 tons during 1992 – 2000. In 2001 the biomass was estimated at 15,369 tons which is an increase from 8,525 tons in 2000 and the highest in the time series. The increase in biomass was mainly seen in Div. 1A (SCR 02/48). The abundance was estimated at 330 mill., the second highest in the time series. The highest abundance was seen in the off shore nursery area (Div.1AS, 1BN). Almost all the catches were comprised of one-year-old fish (85%).

In the Disko Bay the biomass was estimated at 10,552 tons compared to 9,608 tons in 2000 and the second highest in the time series. The abundance was estimated at $201*10^6$ compared to $160*10^6$ in 2000, which is the highest in the time series. Age one was also totally dominating in the Disko Bay

The biomass in the nursery area (1AS and 1B) was estimated at 6,558 tons compared to 4,998 tons in 2000 and the second largest in the time series. The abundance was estimated at $237*10^6$ compared to $125*10^6$ in 2000. The abundance estimate from 2001 is above the level in 1990-1991 and 1997-2000, and at the level in 1992-1996 (145-$342*10^6$).

Recruitment

A recruitment index was provided from the Greenland shrimp trawl survey. By means of the Petersen-method ages 1, 2 and 3+ were separated in the survey catches in the nursery area (Div. 1AS-1B) for the period 1988 to 2001. Catches were standardized as catch in number per hour as described in Bech (1995). Data were plotted by year classes to visualize the relative year class strength and development in relative abundance (Fig. 4).

The recruitment index has been declining since the presumably large 1991 year-class, but the recruitment has been above the level in the 1980'ies. The recruitment increased again with the 1995-year class, which was the largest on record. The 1996 year-class seemed to be small but the recruitment has increased gradually since then. With a mean catch of 443.6 one year old specimens per hour the 2000 year-class was estimated to be the second largest in the time series. In Disko Bay catches of one year old fish was by far the largest on record (1597 specimens per hour).

SSB/Recruitment

The relation between the spawning stock in numbers (age 10+) in Div. 1C-D estimated from the joint Japan/Greenland survey and the Greenland Greenland halibut survey and recruitment, given as the number of fish age 1 in the total survey area, estimated from the Greenland shrimp trawl survey, is shown in Fig 5. The over all recruitment of the 2000 year class was the largest in the time series due to a combination of the second highest recruitment in the off shore areas and the highest recruitment ever seen in Disko Bay (SCR 02/48). Note that the coverage in 1989 and 1990 was

incomplete and that there was no survey in 1996.

2.2 Commercial fishery data.

Length and age distribution

Length distribution were available from the trawl fishery in Div. 0A (SCR 02/46). Only 48.2 % of the fish caught were > 45 cm.

Catch-at-age by gear (trawl and twin trawl combined), fixed gear (longlines and gill net combined) and for all gears combined was available from SA 0B. Catch-at-age in 0A was estimated based on the Div. 0B data.

Catch-at-age data were available from the Russian offshore trawl fishery in Div. 1D (SCS 01/13). Length frequencies were available from the Norwegian trawl fishery in Div. 1D. All trawl catches in SA1, except the Russian, were raised to catch-at-age based on the Canadian data from Div. 0B (SCR 02/50). Catch-at-age for longlines in SA1 and Cumberland Sound was estimated from length distributions in the Russian longline fishery in Div. 1D combined with age-length key from the Greenland GHL survey. Catch-at-age in the gillnet fishery in 1C-D was estimated using the age distribution from fixed gear in Div. 0B (mainly gillnet).

Table 3 and 4 shows catch-at-age and weight-at-age, respectively. The catch-at-age has been relatively stable in recent years as well as the overall mean weight at age for the ages 7-14.

The age distributions for trawl, longline and gillnets, respectively, are given in Fig. 6.

Age 7 is the most dominant in the trawl fishery as seen in most years. The mode in the age distribution in the gill net was at age 10 as seen in most years. The mode in the longline fishery was at age 7, where it was at age 9 in 2000.

Catch rate

Unstandadized catch rates were available from the Trawl fishery in Div. 0A from 1996-2001 (SCR 02/46). The catch rate for single trawlers have fluctuated during the years but increased from 2000 to 2001 to an average level. The catch rates for twintrawlers were stable between 2000 and 2001 and slightly above the catch rate from 1997, the only other observation (Fig. 7).

Unstandardized catch rates were estimated from logbooks from the trawl fishery Div. 1C-D and for EU/German trawlers during 1996-2001 (SCS 02/9) (Fig. 8).

The catch rates from Norway showed a minor increase compared to 2000. The catch rate from Greenland and Germany showed a minor decrease compared to 2000, but are still at the same level as in recent years. The decrease in the Greenlandic catch rates is caused by a decrease in effort and catches by one trawler that usually have high catch rates. One vessel that has been fishing in the area for several years showed stable catch rates between 2000 and 2001. The increase in the Greenland catch rates in 2000 was to some extend caused by the introduction of a new large trawler. The other Greenland trawler engaged in the fishery showed, however, also an increase between 1999 and 2000.

Standardized catch rate series, based on available logbook data and data from the EU-German trawl fishery (SCS 02/9), were available for the offshore trawl fishery in Div. 1C-D for the period 1988-2001 (Appendix 1).

The standardized catch rates in Div. 1C-D dropped from 1989-1990 but has been stable since then and showed a small increase during the latest years and is now a little above average for the period 1990-2000 (Fig. 9).

The combined catch rate from OB and 1C-D could not be updated in 2002 due to lack of data from 0B (Fig. 9).

Due to the frequency of fleet changes in the fishery in both SA0 and SA1 the standardized indices of CPUE should, however, be treated with caution.

3. Assessment

3.1 Yield per Recruit Analysis.

The level of total mortality has in 1994-1996 been estimated by means of catch-curves using data from the offshore longline fishery in Div. 1D. Z was estimated from regression on age 15-21. A relative F-at-age was derived from the catch curve analysis, where the trawl, longline and gillnet catches were weighed and scaled to the estimated stock composition. In all three years STACFIS considered that the estimation of Z was based on too limited samples and represented too small a part of the fishery and that the outcome of the catch curve analysis were too uncertain to be used in the yield per recruit analysis. In 2001 data were sampled from the Russian longline fishery in Div 1D (92 tons) representing less than 1% the catches, hence no Catch-curve analysis was attempted.

3.2 XSA/ separable VPA .

Extended Survivors Analysis

An XSA has been run unsuccessful several times during the 1990'ies, using a survey series covering 1987-1995 as tuning. STAFIS considered the XSA's unsuitable for an analytic assessment due to high log-catchability residuals and S.E.'s and systematic shift in the residuals by year. Further, a retrospective plot of F_{bar} showed poor convergence. In 1999 the XSA analyses was rerun including the latest two years surveys (1997-1998, new vessel and gear) (not presented) but the outcome of the analysis has not improved.

An XSA analysis was run using the stock data for SA 0+1, calibrated with trawl survey data (age 5-15) from the Greenland Deep sea surveys (1997-2001) in Div. 1CD. The assessment results are considered to be provisional due to problems with the catch-at-age data and the short time series, the assessment is, however, considered to reflect the dynamics in the stock. The rate of exploitation has been relative stable in recent years between 0.2-0.3 (F_{bar} 7-13). The input parameters to the analysis and the outcome of the analysis is given in (SCR 02/68)

3.3 Spawning stock/recruitment relations.

A spawning stock/recruitment plot based on the available observations from the joint Japan/Greenland survey and the Greenland survey is shown in Fig. 5. No further analysis of spawning stock recruitment relationships have been made due to few observations distributed on two different surveys, poor estimate of spawning stock biomass (survey trawl only take a small proportion of the mature fish, the survey covers only a restricted part of the area covered by the assessment, and knife edge maturity ogive was applied). Further, the age of the recruits is relatively poor estimated (the Petersen method).

3.4 ASPIC

ASPIC was run in 1999 with standardized CPUE data and a biomass index as inputs. Three CPUE series were available, one series covering Div. 0B during the period 1990-1998, one covering Div. 1CD during the period 1987-1998 and a series combining the two data sets. The biomass index was from 1CD and covered the period 1987-1995 and 1997-1998. Several runs showed that the combined CPUE series from Div. 0B+1CD fitted the total catch data best in terms of r^2 and "total objective function". Runs with biomass alone gave relatively bad fits in terms of "total objective function" and r^2 and the modeled population trajectory declining drastically over the period. Runs with the CPUE series from 0B gave unrealistic high B_{msy} and negative r^2. The run with the combined CPUE series showed, however, that sensitivity analysis should be run, because "the B1-ratio constraint term contributed to loss". Several runs with different realistic values for the constraint did not solve the problem. Further, the coverage index and nearness index was equal in all runs. Several runs with different constraints on r and MSY were tried but it did changes the outcome of the analysis. Removing the three first years from the input data gave negative r^2. To get measures of variance the run with the combined CPUE series was bootstrapped (500 resamplings).

The results showed that estimated fishing moralities 1987-1998 have been less than the (bias-reduced) estimate of F_{msy} (0.22) except for one year (1992).

A number of essential parameters are quite imprecisely estimated (r, q, F_{msy}), and it is considered that the estimates of MSY and F_{msy} were not precise enough to be used.

The input parameters from 2000-2001 (catches, survey biomass index, and CPUE index) have only varied little compared to 1999, and it was not expected that the outcome of an ASPIC analysis would change significantly, hence the analysis was not attempted.

4. Prognosis

Since catches peaked with 18.000 tons in 1992 they have been stable at around 10.000 tons. Catches increased to 13,285 tons in 2001 primarily due to increased effort in 0A. The age composition in the catches seems stable. Standardized catch rates in Div. 1C-D have been slightly increasing during the latest years and the catch rates from Div. 1C-D in 2001 seems to be a little above average level for the period 1990-2000. The combined catch rate for Div. 1C-D+0B has showed very little variation during the period (not updated in 2001). Unstandardized catch rates for Div. 0A increased slightly from 2000 to 2001 and seems to be at an average level.

Survey biomass have increased between 1999 and 2001 in Div 0A, between 2000 and 2001 in 0B and 1CD, where it was the highest seen in the five year long survey series. Biomass in the Greenland shrimp survey increased to the second larges level seen since 1988 and the recruitment of age one, which has been increasing in recent years, was the best seen in same period. A provisional XSA estimated the exploitation rate has been relatively stable, between 0.2-0.3, during resent years.

5. Biological reference points

Yield per recruit analysis or other age-based methods are not available, for estimating biological reference points. Biomass indices and CPUE series are relative short and show little variability and are not useful for estimating reference points.

6. Acknowledgement

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Table 1. Greenland halibut catches (metric tons) by year and country for Subarea 0 from 1987 to 2001.

	Year														
Country	87	88	89	90	91	92	93	94	95	96	97	98	99	00[a]	01[a]
CAN	-	2	-	589	256	2194	883	-	1941	2354	3871	3924	4784	5438	7647
EST	-	-	-	-	-	-	631	-	-	-	-	-	-	-	-
FRO	388	963	596	2252	2401	463	1038	-	-	839	452	-	-	-	-
JAP	-	-	-	113	232	337	252	600	1031	500	-	-	-	-	-
LAV	-	-	-	-	-	-	83	-	-	-	-	-	-	-	-
NOR	-	-	282	5016[c]	3959	-	373	-	-	-	-	-	-	-	-
RUS	-	59	29	1528	1758	9364	4229[b]	3674	261	915	-	-	-	-	-
TOTAL	388	1024	907	9498	8606	12358	7489	4274	3233	4608	4323	3924	4784	5438	7647[d]

[a] Provisional data.
[b] The russian catch is reported as area unknown, but has peviously been reported from 0B
[c] Dobbel reported as 10031 tons
[d] Including 127 tons from Cumberland sound

Table 2. Greenland halibut catches (metric tons) by year and country for Subarea 1 from 1987 to 2001.

	Year														
Country	87	88	89	90	91	92	93	94	95	96	97	98	99	00[a]	01[a]
GRL (excl. 1A inshore)	-	-	-	-	965	227	213	885	1405	1880	2312	2295	2549	2657	2337
FRO	-	-	-	54	123	151	128	780	-	-	127	242	116	243	300[c]
JPN	907	1581	1300	988	677	2902	1198	820	337	-	-	-	-	-	-
NOR	-	-	-	-	611	2432	2344	3119	2472	1785	1893	1338	1360	1115	1550[c]
RUS	-	-	-	-	-	-	5	-	296	254	-	543	552	792	914
EU	-	-	-	-	-	-	46	266	527	455	446	350	330	444	537
1A-F (excl. 1A inshore)	907	1581	1300	1042	2376	5712	3934	5870	5037	4374	4778	4769	4907[b]	5251	5638

[a] Provisional data.
[b] Excluding 7603 tons reported by error
[c] Reported to the Greenland authorities

Table 3. Catch numbers at age.

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE															
5	2	1	1	4	20	53	241	254	152	151	41	71	262	415	70
6	31	29	36	87	318	678	651	862	522	530	311	372	1092	1106	987
7	182	190	244	592	1742	2967	2422	2472	1628	1818	1556	677	1759	1677	3238
8	296	354	409	1711	2679	4311	2356	1692	940	1575	2110	1187	1174	1144	1817
9	193	245	212	1356	1418	2604	1048	954	558	660	1042	900	672	772	1164
10	77	115	75	711	533	951	590	294	259	306	438	572	375	501	780
11	40	80	47	359	221	398	224	183	228	160	232	422	234	443	506
12	18	61	48	195	144	231	130	159	188	127	118	205	184	291	274
13	10	58	44	189	108	158	72	125	104	64	96	153	172	178	101
14	9	46	42	115	60	85	59	58	80	57	21	98	95	68	50
15	6	35	26	67	36	45	37	55	85	39	13	19	61	75	22
16	3	15	12	17	6	23	26	34	41	36	12	4	37	17	10
17	4	4	1	3	2	1	4	10	18	13	0	0	18	4	5
+gp	2	1	0	0	0	0	2	7	10	22	0	0	7	6	3
TOT.NUM	873	1234	1197	5406	7287	12505	7862	7159	4813	5558	5994	4688	6166	6717	9027
TONS	1295	2605	2207	10540	10982	18070	11423	10144	8270	8982	9101	8693	9691	10689	13285

Table 4. Catch weights at age (kg)

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE															
5	0.29	0.29	0.29	0.33	0.34	0.33	0.58	0.43	0.49	0.52	0.36	0.50	0.54	0.53	0.48
6	0.51	0.51	0.51	0.54	0.54	0.56	0.72	0.62	0.66	0.69	0.55	0.74	0.70	0.72	0.67
7	0.74	0.74	0.74	0.79	0.79	0.80	0.96	0.91	0.94	0.94	0.86	1.00	0.98	1.00	0.91
8	1.08	1.08	1.08	1.10	1.12	1.13	1.26	1.26	1.34	1.38	1.27	1.24	1.28	1.29	1.30
9	1.41	1.42	1.42	1.52	1.57	1.59	1.80	1.72	1.81	1.91	1.83	1.54	1.66	1.71	1.76
10	1.97	2.05	2.00	2.11	2.27	2.28	1.43	2.19	2.37	2.48	2.38	2.22	2.25	2.26	2.29
11	2.58	2.80	2.68	2.94	3.22	3.02	3.25	2.73	2.89	3.18	3.01	3.08	2.74	2.84	2.91
12	3.52	3.88	3.73	3.90	4.24	4.02	4.10	3.43	3.62	4.04	3.84	3.84	3.68	3.59	3.51
13	4.64	5.01	4.87	4.96	5.50	5.33	5.26	4.48	4.44	5.05	4.93	4.74	4.73	4.23	4.30
14	5.79	6.16	6.20	6.26	6.82	6.76	6.17	5.75	5.61	5.95	5.69	6.04	5.58	5.19	5.60
15	6.61	7.44	7.65	7.96	8.33	7.76	7.42	6.58	6.65	7.34	6.79	6.60	6.68	5.85	6.11
16	7.99	8.88	9.36	9.90	9.89	8.58	8.04	7.36	7.77	8.64	8.00	13.45	7.75	7.32	7.09
17	9.56	9.86	9.56	11.86	9.56	11.95	9.24	9.42	10.19	9.18			9.08	8.60	8.94
+gp		11.33					10.25	11.15	11.00	11.10			11.10	9.00	11.24

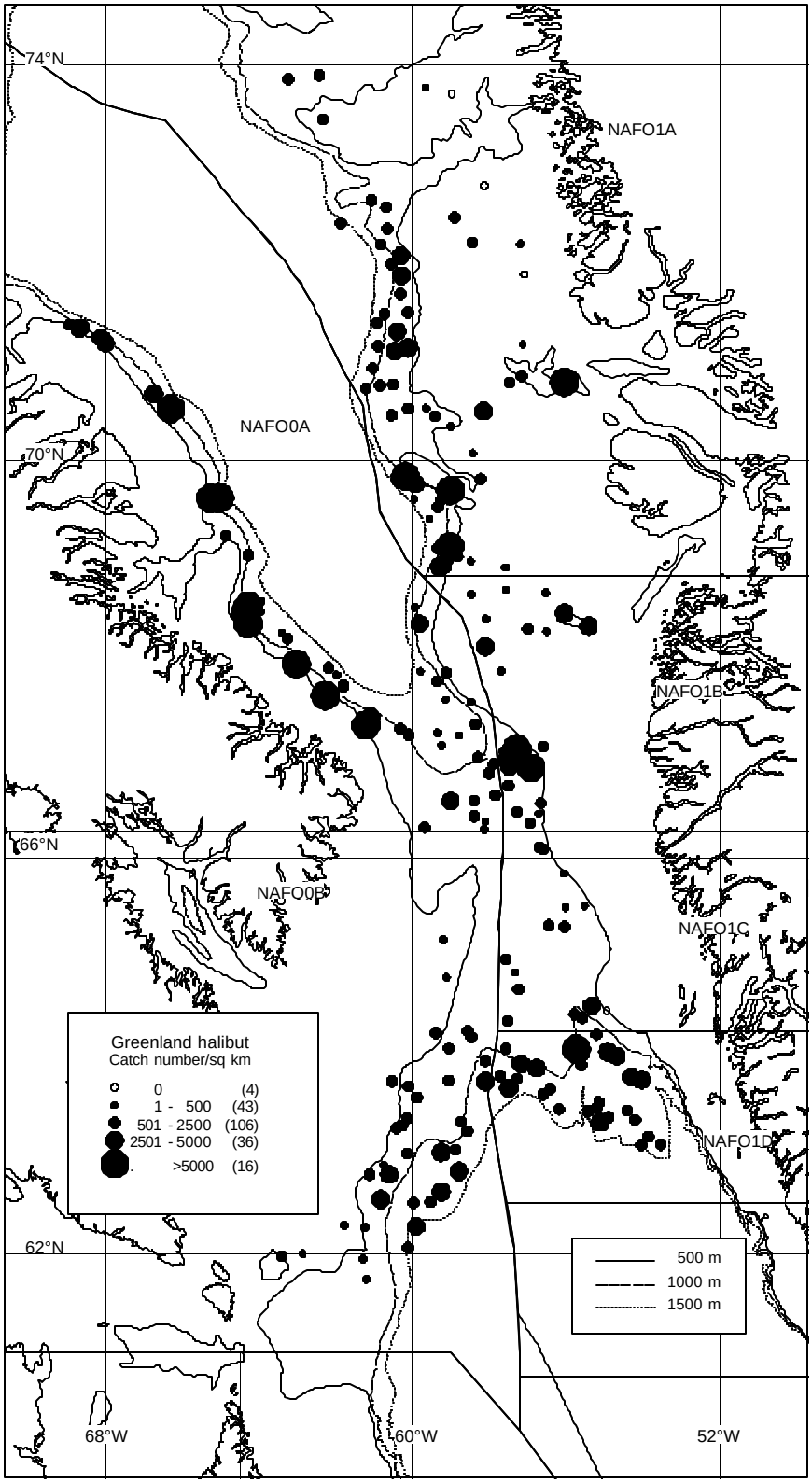

Fig. 1. Catches of Greenland halibut from four surveys in 2001 by Canada and Greenland in number km^{-2}.

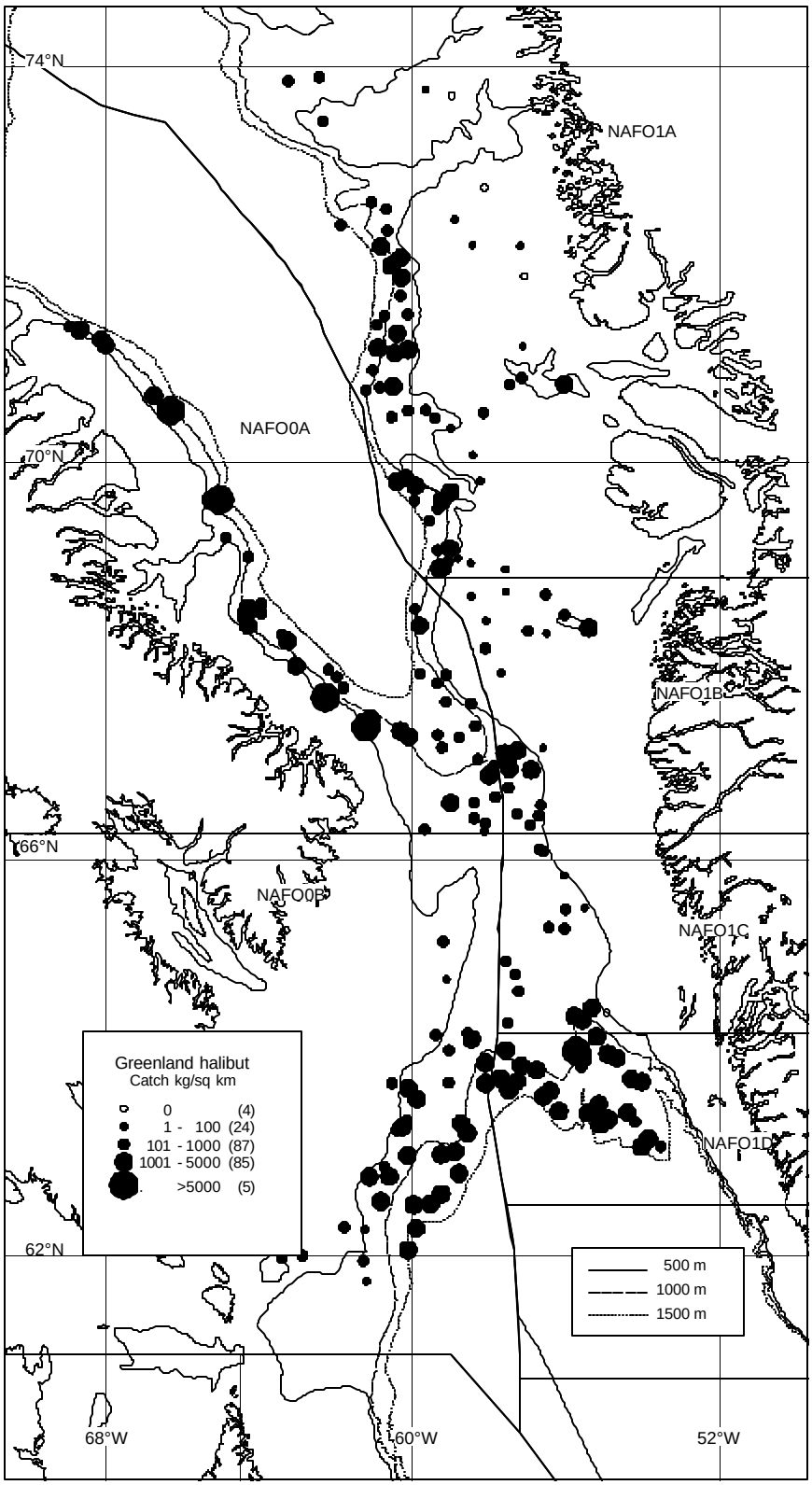

Fig. 2. Catches of Greenland halibut from four surveys in 2001 by Canada and Greenland in kg km^{-2}.

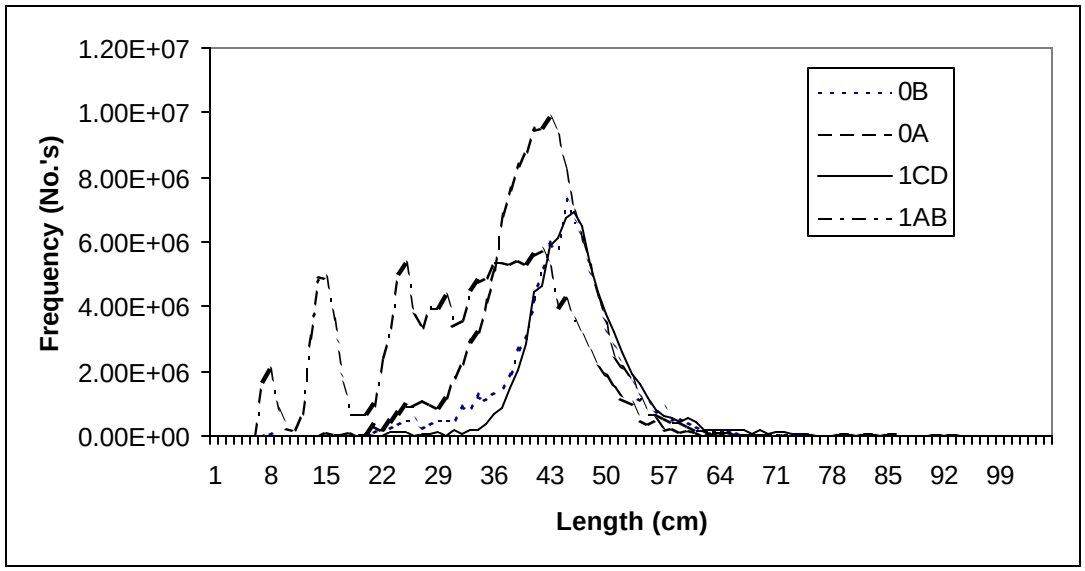

Fig. 3. Length frequencies of Greenland halibut in the four surveys conducted by Greenland and Canada in 2001.

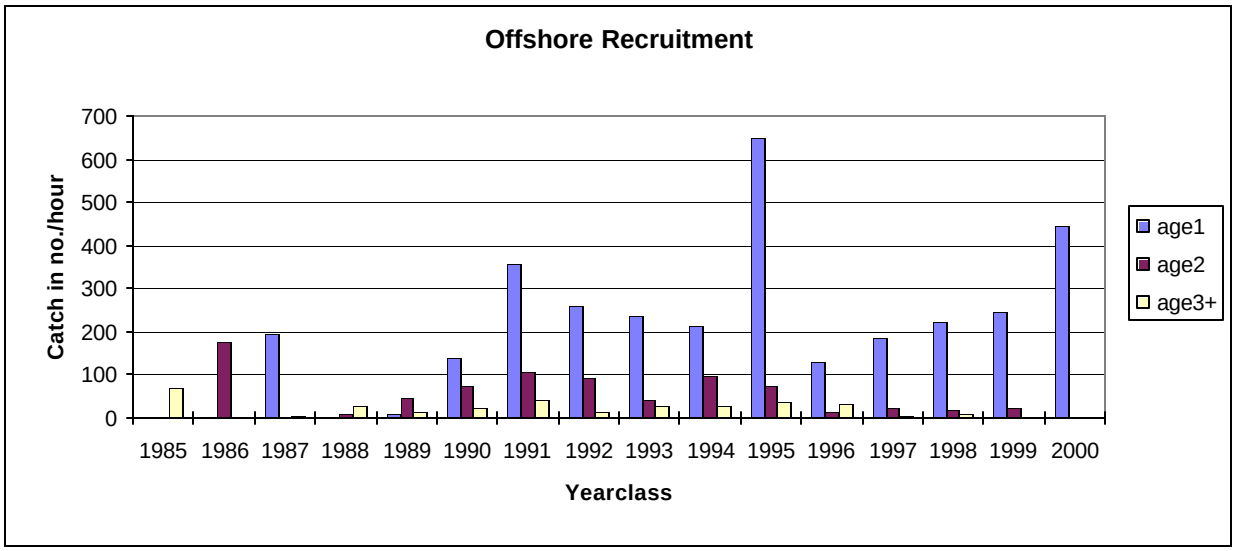

Fig. 4. Year-class strength of Greenland halibut of ages 1-3+ in number per hour trawled in the offshore nursery area.

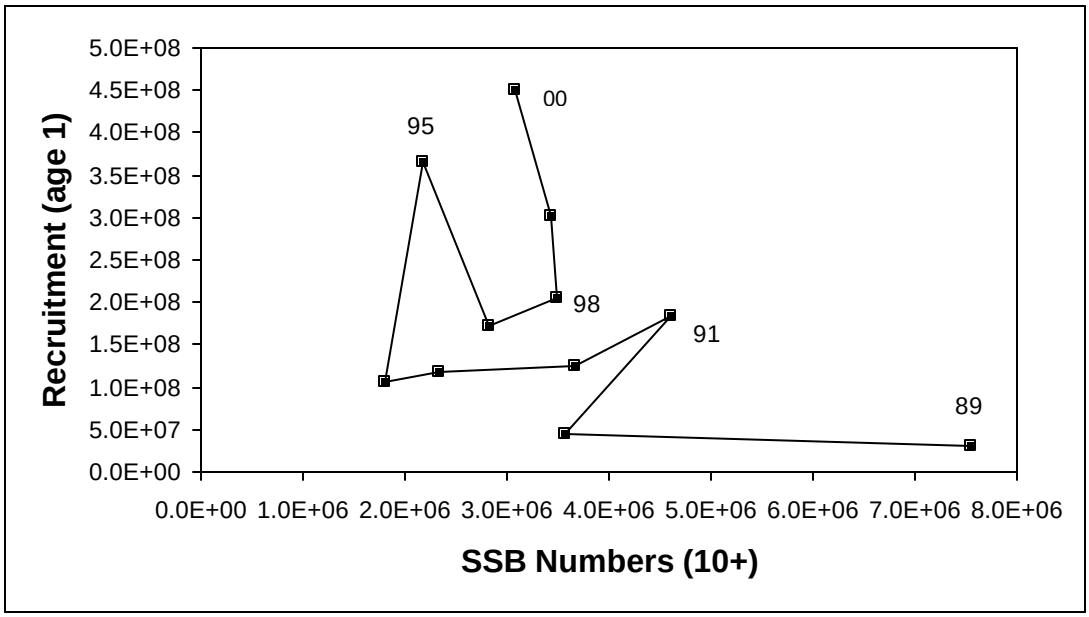

Fig. 5. Spawning stock in numbers (ages 10-18 in Div.1CD from the joint Japan/Greenland survey and the Greenland survey (1997-2001) plotted *vs* number of fish age 1 the following year estimated from the Greenland shrimp trawl survey including the Disko Bay. Note pure coverage in 1989 and 1990 and that there was no survey in 1996.

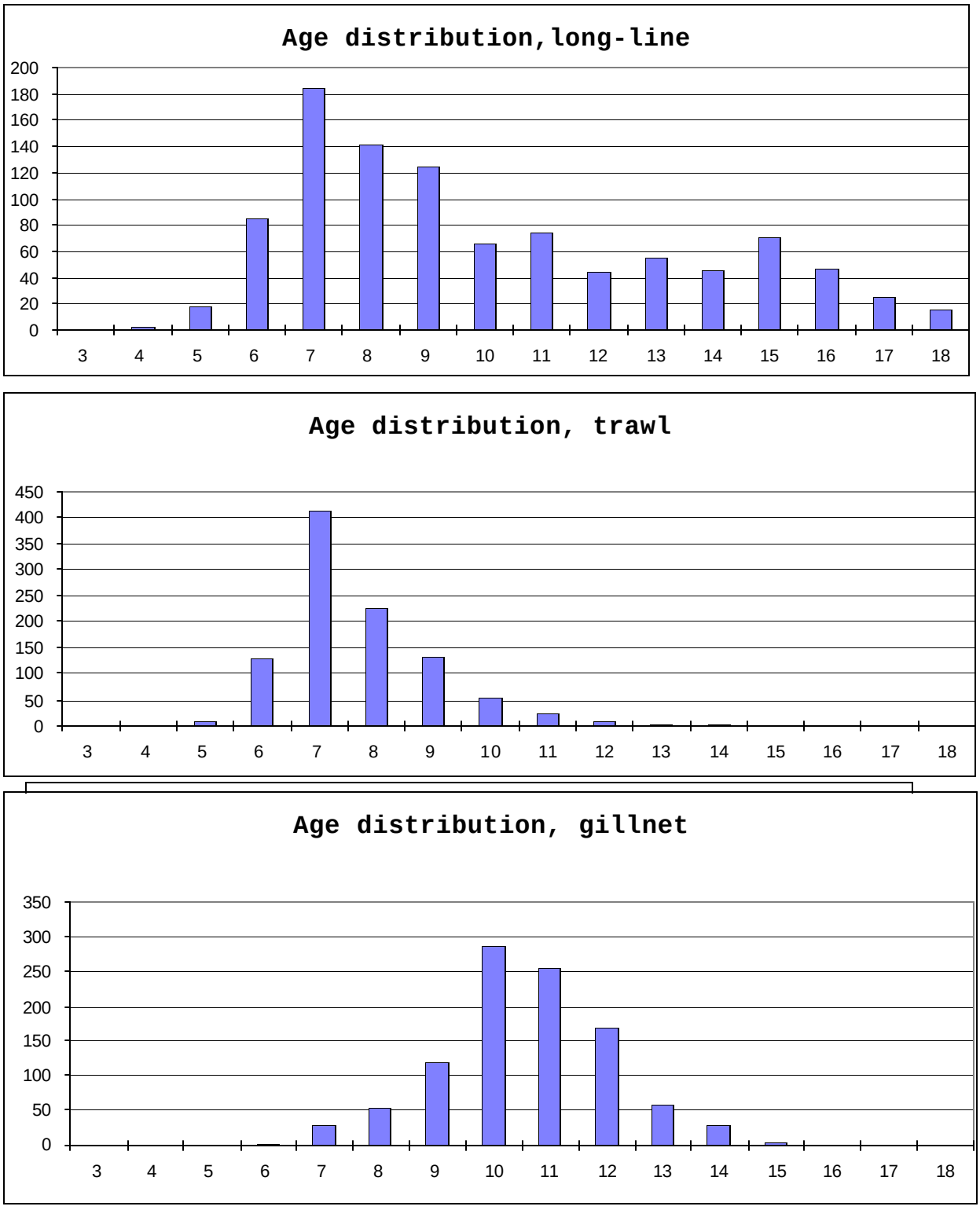

Fig 6. Age distribution in the longline, trawl and gill net fishery in SA 0+1 in 2001 in per mill.

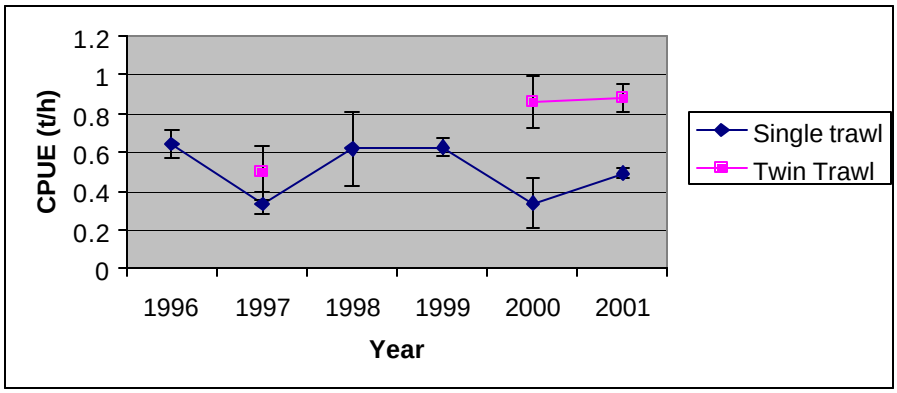

Fig. 7. Unstandardized CPUE for single and twin trawl in Div. 0A during 1996-2001.

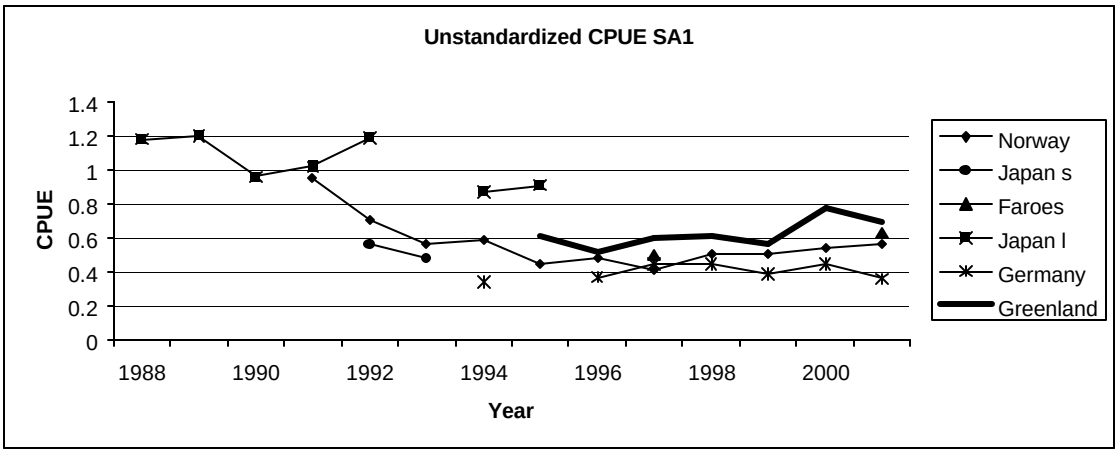

Fig. 8. Unstandardized trawl CPUE series from Div. 1CD.

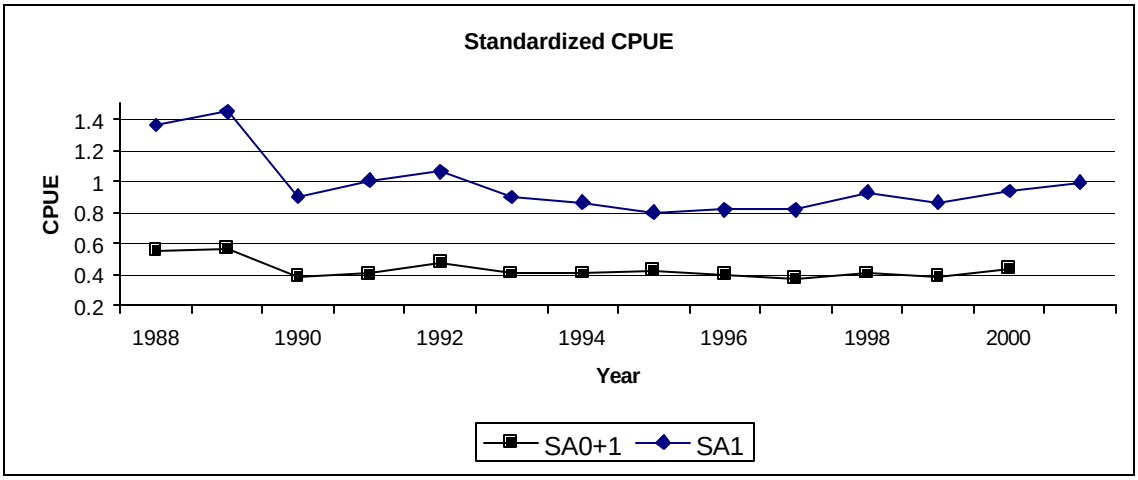

Fig. 9. Standardized trawl CPUE indices from SA1 (Div. 1CD) and SA0+1 (not corrected for retransformation).

Appendix 1. Standardized CPUE index Div.1CD

The SAS System 22
22:02 Sunday, June 9, 2002

The GLM Procedure

Class Level Information

Class	Levels	Values
YR	14	1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
MD	11	1 2 4 5 6 7 8 9 10 11 12
CGT	9	2 3 4 5 6 7 8 9 10

Number of observations 121

The SAS System 23
22:02 Sunday, June 9, 2002

The GLM Procedure

Dependent Variable: lcph

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	19.06548474	0.61501564	8.10	<.0001
Error	89	6.76038286	0.07595936		
Corrected Total	120	25.82586760			

R-Square	Coeff Var	Root MSE	lcph Mean
0.738232	-46.91078	0.275607	-0.587514

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YR	13	10.40553725	0.80042594	10.54	<.0001
MD	10	3.72328518	0.37232852	4.90	<.0001
CGT	8	4.93666231	0.61708279	8.12	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	13	1.20658100	0.09281392	1.22	0.2775
MD	10	2.41392935	0.24139293	3.18	0.0016
CGT	8	4.93666231	0.61708279	8.12	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		-0.006221701 B		0.13350721	-0.05	0.9629
YR	1988	0.314898944 B		0.27582118	1.14	0.2567
YR	1989	0.378156771 B		0.26667624	1.42	0.1597
YR	1990	-0.095749698 B		0.29584241	-0.32	0.7470
YR	1991	0.014720245 B		0.25674374	0.06	0.9544
YR	1992	0.066587550 B		0.25181661	0.26	0.7921
YR	1993	-0.098287890 B		0.29412361	-0.33	0.7390
YR	1994	-0.138847606 B		0.19217280	-0.72	0.4719
YR	1995	-0.215410069 B		0.21942222	-0.98	0.3289
YR	1996	-0.195473428 B		0.11399138	-1.71	0.0899
YR	1997	-0.193045662 B		0.10821583	-1.78	0.0778
YR	1998	-0.067510940 B		0.10826333	-0.62	0.5345

YR	1999	-0.137365663 B	0.11804823	-1.16	0.2477
YR	2000	-0.055703977 B	0.09493603	-0.59	0.5589
YR	2001	0.000000000 B	.	.	.
MD	1	-0.401498114 B	0.22102757	-1.82	0.0727

The GLM Procedure

Dependent Variable: lcph

Parameter		Estimate	Standard Error	t Value	Pr > |t|
MD	2	-1.055703561 B	0.37834879	-2.79	0.0064
MD	4	-0.487300898 B	0.33080944	-1.47	0.1443
MD	5	-0.255849534 B	0.24588513	-1.04	0.3009
MD	6	-0.817363157 B	0.20132419	-4.06	0.0001
MD	7	-0.620157945 B	0.19748663	-3.14	0.0023
MD	8	-0.371605912 B	0.14884018	-2.50	0.0144
MD	9	-0.238471412 B	0.10348042	-2.30	0.0235
MD	10	-0.219365642 B	0.09766436	-2.25	0.0272
MD	11	-0.148985052 B	0.09797333	-1.52	0.1319
MD	12	0.000000000 B	.	.	.
CGT	2	-0.476001599 B	0.13023867	-3.65	0.0004
CGT	3	-0.161189877 B	0.25878485	-0.62	0.5350
CGT	4	-0.601156448 B	0.16048291	-3.75	0.0003
CGT	5	-0.402352059 B	0.30499927	-1.32	0.1905
CGT	6	-0.728550371 B	0.16568861	-4.40	<.0001
CGT	7	0.222544227 B	0.24183744	0.92	0.3599
CGT	8	-0.638948723 B	0.13188876	-4.84	<.0001
CGT	9	-0.229155000 B	0.12913227	-1.77	0.0794
CGT	10	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.