

## **5 COD STOCKS IN THE GREENLAND AREA (NAFO AREA 1 AND ICES SUBDIVISION XIVB)**

### **5.1 Stock definition**

Cod is described a common species in the Greenland fauna, although reaching here its ecological northern boundary. Given suitable environmental conditions, cod in the offshore areas of Greenland are considered to be self-sustaining. Stock parameters, slow growth and poor conditions (Lloret and Rätz 2000), late maturation, and highly variable recruitment strongly affected by environmental conditions, suggest that to be sustainable in long term, exploitation rates would need to be low, particularly in periods of cold water. In productive periods, higher exploitation rates could be sustainable, but it would be advisable to maintain a spawning stock biomass sufficiently large to buffer for brief periods of cold water. In recent years temperature have increased significant in Greenland water, with historic high temperatures registered in 2003 (50 years time series). Recently increased growth rates and earlier maturation as indicated from the surveys might be a response of the stock to such favourable environmental conditions.

For assessment purposes Atlantic cod in Greenland waters is separated into three components: The offshore cod in East and West Greenland waters, West Greenland inshore cod and occasionally Icelandic offspring that are transported with the Irminger current to Greenland water. Historically spawning have occurred in East Greenland offshore water between approximately 62 and 66°N (Jónsson 1959; Meyer 1963), and eggs and larvae are transported towards Southeast and West Greenland (Wieland and Hovgård 2002). In addition, migration of immature cod from East to West Greenland has been seen in some years (Rätz 1994). In west Greenland offshore waters spawning has been observed at the offshore slope of Fylla Bank at 64 °N but more frequently at the various fishing banks further south including the northern part of Julianehåb Bight at 61 °N (Jónsson 1959; Meyer 1963; Diaz 1969). Eggs and larvae are transported along the coast towards Store Hellefisk Bank at about 67 - 68 °N. Spawning have been documented for inshore areas between 64 and 67 °N, where a number of local populations exist.

#### **5.1.1 Cod off Greenland (offshore component)**

Prior to 1996, the cod stocks off Greenland have been divided into West and East Greenland or treated as one stock unit for assessment purposes to avoid migration effects. Fjord populations (inshore) have always been included. In 1996, the offshore component off West and East Greenland, the so called Bank Cod, was assessed separately as one stock unit and distinguished from the inshore populations for the first time. The completion of a re-evaluation of available German sampling data for the offshore catches back to 1955 enabled such an analysis given in the 1996 North-Western Working Group report (ICES 1996/Assess:15). Due to the severely depleted status of the offshore stock component, the directed cod fishery was given up in 1992, the final year in the VPA. Since then, no adequate data were available to update the assessment. Information on the historic VPA is available in ICES 2001/Assess:20. Therefore, the present report only includes updated survey results and catch information.

##### **5.1.1.1 Trends in landings and fisheries (offshore component)**

Officially reported landings are given in Tables 5.1.1 and 5.1.2 for West and East Greenland respectively and includes the inshore landings. Landings as used by the working group are listed in Table 5.1.3 by inshore areas for West Greenland and offshore areas for both West and East Greenland, their trends being illustrated in Figure 5.1.1.

In 1924 the offshore fishery at West Greenland took off and until 1929 the landings increased from 200t to 22000t and exceeded the level of 120 000t in 1931. The next 10 years landings were fluctuating in the range of 60 000 –130 000t (Horsted 2000). During World War II landings decreased by 1/3 as only Greenland and Portugal participated in the fishery. Less is known about cod fisheries at East Greenland waters, but since 1954 landing statistics have been available. In the next 15 years the East Greenland landings were only contributing between 2-10 % of the total offshore landings (Figure 5.1.1.). During a period from the mid 1950s to 1960 the total annual landings taken offshore averaged about 270 000t. In 1962 the offshore landings culminated with landings of 440 000t. After this historic high, landings decreased sharply by 90% to 46 000t in 1974 and even further down in 1977. The level of 40 000t was only exceeded during the periods 1982–83 and 1988–1990. A large changes in effort started in 1970, which increased during exploitation of the strong year classes born in 1973 and 1984. The offshore fishery was closed in 1986 and for the first 10 months in 1987. During 1989–91, the total landings decreased from 125 000t by more than 65% to 41 000t, in West Greenland waters the landings decreased 97% in these three years. Since 1992 no directed cod fishery has taken place offshore at West Greenland, while high quota have been available. In 2003, the officially reported landings amounted to 294t all caught in East Greenland. From total offshore landings, 2t or less than 1% was reported as by-catch in other fisheries. No reports on discards have been available.

Age-1 cod is believed to be caught as by-catch in the shrimp fishery mainly at West Greenland, however no official registrations are available on this subject.

Logbook information about commercial catches and effort has been available from 1990-2003 from the offshore fishery in East Greenland. High landings occurred in the early 1990s reaching close to 35 000t. Since 1994 landings have fluctuated at low levels between 100- 500t. A weighted mean of the CPUE and a GLM model were estimated in the time period to analyse any trends in the stock size. It shows that CPUE decreased dramatically in the early 1990s (5.1.11.). The trend in weighted mean shows a small increase in 1997, but this is probably due to increased fishing power, as the GLM model does not mirror this increase. Both the GLM model and the weighted mean show a small increase in CPUE in 2003. The result of the model should not be interpreted as an indicator of biomass trends as it comprises 1260 factors and only 221 observations, hence only 17% of the cells were accounted for and specially in the last years few ships were accounting for the catches. In 2003, 6 vessels had cod as main target, 1 German, 2 Greenlandic and 3 from the Faroe Island, all used demersal otter board trawls equipped with a mesh size in the codend between 140-145mm.

Miscellaneous gears, mainly long lines and gill nets, contributed 30–40% until 1977 but have disappeared since then (Horsted 2000). At the moment otter trawl board catches (OTB) are the only operating fishing gear and have been the most important throughout the time series for offshore fisheries.

## **5.1.2 Surveys (offshore component)**

### **5.1.2.1 Results of the German groundfish survey off West and East Greenland**

Annual abundance and biomass indices have been derived using stratified random groundfish surveys covering shelf areas and the continental slope off West and East Greenland. Surveys commenced in 1982 and were primarily designed for the assessment of cod (*Gadus morhua* L.). A detailed description of the survey design and determination of these estimates was given in the report ICES 1993/Assess:18 and Working Doc. 12/2004. Figure 5.1.2 indicate names of the 14 strata, their geographic boundaries, depth ranges and areas in nautical square miles (nm<sup>2</sup>). All strata were limited at the 3 mile line offshore except for some inshore regions off East Greenland where there is a lack of adequate bathymetric measurements. In 1984, 1992, and 1994 the survey coverage was incomplete off East Greenland and in 1995 and 2002 in West Greenland partly due to technical problems (Working Doc. 12/2004).

#### **5.1.2.1.1 Stock abundance indices**

Table 5.1.4 lists abundance and biomass indices for West and East Greenland, respectively and then combined for the years 1982–2003. Trends of the biomass estimates for West and East Greenland are shown in Figure 5.1.3, including the spawning stock. The figure illustrate the pronounced increase in stock abundance and biomass indices from 23 million individuals and 45 000t in 1984 to 828 million individuals and 690 000t in 1987. This trend was the result of the recruitment of the predominating year classes 1984 and 1985, which were mainly distributed in the northern and the shallow strata off West Greenland during 1987–89. Such high indices were never observed in strata off East Greenland, although their abundance and biomass estimates increased during the period 1989–91 suggesting an eastward migration. During the period 1987–89, which were years with high abundance, the precision of survey indices was extremely low due to enormous variation in catch per tow data. Since 1988, stock abundance and biomass indices decreased dramatically by 99% to only 5 million fish and 6 000t in 1993. The 2003 survey results confirmed the severely depleted status of the stock, although they represent the highest stock size in 13 years (less than 5% of the abundance in 1987) and indicates a significant recovery signal. The total abundance and biomass indices amounted to 25 million individuals and 53 000t, respectively, were 77% of the stock in numbers were distributed off East Greenland.

#### **5.1.2.1.2 Age composition**

Age disaggregated abundance indices for West, East Greenland and total are listed in Tables 5.1.5–7, respectively, and are based on 1 242 individual age determinations. The recruiting year classes 1998-2002 are considered weak as compared to the strong 1984- and 1985-year classes. The year class 2002 at age 1 however is estimated as the third strongest year class in West Greenland since 1982 and thus to provide some recovery potential in the next few years. The 1999 year class which has earlier been considered relatively strong, are still as age group 4 the third strongest at the East coast, but nearly absent from the west coast. The 0- group indices are considered unrepresentative of year class strength due to gear specifications while the age groups 1 and 2 seem to be quantitatively estimated and to represent a reasonable recruitment index (Figure 5.1.5), the latter being more precise. With this in mind the 0-group index in 2003 from East Greenland waters is by far the largest in the time series (Table 5.1.6.) but there is no basis to predict its size at age 3.

### 5.1.2.1.3 Mean length at age

The trends of the mean length of the age groups 1–10 years for West and East Greenland are illustrated in Figure 5.1.6 and 5.1.7 respectively for the period 1982–2003. They reveal pronounced area and temperature effects. Age groups 3–10 years off East Greenland were found to be significantly longer than those off West Greenland. Driven by the high abundance of cod off West Greenland, weighted mean length and weight for the age groups 1–5 displayed a decrease during 1986–87 and remained at low levels until 1991. Since then, the length at age at ages 3 to 8 years increased significantly and remained at that high level until 2000, when low values were recorded. The 2003 values for East Greenland indicate a small increase in length for the youngest age classes and a stable length for the older age classes. In West Greenland waters a small increase have been registered for all age groups. Mean weight at age can be obtained from regression  $f(x) = 0.00895x^{3.00589}$ , X=length in cm, the equation has been determined on the basis of historic measurements.

### 5.1.2.2 Results of the Greenland groundfish survey off West Greenland

Since 1988, the Greenland Institute of Natural Resources has annually conducted a stratified-random trawl survey off West Greenland from July to September (Working Doc. 3/2004). The main purpose of the survey is to evaluate the biomass and abundance of Northern shrimp (*Pandalus borealis*), but since 1992 data on most fish species have been recorded. The survey covers the offshore areas at West Greenland between 59°00'N and 72°30'N from the 3-mile limit to the 600m (Figure 5.1.8). The survey area is divided into 6 NAFO Divisions, and further subdivided into three depth strata (0-200, 201-400 and 401-600m) on basis of depth contour lines. A minimum of two hauls per stratum is always planned. In 2002 and 2003 the stratification of the survey area changed due to reanalysed depth information, with more detailed information on the isobaths in the area north from 69°30'N and the Julianehåb Bay. The trawl is an Skjervoy 3000/20 with bobbin gear and double bag. The mesh size in the codend is 20 mm. and standard trawling time offshore is 15-30 minutes at a mean towing speed of 2.5 knots. Cod smaller than approximately 20 cm are caught insufficiently due to the distance between the fishing line and the bottom. Stratified abundance and biomass estimates were calculated from catch-per-tow data using the stratum areas as weighting factor (Cochran, 1953). The coefficient of catchability was set at 1.0, implying that estimates are merely indices of abundance and biomass. Confidence intervals (CI) were set at the 95% level of significance of the stratified mean.

#### 5.1.2.2.1 Stock abundance indices

The biomass indices for cod were estimated to be between 4-7000t in the period 1988-1990. In 1992 the biomass decreased with more than 95% to only 217t and remained at this low level until recent years. In 2001 and 2002 a slight increase was detected in the biomass index but in 2003 the biomass level was estimated to be close to 1250t a reduction of 35% compared to last year. Abundance was estimated to be 3.1 millions which is the second highest number in the time series (1992-2003), but a reduction at 25% compared to 2002 (Table 5.1.8 and 5.1.9).

#### 5.1.2.2.2 Age composition

Age disaggregated abundance indices are listed in Table 5.1.10. In 2001, the recruiting year classes 1997, 1998 and 1999 dominated the stock by 94% with equal shares. In 2002, year class 1998 and 1999 contributed to nearly 80% of the total abundance. Their abundance at ages 3 and 4 represent highest values of the time series. Age disaggregated abundance indices for West Greenland indicates occurrence of few year-classes and a dominance of year-class 1998 and 1999. a dominance of year-class 2001 contributing to more than 45% of the total abundance. In 2002, age length keys were determined on the basis of 582 otoliths.

### 5.1.3 Biological sampling of commercial catches

No commercial sampling data were available to assess recent catch in numbers, weight and maturity at age for the offshore areas.

The working group strongly recommends to conduct sampling of commercial catches from the East Greenland offshore areas with the purpose to update the assessment from 1996.

### 5.1.4 State of the stock

A historic XSA tuning was run in 1996 with the final year as 1992 and the output is illustrated in figure 5.1.8. and 5.1.9. The plots indicate the very high and fluctuating fishing mortality as well as periodic good year classes.

The two surveys, the German survey off West and East Greenland and the Greenland shrimp survey off West Greenland, do confirm that the offshore component of the cod off Greenland remains at a very low level.

Both surveys indicate increased recruitment of the year classes 1997, 1998, 1999, 2000 and 2002, the year class 1999 being the third strongest at age 2 since 1982 in the German survey. However, the recruiting year classes were estimated to be less than 10 % of the most recent strong year class of 1984. Although rebuilding to previous high stock sizes cannot be expected to occur based on these year classes, they suggest that the process of rebuilding may have begun.

The age composition of the stock off West Greenland indicates high mortality rates of juvenile cod during the past decade.

The former VPA assessment of the offshore cod stocks off Greenland revealed that over-fishing was an important cause for the collapse of this unit in the beginning of the 70s. Since that time, the spawning stock has remained below 100 000 t and has not been able to produce adequate recruitment. Relatively strong year class were produced in 1973 and 1984 despite the low SSBs, but these are believed to have emigrated from Iceland as larvae. The migration back to Iceland as mature fish further diminished the contribution of those year classes to local egg production. Recruitment pulses from Iceland could contribute to a substantial recovery of the offshore component in the short term. However, strong recruitment pulses are rare events (2 known occurrences in the last 30 years). The links between the cod stocks off Iceland, Greenland and along the Canadian Atlantic shelves through egg and larval drifts were currently investigated by an ICES/GLOBEC project (Wieland and Hovgård, 2002).

### **5.1.5 Management considerations**

As a response to the favourable climate and biological conditions (large shrimp stock and high temperatures) cod could re-colonise the offshore areas and therefore a recovery plan is urgently required to protect the remaining biomass of offshore cod. No fishing should take place until a substantial increase in stock size is evident.

Effective technical measures should be maintained to avoid the by-catch of juvenile cod that are essential to enhance the recovery potential of the stock.

### **5.1.6 Comments on the assessment**

The present assessment is based on survey indices only, due to the termination of the cod directed offshore fishery in 1992.

The VPA assessment conducted in 1996 was affected by several uncertainties in data as well as ecological factors. The effect of emigration was only directly covered for the 1973 and 1984 year classes and had been taken into account by an increase of the natural mortality to 0.3 for age groups 5 and older for all other years. The sampling of commercial catches was historically rather inconsistent and did not cover the 30% taken by miscellaneous gears, mainly longlines and gill nets up to 1977. Since 1991, catch at age and weight at age data had to be calculated using survey data. Maturity data were poorly reported implying uncertainties in spawning stock estimates.

An XSA was attempted in 2004 but not accepted due to incomplete catch at age numbers. Therefore, no XSA tuning has been applied since 1997 when low levels in landings, effort and stock abundance were observed. In 1984, 1992 and 1994 the age disaggregated survey indices were derived from incomplete coverage of the survey area.

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**Table 5.1.1** Nominal catch (t) of Cod in NAFO Sub-area 1, 1988-2003 as officially reported to ICES.

Country	1988	1989	1990	1991	1992	1993	1994	1995
Faroe Islands	-	-	51	1	-	-	-	-
Germany	6.574	12.892	7.515	96	-	-	-	-
Greenland	52.135	92.152	58.816	20.238	5.723	1.924	2.115	1.710
Japan	10	-	-	-	-	-	-	-
Norway	7	2	948	-	-	-	-	-
UK	927	3780	1.631	-	-	-	-	-
Total	59.653	108.826	68.961	20.335	5.723	1.924	2.115	1.710
WG estimate	62.653 <sup>2</sup>	111.567 <sup>3</sup>	98.474 <sup>4</sup>	-	-	-	-	-

Country	1996	1997	1998	1999	2000	2001	2002 <sup>1</sup>	2003 <sup>1</sup>
Faroe Islands	-	-						
Germany	-	-						
Greenland	948	904	319	622	764	1680	3698	3989
Japan	-	-						
Norway	-	-						693 <sup>5</sup>
UK	-	-						
Togo								533 <sup>5</sup>
Total	948	904	319	622	764	1680	3698	5215
WG estimate	-	-	-	-	-	-		

<sup>1</sup>) Provisional data reported by Greenland authorities

<sup>2</sup>) Includes 3,000 t reported to be caught in ICES Sub-area XIV

<sup>3</sup>) Includes 2,741 t reported to be caught in ICES Sub-area XIV

<sup>4</sup>) Includes 29,513 t caught inshore

<sup>5</sup>) Transshipment from local inshore fishers

**Table 5.1.2** Nominal catch (t) of cod in ICES Sub-area XIV, 1988-2003 as officially reported to ICES.

Country	1988	1989	1990	1991	1992	1993	1994	1995
Faroe Islands	12	40	-	-	-	-	1	-
Germany	12.049	10.613	26.419	8.434	5.893	164	24	22
Greenland	345	3.715	4.442	6.677	1.283	241	73	29
Iceland	9	-	-	-	22	-	-	1
Norway	-	-	17	828	1.032	122	14	+
Portugal								
Russia		-	-	-	126		-	-
UK (Engl. and Wales)	-	1.158	2.365	5.333	2.532	-	-	232
UK (Scotland)	-	135	93	528	463	163	-	-
United Kingdom	-	-	-	-	-	46	296	-
Total	12.415	15.661	33.336	21.800	11.351	-	408	284
WG estimate	9.457 <sup>1</sup>	14.669 <sup>2</sup>	33.513 <sup>3</sup>	21.818 <sup>4</sup>	-	736	-	-

Country	1996	1997	1998	1999	2000	2001	2002 <sup>5</sup>	2003 <sup>5</sup>
Faroe Islands	-	-	-	6				
Germany	5	39	128	13	3	92	5	1
Greenland	5	32	37 <sup>5</sup>	+ <sup>5</sup>		4	232	78
Iceland	-	-		-	-	210		
Norway	1	-	+	2	- <sup>5</sup>	43	13	
Portugal			31	-	-	278		
Russia	-	-						
UK (E/W/NI)	181	284	149	95	149	129		
UK (Scotland)	-	-						
United Kingdom							34	
Total	192	355	345	116	152	756	284	79
WG estimate	-	-	-	-	-		448 <sup>6</sup>	294 <sup>7</sup>

<sup>1</sup>) Excluding 3,000t assumed to be from NAFO Division 1F and including 42t taken by Japan

<sup>2</sup>) Excluding 2,74 t assumed to be from NAFO Division 1F and including 1,500t reported from other areas assumed to be from Sub-area XIV and including 94t by Japan and 155t by Greenland (Horsted, 1994)

<sup>3</sup>) Includes 129t by Japan and 48 t additional catches by Greenland (Horsted, 1994)

<sup>4</sup>) Includes 18t by Japan

<sup>5</sup>) Provisional data

<sup>6</sup>) Includes 164t from Faroe Islands

<sup>7</sup>) Includes 215t from Faroe Islands

**Table 5.1.3** Cod off Greenland (offshore component). Catches (t) from 1924 – 2003 as used by the Working Group, inshore and offshore by NAFO div 1Band 1D offshore divided into East and West Greenland. Based on Horsted (1994, 2000).

Cod	Inshore		Offshore			Total	
	Nafo 1 B	Nafo 1D	Total inshore	East	West	Total offshore	Greenland
1924	131	221	843		200	200	1043
1925	122	318	1024		1871	1871	2895
1926	97	673	2224		4452	4452	6676
1927	282	982	3570		4427	4427	7997
1928	426	1153	4163		5871	5871	10034
1929	1479	1335	7080		22304	22304	29384
1930	2208	1681	9658		94722	94722	104380
1931	1905	1520	9054		120858	120858	129912
1932	1713	1042	9232		87273	87273	96505
1933	1799	1148	8238		54351	54351	62589
1934	2080	952	9468		88122	88122	97590
1935	1870	769	7526		65846	65846	73372
1936	2039	705	7174		125972	125972	133146
1937	1982	854	6961		90296	90296	97257
1938	1743	703	5492		90042	90042	95534
1939	2256	896	7161		89807	89807	96968
1940	2478	1061	8026		43122	43122	51148
1941	3229	823	8622		35000	35000	43622
1942	3831	1332	12027		40814	40814	52841
1943	5056	1240	13026		47400	47400	60426
1944	4322	1547	13385		51627	51627	65012
1945	4987	1207	14289		45800	45800	60089
1946	5210	1438	15262		44395	44395	59657
1947	5261	2096	18029		63458	63458	81487
1948	5660	1657	18675		109058	109058	127733
1949	4580	2110	17050		156015	156015	173065
1950	6358	2357	21173		179398	179398	200571
1951	5322	2571	18200		222340	222340	240540
1952	4443	2437	16726		317545	317545	334271
1953	5030	5513	22651		225017	225017	247668
1954	6164	3275	18698	4321	286120	290441	309139
1955	5523	4061	19787	5135	247931	253066	272853
1956	5373	5127	21028	12887	302617	315504	336532
1957	6146	5257	24593	10453	246042	256495	281088
1958	6178	5456	25802	10915	294119	305034	330836
1959	6404	5009	27577	19178	207665	226843	254420
1960	6741	3614	27099	23914	215737	239651	266750
1961	6569	4178	33965	19690	313626	333316	367281
1962	7809	3824	35380	17315	425278	442593	477973
1963	4877	2804	23269	23057	405441	428498	451767
1964	3311	8766	21986	35577	327752	363329	385315
1965	5209	6046	24322	17497	342395	359892	384214
1966	8738	7022	29076	12870	339130	352000	381076
1967	5658	6747	27524	24732	401955	426687	454211
1968	1669	6123	20587	15701	373013	388714	409301
1969	1767	7540	21492	17771	193163	210934	232426

**Table 5.1.3** Cod off Greenland (offshore component). Continued.

Year	Naf0 1 B	Naf0 1D	Total inshore	East	West	Total offshore	Greenland
1970	1469	3661	15613	20907	97891	118798	134411
1971	1807	3802	13506	32616	107674	140290	153796
1972	1855	3973	14645	26629	95974	122603	137248
1973	1362	3682	9622	11752	53320	65072	74694
1974	926	2588	8638	6553	39396	45949	54587
1975	1038	1269	6557	5925	41352	47277	53834
1976	644	904	5174	13027	28114	41141	46315
1977	580	2946	13999	8775	23997	32772	46771
1978	1587	2614	19679	7827	18852	26679	46358
1979	1768	6378	35590	8974	12315	21289	56879
1980	2303	7781	38571	11244	8291	19535	58106
1981	2810	6119	39703	10381	13753	24134	63837
1982	2448	7186	26664	20929	30342	51271	77935
1983	2803	7330	28652	13378	27825	41203	69855
1984	3908	5414	19958	8914	13458	22372	42330
1985	2936	1976	8441	2112	6437	8549	16990
1986	1038	1209	5302	4755	1301	6056	11358
1987	2995	8110	18486	6909	3937	10846	29332
1988	6294	2992	18791	12457	36824	49281	68072
1989	8491	8212	38529	15910	70295	86205	124734
1990	9857	9826	28799	33508	40162	73670	102469
1991	8641	2782	18311	21596	2024	23620	41931
1992	2710	1070	5723	11349	4	11353	17076
1993	323	968	1924	1135	0	1135	3059
1994	332	914	2115	437	0	437	2552
1995	521	332	1710	284	0	284	1994
1996	211	164	948	192	0	192	1140
1997	446	99	1186	370	0	370	1556
1998	118	78	323	346	0	346	669
1999	142	336	622	112	0	112	734
2000	266	332	764	100	0	100	864
2001	1183	54	1680	221	0	221	1901
2002	1803	214	3698*	448	0	448	4146*
2003	1522	274	5215*	286	7	293	5515*

**Table 5.1.4** Cod off Greenland (offshore component), German survey. Abundance (1000) and biomass indices (t) for West, East Greenland and total by stratum, 1982-2003. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance. () incorrect due to incomplete sampling.

YEAR	Abundance					Biomass				
	WEST	EAST	TOTAL	CI	Spawn. St.	WEST	EAST	TOTAL	CI	Spawn. St.
1982	92276	8090	100366	28	33793	128491	23617	152107	25	79511
1983	50204	7991	58195	25	23889	82374	34157	116531	25	57223
1984	16684	(6603)	(23286)	32	17653	25566	(19744)	(45309)	34	36162
1985	59343	12404	71747	33	17349	35672	33565	69236	39	45630
1986	145682	15234	160915	32	14350	86719	41185	127902	26	48976
1987	786392	41635	828026	59	25467	638588	51592	690181	63	65584
1988	626493	23588	650080	48	128578	607988	52946	660935	46	155556
1989	358725	91732	450459	59	332589	333850	239546	573395	46	514773
1990	34525	25254	59777	43	46355	34431	65964	100395	34	77064
1991	4805	10407	15213	29	6404	5150	32751	37901	36	17756
1992	2043	(658)	(2700)	50	560	607	(1216)	(1823)	69	1091
1993	1437	3301	4738	36	2327	359	5600	5959	41	4024
1994	574	(801)	(1375)	36	457	140	(2792)	(2930)	68	1732
1995	278	7187	7463	93	2340	57	15525	15581	155	10445
1996	811	1447	2257	38	592	373	3599	3973	56	2017
1997	315	4153	4469	75	3411	284	13722	14007	90	10416
1998	1723	1671	3394	54	1133	130	4348	4479	91	3820
1999	912	2769	3681	34	809	240	3917	4157	62	3004
2000	1926	4816	6742	36	3556	570	4778	5349	40	4176
2001	8160	7604	15764	39	8252	2666	15271	17937	42	13381
2002	4121	9691	13812	41	11689	2110	19726	21836	51	21299
2003	5632	19904	25537	45	19520	2264	50867	53131	73	50967

**Table 5.1.5** Cod off West Greenland (offshore component), German survey. Age disaggregate abundance indices (1000), 1982-2003. \*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES 1984/Assess:5).

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	0	176	884	33470	11368	32504	9528	2622	578	939	91	90	92250
*1983	0	0	1469	2815	26619	4960	10969	1882	992	317	168	13	50204
1984	159	5	38	2070	1531	9848	842	1873	87	186	27	0	16666
1985	831	38016	1481	948	6403	2833	7682	467	646	27	35	0	59369
1986	0	14148	112532	4089	903	6823	2095	4271	133	616	34	39	145683
1987	0	317	45473	692567	24230	5929	11813	1637	4006	0	366	30	786368
1988	0	257	3332	102767	510980	5425	613	1122	654	1274	32	35	626491
1989	12	204	2461	3565	93687	254002	3934	0	535	114	228	0	358742
1990	159	47	1007	3005	1244	21724	7221	47	0	0	0	19	34473
1991	0	293	224	476	1397	164	1894	317	6	0	0	0	4771
1992	0	263	1427	220	36	77	0	28	0	0	0	0	2051
1993	0	10	832	544	20	28	6	0	0	0	0	0	1440
1994	0	283	45	199	38	5	0	5	0	0	0	0	575
1995	0	0	241	16	22	0	0	0	0	0	0	0	279
1996	0	147	11	638	10	0	10	0	0	0	0	0	816
1997	0	12	27	15	263	0	0	0	0	0	0	0	317
1998	48	1642	0	0	5	25	0	0	0	0	0	0	1720
1999	29	401	392	87	7	0	6	0	0	0	0	0	922
2000	0	165	1015	615	116	0	0	0	0	0	0	0	1911
2001	0	620	6202	1100	159	51	0	0	0	0	0	0	8132
2002	12	13	1061	2972	64	0	0	0	0	0	0	0	4122
2003	68	3225	392	1090	743	93	25	0	0	0	0	0	5636

**Table 5.1.6** Cod off East Greenland (offshore component), German survey. Age disaggregate abundance indices (1000), 1982-2003. \*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES 1984/Assess:5). () incomplete sampling.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	0	0	239	841	1764	1999	1227	379	130	1392	73	72	8116
*1983	0	0	411	605	1008	1187	2125	1287	302	265	703	101	7994
(1984)	0	18	74	1342	657	1397	855	1617	407	103	36	95	6601
1985	230	1932	556	118	2494	2034	1852	785	2000	295	56	36	12388
1986	0	1397	3351	1693	551	2417	1120	2191	566	1627	116	139	15168
1987	0	13	13785	17788	3890	1027	1770	457	1571	187	1093	36	41617
1988	11	25	163	6982	11094	2016	480	1435	152	674	98	469	23599
1989	0	7	179	489	17396	63216	3021	294	4870	406	1795	42	91715
1990	0	38	80	551	462	5128	18012	265	72	251	0	349	25208
1991	0	106	377	394	685	147	3512	5035	81	37	11	9	10394
(1992)	15	44	77	74	69	54	47	143	52	0	0	6	581
1993	0	17	44	1857	370	279	278	88	272	95	0	0	3300
(1994)	0	87	0	29	261	143	87	145	0	29	0	0	781
1995	0	7	2523	1125	370	1730	450	141	460	36	217	125	7184
1996	0	0	0	502	258	295	255	60	77	0	0	0	1447
1997	0	0	37	28	1508	1611	566	236	140	0	0	19	4145
1998	63	240	192	21	45	462	435	156	43	0	0	0	1657
1999	191	632	665	417	138	302	179	200	0	35	24	0	2783
2000	0	808	1074	1341	787	157	291	75	141	115	31	0	4820
2001	0	309	944	1468	2244	1349	705	211	191	73	36	9	7539
2002	96	8	415	1824	2026	2080	1952	889	235	83	36	30	9674
2003	1102	585	141	1067	4530	4285	4486	2374	1074	188	0	25	19857

**Table 5.1.7** Cod off Greenland (total offshore component), German survey. Age disaggregate abundance indices (1000), 1982-2003. \*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES 1984/Assess:5). () incomplete sampling.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	0	176	1123	34311	13132	34503	10755	3001	708	2331	164	162	100366
*1983	0	0	1880	3420	27627	6147	13094	3169	1294	582	871	1140	58198
(1984)	159	23	112	3412	2188	11245	1697	3490	494	289	63	95	23267
1985	1061	39948	2037	1066	8897	4867	9534	1252	2646	322	91	36	71757
1986	0	15545	115883	5782	1454	9240	3215	6462	699	2243	150	178	160851
1987	0	330	59258	710355	28120	6956	13583	2094	5577	187	1459	66	827985
1988	11	282	3495	109749	522074	7441	1093	2557	806	1948	130	504	650090
1989	12	211	2640	4054	111083	317218	6955	294	5405	520	2023	42	450457
1990	159	85	1087	3556	1706	26852	25233	312	72	251	0	368	59681
1991	0	399	601	870	2082	311	5406	5352	87	37	11	9	15165
(1992)	15	307	1504	294	105	131	47	171	52	0	0	6	2632
1993	0	27	876	2401	390	307	284	88	272	95	0	0	4740
(1994)	0	370	45	228	299	148	87	150	0	29	0	0	1356
1995	0	7	2764	1141	392	1730	450	141	460	36	217	125	7463
1996	0	147	11	1140	268	295	265	60	77	0	0	0	2263
1997	0	12	64	43	1771	1611	566	236	140	0	0	19	4462
1998	111	1882	192	21	50	487	435	156	43	0	0	0	3377
1999	220	1033	1057	504	145	302	185	200	0	35	24	0	3705
2000	0	973	2089	1956	903	157	291	75	141	115	31	0	6731
2001	0	929	7146	2568	2403	1400	705	211	191	73	36	9	15671
2002	108	21	1476	4796	2090	2080	1952	889	235	83	36	30	13796
2003	1170	3810	533	2157	5273	4378	4511	2374	1074	188	0	25	25493

**Table 5.1.8** Cod off Greenland (offshore component), Greenland survey. Abundance indices (1000) for West Greenland by stratum, 1991-2003. Confidence intervals (CI) are given in percent of the stratified mean at 95% level of significance. ( ) incorrect due to incomplete sampling.

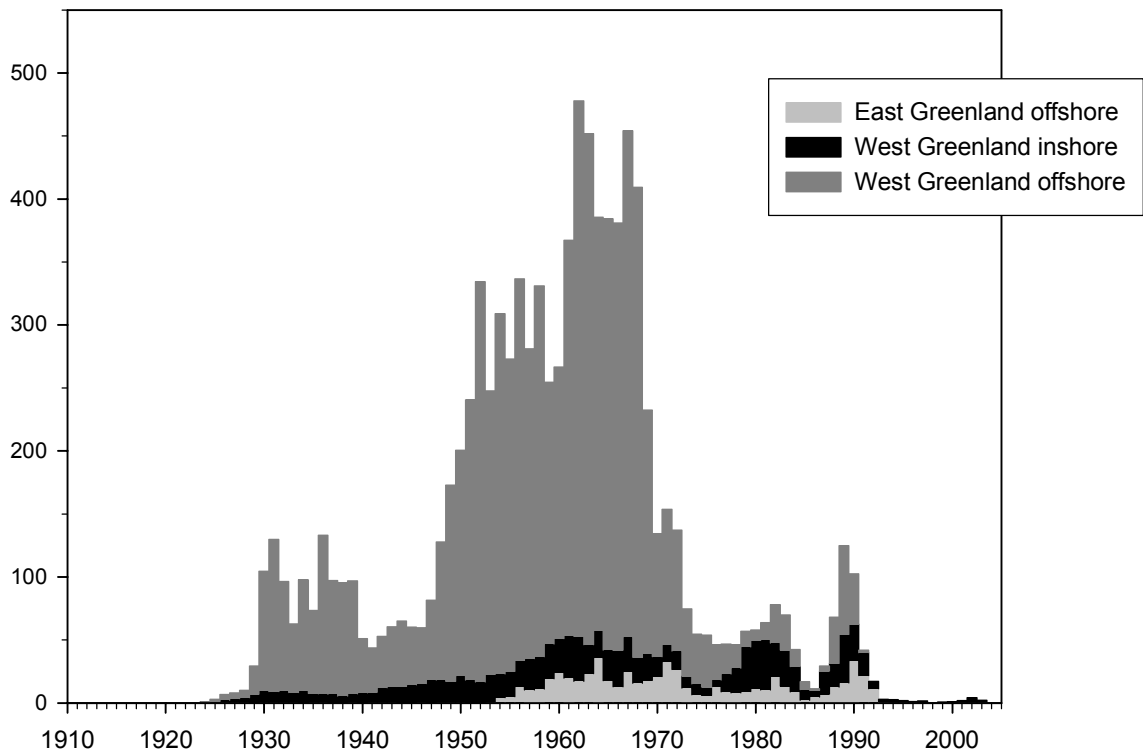
Year	1AN	1AS	1AX	1BN	1BS	1C	1D	1E	1F	West.	CI
1991	*	0	11	7	32	429	78	*	*	(528)	73
1992	0	0	4	16	33	242	242	0	9	547	45
1993	0	0	0	0	0	54	36	205	12	308	67
1994	9	0	0	0	54	98	0	7	0	167	43
1995	0	0	0	33	17	504	42	20	46	662	58
1996	0	0	0	0	0	47	78	66	108	298	40
1997	0	0	0	2	8	35	0	0	0	45	64
1998	0	0	0	5	0	0	25	28	4	62	44
1999	0	10	18	141	52	17	18	8	0	261	41
2000	0	188	273	311	201	86	47	9	205	1321	19
2001	0	0	15	249	86	140	498	210	373	1570	23
2002	0	0	9	75	172	99	3595	102	202	4254	52
2003	0	122	128	1419	39	351	727	214	139	3139	23

**Table 5.1.9** Cod off Greenland (offshore component), Greenland survey. Biomass indices (t) for West Greenland by stratum, 1988-2003. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance. ( ) incorrect due to incomplete sampling.

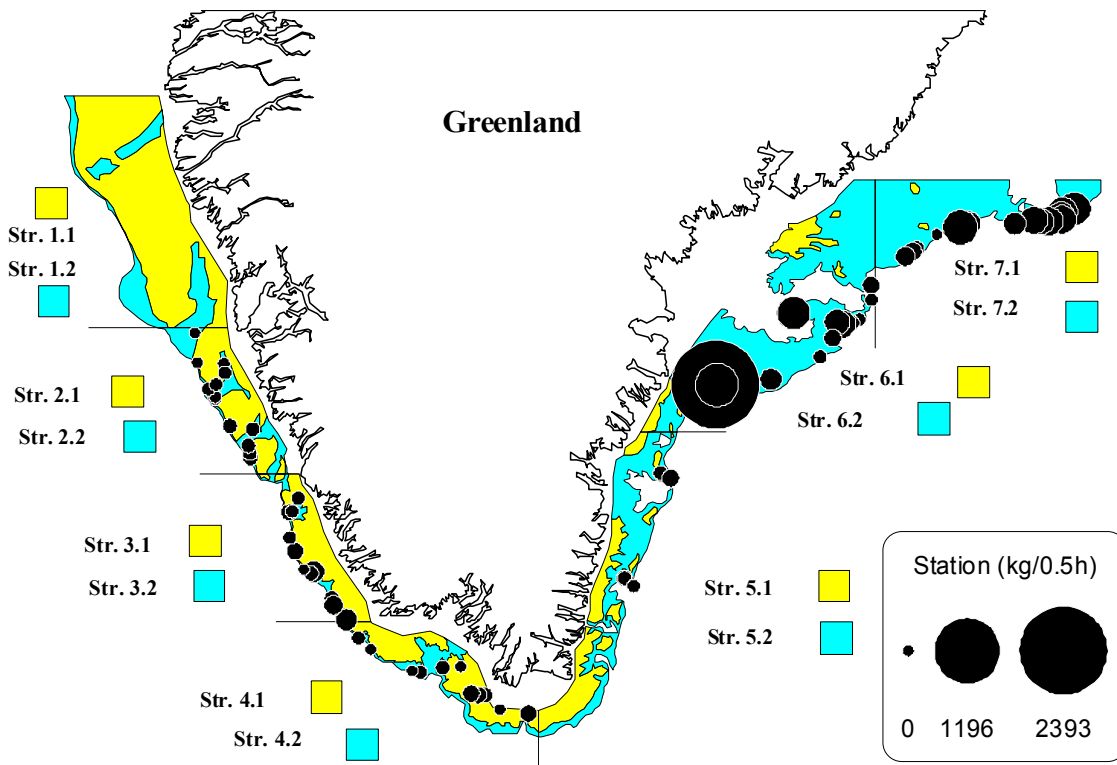
Year	1AN	1AS	1AX	1BN	1BS	1C	1D	1E	1F	West.	CI
1988	0	0	*	35	0	1230	2613	*	*	(3879)	81
1989	44	0	*	73	0	41	1002	*	*	(1217)	51
1990	4	13	*	7	7	118	6825	*	*	(7004)	45
1991	*	0	7	1	2	188	53	*	*	(250)	58
1992	0	0	3	22	31	74	85	0	2	217	44
1993	0	0	0	0	0	24	8	87	4	122	69
1994	0	3	0	0	12	41	0	1	0	58	43
1995	0	0	0	3	2	158	22	2	5	190	67
1996	0	0	0	0	0	16	26	21	49	112	41
1997	0	0	0	2	2	60	0	0	0	64	65
1998	0	0	0	<1	0	0	55	57	4	117	43
1999	0	1	4	38	5	<1	13	1	0	64	31
2000	0	63	65	80	60	27	6	2	56	360	20
2001	0	0	9	126	38	72	186	67	110	609	26
2002	0	0	9	59	96	52	1629	38	87	1967	48
2003	0	20	27	341	8	264	453	118	29	1260	27

**Table 5.1.10** Cod off Greenland (offshore component), Greenland survey. Age disaggregate abundance indices (1000) for West Greenland, 1992-2003.

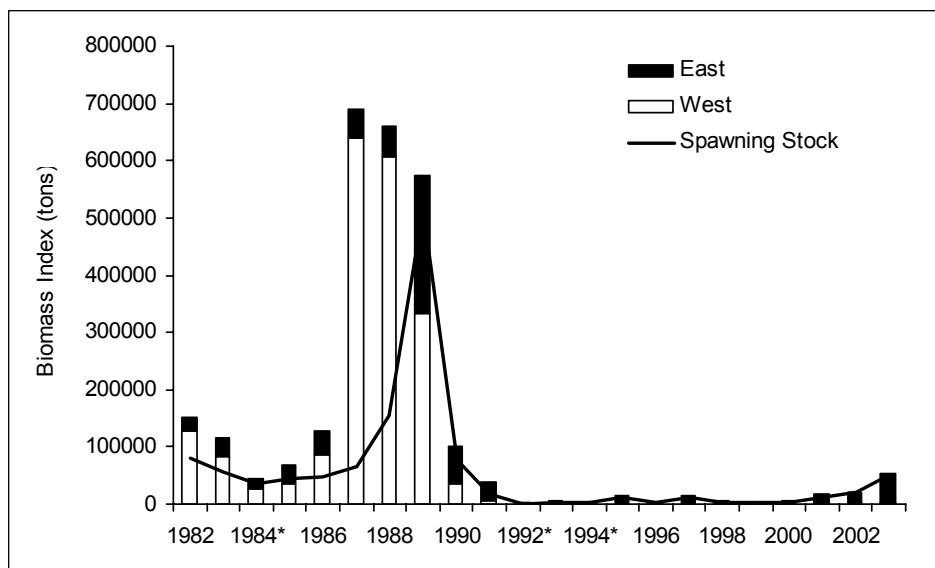
YEAR	1	2	3	4	5	6	7	8+	TOTAL
1992	0	221	126	123	63	10	3	1	547
1993	0	39	170	73	16	7	1	2	308
1994	0	10	126	22	8	1	0	0	167
1995	19	345	101	157	40	0	0	0	662
1996	0	14	203	78	3	0	0	0	298
1997	0	0	10	3	24	8	1	0	46
1998	0	17	25	20	0	0	0	0	62
1999	7	144	66	23	6	1	1	1	249
2000	90	711	363	92	13	52	0	0	1321
2001	97	540	546	376	0	0	0	0	1559
2002	0	603	2323	1078	245	0	4	0	4253
2003	81	1416	1037	433	135	18	0	0	3120



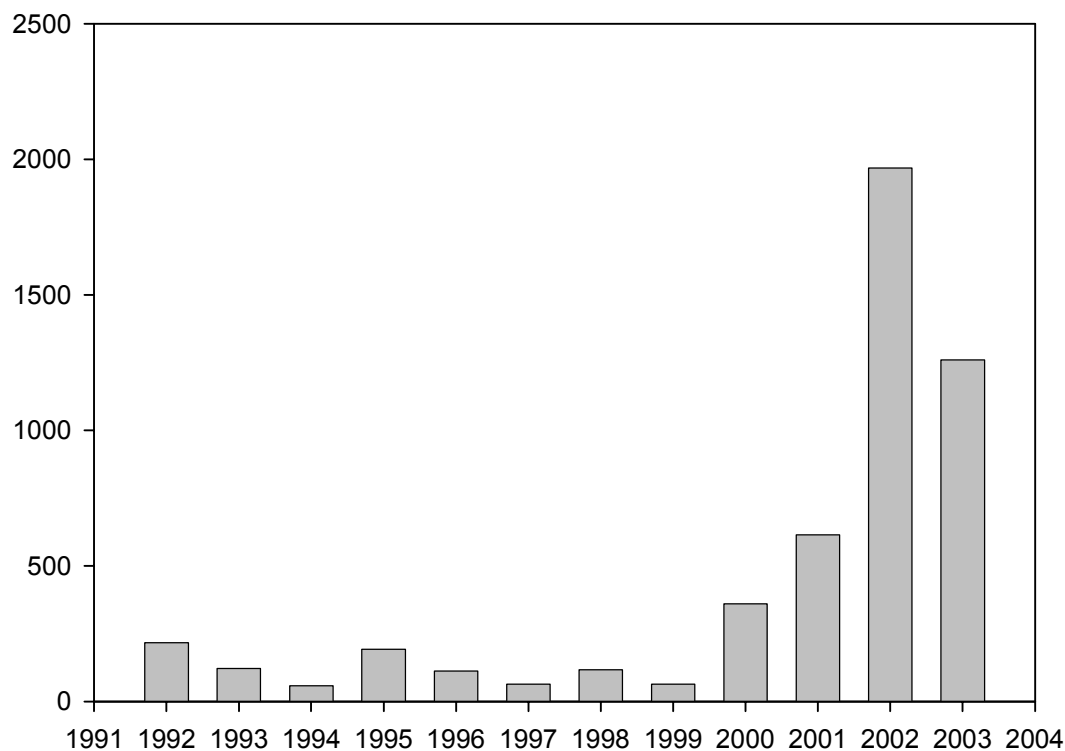
**Figure 5.1.1** Cod off Greenland. Catches 1911-2003 as used by the Working Group, inshore and offshore by West and East Greenland (Horsted 1994,2000).



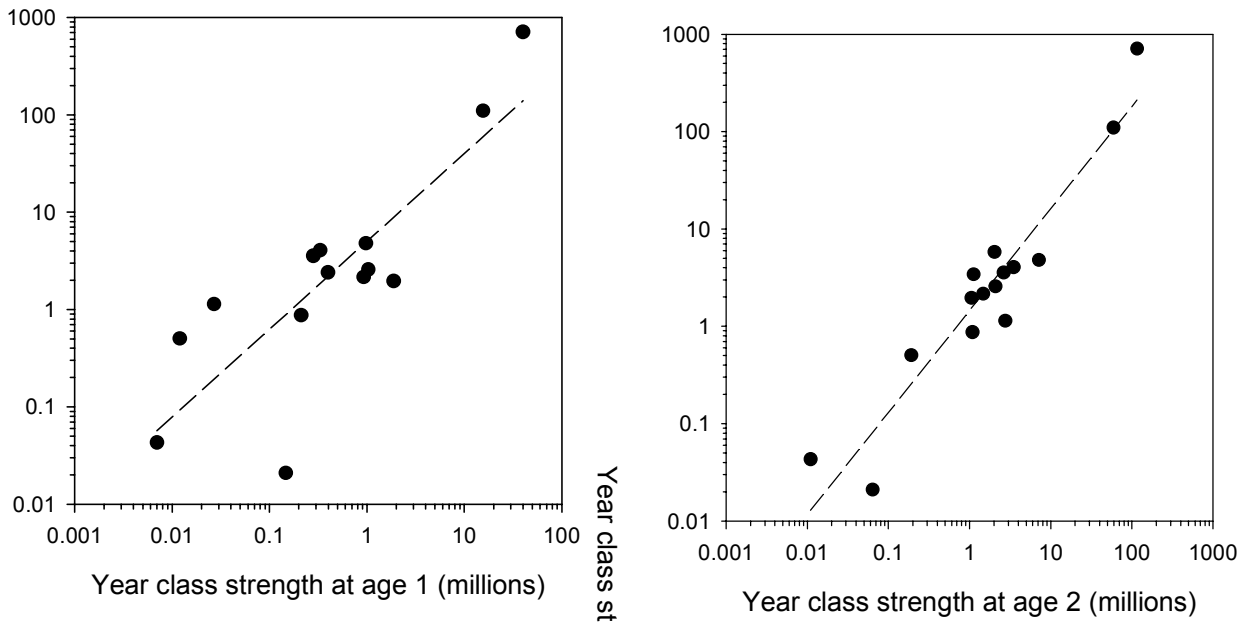
**Figure 5.1.2** Cod off Greenland (offshore component), German survey. Survey area, stratification and position of hauls carried out in 2003.



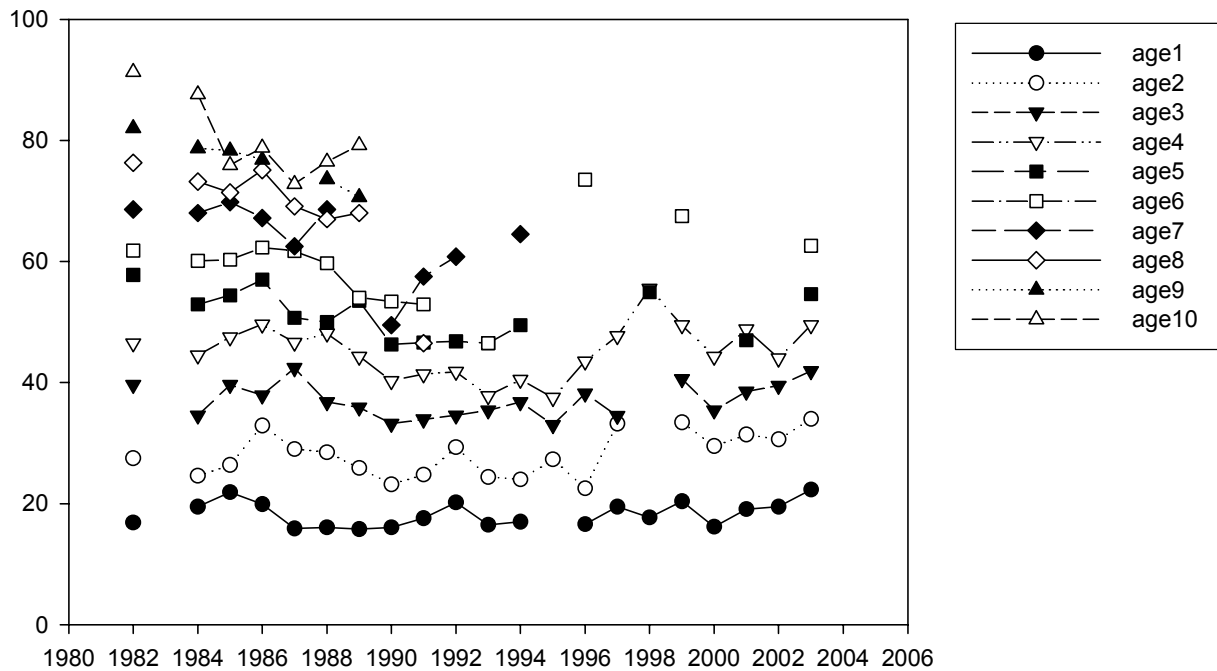
**Figure 5.13** Cod off Greenland (offshore component), German survey. Aggregated survey biomass indices for West and East Greenland and spawning stock biomass, 1982-2003. \*)incomplete survey coverage.



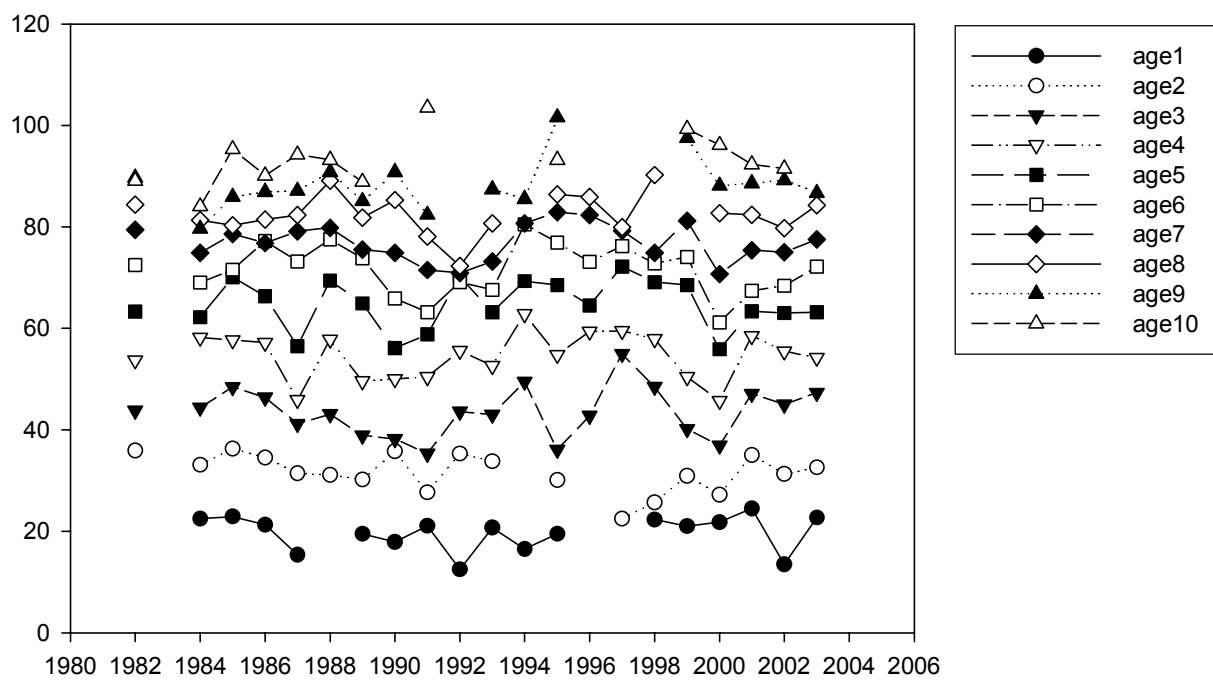
**Figure 5.14** Cod off Greenland (offshore component), Greenland survey. Aggregated survey biomass indices for West Greenland, 1992-2003.



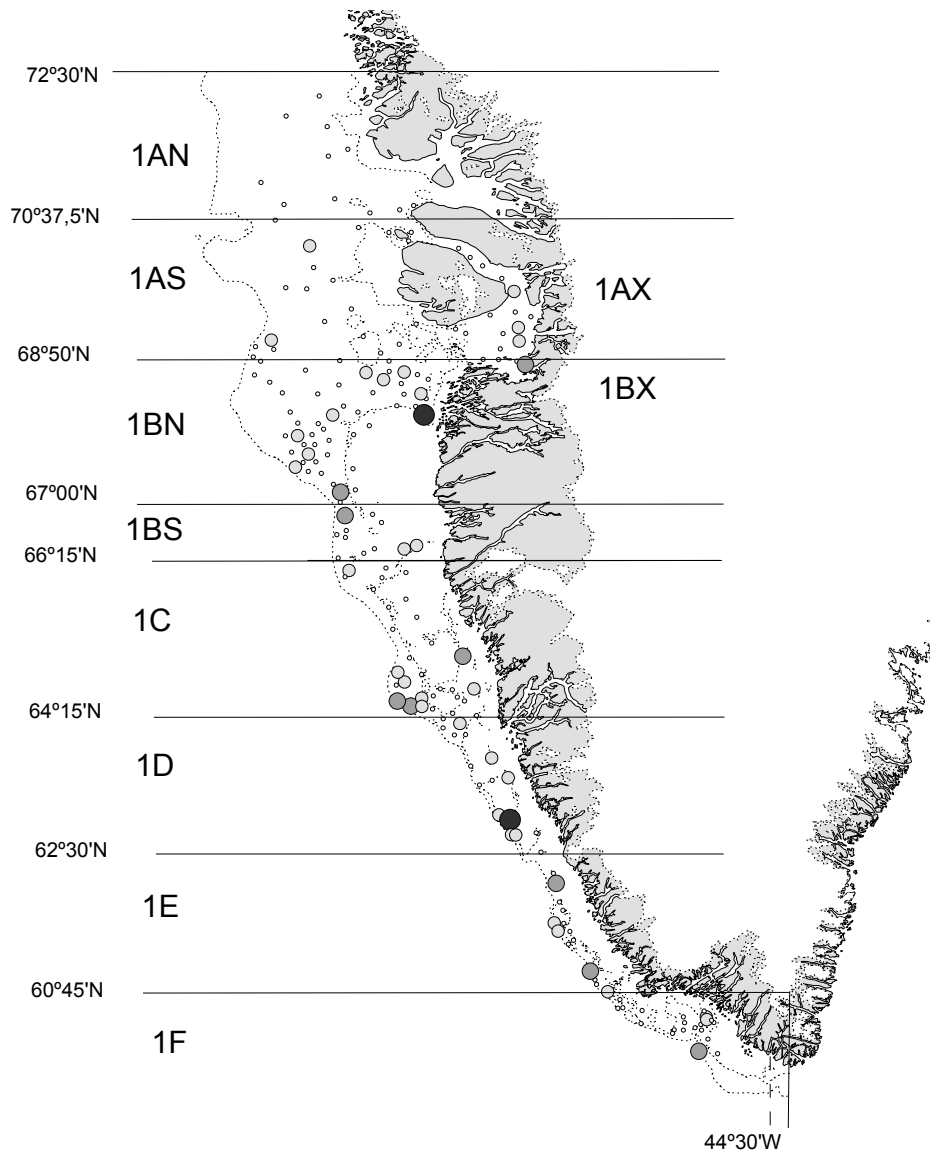
**Figure 5.1.5** Comparison of survey estimates of abundance at age 3 in a given year with age 1 two years earlier ( $r^2=0.69$ ) and with age 2 one year earlier ( $r^2=0.90$ ) for East and West Greenland offshore cod. Years with incomplete coverage off East Greenland omitted. Data derived from the German survey.



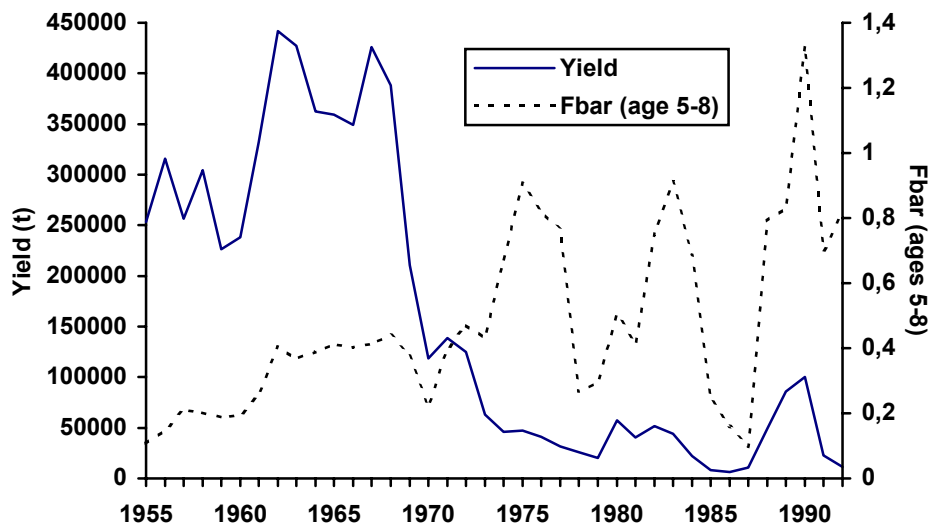
**Figure 5.1.6** Weighted mean length at age 1-10 years 1982, 1984-2003 sampled in West Greenland. Data derived from German survey.



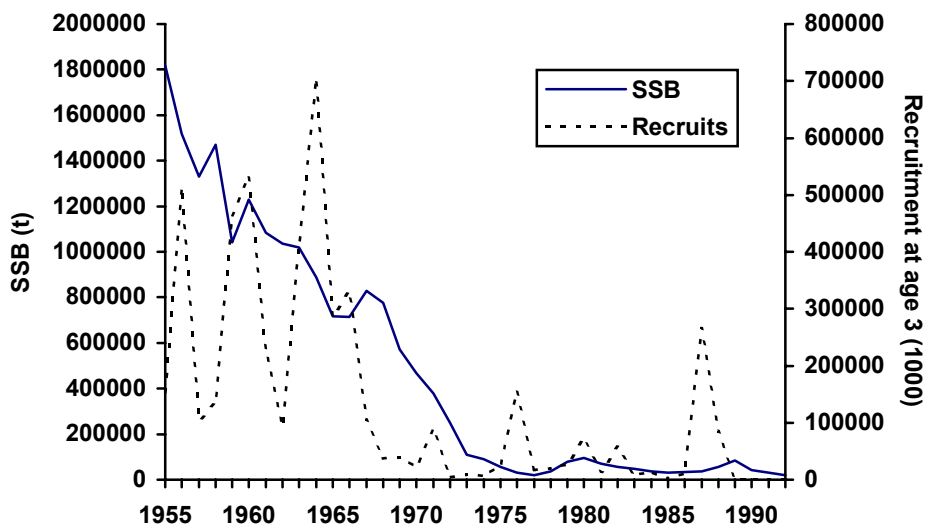
**Figure 5.1.7** Weighted mean length at age 1-10 years 1982, 1984-2003 sampled in East Greenland. Data derived from German survey.



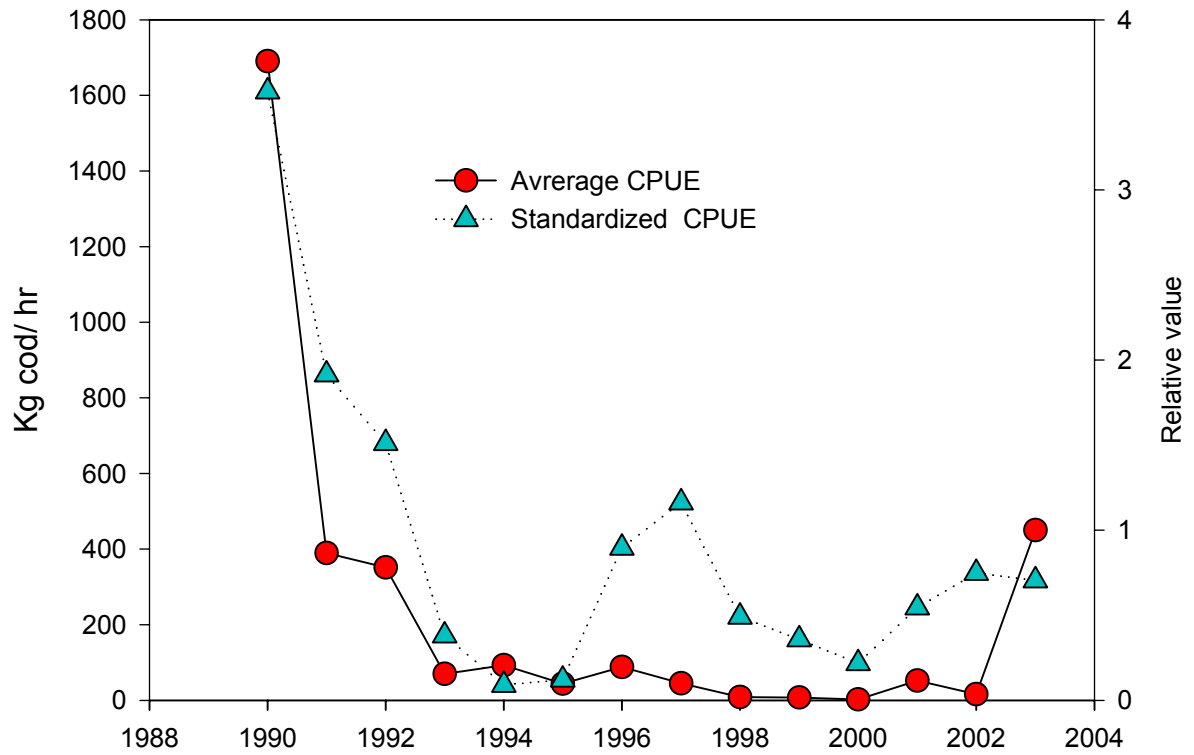
**Figure 5.1.8** Number of cod /hour trawl off Greenland (offshore component), Greenland survey. Survey area, stratification and position of hauls carried out in 2003.



**Figure 5.1.9** Greenland cod (offshore component). Trends in yield and fishing mortality.



**Figure 5.1.10** Greenland cod (offshore component). Trends in spawning stock biomass (SSB) and recruitment.



**Figure 5.1.11.** Average CPUE and standardized CPUE from the East Greenland offshore fishing fleet. 7 ships are used in standardized (GLM) model and in the period 1990 – 2003. 17% of the cells were accounted for.

## 5.2 Inshore cod stock off Greenland

Spawning cod is documented for several fjords and costal areas between 64 and 67°N in West Greenland (Hansen 1949, Smidt 1979, Buch *et al.*, 1994). The inshore cod populations are believed to be relatively stationary, as most (82-86%) of the cod recaptured were found in the same area as they were tagged (Hovgård and Christensen 1990). Some interactions between the offshore and inshore cod stocks probably exist as the strong 1984- and partly 1985 year-class was registered in the inshore gillnet survey as well as in the inshore landings. These strong year-classes are believed to be Icelandic cod spawned off South-western Iceland. Some year's larvae are carried by the Irminger current to settle in South and West Greenland and contribute to the local fjord populations (Wieland and Hovgaard 2002).

### 5.2.1 Trends in Landings and Effort

The Greenland commercial cod fishery started locally in West Greenland in 1911 at some localities where cod seemed to occur regularly during summer and autumn. It took 15 years to reach 1 000t (Hansen 1949). In 1924 an offshore fishery started and until 1974 the inshore landings have been of limited importance accounting for only 5-15% of the total fishery in Greenland water. Annual catches above 20 000t have been taken inshore during the period 1955-1969 and in 1980 and 1989 catches of approximately 40 000t were landed, partly driven by a few strong year classes entering from the offshore stock (Horsted 2000). Due to the very low offshore landings the importance of the inshore landings has increased accounting for between 50-90% landings in the period 1993 –2003. In the same period the inshore landings have been fluctuating between 500-4 000t.

A historic low was reached in 1998 with a total inshore catch at 326t, the lowest catch registered since 1918. Since 1998, slight improvements have been registered with catches increasing to approximately 4000t in 2002. Preliminary catch statistics for 2003 are at 4000t where the two Northern NAFO division are accounting for approximately 2/3 of the total inshore landings (table 5.2.1). Besides 1250t have been transhipped from local inshore areas to foreign vessels (Table 5.1.1.)

Pound nets are used to take about 50% of the inshore catch, handline, longline and set gillnets are accounting for 30%. Peak fishing time is June and July where more than 50% of the catches are taken.

A commercial pound net CPUE series is available between 1992-1999. The mean catch per pound net setting decreased from 804 t in 1994 to 284 in 1999. No commercial effort data from 2000 to 2002 and catch at age data in 1997-1998 and 2000-2001 have been available to the working group. The catch at age sampling from 2003 is not considered representative as weight at age has increased unrealistic since 2002 (Table 5.2.3). Therefore, the weight at age from 2002 was used in the CAM-model.

Commercial samples 2003			
Samples	Length	Otolith	Weight
8	4372	132	132

### 5.2.2 West Greenland young cod survey

A survey using gangs of gill nets with different mesh-sizes has been conducted since 1985 with the objective to assess the abundance and distribution of pre-recruit cod in inshore areas of Greenland. The survey has usually been carried out in three inshore areas off West Greenland: Qaqortoq (NAFO Div. 1F), Nuuk (Div. 1D) and Sisimiut (Div. 1B). The Greenland inshore cod stock is not distributed in the Qaqortoq area, but occasional inflow of pre-recruited cod from East Greenland and Iceland shows up here. Technical problems caused that only Division 1D was covered in 1999, and again in 2000 only Div. 1D and Div. 1F was covered. A more detailed description of the survey is provided in the 2001 report and WD 3/2004. No survey took place in 2001, in 2003 Div. 1B and 1D were covered.

The recruitment index of 2-year old cod is shown in Figure 5.2.1 and reveals a strong 1984 -year class. Between 1996 and 2000 the recruitment index was very low. An increase in 2-year recruits was observed in 2002 Div 1B, reaching the levels from 1986-87 suggesting a strong 2000 year-class in this division however as this area has not been covered during the three previous years, the size of the year class remains uncertain. The overall survey results for 2003 indicate a decrease of the recruitment index in division 1B compared to the relative large value from last year and slightly below average (1985-2003). The recruitment index for division 1D is still at a very low level.

### **5.2.3 Assessment of the stocks**

Previously an Schaefer general production model was fitted to the Greenland inshore cod landing data using the commercial pound net CPUE results for 1993 to 1997 as an index of stock biomass. Lack of contrast in data impeded the model to run satisfactory.

Catch-at-age and weight-at-age data for the period 1985-1996 and for 1999 and 2002-2003 were available to the working group (Table 5.2.2 and 5.2.3). A statistical age structured model implemented MS Excel on the inshore cod stock was used by the working group in 2003 as an exploratory tool to estimate the likely historical stock and exploitation dynamics. The model has been updated this year but due to insufficient data it was not accepted by the working group for assessment purpose (ICES CM 2003/ACFM:24, WD XX).

### **5.2.4 Status of the stock**

The exploitation rate of the stock is unknown as no logbook information is available. The survey data presented indicate that the stock has undergone a series of poor recruitment in recent years, but recovery potential was observed in Div. 1B in 2002.

### **5.2.5 Biological reference points**

No specific values can be put forward as reference points due to the depleted state of the stocks.

### **5.2.6 Management Considerations**

The inshore fishery exploiting possible self-sustained local fjord populations off West Greenland has historically been small, and the fishery has never been regulated. The data from the commercial fishery are considered insufficient to provide advice. If advice is required, additional information from the commercial fishery would be required. In particular logbook information would be very valuable. A recovery plan should be developed for this stock.

**Table 5.2.1** Cod catches divided to NAFO -divisions, caught inshore from vessels < 50 GRT (Horsted 2000, Statistic Greenland 2003). <sup>1</sup>Including 1258t transshipped from local inshore fishers to foreign vessels.

Year\Div	Nafo 1A	Nafo 1B	Nafo 1C	Nafo 1D	Nafo 1E	Nafo 1F	Total
1984	175	3908	1889	5414	1149	1333	19958
1985	149	2936	957	1976	1178	1245	8441
1986	76	1038	255	1209	1456	1268	5302
1987	97	2995	536	8110	4560	1678	8402
1988	333	6294	1342	2992	3346	4484	22829
1989	634	8491	5671	8212	10845	4676	28529
1990	476	9857	1482	9826	1917	5241	29026
1991	876	8641	917	2782	1089	4007	18311
1992	695	2710	563	1070	239	450	5723
1993	333	323	173	968	18	109	1924
1994	209	332	589	914	11	62	2115
1995	53	521	710	332	4	81	1710
1996	41	211	471	164	11	46	948
1997	18	446	198	99	13	130	1186
1998	9	118	79	78	0	38	319
1999	68	142	55	336	8	4	622
2000	154	266	0	332	0	12	764
2001	117	1183	245	54	0	81	1680
2002	263	1803	505	214	24	813	3622
2003	1109	1522	334	274	3	479	5215 <sup>1</sup>

**Table 5.2.2** Catch at age (abundance in millions) 1985-2003, missing values in 1997, 1998, 2000 and 2001.

Year\Age	1	2	3	4	5	6	7	8	9
1985				0.742	0.588	2.464	0.154	0.604	0.016
1986				0.172	0.170	1.245	0.117	0.565	0.014
1987	0.043	0.594	7.638	4.153	0.320	0.877	0.229	0.415	
1988	0.052	0.214	7.533	6.446	0.421	0.452	0.088	0.184	
1989	0.006	0.218	11.813	12.619	1.318	1.369	0.172	0.276	
1990	0.002	0.154	10.169	9.340	2.632	0.742	0.137	0.116	
1991	0.004	0.125	7.177	8.562	2.499	0.288	0.012	0.003	
1992	0.001	0.051	1.767	2.634	0.730	0.126	0.008	0.005	
1993	0.000	0.029	0.647	0.706	0.208	0.044	0.006	0.006	
1994	0.001	0.053	1.152	0.727	0.079	0.053	0.012	0.003	
1995		0.008	0.593	0.729	0.140	0.036	0.001	0.001	
1996		0.002	0.148	0.262	0.119	0.056	0.009	0.007	
1997									
1998									
1999			0.082	0.396	0.238	0.037	0.004		
2000									
2001									
2002	0.001	0.565	1.952	1.282	0.333	0.091	0.000	0.000	
2003		0.0665	0.2871	0.4081	0.1068	0.0496	0.0069	0.0073	

**Table 5.2.3** Weight at age in landing 1985-2003, missing values in 1997, 1998, 2000 and 2001.

<b>Year\Age</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
1985				0.84	1.29	1.82	2.25	2.97	3.55
1986				0.86	1.44	2.05	2.39	2.94	3.30
1987		0.46	0.69	0.88	1.17	2.30	2.91	4.37	4.15
1988		0.32	0.65	1.05	1.17	1.66	2.51	4.35	4.14
1989		0.57	0.75	1.19	1.34	1.80	2.21	3.61	3.63
1990		0.72	0.64	1.08	1.28	1.33	1.78	3.26	3.34
1991		0.72	0.60	0.84	1.07	1.04	1.42	1.77	2.75
1992		0.71	0.54	0.84	1.17	1.16	1.61	2.39	4.03
1993		0.72	0.53	0.76	1.25	1.23	1.97	3.57	3.97
1994		0.72	0.43	0.83	1.13	1.64	2.32	3.35	3.68
1995			0.45	0.87	1.28	1.67	1.78	3.17	6.18
1996			0.39	0.94	1.39	2.03	2.71	3.40	1.97
1997									
1998									
1999		0.31	0.56	0.71	1.02	1.25	1.58		
2000									
2001									
2002		0.32	0.52	0.69	1.09	1.51	1.70	3.36	0.31
2003		0.58	1.06	1.41	2.11	2.76	3.18	5.02	6.14

**Table 5.2.4** CPUE (number of age 1,2,3 and 4 cod caught per 100 hours net setting) in the Greenland Gill net cod survey covering West Greenland 1987-2003.

<b>Age</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
1985	107.51	45.36	0.37	2.53
1986	6.22	124.04	11.77	1.26
1987	0.34	75.04	119.82	6.73
1988	0.03	15.27	72.32	34.32
1989	0.11	58.47	37.33	21.67
1990	0.00	24.12	34.95	12.22
1991	63.63	2.40	29.00	12.16
1992	0.10	38.22	13.14	7.69
1993	0.00	6.89	33.20	10.45
1994	0.65	1.40	6.37	4.32
1995	0.23	18.95	3.76	3.16
1996	0.00	7.45	10.32	1.66
1997	1.92	5.88	2.71	0.82
1998	0.32	7.66	13.46	1.28
1999	0.00	0.40	1.20	2.70
2000	0.12	6.96	4.14	0.40
2001	no	survey		
2002	6.60	53.70	19.10	6.70
2003	0.45	20.16	19.09	6.72

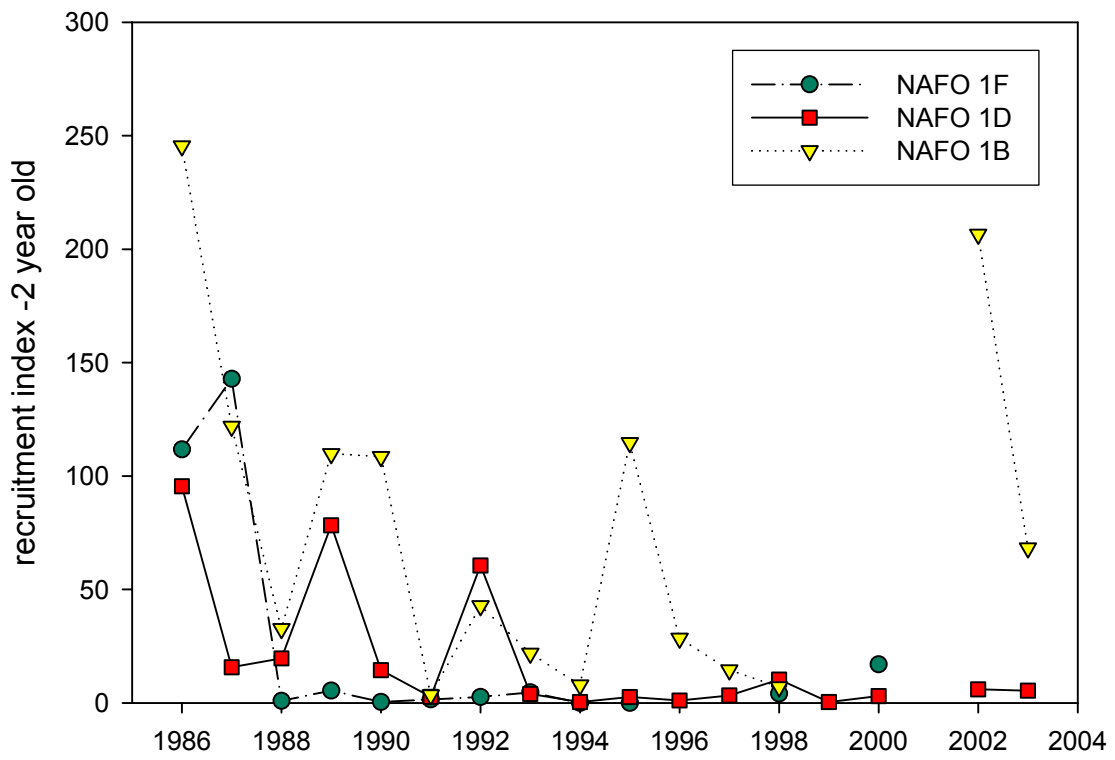


Figure 5.2.1