

Groundfish Survey Results
for
Cod off Greenland (offshore component)

1982-2001

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Abstract

The stock abundance and biomass increased from 23 million individuals and 45 000 tons in 1984 to 828 million individuals and 690 000 tons in 1987 due to the recruitment of the predominating year classes 1984 and 1985. Since 1988, stock abundance and biomass decreased dramatically by 99 % to 5 million individuals and 6 000 tons in 1993. The 2001 estimates confirmed the severely depleted status of the stock. However, the 2001 estimates confirmed the severely depleted status of the stock, although they represent the highest stock size since 10 years. The total abundance and biomass indices amounted to 16 million individuals and 18 000 tons, respectively.

48 % of the stock in number was distributed off East Greenland with a more diverse age structure than off West Greenland. The recruiting year classes 1998, 1999 and 2000 are considered weak as compared to the strong 1984 and 1985 year classes. The year class 1999 at age 2 however is estimated as the third strongest year class since 1982 and thus to provide some recovery potential in the next few years. The O-group indices are considered unrepresentative of year class strength at age 3 due to gear specifications while the age group 1 seems to be quantitatively estimated and to represent a reasonable recruitment index.

Since 1997, the cod did mature at significantly lower ages, probably as a reaction to the continued favourable water temperature in the near bottom layers. The weighted mean length and weight of the age groups 3-6 revealed pronounced area and temperature effects. Driven by the high abundance of cod off West Greenland, the mean sizes of the age groups 1-6 were low in 1987-91. The mean length and weight of age groups 3-6 increased significantly from low levels since 1991 as a consequence of their increased occurrence off East Greenland and higher temperatures.

Introduction

This paper presents estimates of cod stock abundance and biomass indices disaggregated by age groups as derived from annual groundfish surveys commenced in 1982, the only regular source of quantitative information from the traditional fishing grounds off West and East Greenland south of 67° northern latitude. Size at age is given in terms of length and weight. Changes in size at age are analysed for area and temperature effects.

Materials and Methods

Abundance, biomass estimates and length structures were derived from annual 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. Because of favourable weather and ice conditions and to avoid spawning concentrations, autumn was chosen for the time of the surveys. These were carried out by the research vessel (R/V) WALTHER HERWIG (II) throughout most of the time period. In 1984 R/V ANTON DOHRN was used and she was replaced by the new R/V WALTHER HERWIG III since 1994, respectively.

The fishing gear used was a standardized 140-foot bottom trawl, its net frame rigged with heavy ground gear because of the rough nature of the fishing grounds. A small mesh liner (10mm) was used inside the cod end. The horizontal distance between wing-ends was 25 m at 300 m depth, the vertical net opening being 4 m. In 1994, smaller Polyvalent doors (4.5 m², 1,500 kg) were used for the first time to reduce net damages due to overspread caused by bigger doors (6 m², 1,700 kg), which have been used earlier. All calculations of abundance and biomass indices were based on the 'swept area' method using 22 m horizontal net opening as trawl parameter, i. e. the constructional width specified by the manufacturer. The towing time was normally 30 min. at a speed of 4.5 knots. Trawl parameters are listed in Table 1. Hauls, which received net damage or became hang-up after less than 15 minutes, were rejected. Some hauls of the 1987 and 1988 surveys were also included although their towing time had been intentionally reduced to 10 minutes because of the expected large cod catches as observed from echo sounder traces.

Fish were identified to species or lowest taxonomic level and the catch in number and weight was recorded. Total fish lengths were measured to cm below. Weight (g) at age calculations were based on the regression $f(x)=0.00895x^{3.00589}$, x =length (cm), which was determined on the basis of 3 482 individual measurements.

The surveys were primarily designed for the assessment of cod. In order to reduce the error of abundance estimates, the subdivision of shelf areas and the continental slope into different geographic and depth strata was required due to a pronounced heterogeneity of cod distribution. The survey area was thus split into seven geographic strata. Each stratum was itself subdivided into two depth strata covering the 0-200 m and 201-400 m zones. Figure 1 and Table 2 indicate the names of the 14 strata, their geographic boundaries, depth ranges and areas in nautical square miles (nm²). All strata were limited at the 3 mile offshore line.

The applied strategy was to distribute the sampling effort according both to the stratum areas and to cod abundance. Consequently, fifty percent of the hauls were allocated proportionally to strata by stratum area while the other fifty percent were apportioned on the basis of a review of the historical mean cod abundance/nm², all hauls being randomly distributed within trawlable areas of the various strata. Non-trawlable areas were mainly located inshore. During 1982-2001, 2 854 successful sets were carried out, the numbers of valid sets by year and stratum being listed in Table 3. Apart from stratum 7.2 (Dohrn Bank), East Greenland strata were not covered adequately in 1984, 1992 and 1994 due to technical problems. In 1995, the survey area off West Greenland was incompletely covered for the first time again due to technical problems. Only 50 % of the strata of West Greenland were covered, namely the southern strata 3.1, 3.2, 4.1, and 4.2. Stratum 7.1 has a very low area and therefore never been covered. Since 1996, the survey area was covered almost completely. Figure 1 shows the positions of hauls conducted during the most recent survey.

Stratified abundance estimates were calculated from catch-per-tow data using the stratum areas as weighting factor (Cochran, 1953; Saville, 1977). Strata with less than five valid sets were rejected from the calculation. The coefficient of catchability was set arbitrarily at 1.0, implying that estimates are merely indices of abundance and biomass. Respective confidence intervals (CI) were set at the 95% level of significance of the stratified mean.

Age determinations were based on length-stratified otolith (sagitta) collections and conducted using transmitted light. Until 1992, otoliths were cut into 2 halves and annuli were counted under a binocular microscope. Since 1993, thin sections were cut from the central region of the otolith after embedding in black polyester resin.

Comparative age readings revealed no significant differences between both methods. Calculations of age structures, compositions and growth were based on data pooled to 3 cm length groups. In 2001, 1 242 individual age determinations were available.

Maturity at age was determined from visual observations. However, the results should be interpreted carefully since the surveys were conducted in autumn when the gonads were in resting stages. During this season, it was often difficult to distinguish immature from mature cod.

As a standard procedure, near bottom temperatures were measured directly before or after trawling in the vicinity of the swept area by a CTD-sonde with a precision of a hundredth °C. Mean weighted temperature in the near bottom layer was calculated using the stratum areas as weighting factor. The values are given in Table 3.

Results

Tables 4 and 5 list abundance and biomass indices by stratum, West and East Greenland and total in 1982-2001. Indices varied significantly between strata and years. Trends of the abundance and biomass estimates for West and East Greenland are shown in Figures 2 and 3, respectively. These Figures illustrate the pronounced increase in stock abundance and biomass from 23 million individuals and 45 000 tons in 1984 to 828 million individuals and 690 000 tons in 1987. This trend was caused by the recruitment of the predominating year classes 1984 and 1985, which were mainly distributed in the northern and shallow strata 1.1, 2.1 and 3.1 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 pointing to eastbound migration. During the period 1987-89, the high abundance estimates were accompanied with high confidence intervals. The low precisions were due to enormous variation in catch per tow data. Since 1988, stock abundance and biomass decreased dramatically by 99 % to 5 million individuals and 6 000 tons in 1993. However, the 2001 estimates confirmed the severely depleted status of the stock, although they represent the highest stock size since 10 years. The total abundance and biomass indices amounted to 16 million individuals and 18 000 tons, respectively.

Age disaggregated abundance indices for West, East Greenland and total are listed in Tables 6, 7 and 8, respectively. The very strong year classes 1984 and 1985 dominated the stock during 1985-1991. In 2001, the stock structure off West Greenland was found to be composed almost exclusively of the recruiting age groups 1, 2 and 3 (97 %). 48 % of the stock in number was distributed off East Greenland with a more diverse age structure. As the abundance indices of the fully recruited age groups 4 and 5 increased from 2000 to 2001, the higher stock abundance estimate is subject to a small year effect in catchability (overestimation). The recruiting year classes 1998, 1999 and 2000 are considered weak as compared to the strong 1984 and 1985 year classes. The year class 1999 at age 2 however is estimated as the third strongest year class since 1982 and thus to provide some recovery potential in the next few years. The O-group indices are considered unrepresentative of year class strength at age 3 due to gear specifications while the age group 1 seems to be quantitatively estimated and to represent a reasonable recruitment index (Fig. 4).

The proportion mature at age and resulting estimates of spawning stock sizes in numbers and weight are given in Tables 9, 10 and 11, respectively. The calculation of the spawning stock biomass indices were based on the weighted mean weight by age and years as listed in Tables 15-17. In the past four years, the cod did mature at significantly lower ages, probably as a reaction to the continued favourable water temperature in the near bottom layers (Rätz, 1999). The indices of spawning stock sizes are illustrated in Figures 2 and 3 as solid lines. Both estimates peaked in 1989 when the strong year class 1984 became mature. In recent years, the spawning stock was practically absent.

The weighted mean length and weight of the age groups 1-10 years for West, East Greenland and total are listed in Tables 12-17, respectively. Trends of these values are illustrated in Figures 5 and 6 for the period 1982-2001. They reveal pronounced area and temperature effects as demonstrated by multiple linear regression models (Fig. 7 and Tab. 18). 38, 57, 62, and 39 % of the observed variation in length at ages 3-6 are explained by the positive influence of the near bottom temperature and the ratio of fish distributed off East Greenland, respectively. The majority of recorded sizes at ages 2 to 10 years off East Greenland were found to be bigger than those off West Greenland. Driven by the high abundance of small growing cod off West Greenland, the mean sizes of the age groups 1-6 were low in 1987-91. Thereafter, mean length and weight of age groups 3-6 increased significantly from low levels as a consequence of their increased occurrence off East Greenland and higher temperatures.

References

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Table 1 Trawl parameters of the survey.

Gear	140-feet bottom trawl
Horizontal net opening	22 m
Standard trawling speed	4.5 kn
Towing time	30 minutes
Coefficient of catchability	1.0

Table 2 Specification of strata.

Stratum	geographic boundaries				depth	area
	south	north	east	west	(m)	(nm ²)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1-200	6805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201-400	1881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1-200	2350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201-400	1018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1-200	1938
3.2	60°45'N	62°30'N	48°00'W	53°00'W	201-400	742
4.1	59°00'N	60°45'N	44°00'W	50°00'W	1-200	2568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201-400	971
5.1	59°00'N	63°00'N	40°00'W	44°00'W	1-200	2468
5.2	59°00'N	63°00'N	40°00'W	44°00'W	201-400	3126
6.1	63°00'N	66°00'N	35°00'W	41°00'W	1-200	1120
6.2	63°00'N	66°00'N	35°00'W	41°00'W	201-400	7795
7.1	64°45'N	67°00'N	29°00'W	35°00'W	1-200	92
7.2	64°45'N	67°00'N	29°00'W	35°00'W	201-400	4589
Sum						37463

Table 3 Numbers of valid hauls by stratum and total and weighted (by stratum area) mean near bottom temperature, 1982-2001.

Year	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	6.1	6.2	7.1	7.2	Sum	Temperature (°C)
1982	20	11	16	7	9	6	13	2	1	10	3	12	1	25	136	3.139
1983	26	11	25	11	17	5	18	4	3	19	10	36	0	18	203	3.012
1984	25	13	26	8	18	6	21	4	5	4	2	8	0	5	145	2.698
1985	10	8	26	10	17	5	21	4	5	21	14	50	0	28	219	4.181
1986	27	9	21	9	16	7	18	3	3	15	14	37	1	34	214	4.136
1987	25	11	21	4	18	3	21	3	19	16	13	40	0	18	212	3.783
1988	34	21	28	5	18	5	18	2	21	8	13	39	0	26	238	3.959
1989	26	14	30	9	8	3	25	3	17	18	12	29	0	11	205	3.295
1990	19	7	23	8	16	3	21	6	18	19	6	15	0	13	174	3.461
1991	19	11	23	7	12	6	14	5	8	11	10	28	0	16	170	3.558
1992	6	6	6	5	6	6	7	5	0	0	0	0	0	6	53	3.489
1993	9	6	9	6	10	8	7	0	9	6	6	18	0	14	108	3.597
1994	16	13	13	8	10	6	7	5	0	0	0	0	0	6	84	3.620
1995	0	0	3	0	10	7	10	5	8	6	6	17	0	12	84	3.862
1996	5	5	8	5	12	5	10	5	7	9	5	13	0	9	98	4.709
1997	5	6	5	5	6	5	8	5	5	5	4	8	0	8	75	4.189
1998	9	5	10	7	11	6	10	5	5	8	6	12	0	9	103	5.181
1999	8	6	14	8	13	6	9	3	5	6	6	13	0	5	102	4.435
2000	13	6	14	7	14	5	9	5	6	5	8	16	0	11	119	3.860
2001	0	0	15	7	15	5	12	5	6	5	11	15	0	16	112	5.128

Table 4 *G. morhua*. Abundance indices (1000) for West, East Greenland and total by stratum, 1982-2001. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance. () incorrect due to incomplete sampling.

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	6.1	6.2	7.1	7.2	WEST	EAST	TOTAL	CI
1982	5092	729	47957	1888	15114	3706	17790			468		6173		1449	92276	8090	100366	28
1983	431	467	16013	5170	14881	2326	10916			2228	1274	2276		2213	50204	7991	58195	25
1984	377	179	4714	171	5201	689	5353		4063			1750		790	16684	(6603)	(23286)	32
1985	19630	2428	13222	4395	10531	1638	7499		3564	373	3978	3348		1141	59343	12404	71747	33
1986	32438	1236	50908	229	37446	1321	22104			780	6950	6676		828	145682	15234	160915	32
1987	330944	1651	248002		154681		51114		18317	9832	6527	6081		878	786392	41635	828026	59
1988	92024	2423	338740	84935	47336	89	60946		7985	8085	2060	4375		1083	626493	23588	650080	48
1989	2497	920	27930	673	261502		65203		30906	38407	11600	9383		1436	358725	91732	450459	59
1990	965	513	4155	362	6014		10303	12213	4956	2524	4533	9041		4200	34525	25254	59777	43
1991	268	205	180	152	1027	611	1839	523	2343	1786	779	1958		3541	4805	10407	15213	29
1992	552	622	117	137	121	74	151	269						658	2043	(658)	(2700)	50
1993	566	457	176	127	80	31	0		1252	98	922	502		527	1437	3301	4738	36
1994	206	103	33	33	72	23	82	22						801	574	(801)	(1375)	36
1995					138	67	58	15	265	78	2933	3654		257	278	7187	7463	93
1996	152	126	76	38	121	0	298	0	290	0	260	382		515	811	1447	2257	38
1997	0	47	35	0	120	5	108	0	74	0		624		3456	315	4153	4469	75
1998	1524	0	45	49	14	0	77	15	296	0	405	148		821	1723	1671	3394	54
1999	191	70	56	19	380	14	182		518	19	1257	631		344	912	2769	3681	34
2000	374	457	101	283	545	16	128	21	985	22	2975	288		546	1926	4816	6742	36
2001			1072	65	6415	16	586	7	785	22	1753	1107		3937	8160	7604	15764	39

Table 5 *G. morhua*. Biomass indices (tons) for West, East Greenland and total by stratum, 1982-2001. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance.
() incorrect due to incomplete sampling.

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	6.1	6.2	7.1	7.2	WEST	EAST	TOTAL	CI
1982	2378	307	63684	2632	20319	8745	30426			1927		14563		7127	128491	23617	152107	25
1983	353	205	20215	7827	22806	9594	21374			6147	3512	11344		13154	82374	34157	116531	25
1984	824	234	7508	234	7218	1055	8493		10397			4110		5237	25566	(19744)	(45309)	34
1985	2528	251	12869	2351	10731	990	5952		7073	1356	9955	9437		5744	35672	33565	69236	39
1986	10641	484	26098	80	28510	1423	19483			2645	18631	16543		3366	86719	41185	127902	26
1987	283591	545	200632		116610		37210		10315	9054	9291	17616		5316	638588	51592	690181	63
1988	94175	1367	333848	77967	44593	93	55945		8750	18204	6162	16258		3572	607988	52946	660935	46
1989	727	228	25829	441	231239		75386		40614	127865	34957	31324		4786	333850	239546	573395	46
1990	224	114	3552	190	5778		13185	11388	9229	6813	12954	24408		12560	34431	65964	100395	34
1991	91	72	73	45	1208	589	2621	451	4236	5779	1263	7467		14006	5150	32751	37901	36
1992	135	195	23	36	21	14	81	102						1216	607	(1216)	(1823)	69
1993	135	88	49	33	44	10	0		862	60	1742	1076		1860	359	5600	5959	41
1994	27	33	6	23	23	11	4	13						2792	140	(2792)	(2930)	68
1995					26	13	11	7	93	185	1115	13750		382	57	15525	15581	155
1996	23	64	23	20	51	0	192	0	167	0	755	1004		1673	373	3599	3973	56
1997	0	40	24	0	107	4	110	0	57	0		1193		12473	284	13722	14007	90
1998	75	0	2	9	2	0	21	21	84	0	620	592		3052	130	4348	4479	91
1999	27	24	7	6	120	9	46		64	3	1630	1738		482	240	3917	4157	62
2000	102	130	21	135	140	10	18	15	365	31	1409	935		2038	570	4778	5349	40
2001			296	31	2171	8	149	12	333	13	1953	1918		11055	2666	15271	17937	42

Table 6 *G. morhua*, West Greenland. Age disaggregate abundance indices (1000), 1982-2001.
*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (Anon., 1984).

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

Table 7 *G. morhua*, East Greenland. Age disaggregate abundance indices (1000), 1982-2001.
*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (Anon., 1984). () 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

Table 8 *G. morhua*, Greenland (total). Age disaggregate abundance indices (1000), 1982-2001. *) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (Anon., 1984). () 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

Table 9 *G. morhua*, Greenland (total). Proportion mature at ages 0-10 years, 1982-2001. *) No observations available, values taken from previous years.

YEAR	0	1	2	3	4	5	6	7	8	9	10
1982	0	0	0	0.02	0.1	0.52	0.73	0.89	0.95	1	1
*1983	0	0	0	0.02	0.2	0.52	0.73	0.89	0.98	1	1
1984	0	0	0.15	0.12	0.53	0.89	0.98	0.99	1	1	1
1985	0	0	0.01	0.02	0.18	0.68	0.86	0.97	0.97	0.9	1
1986	0	0	0	0	0.13	0.25	0.84	0.93	0.91	0.97	1
*1987	0	0	0	0	0.13	0.25	0.84	0.93	0.91	0.97	1
1988	0	0	0	0.02	0.22	0.66	0.86	0.92	1	0.99	0.92
1989	0	0	0	0.02	0.55	0.81	0.91	1	0.98	1	0.98
*1990	0	0	0	0.02	0.55	0.81	0.91	1	0.98	1	0.98
1991	0	0	0	0.01	0.04	0.13	0.4	0.75	1	1	1
1992	0	0	0.04	0.27	0.69	0.71	1	0.92	1	1	1
1993	0	0	0.05	0.53	0.63	0.48	0.76	0.75	0.92	0.89	1
1994	0	0	0	0.04	0.36	0.5	1	1	1	1	1
1995	0	0	0	0	0.29	0.51	0.81	1	1	1	1
1996	0	0	0	0	0.33	0.56	0.82	1	0.8	1	1
1997	0	0	0	0.29	0.7	0.78	0.9	0.92	1	1	1
1998	0	0	0	0.67	0.6	0.97	0.96	1	1		
1999	0	0	0.02	0.07	0.36	0.89	1	0.94		1	1
2000	0	0	0.28	0.7	0.91	0.95	0.97	0.83	1	1	1
2001	0	0.06	0.22	0.73	0.91	0.97	0.97	1	1	1	1

Table 10 *G. morhua*, Greenland (total). Spawning stock indices in numbers (1000), 1982-2001.

YEAR	0	1	2	3	4	5	6	7	8	9	10	TOTAL
1982	0	0	0	686	1313	17942	7851	2671	673	2331	164	33793
1983	0	0	0	68	5525	3196	9559	2820	1268	582	871	23889
1984	0	0	17	409	1160	10008	1663	3455	494	289	63	17653
1985	0	0	20	21	1601	3310	8199	1214	2567	290	91	17349
1986	0	0	0	0	189	2310	2701	6010	636	2176	150	14350
1987	0	0	0	0	3656	1739	11410	1947	5075	181	1459	25467
1988	0	0	0	2195	114856	4911	940	2352	806	1929	120	128578
1989	0	0	0	81	61096	256947	6329	294	5297	520	1983	332589
1990	0	0	0	71	938	21750	22962	312	71	251	0	46355
1991	0	0	0	9	83	40	2162	4014	87	0	0	6404
1992	0	0	60	79	72	93	47	157	52	0	0	560
1993	0	0	44	1273	246	147	216	66	250	85	0	2327
1994	0	0	0	9	108	74	87	150	0	29	0	457
1995	0	0	0	0	114	882	365	141	460	36	217	2340
1996	0	0	0	0	88	165	217	60	62	0	0	592
1997	0	0	0	12	1257	1257	509	217	140	0	0	3411
1998	0	0	0	14	30	472	418	156	43	0	0	1133
1999	0	0	21	35	52	269	185	188	0	35	24	809
2000	0	0	585	1369	822	149	282	62	141	115	31	3556
2001	0	56	1572	1875	2187	1358	684	211	191	73	36	8252

Table 11 *G. morhua*, Greenland (total). Spawning stock biomass indices (tons), 1982-2001.

YEAR	0	1	2	3	4	5	6	7	8	9	10	TOTAL
1982	0	0	0	393	1280	32259	18003	8408	2908	13909	1110	79511
1983	0	0	0	37	5456	5761	22134	8937	5510	3479	5909	57223
1984	0	0	4	212	1219	14442	4113	11447	2314	1309	363	36162
1985	0	0	5	13	1879	6887	18358	4761	11226	1652	566	45630
1986	0	0	0	0	251	4438	7621	19327	3014	11932	927	48976
1987	0	0	0	0	3364	2189	26414	5158	17971	1099	9389	65584
1988	0	0	0	1034	118532	7612	2653	9076	2648	8898	780	155556
1989	0	0	0	35	51626	407003	14240	1162	25377	2624	12329	514773
1990	0	0	0	25	677	22294	50907	1029	405	1727	0	77064
1991	0	0	0	3	67	53	4197	13017	349	0	0	17756
1992	0	0	14	36	88	153	142	478	180	0	0	1091
1993	0	0	6	820	315	317	601	238	1208	519	0	4024
1994	0	0	0	5	213	219	417	711	0	167	0	1732
1995	0	0	0	0	162	2602	1522	738	2726	347	1615	10445
1996	0	0	0	0	165	407	779	307	359	0	0	2017
1997	0	0	0	12	2214	4340	2069	991	656	0	0	10416
1998	0	0	0	15	53	1381	1479	602	290	0	0	3820
1999	0	6	21	61	793	685	924	0	298	216	0	3004
2000	0	0	121	604	708	239	593	202	733	723	253	4176
2001	0	5	467	1412	3890	3084	1921	830	982	467	260	13381

Table 12 *G. morhua*, West Greenland. Weighted mean length (cm, by stratum abundance) at age 1-10 years, 1982, 1984-2001.

YEAR	1	2	3	4	5	6	7	8	9	10
1982	16.9	27.5	39.6	46.5	57.8	61.8	68.6	76.3	82.0	91.3
1983										
1984	19.5	24.6	34.6	44.5	52.9	60.1	68.0	73.2	78.7	87.6
1985	21.9	26.4	39.6	47.5	54.4	60.3	69.8	71.4	78.3	75.9
1986	19.9	32.9	37.9	49.6	57.0	62.3	67.2	75.1	76.8	78.8
1987	15.9	29	42.4	46.6	50.7	61.7	62.5	69.1		72.8
1988	16.1	28.5	36.8	48.1	50	59.7	68.6	67	73.6	76.5
1989	15.8	25.9	35.9	44.3	53.5	54.0		68.0	70.6	79.2
1990	16.1	23.2	33.2	40.3	46.3	53.4	49.5			
1991	17.6	24.8	33.9	41.4	46.6	52.9	57.5	46.5		
1992	20.2	29.3	34.6	41.8	46.8		60.8			
1993	16.5	24.4	35.4	37.8	46.5	46.5				
1994	17.0	24.0	36.8	40.5	49.5		64.5			
1995		27.3	33.0	37.5						
1996	16.6	22.5	38.2	43.5		73.5				
1997	19.5	33.2	34.5	47.7						
1998	17.7			55.5	54.9					
1999	20.4	33.4	40.6	49.5		67.5				
2000	16.2	29.5	35.4	44.3						
2001	19.1	31.4	38.5	48.8	47.0					

Table 13 *G. morhua*, East Greenland. Weighted mean length (cm, by stratum abundance) at age 1-10 years, 1982, 1984-2001. () incomplete sampling.

YEAR	1	2	3	4	5	6	7	8	9	10
1982		35.9	43.8	53.7	63.3	72.5	79.4	84.4	89.7	89.1
1983										
(1984)	22.5	33.1	44.4	58.2	62.2	69.0	74.9	81.3	79.6	84.0
1985	22.9	36.3	48.4	57.7	70.1	71.6	78.6	80.3	85.9	95.3
1986	21.3	34.5	46.4	57.2	66.3	77.2	76.8	81.4	86.9	90.1
1987	15.4	31.4	41.2	45.9	56.5	73.2	79.1	82.3	87.1	94.2
1988		31.1	43.1	57.8	69.4	77.5	79.8	89.1	90.8	93.2
1989	19.5	30.2	38.9	49.6	64.9	73.8	75.5	81.8	85.1	88.9
1990	17.9	35.8	38.2	50.0	56.1	65.9	74.9	85.3	90.8	
1991	21.1	27.7	35.3	50.4	58.8	63.2	71.5	78.1	82.4	103.5
(1992)	12.5	35.3	43.6	55.6	70.2	69.1	70.9	72.3		
1993	20.7	33.8	43.0	52.6	63.2	67.6	73.2	80.7	87.4	
(1994)	16.5		49.5	62.8	69.3	80.5	80.7		85.5	
1995	19.5	30.1	36.1	54.8	68.5	76.9	82.9	86.4	101.6	93.2
1996			42.8	59.4	64.5	73.1	82.3	85.9		
1997		22.5	55.0	59.5	72.2	76.2	79.2	79.9		
1998	22.3	25.7	48.5	57.9	69.1	72.8	74.9	90.2		
1999	21.0	30.9	40.2	50.4	68.5	74.1	81.2		97.5	99.3
2000	21.8	27.2	36.9	45.7	55.9	61.2	70.7	82.7	88.1	96.1
2001	24.5	35.0	47.1	58.5	63.4	67.4	75.4	82.4	88.6	92.3

Table 14 *G. morhua*, Greenland (total). Weighted mean length (cm, by stratum abundance) at age 1-10 years, 1982, 1984-2001. () incomplete sampling.

YEAR	1	2	3	4	5	6	7	8	9	10
1982	16.9	29.3	39.7	47.4	58.1	63.0	70.0	77.8	86.6	90.3
1983										
(1984)	21.8	30.2	38.4	48.6	54.0	64.6	71.2	79.9	79.0	85.6
1985	22.0	29.1	40.6	50.4	61.0	62.5	75.3	78.1	85.3	87.8
1986	20.0	32.9	40.4	52.5	59.4	67.5	70.5	80.2	84.2	87.6
1987	15.8	29.6	42.4	46.5	51.6	63.2	66.1	72.8	87.1	88.8
1988	18.8	28.6	37.2	48.3	55.3	67.5	74.8	71.1	79.4	88.8
1989	15.9	26.2	36.3	45.2	55.7	62.6	75.5	80.5	81.9	87.8
1990	16.9	24.1	34.0	42.9	48.2	62.3	71.1	85.3	90.8	
1991	18.5	26.6	34.5	44.4	52.4	59.6	70.7	75.9	82.4	103.5
(1992)	19.1	29.6	36.9	50.9	56.4	69.1	69.2	72.3		
1993	19.2	24.9	41.3	51.9	61.7	67.2	73.2	80.7	87.4	
(1994)	16.9	24.0	38.4	60.0	68.6	80.5	80.2		85.5	
1995	19.5	29.9	36.0	53.8	68.5	76.9	82.9	86.4	101.6	93.2
1996	16.6	22.5	40.2	58.8	64.5	73.1	82.3	85.9		
1997	19.5	27.0	47.8	57.7	72.2	76.2	79.2	79.9		
1998	18.3	25.7	48.5	57.7	68.3	72.8	74.9	90.2		
1999	20.8	31.8	40.2	50.4	68.5	73.9	81.2		97.5	99.3
2000	20.8	28.3	36.4	45.5	55.9	61.2	70.7	82.7	88.1	96.1
2001	20.9	31.9	43.5	57.9	62.8	67.4	75.4	82.4	88.6	92.3

Table 15 *G. morhua*, West Greenland. Weighted mean weight (g., by stratum abundance) at age 1-10 years, 1982, 1984-2001.

YEAR	1	2	3	4	5	6	7	8	9	10
1982	44	190	568	920	1770	2164	2962	4078	5065	6995
1983										
1984	68	136	379	807	1356	1990	2885	3600	4476	6177
1985	96	168	568	981	1475	2010	3121	3341	4408	4014
1986	72	325	498	1118	1697	2217	2784	3889	4159	4493
1987	37	223	697	926	1194	2154	2239	3028		3541
1988	38	211	456	1019	1145	1941	2949	2735	3630	4192
1989	36	159	423	796	1403	1443		2885	3229	4562
1990	38	114	334	599	909	1395	1111			
1991	50	139	356	649	926	1356	1743	920		
1992	75	230	379	668	938		2061			
1993	41	132	405	494	920	920				
1994	45	126	456	608	1111		2461			
1995		186	328	482						
1996	42	104	510	753		3645				
1997	68	334	375	994						
1998	50			1567	1516					
1999	77	340	612	1111		2822				
2000	39	234	405	796						
2001	63	283	522	1064	951					

Table 16 *G. morhua*, East Greenland. Weighted mean weight (g., by stratum abundance) at age 1-10 years, 1982, 1984-2001. () Incomplete sampling.

YEAR	1	2	3	4	5	6	7	8	9	10
1982		423	769	1419	2326	3498	4597	5523	6633	6500
1983										
(1984)	104	331	801	1807	2207	3014	3858	4936	4632	5445
1985	109	437	1038	1761	3161	3369	4459	4755	5824	7957
1986	88	375	915	1715	2674	4225	4159	4954	6030	6722
1987	33	283	640	885	1653	3600	4545	5120	6072	7684
1988		275	733	1770	3067	4291	4702	6500	6949	7418
1989	68	252	538	1118	2507	3690	3951	5027	5662	6457
1990	52	419	510	1145	1618	2625	3858	5702	6880	
1991	86	194	402	1173	1864	2315	3355	4374	5139	10198
(1992)	18	402	758	1575	3175	3028	3271	3469		
1993	81	353	728	1333	2315	2834	3600	4827	6135	
(1994)	41		1111	2271	3054	4791	4827		5742	
1995	68	249	430	1508	2949	4176	5233	5926	9645	7442
1996			717	1921	2461	3586	5120	5824		
1997		104	1525	1931	3454	4062	4562	4685		
1998	101	155	1045	1779	3028	3541	3858	6745		
1999	84	269	594	1173	2949	3735	4917		8522	9004
2000	94	184	459	874	1601	2102	3243	5196	6284	8160
2001	134	392	957	1835	2337	2809	3935	5139	6391	7228

Table 17 *G. morhua*, Greenland (total). Weighted mean weight (g., by stratum abundance) at age 1-10 years, 1982, 1984-2001. () Incomplete sampling.

YEAR	1	2	3	4	5	6	7	8	9	10
1982	44	230	572	975	1798	2293	3148	4324	5967	6767
1983										
(1984)	104	331	801	1807	2207	3014	3858	4936	4632	5445
1985	97	225	612	1173	2081	2239	3920	4374	5702	6219
1986	73	325	603	1326	1921	2822	3216	4738	5484	6177
1987	36	237	697	920	1259	2315	2649	3541	6072	6435
1988	61	214	471	1032	1550	2822	3858	3285	4614	6522
1989	37	164	437	845	1584	2250	3951	4791	5046	6219
1990	44	128	359	722	1025	2217	3299	5702	6880	
1991	58	172	375	801	1318	1941	3243	4014	5139	10198
(1992)	63	237	459	1208	1644	3028	3041	3469		
1993	64	141	644	1281	2154	2784	3600	4827	6135	
(1994)	44	126	518	1980	2962	4791	4738		5742	
1995	68	244	426	1427	2949	4176	5233	5926	9645	7442
1996	42	104	594	1864	2461	3586	5120	5824		
1997	68	180	1000	1761	3454	4062	4562	4685		
1998	56	155	1045	1761	2923	3541	3858	6745		
1999	82	294	594	1173	2949	3705	4917		8522	9004
2000	82	207	441	862	1601	2102	3243	5196	6284	8160
2001	83	297	753	1779	2271	2809	3935	5139	6391	7228

Table 18 *G. morhua*, Greenland. Linear multiple regression analyses for length at ages 3-6.

dependent variable $f(x,y)$ = length at age (cm)

independent variable x = temperature (°C)

independent variable y = ration of fish distributed off East Greenland

Age Group	function	n	r^2
3	$f(x,y)=25.140+3.610x+0.869y$	19	0.38
4	$f(x,y)=35.676+2.814x+7.697y$	19	0.57
5	$f(x,y)=47.690+1.260x+12.643y$	19	0.62
6	$f(x,y)=54.925+1.603x+9.560y$	19	0.39

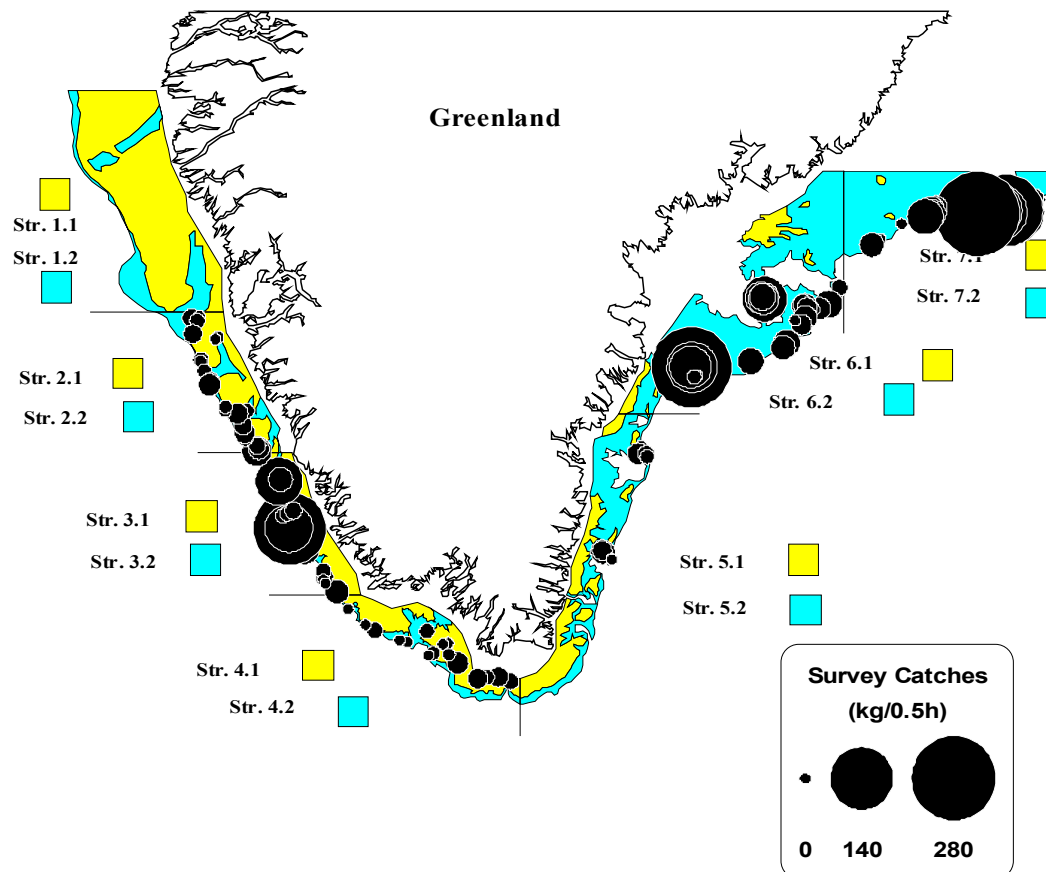


Fig. 1 Stratification of the survey area as specified in Table 2, positions of hauls carried out in 2001 and catches of cod.

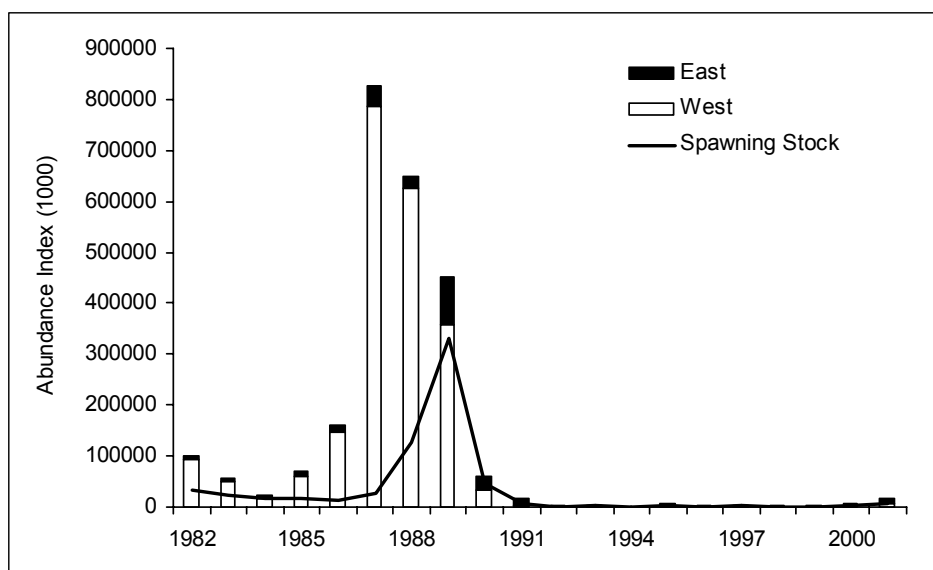


Fig. 2 *G. morhua*. Aggregated survey abundance indices for West and East Greenland and spawning stock size as listed in Tables 4 and 10, 1982-2001. *) incomplete survey coverage.

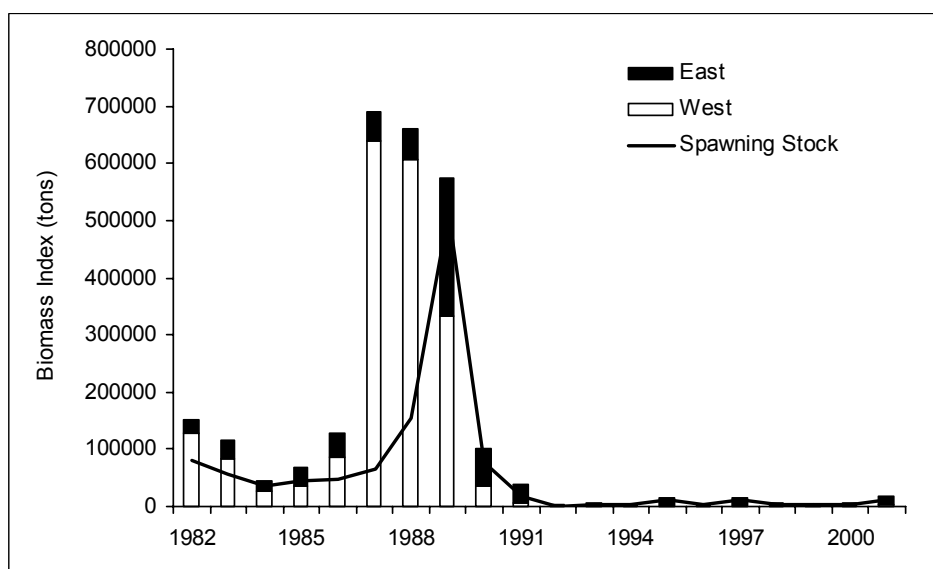


Fig. 3 *G. morhua*. Aggregated survey biomass indices for West and East Greenland and spawning stock size as listed in Tables 5 and 11, 1982-2001. *) incomplete survey coverage.

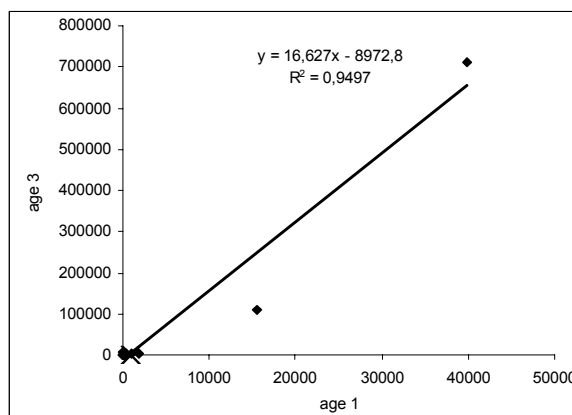
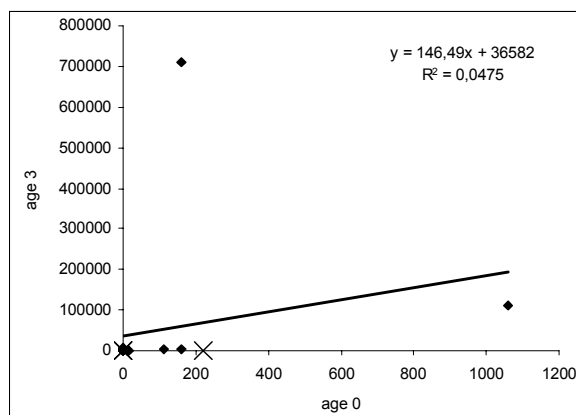


Fig. 4 *G. morhua*. Use of 0 and 1 age group indices to predict year class strength at age 3. The x indicate the 1999, 2000 and 2001 year classes at age 0 and the 1999 and 2000 at age 1, respectively. Values are listed in Table 8.

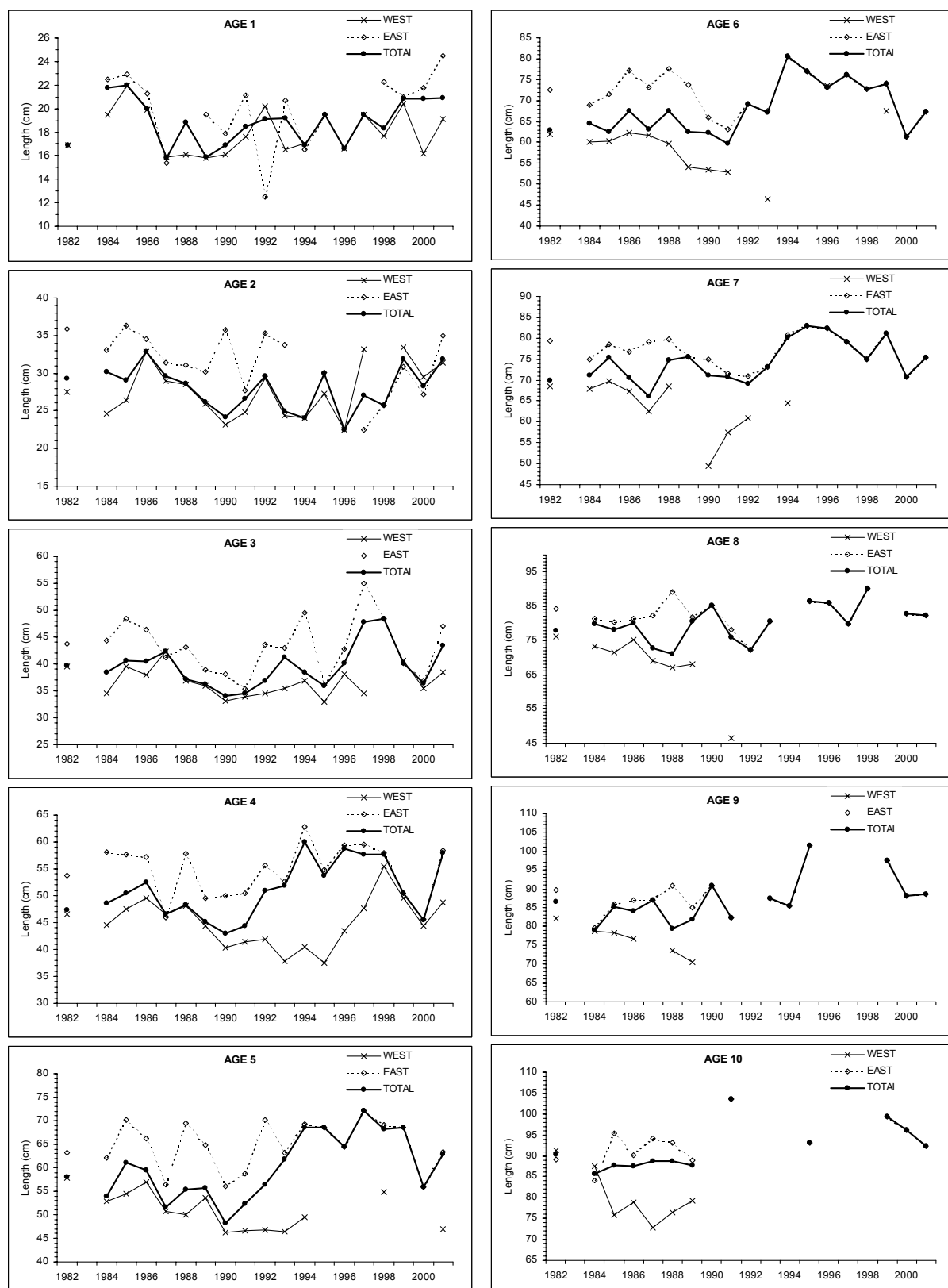


Fig. 5 *G. morhua*. Weighted mean length at age 1-10 years for West, East Greenland and total as listed in Tables 12-14, 1982-2001.

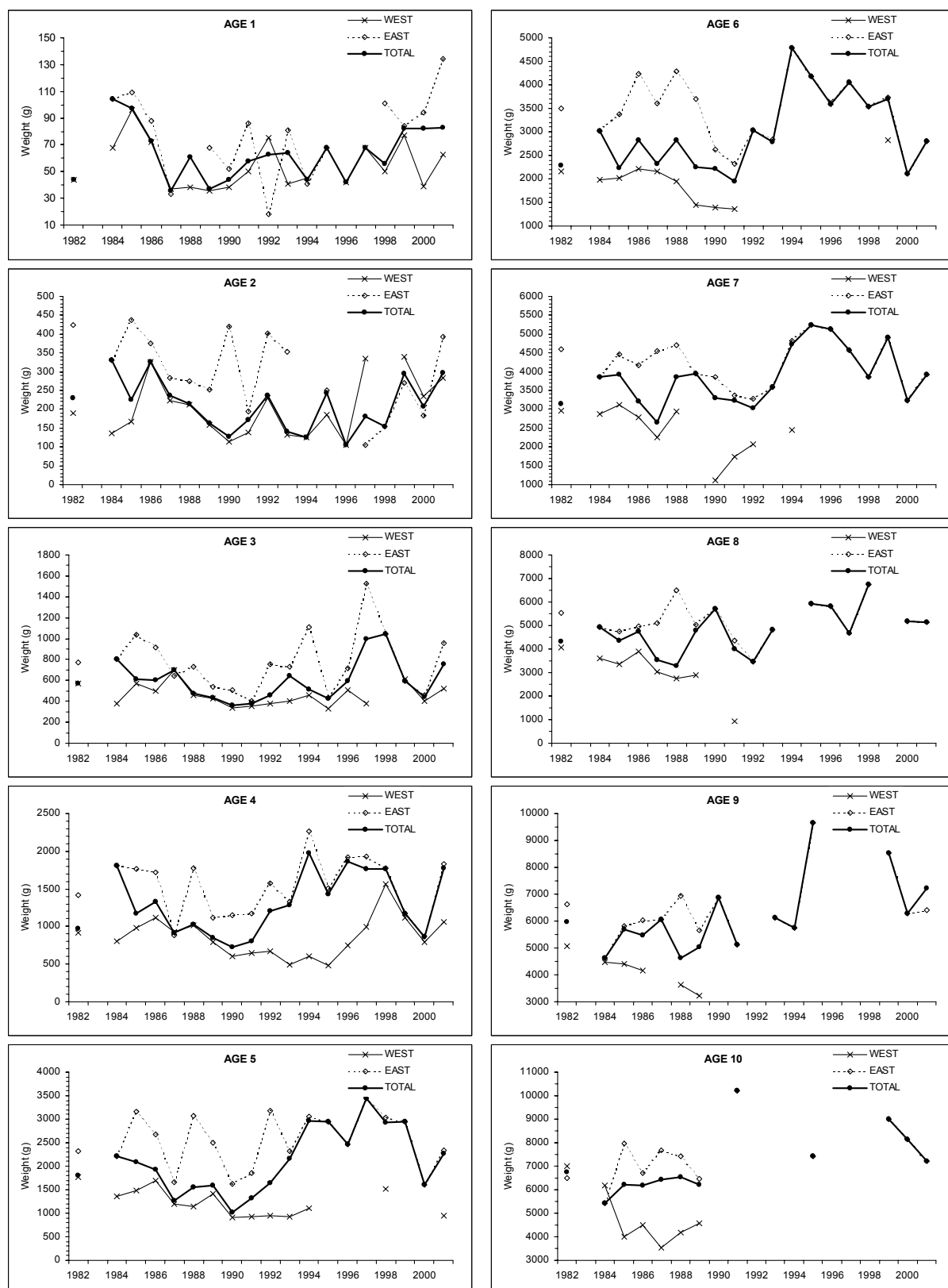


Fig. 6 *G. morhua*. Weighted mean weight at age 1-10 years for West, East Greenland and total as listed in Tables 15-17, 1982-2001.

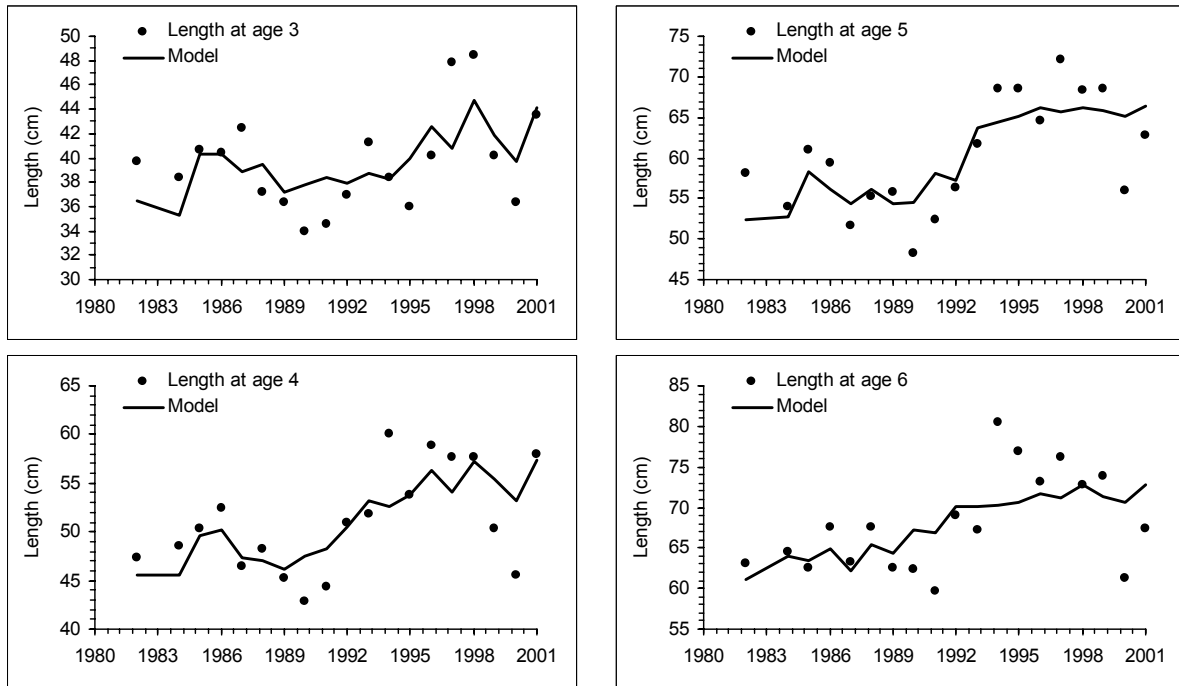


Fig. 7 *G. morhua*, Greenland. Multiple linear regression models for length at ages 3-6 based on near bottom temperature and the ratio of fish distributed off East Greenland. The models are specified in Table 18.