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

by

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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. In 1994 it was decided to make separate assessments for Div. 1A and Sub 0+Div.1B-1F. From 1995-1997 a TAC for Sub. 0+Div.1B-1F was set at 11,000 tons.

In the period 1982-1989 nominal catches of Greenland halibut in Sub. 0+Div.1B-1F fluctuated between 300 and 4,500 tons. Catches increased from 2,200 in 1989 tons to 15,500 1990. In 1991 catches dropped to 11,000 tons and then increased to 18,100 tons in 1992, the highest in the time series. Since then catches haven been about 10,000 tons. In 1996 catches were 10,430 tons compared to 10,884 tons in 1995. The increase in catches from 1989 to 1990 was mainly due to a new trawl fishery by Canada and Norway in Div. 0B, while the increase from 1991 to 1992 was due to the introduction of a trawl fishery by Russia in Div. 0B and an increase in fishing activity in SA 1.

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 14,513 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 4,722 tons in 1994, but increased again to 5,874 tons in 1996 over 5,299 tons in 1995 (Table 1).

Offshore catches amounted to 5,814 tons in 1996. Canadian and Japanese trawlers took 1142 tons and 500 tons, respectively, and 295 tons was taken in an exploratory trawl fishery in Div. 0A. Non-reported trawl catches amounted to 2730 tons. Further, 1147 tons was taken by Canadian gillnetters. Inshore catches, in Cumberland Sound, amounted to 60 tons.

The catches in Subarea 1 (Div. 1B-1F) were below 1,600 tons during the period 1982-1990. In 1991 catches increased to 2,376 tons and were around 5,500 tons in the period 1992-1995. Total catches in Div. 1B-1F decreased from 5,585 tons in 1995 to 4,455 tons in 1996, of which 4,451 were taken offshore, mainly in Div. 1D. 830 tons was taken by longlines from Greenland and Norway, while 3,493 tons was taken by trawlers from Greenland, EU (Germany and Spain), Norway and Russia. 128 tons taken by trawl was not reported. Inshore catches amounted to 105 tons of which 91 tons was taken in Div. 1D, mainly on longlines (84%) (Table 2).

2. Input data

2.1 Research trawl survey

Since 1988 annual trawl survey with a shrimp trawler have been conducted off West Greenland in July-September between 59°N and 72°30'N, from the 3-mile limit to the 600 m depth contour line.

Estimated total trawlable biomass of Greenland halibut in the offshore areas increased from 2,943 tons in 1991 to about 9,000 tons in 1992 and 1993 and further to 11,000 tons in 1994. After a drop in 1995 to 6,800 tons the total offshore biomass increased to 14,772 tons in 1996. The catches were almost exclusively comprised of one and two year old fish. The abundance was estimated to 491 mill, which is well above the level in 1992-1994 (about 250 mill) and an increase from 185 mill in 1995. In the Disko Bay the biomass was estimated to 8,047 tons and the abundance to 112 mill.

The biomass in the nursery area (1AS and 1B) was estimated to 7,753 tons compared to 3,422 tons in 1995. The abundance was estimated to 342 mill, which is well above the level in 1992-1995 (200 mill).

A recruitment index was provided from the Greenland trawl survey. By means of the Petersen-method ages 1, 2 and 3 were separated from survey catches in the nursery area for the period 1988 to 1995. In 1996 the age distribution was calculated from a age/length key sampled during the survey. 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. 1).

The recruitment has been declining since the presumably large 1991 year-class, but the recruitment since have been above the level in the 1980s. The 1995 yearclass seems, however, to be the largest on record. The mean catch of one year old fish was about 650 specimens per hour compared to about 350 in 1991. The figure from 1996 was, however, to some extent driven by one large catch. Is this catch excluded from the calculations mean catch per hour was 467 specimens, still well above the 1991 level. Catches of one year old fish in Disko Bay was also the highest on record. A great number of one year old fish were seen outside the traditional nursery area, especially north of Disko Island.

A Spawning stock biomass (SSB) index was calculated for the years 1988 to 1995, assuming knife-edge maturity ogive, using catch in numbers in Div. 1CD of ages 10 to 18 in the joint Japan/Greenland survey as index for spawning biomass. The standardized CPUE-values for age 1 from the Greenland trawl survey is plotted against SSB at spawning time (Fig. 2). Although the SSB in 1995 is the second lowest recorded, the recruitment of age 1 in 1996 is the highest in the time series.

An exploratory trawl fishery for Greenland halibut was conducted in Div. 0A in 30 days in September-October. Fishing took place within the 1,000 m and 1,300 m depth contours. Average catch rate was 0.6 tons and the biomass was estimated to 31,200 tons. Average length was 45.5 cm for males and 48.3 for females.

A tagging experiment was initiated in Cumberland Sound in May 1997. In total 144 Greenland halibut were tagged. Two tags have already been recovered, one in Cumberland Sound and one in the Davis Strait.

2.3 Commercial fishery data.

From the offshore fishery length frequency samples were obtained from trawlers in 0B and 1D, from gilnetters in 0B and from a longliner in Div. 1D.

Catch weight-at-age was calculated from data sampled from commercial trawlers in 0B and 1D and gilnetters in 0B. Table 3 and 4 shows catch-at-age and weight-at-age, respectively. The age distributions for trawl, longline and gillnets are given in Fig.3.

Age 7 is the most dominant yearclass in the trawl fishery and in the overall catches, but due to an increase in the longline catches, introduction of offshore gill net fishery in Div. 0B, and a tendency towards larger fish in the trawl catches in Div. 1D there has been a shift towards older fish in the catches last two years compared to the previous years.

Standardized catch rate series were calculated by means of division, tonnage, month and year based on available logbook data from the offshore fishery in Subarea 1 (1CD) in 1988-1996 and (EU) German data broken down by month and Division in 1996.

Catch rates for the Japanese trawler 'Shinkai Maru' were available for the period 1987-1995. No values were obtained from 1993 and 1996, as there was no commercial fishery by this vessel in West Greenland waters these years (Table 5).

Average catch rates were available from the Norwegian trawl fishery in Div. 1CD in the period 1991-1996 and from Div. 0B in 1993 and 1995. Data from Russian/Baltic States trawl fishery in Div. 0B were available for the period 1991-1995 (Table 5 and 6).

Further, catch rates from one offshore longliner were available from the period 1994-1996.

The standardized catch rate series fluctuated in the period 1988-1992, where the catch rate peaked. Since then catch rates has gradually decreased and is now about 45% lower than in 1992 (Fig. 4, Appendix 1). The available logbooks covered only a minor fraction of the fishery in 1996 and the last months in the year, where catch rates usually are highest, have only been covered by the German data (totally 452 tons).

Catch rates from 'Shinkai Maru' decreased substantially from 1992 to 1994, but increased again in 1995. Norwegian catch rates in SA 1 also decreased from 1991-1993, stabilized between 1993 and 1994, but decreased again in 1995. In 1996 the catch rates increased slightly and is now little below the 1993-1994 level (Fig. 5).

Catch rates in the Russian trawl fishery in Div. 1D was reported to be 4.2-5.0 tons per day in 1996.

The catch rates from the longline fishery in Div. 1CD increased from 116 kg/hr in 1994 to 181 kg/hr in 1995, but decreased again in 1996 to 112 kg/hr.

Norwegian catch rates in SA 0 have increased from 1991 to 1993, while Russian/Baltic catch rates have been stable in the same period.

Standardized catch rates from 0B increased from 1990 to 1991, but were reduced with about 30 percent from 1991 to 1993 (Atkinson et al, 1994).

All the CPUE series are more or less incomplete and it is difficult to make any firm conclusions about the development in the catch rates based on them, except that catch rates generally seem to have decreased in the period since 1988. The unstandardized Norwegian catch rate series indicates that the catch rates have stabilized in resent years.

3. Assessment.

3.1 Yield per Recruit Analysis.

The recent level of total mortality was estimated by means of a catch-curve using Norwegian data from the offshore longline fishery in Div. 1D. Z was estimated from a regression on age 15-21 and was found to be 0.38. Assuming a natural mortality of 0.15, overall F is 0.23. This is well below the estimates from 1994 and 1995 on 0.57. The relative F-at-age was derived from the catch curve analysis, where the trawl, longline and gill net catches were weighed and scaled to the estimated stock composition. Mean-weight-at-age was the average of 1992-1996. The input parameters for the Y/R analysis are given in Table 7. $F_{(max)}$ and $F_{(0.1)}$ were estimated to be 0.32 and 0.22, respectively (Fig. 6). The estimation of z was based on about 1200 fish only. The clear change in estimated F between 1995 and 1996 also implies that the outcome of the analysis is uncertain. STACFIS considered that the estimation of Z was based on a limited sample and represented a too small part of the fishery. Thus the outcome of the catch curve analysis was too uncertain to be used in the yield per recruit analysis.

4. Prognosis

Since catches peaked with 18.000 tons in 1992 they have been stable at around 11.000 tons. The age composition in the catches seems stable. The recruitment has declined compared to the presumably good 1991 yearclass, but increased again and the 1995 yearclass seem to be to the largest in the time series. Standardized catch rates declined further in 1996, but the 1996 data are considered poor. A Norwegian unstandardized catch rate series showed a slight increase between 1995 and 1996.

5. Biological reference points.

During the brief discussion on biological reference points to be used in the future in connection to the "precautionary approach" adopted during the meeting, yield per recruit analysis, biomass indices and CPUE series were mentioned as relevant possibilities.

6. References

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Table 1. Greenland halibut landings (metric tons) by year and country for Subarea 0 from 1987 to 1996.

	Year									
Country	87	88	89	90	91	92	93[a]	94[a]	95[a]	96[a]
CAN	-	2	-	589	256	2194	883	-	1366	2349[f]
EST	-	-	-	-	-	-	631	-	-	-
FRO	388	963	596	2252	2401	463	-	-	-	-
JAP	-	-	-	113	232	337	252	600	1031	500
LAV	-	-	-	-	-	-	83	-	-	-
NOR	-	-	282	10031	3959	-	373	-	-	-
RUS	-	59	29	1528	1758	9364	4229[b]	3674	261	-
TOTAL	388	1024	907	14513	8606	12358	7060[c]	4274	5299[d]	5874[e]

[a] Provisional data.
[b] The russian catch is reported as area unknown, but has peviously been reported from 0B
[c] Including 609 tons non-reported.
[d] Including 2641 tons non-reported.
[e] Including 3025 tons non-reported, but excluding 295 tons from an exploratory fishery in 0A.
[f] Including 60 tons from Cumberland Sound

Table 2. Greenland halibut landings (metric tons) by year and country for Subarea 1 from 1987 to 1996.

	Year									
Country	87	88	89	90	91	92	93[a]	94[a]	95[a]	96[a]
GRL	8385	7003	7492	8352	10209	12164	13417	14952	18385	19153
FRO			-	54	123	151	-	-	-	-
JPN	907	1581	1300	988	677	2902	1198	820	337	-
NOR	-	-	-	-	611	2432	2305	3166	2377	1856
RUS	-	-	-	-	-	-	5	-	269	229
EU	-	-	-	-	-	-	46	266	528	457
1A	8385	7003	7492	8352	9244	11937	13204	14067	16978	17267
1B-F	907	1581	1300	1042	2376	5712	3897[b]	5917[c]	5585[d]	4556[e]
TOTAL	9292	8584	8792	9394	11620	17649	17101[b]	19984[c]	22563[d]	21553[e]

[a] Provisional data.
[b] Including 130 tons non-reported.
[c] Including 780 tons non-reported.
[d] Including 667 tons non-reported.
[e] Including 128 tons non-reported.

Table 3. Catch numbers at age

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE										
5	2	1	1	121	22	50	235	388	101	165
6	31	29	36	895	322	678	615	1252	491	606
7	182	190	244	3192	1775	2967	2243	2630	2035	2195
8	296	354	408	2884	2734	4315	2141	1734	1217	1853
9	193	245	212	1602	1453	2603	951	862	761	790
10	77	115	75	769	549	950	541	280	378	372
11	40	80	47	419	226	397	210	177	333	189
12	18	61	48	406	147	234	123	138	290	146
13	10	58	44	243	110	154	67	110	161	72
14	9	46	42	143	59	83	57	48	112	62
15	6	35	26	34	39	46	35	49	124	42
16	3	15	12	3	7	23	27	29	54	37
17	4	4	2	1	2	2	4	9	27	14
+gp	2	1	0	0	0	0	2	6	13	22
TOT.NUM	873	1234	1197	10712	7445	12502	7251	7712	6097	6564
TONS	1295	2605	2207	15555	10982	18070	10957	10191	10884	10430

Table 4. Catch weights at age (kg)

YEAR / AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
5	0,289	0,29	0,29	0,38	0,338	0,326	0,59	0,431	0,471	0,516
6	0,508	0,51	0,51	0,56	0,538	0,557	0,73	0,636	0,644	0,676
7	0,739	0,74	0,74	0,81	0,795	0,802	0,97	0,944	0,931	0,938
8	1,078	1,08	1,08	1,1	1,124	1,131	1,27	1,288	1,329	1,371
9	1,41	1,42	1,42	1,52	1,577	1,592	1,81	1,737	1,813	1,895
10	1,965	2,05	2	2,11	2,275	2,278	2,44	2,142	2,4	2,472
11	2,582	2,8	2,68	2,94	3,225	3,019	3,25	2,695	2,921	3,175
12	3,522	3,88	3,73	3,91	4,238	4,023	4,1	3,42	3,643	4,035
13	4,643	5,01	4,87	4,96	5,504	5,329	5,24	4,389	4,468	5,056
14	5,789	6,16	6,2	6,27	6,813	6,753	6,15	5,572	5,662	5,946
15	6,605	7,44	7,64	7,88	8,348	7,781	7,4	6,572	6,653	7,302
16	7,987	8,88	9,42	7,99	10,077	8,568	8,1	7,723	7,739	8,634
17	9,557	9,86	10,58	9,56	9,557	11,951	9,24	9,089	10,276	9,167
+gp	11,334	11,334	11,33	11,347	11,334	11,951	10,25	11,815	11	11,1

Table 5. CPUE in Div. 1C+D by the Japanese trawler Shinkai Maru in the period 1987-1995.

Year	min.	Catch (tons)	CPUE tons/hour
1987	39,285	877	1.34
1988	76,473	1,567	1.23
1989	61,845	1,298	1.30
1990	52,020	963	1.11
1991	42,210	657	0.93
1992	50,220	991	1.18
1993	-	-	-
1994	18,956	242	0.77
1995	19,345	315	0.98

Table 6. CPUE in Divs. 1C+1D by Norwegian factory trawlers 1991-1996.

DIVISION		1991	1992	1993	1994	1995	1996
1C Norwegian trawlers	min	12,279	19,702	20,222	1,077	43,8376	
	catch (t)	176	243	182	7	234	
	CPUE	0.86	0.74	0.54	0.39	0.32	
1D Norwegian trawlers	min	42,495	207,802	238,500	321,457	286,468	194,204
	catch (t)	687	2,459	2,226	3,161	2,2244	1,586
	CPUE	0.97	0.71	0.56	0.59	0.47	0.49

Table 7. CPUE in Divs. 0B and by Norwegian factory trawlers and by Russian/Baltic States trawlers in 1990-1993.

DIVISION		1990	1991	1992	1993
0B Norwegian trawlers	min		236,259		24,191
	catch (t)		3,032		379
	CPUE		0.77		0.94
0B Russian and Baltic trawlers	min	255,660	241,980	964,680	615,600
	catch (t)	1,332	1,438	5,731	3,361
	CPUE	0.31	0.36	0.36	0.33

Table 8. Input parameters for Yield per Recruit analysis. Mean weight is mean of 1992-1996.

Age	Mean weight	Relative S	Natural Mort.
5	0.446	0.48	0.15
6	0.648	0.70	0.15
7	0.916	1.0	0.15
8	1.277	1.0	0.15
9	1.796	0.87	0.15
10	2.345	0.74	0.15
11	3.012	0.81	0.15
12	3.844	0.55	0.15
13	4.897	0.42	0.15
14	6.017	0.39	0.15
15	7.140	0.32	0.15
16	8.159	0.27	0.15
17	9.944	0.13	0.15
18+	11.223	0.06	0.15

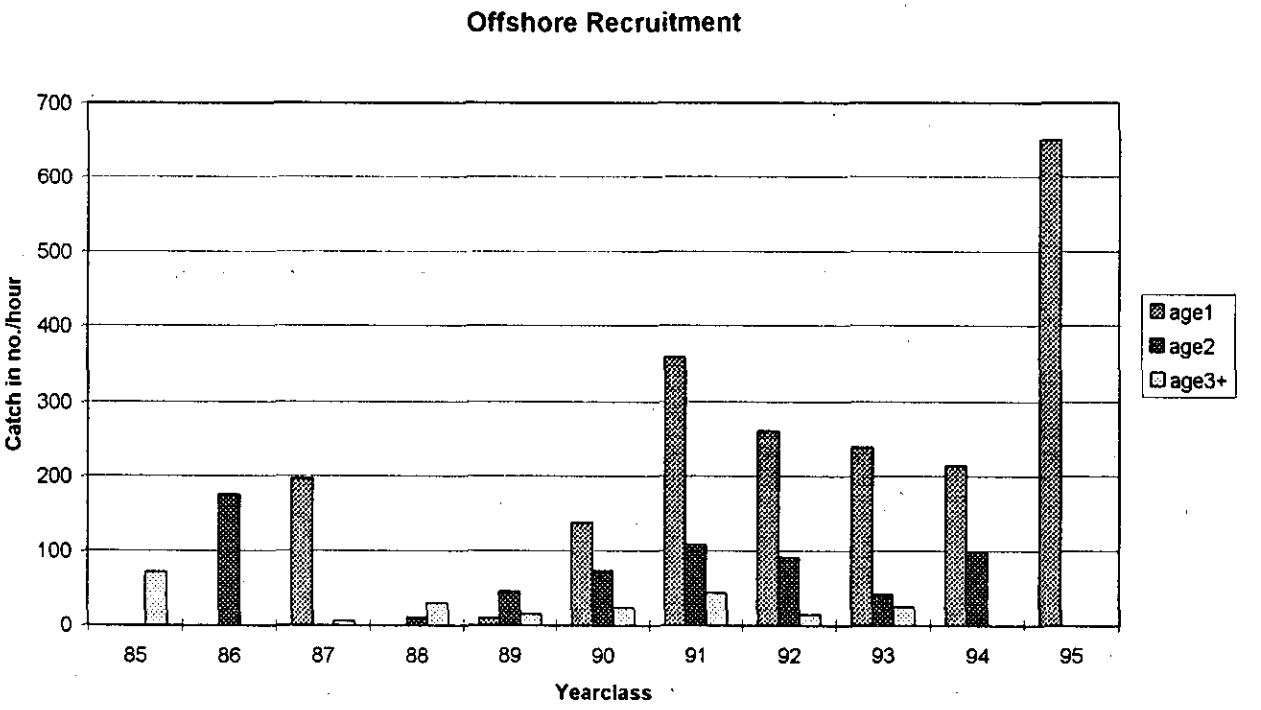


Fig. 1. Yearclass strength of Greenland halibut of ages 1-3 in number per hour trawled in the offshore nursery area.

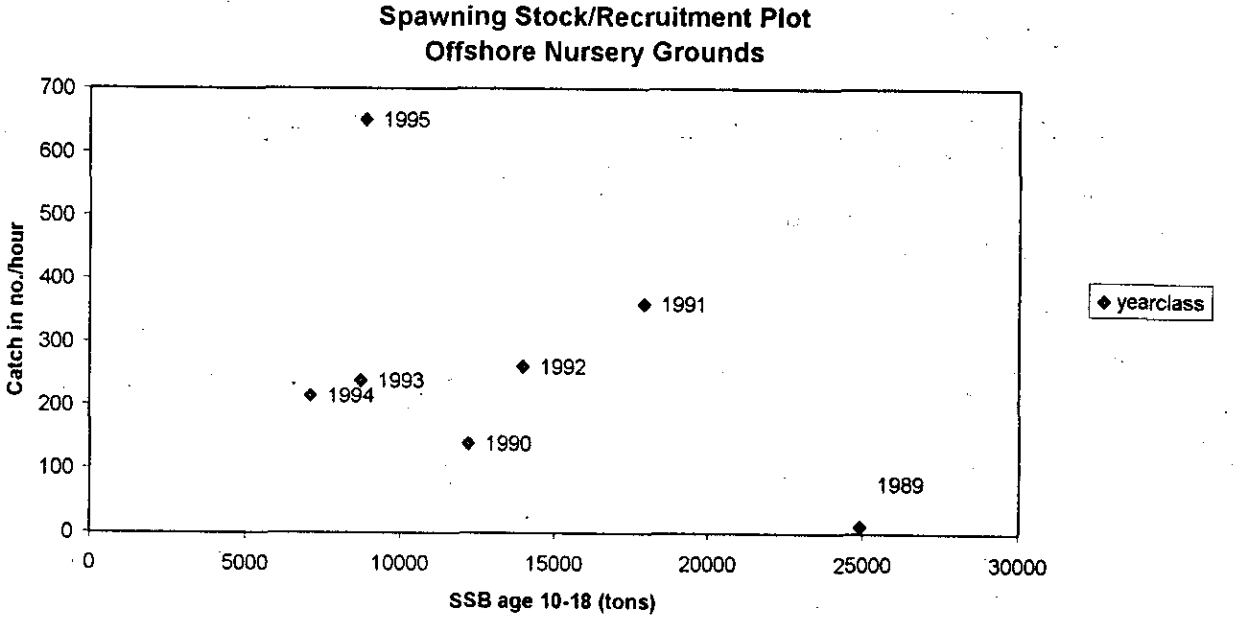
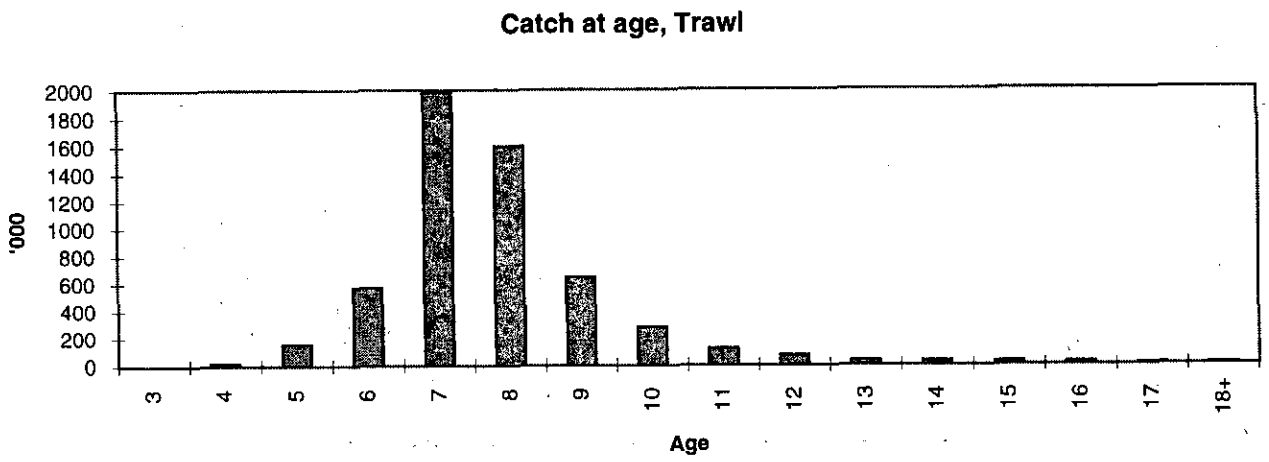
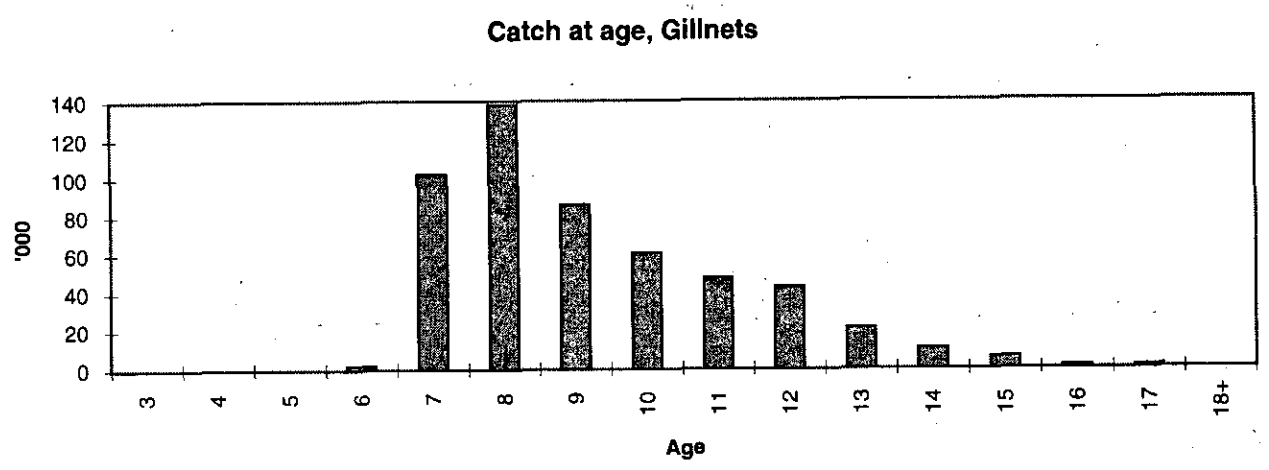


Fig.2. Spawning stock (ages 10-18 in Div.1CD from the joint Japan/Greenland survey) plotted vs number of fish age 1 per hour trawling the following year from the Greenland trawl survey.





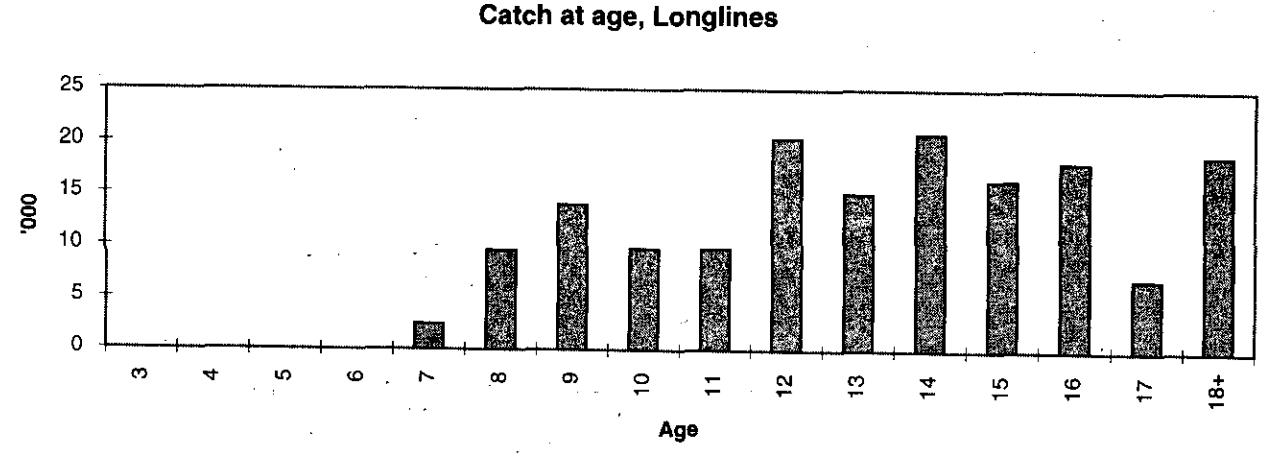


Fig. 3. Age distribution in the offshore trawl, gillnet and longline fishey in SA 0+1 in 1996.

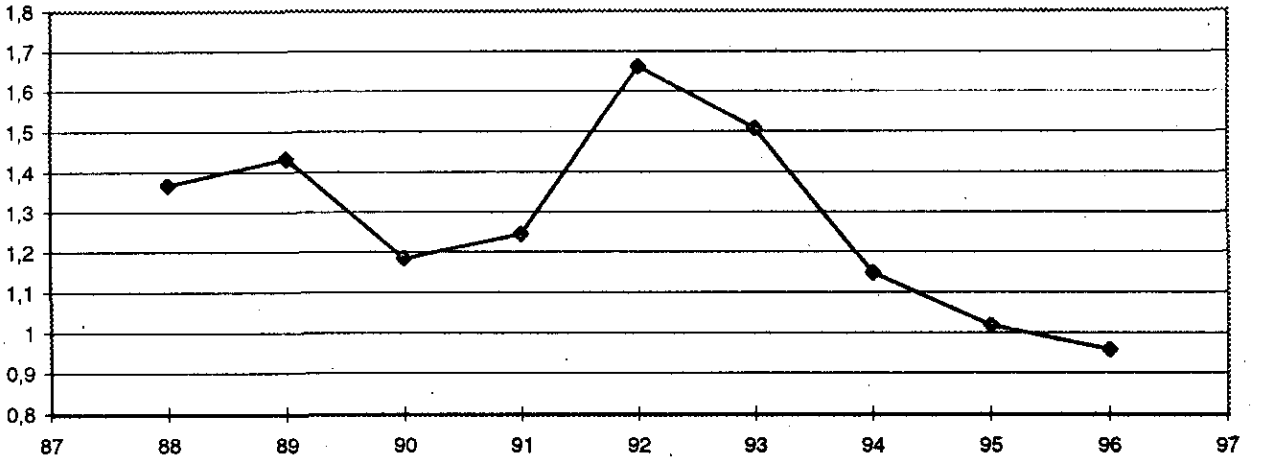


Fig. 4. Standardized CPUE Series from Div. 1CD.

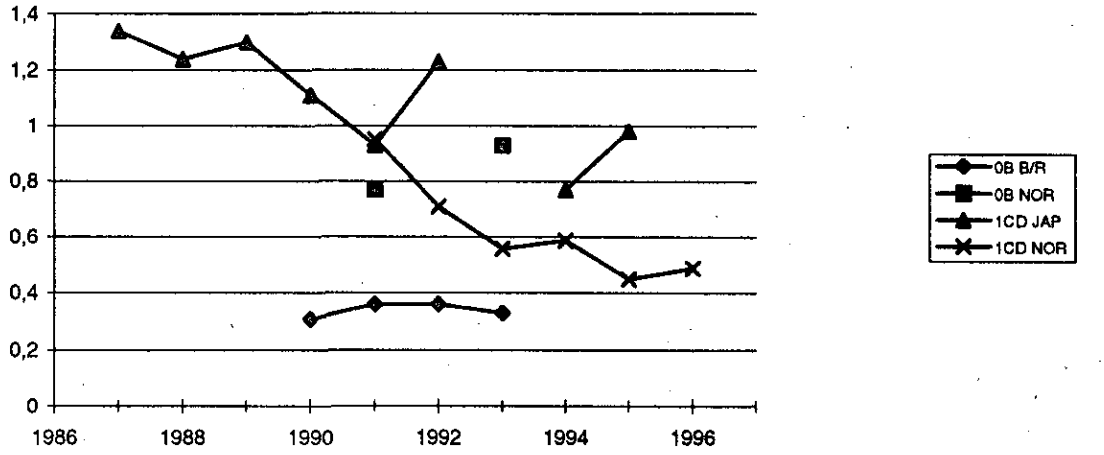


Fig. 5. Unstandardized CPUE Series from SA 0 and SA 1. B/R: Baltic State and Russian trawlers, NOR: Norweigian trawlers and JAP:One large Japanese Trawler (Shinkai Maru).

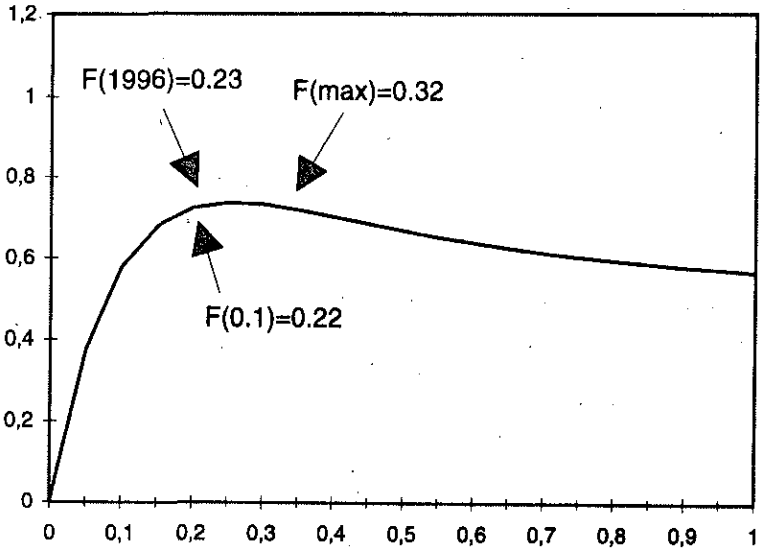


Fig. 6. Yield pr Recruit analysis for SA 0+1 for 1995.

Appendix 1

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YR	9	88 89 90 91 92 93 94 95 96
MD	9	4 5 6 7 8 9 10 11 12
DIV	2	1C 1D
CGT	3	5 6 7

Number of observations in data set = 81

Dependent Variable: LCPH

Source	DF	Sum of Squares	F Value	Pr > F
Model	19	16.16504944	9.65	0.0001
Error	61	5.37753375		
Corrected Total	80	21.54258319		

R-Square	C.V.	LCPH Mean
0.750377	-77.69199	-0.38216455

Source	DF	Type I SS	F Value	Pr > F
YR	8	10.53628638	14.94	0.0001
MD	8	0.61770576	0.88	0.5418
DIV	1	0.00352139	0.04	0.8423
CGT	2	5.00753591	28.40	0.0001

Source	DF	Type III SS	F Value	Pr > F
YR	8	1.94227285	2.75	0.0115
MD	8	0.86863278	1.23	0.2964
DIV	1	0.05245781	0.60	0.4434
CGT	2	5.00753591	28.40	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-.0441963268	B	-0.17	0.8657	0.26013134
YR	88	0.3571411184	B	1.59	0.1160	0.22400311
	89	0.4049164881	B	1.73	0.0883	0.23375941
	90	0.2132761770	B	0.93	0.3579	0.23022122
	91	0.2638197583	B	1.24	0.2204	0.21309362
	92	0.5534514249	B	3.27	0.0018	0.16940731
	93	0.4544060174	B	2.58	0.0122	0.17597000
	94	0.1830830883	B	1.05	0.2960	0.17368318
	95	0.0619463317	B	0.35	0.7239	0.17457427
	96	0.0000000000	B	.	.	.
MD	4	-.1621298509	B	-0.47	0.6380	0.34287081
	5	-.1000582369	B	-0.32	0.7504	0.31311635
	6	-.1352572186	B	-0.43	0.6696	0.31545665
	7	-.2119775625	B	-0.52	0.6066	0.40953975
	8	-.2586727666	B	-1.07	0.2869	0.24075508
	9	-.4180399073	B	-1.76	0.0837	0.23776252
	10	-.1937409766	B	-0.81	0.4230	0.24019274
MD	11	-.1526683518	B	-0.63	0.5309	0.24224243
	12	0.0000000000	B	.	.	.
DIV	1C	-.0553487096	B	-0.77	0.4434	0.07175119
	1D	0.0000000000	B	.	.	.
CGT	5	-.8307722946	B	-6.01	0.0001	0.13826773
	6	-.7674898896	B	-7.17	0.0001	0.10700027
	7	0.0000000000	B	.	.	.

CGT: 5 small Japanese trawlers. 6 Various trawlers from Greenland, Norway, Germany and Faroe Islands. 7 one large Japanese trawler