Northwest Atlantic Fisheries Organization

Serial No. N2743 NAFO SCR Doc. 96/67

SCIENTIFIC COUNCIL MEETING - JUNE 1996

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

by

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SCS: 1996/3, 9, 11 and 13. SCR: 1996/14, 29 and 36.

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

Between 1979 and 1994 a TAC has been 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. A TAC for Sub. 0+Div.1B-1F was set to 11,000 tons for 1995 and 1996.

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 gradually decreased to 10,572 tons in 1994, but increased again to 11,054 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 Sub 1.

In 1983 annual catches in Division 0B was at 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 in 1995 to 5,880 tons (Table 1). Offshore catches amounted to 5,595 tons, - 4,072 tons were taken by Canadian trawlers and trawlers chartered by Canada, 1,249 tons were taken by gillnets and 274 tons by longline (Russia). Inshore catches, in Cumberland Sound, amounted to 285 tons taken by longlines and gillnets.

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 1992-1994. Total catches in Div. 1B-1F decreased to 5,174 tons in 1995, of which 5,095 were taken offshore, mainly in Div. 1CD. 529 tons was taken by longlines while 4,593 tons was taken by trawlers from Greenland, EU, Norway and Russia. Inshore catches amounted to 79 tons taken by gillnets. (Table 2).

2. Input data

2.1 Research trawl surveys

Since 1987 bottom-trawl surveys have been conducted in Subarea 1 jointly by Japan and Greenland. In 1995 a survey was conducted, in August (Yokawa et al. 1996). The survey covered Div. 1A (south of 70°N) to 1D at depths between 400 and 1500 m. The trawlable biomass was estimated to be 40,800 tons, which is a statistically insignificant increase compared to 31,300 tons in 1994. The 1995 estimate includes 400 tons from 1A, which was not covered in 1994. As in 1994 estimate the estimate from 1995 is significantly lower than the estimates from 1992 (62,000 tons) and 1991 (77,00 tons) (Table 3). The increase in estimated biomass between 1994 and 1995 was seen in all divisions, but was mainly due to an increase in the estimated biomass in Div. 1CD depth stratum 601-1000 m. Abundance estimates for Div. 1CD for the period 1988-1995 are given in Table 4. Total abundance fluctuated between 35 mill. and 53 mill. in the period 1988 to 1991 and declined gradually from 53 mill. to 25 mill. in 1994, the lowest in the time series. In 1995 the abundance increased to 31 mill. The increase is seen in most age groups, but is most pronounced in age group 4, - the presumably good 1991 year class, which now seems to have started to migrate into Div.1CD. In Div. 1B there was observed an 2.5 - 4 times increase in the abundance of 1-4 year old fish compared to 1994, but the observation is based on few hauls.

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 in the offshore areas increased from 2,943 tons in 1991 to about 9,000 tons in 1992 and 1993 and further to 12,222 tons in 1994 (Bech 1995). In 1995 total offshore biomass dropped of to 7,782 tons. The catches were almost exclusively comprised of one and two year old fish. The abundance was estimated to 184 mill, which is somewhat below the level in 1992-1994 (about 250 mill) but above the 70-80 mill. recorded in 1990 and 1991.

The biomass in the nursery area (1AS and 1B) was estimated to 4,404 tons compared to 8,224 tons in 1994 and 5,500 tons in 1993-1994. The abundance was estimated to 145 mill. This is below the level in 1992-1994 (200 mill) but above the level in 1990-1991 (60 mill) (Bech, 1995). In the Disko Bay the biomass was estimated to 5,452 tons and the abundance to 83 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. Catches were standardized as catch in number per hour as described in Bech, 1995. Data were plotted by yearclasses to visualize the relative year class strength and development in relative abundance (Fig. 1). The recruitment has been declining since the large 1991 yearclass and the 1994 yearclass seems at an average level.

A Spawning stock biomass (SSB) index was calculated for the years 1988 to 1994, assuming knife-edge maturity ogive, using catch in numbers of ages 10 to 18 in the joint Japan/Greenland survey in Div. 1CD (Tab. 4). The standardized CPUE-values for age 1 from the Greenland trawl survey is plotted against SSB at spawning time (Fig. 2). Although the SSB the lowest recorded in 1994 the recruitment of age 1 in 1995 seems to be at an average level.

Based on the Greenland shrimp trawl survey the by catch of Greenland halibut in the shrimp fishery at West Greenland in 1994 was estimated to 1,467 tons (21 mill specimens) (Engelstoft 1996). The total biomass and abundance of the area was estimated to 15,400 tons and 297 mill, respectively (Bech 1995. The bulk of the by catch consisted of 1 and 2 year old fish and was taken mainly in Div. 1A and 1B.

2.3 Commercial fishery data.

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

Catch weight-at-age was calculated from data sampled in 1995 from the Greenland/Japan survey, the Greenlandic trawl survey and from the commercial offshore long-line fishery. Table 5 and 6 shows catch-at-age and weight-at-age, respectively. The relative age distributions for trawl, offshore longlines and gill nets are given in Fig.3. Age 7 is still the most dominant yearclass 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 there has been a shift towards older fish in the catches 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 1988-1995. The catch rate series fluctuated in the period 1988-1992, but have shown a decrease of about 45% between 1992 and 1994. In 1995 the index increased again to a little below the average of the period 1988-1994 (1.021 vs 0.976) (Fig. 4, Appendix 1).

Catch rates for the Japanese trawler 'Shinkai Maru' were available for the period 1987-1995. No values were obtained from 1993, as there was no commercial fishery by this vessel in West Greenland waters this year (Table 7). Average catch rates from the Norwegian trawl fishery in Divisions 0B and 1CD and from Russian/Baltic States trawl fishery in Division 0B were available for the period 1991-1995. Further, catch rates from one offshore longliner were available from 1994 and 1995. Catch rates from 'Shinkai Maru' decreased substantially from 1992 to 1994, but increased again in 1995. Norwegian catches in SA 1 also decreased from 1991-1993, and stabilized between 1993 and 1994, but decreased again in 1995. Norwegian catch rates in SA 0 have increased from 1991 to 1993, while Russian/Baltic catch rates have been stable in the same period (Fig. 5). The catch rate from the longline fishery increased from 116 kg/hr to 181 kg/hr, but due to large variations in data there was no statistically difference between the 1994 and 1995 in the standardized catch rate.

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).

Most of the CPUE series are, however, incomplete and it is difficult to make any firm conclusions about the development based on them.

3. Assessment.

3.1 Yield per Recruit Analysis.

The recent level of total mortality was estimated by means of a catch-curve using data from the offshore longline fishery in Div 1D in September. Z was estimated from a regression on age 15-21 and was found to be 0.72, the same as in 1994. Assuming a natural mortality of 0.15, overall F is 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 1993-1995. The input parameters for the Y/R analysis is given in Table 9. $F_{(max)}$ and $F_{(0.1)}$ were estimated to be 0.26 and 0.17, respectively (Fig. 6). 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 analysis was too uncertain to be used in a yield per recruit analysis. It was proposed to try to estimate z by other methods, e.g. by looking at changes in z in the trawl survey. The length distribution in the trawl catches is assumed to be dome shaped, but the relative changes in z from year to year could be used to get an impression of the changes in the fishing mortality.

3.2 Extended Survivors Analysis (XSA).
Abundance estimates from RV 'Shinkai Maru' for the age groups 9-13, during the period 1989-1995 and standardized CPUE data from SA1 for the age groups 5-13 during the period 1988-1995 were used to tune the catch-at-age data using a XSA. Natural mortality was set to 0.15, catch-at-age and weight-at-age data used are shown in Table 5 and 6. The XSA had not converged after 100 iterations and the outcome of the tuning showed that neither the survey data nor the CPUE series did match the catch data as shown by high log-catchability residuals and S.E.'s and systematic shift in the residuals by year. Further, a retrospektiv plot of $F_{(bar)}$, ages 8-13, covering the years 1990-1995 showed poor convergence. The output from the analysis and the plot is given in Appendix 2. STACFIS considered that the XSA was unsuitable for an analytic assessment.

4. Prognosis

Since catches peaked with 18.000 tons in 1992 they have been stable at around 11.000 tons. The estimated biomass in SA1 showed an increase from 31.000 in 1994 to 41.000 tons in 1995 and seems to have stabilized, on, however, a lower level compared to the late 80'ies and early 90'ies. The recruitment has declined compared to the presumably good 1991 yearclass, but is still considered to be at or above average for the last decade. The 1991 yearclass was still considered to be good at age 4 and will enter the trawl fishery in 1996 and 1997. Although incomplete three out of four available CPUE indices showed an increase.

5. References

Atkinson, D.B., W.R. Bowering and W. Brodie. 1994. Analysis of Data Collected by Observers During the Greenland Otter Trawl Fisheries in Subarea 0 During 1988-1993. NAFO SCR Doc. 94/47.

Bech, G. 1995. Recruitment of Greenland halibut at West Greenland. NAFO SCR Doc. 95/19.

Engelstoft, J.J. 1996. By-catches in the Shrimp Fishery at West Greenland. NAFO SCR Doc. 96/36.

Yokawa, K., I.Kouya and O. Jorgensen. 1996. Results of a Stratified Random Bottom Trawl Survey off West Greenland in 1995. NAFO SCR Doc. 96/29

Table 1. Greenland halibut landings (metric tons) by year and country for Subarea 0 from 1984 to 1995.

							YEAR					
Country	84	85	86	87	88	89	90	91	92	93[a]	94[a]	95[a]
CAN	-	-	-	-	2	-	589	256	2194	883	400	1934
E/DEU	-	335	-	-	-	-	-	-	-	-	-	-
EST	-	-	-	-	-	-	-	-	-	631	-	-
FRO	370	525	240	388	963	596	2252	2401	463	609	-	-
JPN	-	-	-	-	-	-	113	232	337	252	599	1031
LAV	-	-	-	-	-	-	-	-	-	83	-	-
NOR	-	-	-	-	-	282	10031	3959	-	754	-	-
RUS	109	179	32	-	59	29	1528	1758	9364	4229	3723	274
Total	479	1039	272	388	1024	907	14513	8606	12358	7441	4722	5880[b]

[a] Provisional data. [b] Including 2641 tons non reported.

Table 2. Greenland halibut landings (metric tons) by year and country for Subarea 1 from 1984 to 1995.

							YEAR					
Country	84	85	86	87	88	89	90	91	92	93[a]	94[a]	95[a]
E/DEU	15	-	-	-	-	-	-	-	-	46	217	-
GRL	6509	9127	8333	8385	7003	7492	8352	10209	12164	13054	14933	19319
FRO	-	-	-	-	-	-	54	123	151	130	780	-
JPN	26	5	-	907	1581	1300	988	677	2902	1432	819	371
NOR	2	-	-	-	-	-	-	611	2432	2957	3168	2471
RUS	-	-	-	-	-	-	-	-	-	5	-	270
EEC	-	-	-	-	-	-	-	-	-	-	-	-
1A	6509	9127	8333	8385	7003	7492	8352	9244	11937	12136	14067	17924
1B-F	43	5	0	907	1581	1300	1042	2376	5712	5488	5850	5174[b]
Total	6552	9132	8333	9292	8584	8792	9394	11620	17649	17624	19917	23098[b]

[a] Provisional data. [b] Including 667 tons non-reported.

Table 3. Biomass estimates (000' tons) from Greenland/Japanese surveys and USSR(RUS)/DDR(FRG) surveys for the years 1987-1993 in Subareas 0+1.

	USSR(RUS)/DDR(FRG) SURVEY		JAPAN/GREENLAND SURVEY		
	0B	1BCD	1ABCD	1BCD	0B+1ABCD
1987	37	56	58[a]	54[a]	91
1988	55	47	63	53	118
1989	79	-	-	63[c]	142
1990	72	88	56[b]	53[b]	128
1991	46	-	79	77	125
1992	38	-	64	62	102
1993	-	-	-	38	-
1994	-	-	-	31	-
1995	-	-	41	40	-

- no survey
[a] In 1987 the survey did not cover the depth stratum 1000-1500 m.
[b] Average values of two surveys.
[c] Estimate only for Division 1CD

Table 4.

Shinkai Maru abundance 1988-1995

AGE	1988	1989	1990	1991	1992	1993	1994	1995
2	233667	999	39653	81442	177352	246951	106885	234707
3	824877	33120	180794	203924	603235	830089	120873	383537
4	904683	135846	381028	475877	1176244	804394	665196	1619109
5	1149580	851510	939230	1450093	1422248	1346292	2856823	3654149
6	3528429	5343530	3425214	6430029	5400272	4360004	6134362	6015273
7	9682494	14409742	9446792	15945431	13675362	8827242	7010101	9739100
8	11513663	15878658	11313019	16536178	14699904	7951066	4305453	4736611
9	6011974	8368264	5834808	7490318	6837729	3598001	1490005	1916770
10	1964384	3122991	1681039	1985161	1628587	1033467	578162	523811
11	1108287	1876087	858729	1049217	851909	546716	385302	530535
12	528384	951817	343344	491207	379638	237588	204214	320888
13	348397	640065	190215	325502	229556	153837	217956	203840
14	304134	473411	175170	320871	209676	146353	46177	126522
15	212210	350603	135833	222022	164241	109022	200199	238374
16	81195	56094	66475	53230	72466	44209	68170	134467
17	102960	61352	72065	90491	78903	37815	23692	99322
18	62093	17980	49672	62013	52681	25271	74868	7640
19	16208		12655	6388	11442	1818	85951	20476
20	5403		5625	5536	3814	606	36400	15280
21			2109	5110			16993	20476
22	7718							19864
TOTAL	38590740	52572070	35153470	53230040	47675260	30300740	24627781	30560751
CHECK	38590740	52572070	35153470	53230040	47675260	30300740	24627781	30560751

Table 5 Catch numbers at age

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE									
5	2	1	1	121	22	50	322	389	260
6	31	29	36	895	322	678	761	1290	780
7	182	190	244	3192	1775	2967	2631	2758	1661
8	296	354	408	2884	2734	4315	2408	1842	1061
9	193	245	212	1602	1453	2603	1059	893	645
10	77	115	75	769	549	950	611	287	232
11	40	80	47	419	226	397	245	179	321
12	18	61	48	406	147	234	144	139	246
13	10	58	44	243	110	154	79	111	192
14	9	46	42	143	59	83	73	48	148
15	6	35	26	34	39	46	46	49	177
16	3	15	12	3	7	23	36	29	75
17	4	4	2	1	2	2	6	9	36
+gp	2	1	0	0	0	0	3	6	21
TOT.NUM	873	1234	1197	10712	7445	12502	8424	8029	5855
TONS	1295	2605	2207	15555	10982	18070	12929	10572	11054
SOP %	101	100	100	100	100	100	100	100	100

Table 6. Catch weights at age (kg)

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE									
5	0.289	0.29	0.29	0.38	0.338	0.326	0.59	0.431	0.496
6	0.508	0.51	0.51	0.56	0.538	0.557	0.76	0.638	0.692
7	0.739	0.74	0.74	0.81	0.795	0.802	1	0.948	0.987
8	1.078	1.08	1.08	1.1	1.124	1.131	1.29	1.292	1.36
9	1.41	1.42	1.42	1.52	1.577	1.592	1.84	1.738	1.817
10	1.965	2.05	2	2.11	2.275	2.278	2.46	2.14	2.165
11	2.582	2.8	2.68	2.94	3.225	3.019	3.25	2.694	2.68
12	3.522	3.88	3.73	3.91	4.238	4.023	4.06	3.42	3.241
13	4.643	5.01	4.87	4.96	5.504	5.329	5.19	4.388	4.123
14	5.789	6.16	6.2	6.27	6.813	6.753	6.09	5.572	5.581
15	6.605	7.44	7.64	7.88	8.348	7.781	7.35	6.573	6.623
16	7.987	8.88	9.42	7.99	10.077	8.568	8.01	7.724	7.664
17	9.557	9.86	10.58	9.56	9.557	11.951	9.24	9.089	10.251
+gp	11.334	11.334	11.33	11.347	11.334	11.951	10.25	11.815	11
SOP	*1.0093*	*1.0017*	*1.0016*	*0.9981*	*1.0002*	*1.0005*	*1.0018*	*1.0009*	*1.0006*

Table 7. 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 8. CPUE in Divs. 0B and 1C+1D by Norwegian factory trawlers 1991-1995 and by Russian/Baltic States trawlers in Div. 0B 1990-1993.

DIVISION		1990	1991	1992	1993	1994	1995
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		
1C Norwegian trawlers	min		12,279	19,702	20,222	1,077	43,875
	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	285,572
	catch (t)		687	2,459	2,226	3,161	2,237
	CPUE		0.97	0.71	0.56	0.59	0.47

Table 9. Input parameters for Yield per Recruit analysis.

Age	Mean weight	Relative S	Natural Mort.
5	0.506	0.62	0.15
6	0.697	0.81	0.15
7	0.978	1.0	0.15
8	1.314	0.96	0.15
9	1.798	0.93	0.15
10	2.255	0.74	0.15
11	2.874	0.80	0.15
12	3.574	0.75	0.15
13	4.567	0.71	0.15
14	5.748	0.65	0.15
15	6.848	0.71	0.15
16	7.799	0.50	0.15
17	9.527	0.41	0.15
18+	11.020	0.24	0.15

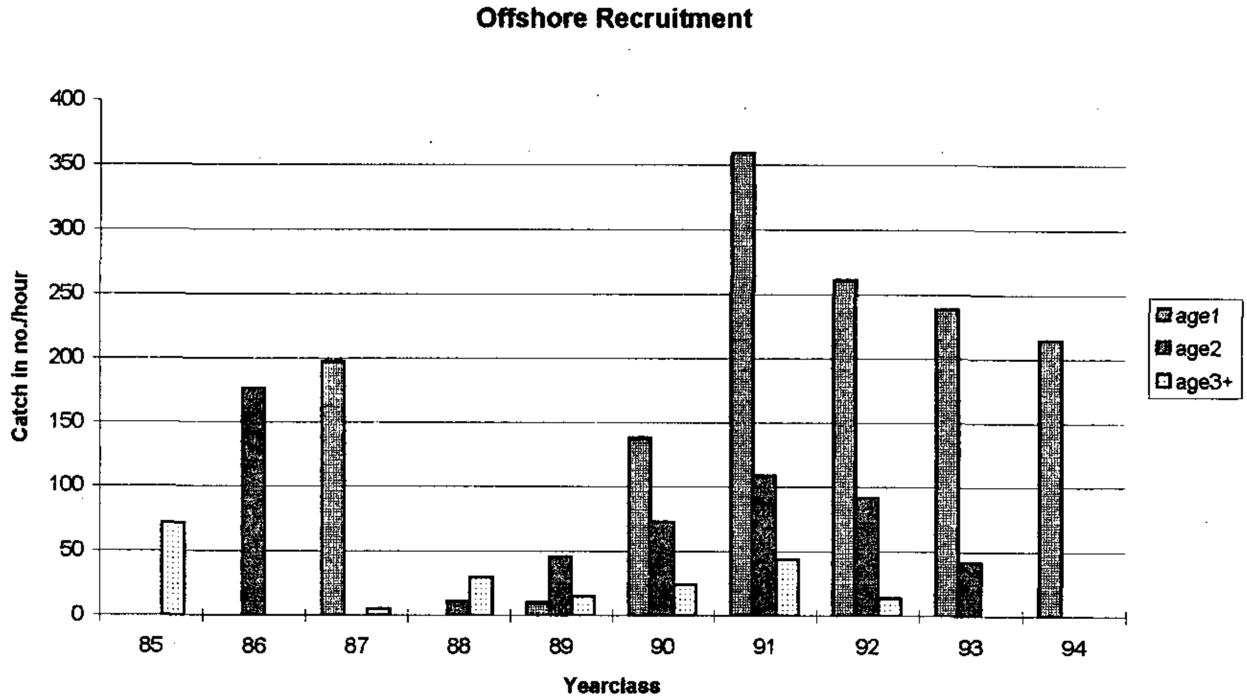


Fig. 1. Yearclass strength of Greenland halibut of ages 1-3 in number per hour trawled.

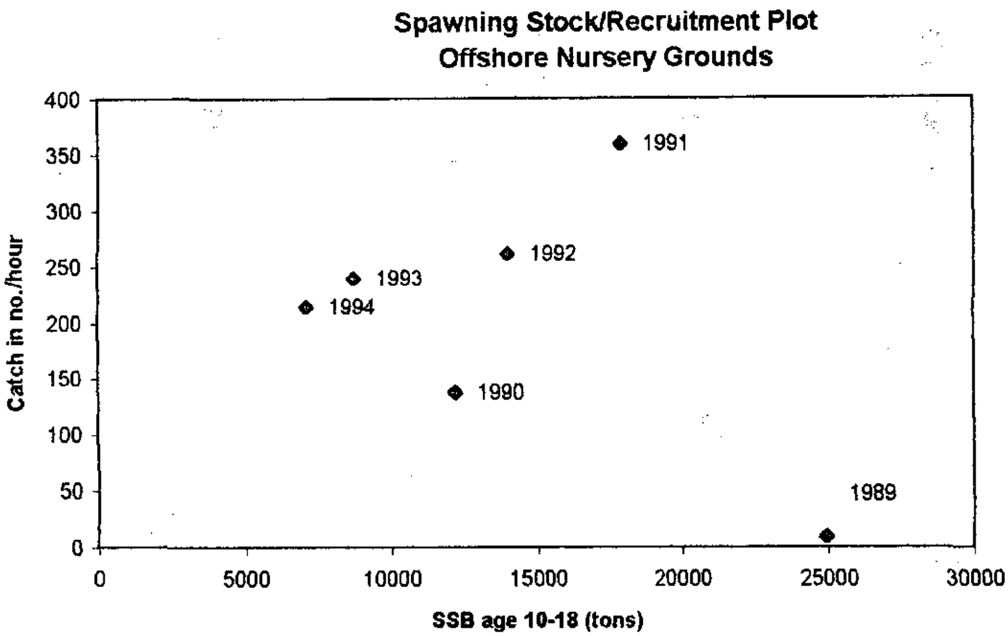


Fig.2. Spawning stock (ages 10-18 in Div.1CD from the joint Japan/Greenland survey) plotted vs number of fish age 1 per hour trawling the following year from the Greenland trawl survey.

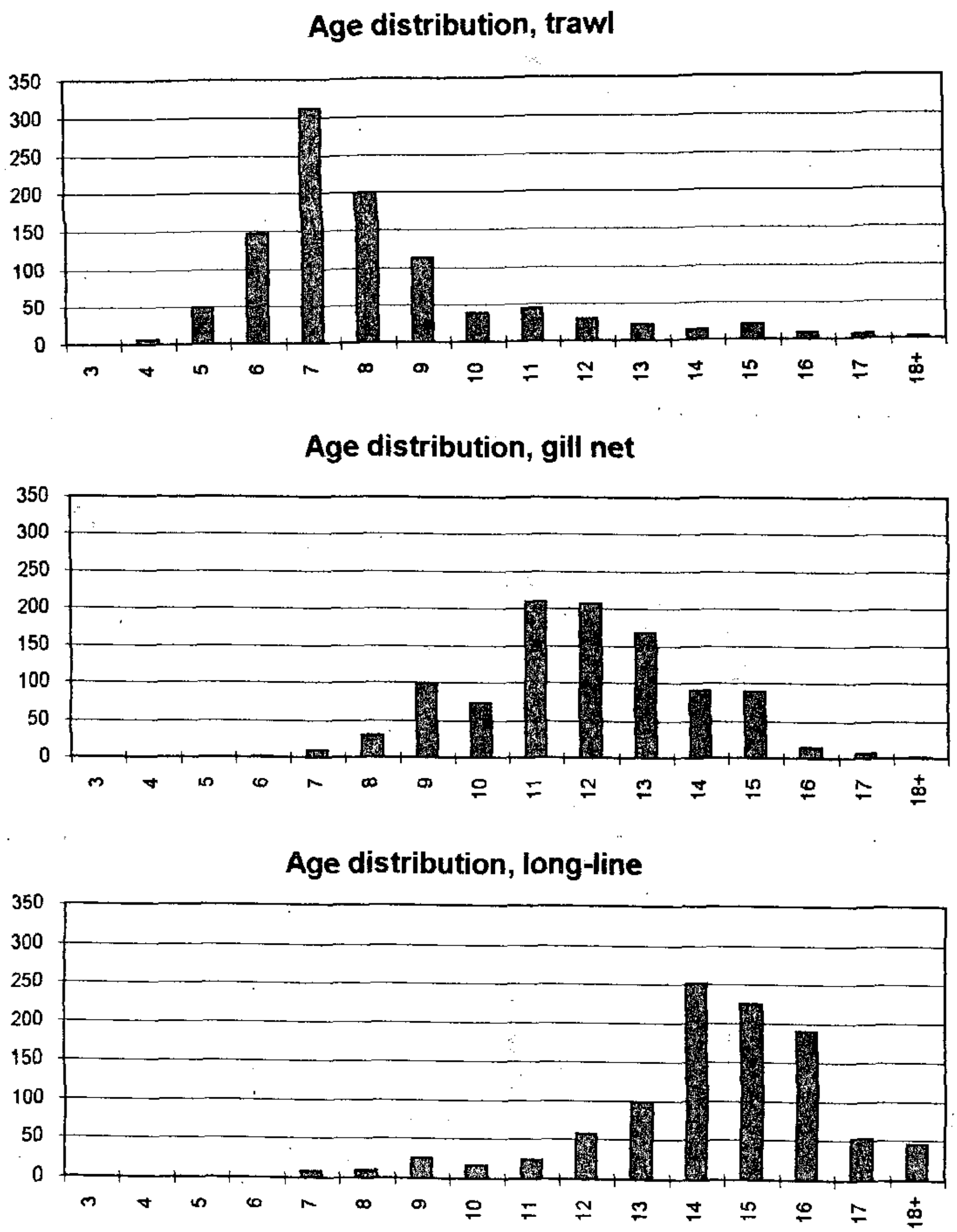


Fig. 3. Age distribution in the offshore trawl gill net and longline fishey in SA 0+1 in 1995.

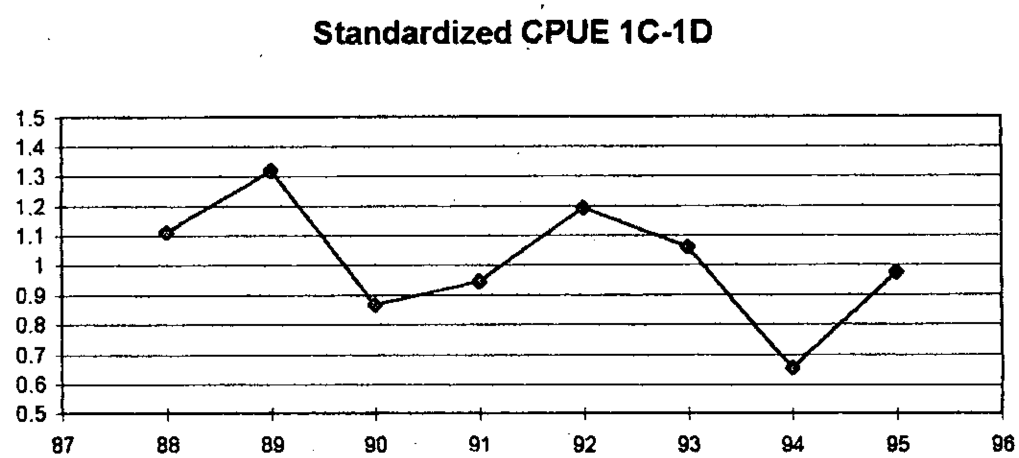


Fig. 4. Standardized CPUE Series from Div. 1CD.

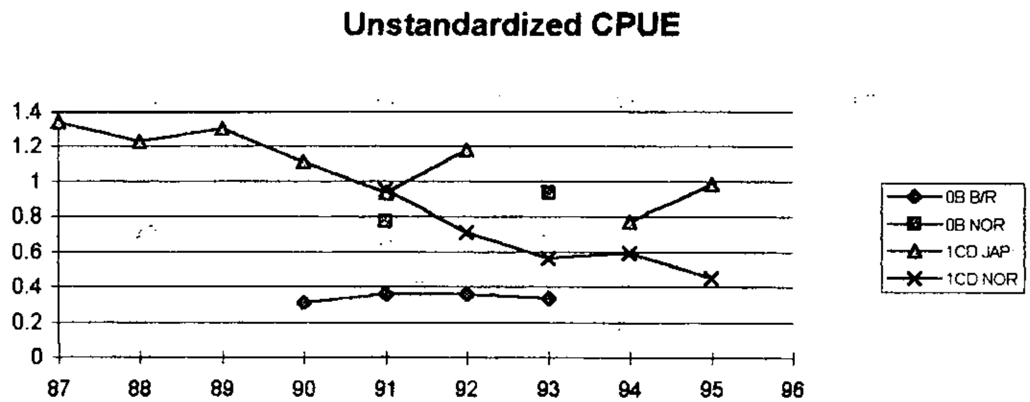


Fig. 5. Unstandardized CPUE Series from SA 0 and SA 1. B/R: Baltic State and Russian trawlers, NOR: Norweigian trawlers and JAP:One large Japanese Trawler (Shinkai Maru).

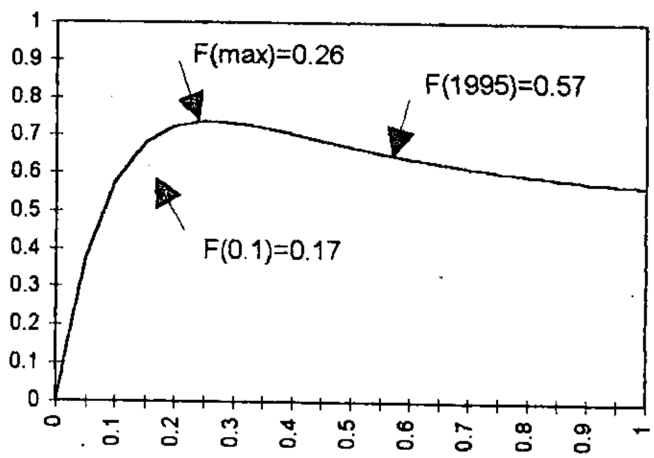


Fig. 6. Yield pr Recruit analysis for SA 0+1 for 1995.

APPENDIX 1

General Linear Models Procedure
Class Level Information

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

Number of observations in data set = 81

Dependent Variable: LCPH

Source	DF	Sum of Squares	F Value	Pr > F
Model	20	54.45730049	21.76	0.0001
Error	60	7.50878853		
Corrected Total	80	61.96608902		

R-Square	C.V.	LCPH Mean
0.878824	-57.45530	-0.61571430

Source	DF	Type I SS	F Value	Pr > F
YR	7	28.85516921	32.94	0.0001
MD	8	9.20004808	9.19	0.0001
DIV	1	0.00066327	0.01	0.9422
CGT	4	16.40141993	32.76	0.0001

Source	DF	Type III SS	F Value	Pr > F
YR	7	2.13435716	2.44	0.0289
MD	8	2.28803545	2.29	0.0331
DIV	1	0.20539502	1.64	0.2051
CGT	4	16.40141993	32.76	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-0.024373491	B	-0.08	0.9352	0.29872659
YR	88	0.127469284	B	0.64	0.5232	0.19847525
	89	0.302463283	B	1.45	0.1526	0.20878345
	90	-0.119799495	B	-0.54	0.5932	0.22303206
	91	-0.032124507	B	-0.16	0.8719	0.19831569
	92	0.200274870	B	1.17	0.2460	0.17095640
	93	0.083032207	B	0.35	0.7264	0.23619149
	94	-0.400213477	B	-2.93	0.0048	0.13646964
	95	0.000000000	B	.	.	.
MD	4	0.051712136	B	0.16	0.8737	0.32397464
	5	0.153490939	B	0.49	0.6264	0.31366102
	6	0.008064869	B	0.03	0.9796	0.31456479
	7	-0.812930634	B	-2.40	0.0193	0.33812777
	8	0.166099915	B	0.54	0.5884	0.30525866
	9	-0.025438252	B	-0.09	0.9294	0.28571436
	10	0.101151731	B	0.36	0.7189	0.27971237
MD	11	0.079684611	B	0.28	0.7788	0.28238643
	12	0.000000000	B	.	.	.
DIV	1C	-0.116337399	B	-1.28	0.2051	0.09081001
	1D	0.000000000	B	.	.	.
CGT	1	-1.802877643	B	-10.43	0.0001	0.17287482
	3	-0.731144785	B	-3.99	0.0002	0.18304172
	5	-0.803379439	B	-4.14	0.0001	0.19389787
	6	-0.505824404	B	-2.41	0.0188	0.20948153
	7	0.000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

CGT. 1:Longliner, 3:Norwegian trawlers, 5:Small Japanese trawlers, 6:Larger Grenlandic and Faroese trawlers 7:One large Japanese trawler (Shinkai Maru).

APPENDIX 2.

Lowestoft VPA Version 3.1

Extended Survivors Analysis

GREENLAND HALIBUT NAFO SUBAREAS 0+1

CPUE data from file tuncpue.dat

Catch data for 9 years. 1987 to 1995. Ages 5 to 18.

Fleet,	First, *year,*	Last, *year,*	First, *age ,*	Last, *age*	Alpha,	Beta
SHINKAI MARU SURVEY ,	1989,	1995,	9,	13,	.500,	.750
CPUE SUB. 1 ,	1988,	1995,	5,	13,	.500,	1.000

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 7

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 7

Catchability independent of age for ages >= 15

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 100 iterations

Total absolute residual between iterations
99 and 100 = .00239

Final year F values

Age ,	5,	6,	7,	8,	9,	10,	11,	12,	13,	14
Iteration 99,	.0261,	.1061,	.4978,	.5328,	.5445,	.3996,	.4557,	.3977,	.3850,	.3805
Iteration **,	.0261,	.1063,	.4983,	.5321,	.5443,	.3995,	.4558,	.3977,	.3849,	.3804

Age ,	15,	16,	17
Iteration 99,	.4857,	.3149,	.3250
Iteration **,	.4856,	.3147,	.3248

1

Regression weights
, .877, .921, .954, .976, .990, .997, 1.000, 1.000

Fishing mortalities

Age,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995
5,	.000,	.000,	.011,	.002,	.006,	.044,	.042,	.026
6,	.003,	.002,	.072,	.034,	.082,	.108,	.233,	.106
7,	.030,	.027,	.288,	.190,	.458,	.485,	.654,	.498
8,	.092,	.080,	.464,	.404,	.893,	.793,	.709,	.532
9,	.104,	.070,	.481,	.425,	.799,	.529,	.738,	.544
10,	.076,	.040,	.362,	.282,	.514,	.406,	.248,	.400
11,	.092,	.038,	.306,	.161,	.321,	.225,	.187,	.456
12,	.132,	.070,	.492,	.158,	.236,	.173,	.182,	.398
13,	.392,	.126,	.554,	.223,	.233,	.110,	.186,	.385
14,	.693,	.517,	.709,	.234,	.247,	.156,	.086,	.380
15,	1.123,	1.070,	1.011,	.396,	.273,	.199,	.141,	.486
16,	1.455,	1.749,	.297,	.541,	.405,	.336,	.176,	.315
17,	.765,	.711,	.616,	.312,	.272,	.164,	.123,	.325

1

XSA population numbers (Thousands)

	AGE									
YEAR ,	5,	6,	7,	8,	9,	10,	11,	12,	13,	14,
1988 ,	1.86E+04,	1.16E+04,	6.82E+03,	4.33E+03,	2.67E+03,	1.70E+03,	9.78E+02,	5.31E+02,	1.93E+02,	9.91E+01,
1989 ,	1.61E+04,	1.60E+04,	9.99E+03,	5.69E+03,	3.40E+03,	2.07E+03,	1.36E+03,	7.68E+02,	4.00E+02,	1.12E+02,
1990 ,	1.23E+04,	1.38E+04,	1.37E+04,	8.37E+03,	4.52E+03,	2.73E+03,	1.71E+03,	1.13E+03,	6.16E+02,	3.03E+02,
1991 ,	1.08E+04,	1.05E+04,	1.11E+04,	8.87E+03,	4.53E+03,	2.40E+03,	1.64E+03,	1.09E+03,	5.93E+02,	3.05E+02,
1992 ,	9.37E+03,	9.30E+03,	8.70E+03,	7.88E+03,	5.10E+03,	2.55E+03,	1.56E+03,	1.20E+03,	7.98E+02,	4.09E+02,
1993 ,	8.12E+03,	8.02E+03,	7.38E+03,	4.74E+03,	2.78E+03,	1.97E+03,	1.31E+03,	9.75E+02,	8.15E+02,	5.44E+02,
1994 ,	1.01E+04,	6.69E+03,	6.19E+03,	3.91E+03,	1.84E+03,	1.41E+03,	1.13E+03,	9.02E+02,	7.05E+02,	6.28E+02,
1995 ,	1.09E+04,	8.34E+03,	4.56E+03,	2.77E+03,	1.66E+03,	7.59E+02,	9.45E+02,	8.08E+02,	6.48E+02,	5.04E+02,

Estimated population abundance at 1st Jan 1996

, 0.00E+00, 9.10E+03, 6.45E+03, 2.38E+03, 1.40E+03, 8.27E+02, 4.38E+02, 5.16E+02, 4.67E+02, 3.79E+02,

Taper weighted geometric mean of the VPA populations:

, 1.17E+04, 9.83E+03, 7.75E+03, 5.18E+03, 2.97E+03, 1.75E+03, 1.22E+03, 7.98E+02, 4.85E+02, 2.72E+02,

Standard error of the weighted Log(VPA populations) :

, .2614, .2857, .3615, .4203, .4164, .4186, .3035, .4789, .6417, .7927,

YEAR ,	AGE 15,	16,	17,
1988 ,	5.59E+01,	2.11E+01,	8.07E+00,
1989 ,	4.26E+01,	1.57E+01,	4.23E+00,
1990 ,	5.76E+01,	1.26E+01,	2.34E+00,
1991 ,	1.29E+02,	1.81E+01,	8.05E+00,
1992 ,	2.08E+02,	7.45E+01,	9.04E+00,
1993 ,	2.75E+02,	1.36E+02,	4.28E+01,
1994 ,	4.01E+02,	1.94E+02,	8.37E+01,
1995 ,	4.96E+02,	2.99E+02,	1.40E+02,

Estimated population abundance at 1st Jan 1996

, 2.97E+02, 2.63E+02, 1.88E+02,

Taper weighted geometric mean of the VPA populations:

, 1.29E+02, 4.59E+01, 1.67E+01,

Standard error of the weighted Log(VPA populations) :

, 1.0254, 1.2835, 1.4100,

1

Log catchability residuals.

Fleet : SHINKAI MARU SURVEY

Age ,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995
5 ,	No data for this fleet at this age							
6 ,	No data for this fleet at this age							
7 ,	No data for this fleet at this age							
8 ,	No data for this fleet at this age							
9 ,	99.99,	.32,	-.07,	.15,	.17,	-.03,	-.38,	-.14
10 ,	99.99,	.62,	-.08,	.17,	.05,	-.21,	-.55,	.06
11 ,	99.99,	.77,	-.08,	.08,	.02,	-.31,	-.54,	.13
12 ,	99.99,	1.08,	-.06,	.13,	-.18,	-.48,	-.55,	.15
13 ,	99.99,	1.34,	-.04,	.33,	-.31,	-.81,	-.27,	-.13

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age ,	9,	10,	11,	12,	13
Mean Log q,	.7151,	-.0874,	-.3282,	-.7283,	-.6953,
S.E(Log q),	.2305,	.3564,	.4054,	.5368,	.6664,

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
9,	.74,	2.132,	1.57,	.93,	7,	.13,	.72,
10,	.87,	.426,	1.06,	.69,	7,	.33,	-.09,
11,	.81,	.275,	1.63,	.30,	7,	.36,	-.33,
12,	-1.92,	-1.204,	18.66,	.03,	7,	.99,	-.73,
13,	-.58,	-8.776,	9.79,	.86,	7,	.10,	-.70,

1

Fleet : CPUE SUB. 1

Age ,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995
5 ,	-.07,	.00,	.16,	.21,	.43,	-.18,	-.36,	-.18
6 ,	.35,	-.30,	-.04,	.01,	.27,	-.14,	-.27,	.14
7 ,	-.35,	-.12,	-.67,	-.22,	.06,	.34,	.53,	.34
8 ,	.12,	.34,	-.18,	-.12,	.27,	-.21,	-.10,	-.09
9 ,	.36,	.30,	-.06,	-.08,	.38,	-.70,	-.28,	.15
10 ,	.51,	.22,	-.28,	-.34,	.35,	-.13,	-.68,	.41
11 ,	.68,	.15,	-.39,	-.49,	.41,	-.21,	-.72,	.64
12 ,	.91,	.28,	-.30,	-.56,	.11,	-.17,	-.89,	.72
13 ,	1.51,	.44,	-.28,	-.53,	-.31,	-.70,	-.66,	.71

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age ,	7,	8,	9,	10,	11,	12,	13
Mean Log q,	-10.3603,	-9.7160,	-9.8616,	-10.4933,	-10.6785,	-10.9423,	-10.9230,
S.E(Log q),	.4067,	.2106,	.3750,	.4272,	.5385,	.6153,	.7772,

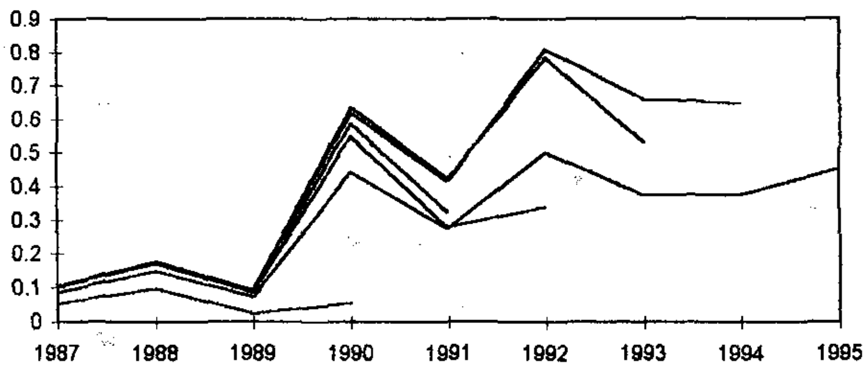
Regression statistics :

Ages with q dependent on year class strength

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Log q
5,	-.21,	-3.069,	8.23,	.53,	8,	.28,	-14.58,
6,	-.57,	-4.606,	7.57,	.60,	8,	.26,	-12.12,

Ages with q independent of year class strength and constant w.r.t. time.

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
7,	7.87,	-2.804,	19.72,	.03,	8,	2.25,	-10.36,
8,	.93,	.336,	9.64,	.82,	8,	.21,	-9.72,
9,	.83,	.565,	9.55,	.66,	8,	.33,	-9.86,
10,	1.32,	-.585,	11.44,	.37,	8,	.59,	-10.49,
11,	-6.04,	-1.362,	-14.01,	.01,	8,	3.06,	-10.68,
12,	-1.84,	-2.039,	-.81,	.08,	8,	.93,	-10.94,
13,	-2.54,	-3.609,	-5.34,	.15,	8,	1.18,	-10.92,



Retrospektiv plot of F(bar), ages 8-13, from the years 1990-1995.