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An Assessment of Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO

by

W. R. Bowering[1], W. B. Brodie[1], M.J. Morgan[1], D. Power[1], and D. Rivard[2]
Science Oceans and Environment Branch
Department of Fisheries and Oceans
[1]P. O. Box 5667, St. John's, Newfoundland, Canada AlC 5Xl
[2]Ottawa, Ontario, Canada K1A 0E6

Abstract

The fishery for Greenland halibut in this management area began in the early 1960s, using synthetic gillnets in the deepwater bays of eastern Newfoundland, particularly Trinity Bay. As catches declined here, the effort moved progressively northward in the other bays along the east and northeast coast of Newfoundland. Catches increased from fairly low levels in the early 1960s to over 36,000 tons by 1969 and ranged from 24,000 tons to 39,000 tons over the next 15 years. With the exception of 1987, catches in the late 1980's were around 18,000 to 20,000 tons. In 1990, an intense fishery for Greenland halibut developed in the NAFO Regulatory Area (NRA) of Div 3L and 3M, in the deepwater areas known as Sackville Spur and Flemish Pass. The development of this fishery resulted in a rapid escalation of catches to between 47,000-65,000 tons during the early 1990's. After 1994 catches declined to between 15,000-24,000 tons due to regulation of the fishery from 1995-99. A virtual population analysis was conducted using various ADAPT formulations. Results from the assessment and mortality estimates from survey data both indicated that fishing mortality was high during the early 1990's with the escalation in catches up to 1994 but declined to relatively low levels since then. Year-classes of the early 1990's appear to be above average especially 1993-95. While the direction of the change in recruitment and population abundance was obvious from these analyses, results may be affected by factors that cannot be taken into account in traditional analyses such as the ones presented here. In particular, there is concern with the possible effect of the conversion of the Canadian survey indices from Engel trawl estimates to Campelen trawl equivalents for very young ages and with the apparent change in survey catchability over time. Also, as the data available could be equally well explained with very different values for population dynamic parameters such as natural mortality, it is not possible to estimate without ambiguity the actual population mechanisms at play.

Catch History and TACs

The fishery for Greenland halibut in this management area began in the early 1960s, using synthetic gillnets in the deepwater bays of eastern Newfoundland, particularly Trinity Bay. As catches declined here, the effort moved progressively northward in the other bays along the east and Northeast coast of Newfoundland. Subsequently, vessels moved further offshore to the deep channels running between the shallow fishing banks. Catches increased from fairly low levels in the early 1960s to over 36,000 tons by 1969 and ranged from 24,000 tons to 39,000 tons over the next 15 years (Table 1A; Fig. 1). With the exception of 1987, catches in the late 1980's were around 18,000 to 20,000 tons (Table 1A; Fig. 1).

In 1990, an intense fishery for Greenland halibut developed in the NAFO Regulatory Area (NRA) of Div. 3L and 3M, in the deepwater areas known as Sackville Spur and Flemish Pass. The development of this fishery resulted in a rapid escalation of catches to about 47,000 tons in 1990. Catches in the NRA in 1991 to 1993 were estimated to be around 55,000 tons in each year although some estimates were nearer 75,000 tons in at least one of these years. Overall, catches from the stock during 1991 to 1993 were estimated to be between 62,000 and 65,000 tons annually (Table 1B). Best estimates of catch suggested a decline to about 51,000 tons in 1994, although some estimates ranged as high as 56,000 tons (Table 1B). As a result of management measures introduced by the NAFO Fisheries Commission in 1995 (extensive quota restrictions and 100% observer coverage in the NRA), catches were greatly reduced (Table 1B). In 1995, the catch was estimated to be about 15,000 tons, increasing to almost 19,000 in 1996, and to about 20,000 tons in 1997-98. Catches from the stock in 1995-98 represent a reduction of about two-thirds compared to the average annual catch of the previous 5 years. The catch increased to about 24,000 tons in 1999.

The major participants in this fishery in the NRA have been EU/Spain and EU/Portugal, as well as a variety of non NAFO-member countries such as Panama, although by 1994, more than 80% of the catch was estimated to have been caught by EU (Spain) alone. Prior to 1990, Canada, the former USSR and GDR, as well as Poland were usually the main participants in the fishery, although Portugal and Japan became increasingly involved in the fishery after 1984 (Table 2). Canadian catches have been taken mostly by gillnet, although a significant proportion has been taken by otter trawlers. With the exception of 1987, catches declined steadily inside the Canadian zone since the late 1970's from a high of over 30,000 tons to less than 3,000 tons in 1994 and 1995. This declining trend was mainly a result of low catch rates and reduced effort, as multi-licensed vessels fished other species such as snow crab that offered a better return on costs. This fishery improved in 1996 and 1997, and catches increased to around 6,000 tons in each year, but were lower in both 1998 and 1999 at just over 4000 tons (Table 3). The majority of Canadian catch in the last 3 years has come from Div. 3K, and the seasonal patterns are similar in both years (Table 3). The breakdown of total catches in 1999, by country and division, is given in Table 4.

The traditional gillnet fishery has been conducted by relatively small vessels (<20 m) fishing in the deepwater channels near the Newfoundland and Labrador coast as well as the Newfoundland east coast deepwater bays using an average mesh size of 150 mm. However, this component of the fishery has declined in recent years. The Canadian gillnet catches taken during recent years are mainly from a fishery along the deep edge of the continental slope in Subarea 2 and Divisions 3KL, although some fishing still occurs nearshore, mainly with 140 mm gillnets. Some fishing by Canadian gill-netters is now taking place along the southwest slope of the Grand Bank in Division 3O although catches have been relatively low. In an attempt to reduce the catch of young Greenland halibut in the new deepwater gillnet fishery, it is illegal to use a gillnet mesh size of less than 190 mm while fishing Greenland halibut in the Canadian zone in depths > 400 fath. (732 m).

Canadian otter trawl catches peaked at about 8,000 tons in 1982, declined to less than 1,000 tons in 1988, then increased to about 7,400 tons in 1991 which is the highest level since 1982. In 1992 , otter trawl catches were less than half that of 1991 due to low catch rates. Since then, catches by this fleet have been less than 1600 tons annually, and were at very low levels in 1998 and 1999. Almost all the Canadian otter trawl catch in 1996-99 occurred in Divs. 2J and 3K.

The TAC for this resource (Subarea 2 and Div. 3KL only), increased from 35,000 tons in 1980 to 55,000 tons in 1981-84, and 100,000 tons in 1986-89 (Table 1A, Fig. 1). These increases in TACs were the result of research vessel survey estimates of stock biomass which indicated high levels of fishable biomass (in excess of 400,000 tons) as well as prospects of several better than average recruiting year-classes. Despite the large TAC's, catches in the 1985 to 1989 period were lower than in the preceding years. After observing an estimated reduction in stock biomass from the late 1970s to the late 1980s in Subarea 2 and Div. 3KL of about 50%, the TAC was reduced to 50,000 tons in 1990. This level was maintained to 1993 despite the substantive declines in stock size throughout the normal range of observed historical stock distribution. Although the Scientific Council, in June 1993, could not advise an appropriate catch level for 1994, the TAC was reduced to 25,000 tons by Canada in Subarea 2 and Divisions 3KL in consideration of low levels of stock size estimated for the area. It was intended that this catch should include all catches in Subarea 2 and 3 for conservation purposes. In 1994, management of G. halibut in Subarea 2 and Div. 3KLMNO became the responsibility of the NAFO Fisheries Commission, which imposed a TAC of 27,000 tons for 1995. This level was maintained for 1996 to 1998 inclusive, and was proportioned throughout the management area in an attempt to reduce high concentrations of effort in localised areas. For both 1999 and 2000, Scientific Council advised that an increase in catch to about 30,000 tons should not impede stock recovery. Notwithstanding the advice, the Fisheries Commission set the TAC for 1999 and 2000 at 33,000 and 35,000 tons, respectively.

Commercial fishery data

i) Catch-at-age and mean weights-at age

Due to the uncertainty regarding catch information on fisheries in the NRA since 1989, as well as the lack of adequate sampling data for some fleets in some years, catch-at-age data for this stock in previous assessments have been incomplete. Brodie et al. (1998) presented catch at age for Canadian catches only from 1988-97. Prior to 1989, data are available from the entire annual fisheries which took place mainly in the Canadian zone, and have been presented in previous assessments of this stock (see Bowering et al. 1996). As recommended by STACFIS in the June 1999 report, an attempt was made to update the Canadian catch-at-age for 1998 and 1999, and to compile the total international catch-at-age for this stock for years since 1989. The details describing how the updated catch-at-age matrix was constructed are presented in SCR Doc. 00/24. The catch numbers at age and catch biomass at age are presented in Tables 5 and 6, respectively.

Ages 6-8 dominated the catch throughout the entire time period (Table 5) with ages 12+ contributing about 10-15% on average to the catch biomass (Table 6). Mean weights (kg) show peculiar patterns in the earliest period likely due to poor sampling and lack of individual weights (Table 7). Mean weights at age for age groups 5-9 during the recent period are relatively stable. For older fish they are rather variable but with little appreciable trend (Table 7).

ii) Catch and effort

Catch and effort data from the directed fishery for G. halibut during the period 1975 to 1993 were obtained from ICNAF/NAFO Statistical Bulletins and were combined with provisional 1994-1998 NAFO Statlant 21B data and 1999 Canadian data. The catch/effort data were analysed with a multiplicative model (Gavaris, 1980) to derive a standardised catch rate index for hours fished, as has been done in the recent assessments of this stock. A second standardisation was conducted for days fished due to missing hours fished data from EU-Portugal since 1992 and EU-Spain since 1995. Factors included in each model were a combination country-gear-tonnage-class category type (CGT), month, NAFO Division and year. Consistent with previous catch rate standardisation's utilising "hours fished", individual observations of catch less than 10 tons or effort less than 10 hours fished were eliminated prior to analysis. Subsequently, any remaining categories where there were less than five occurrences in the database were also eliminated. For the days fished model the only difference in a priori elimination was that for the effort, data less than 5 days fished were eliminated.

For the "hours fished" standardisation, the regression was significant ($p < 0.05$), explaining 59% of the variation in catch rates (Table 8). The standardised catch rate index (Table 9, Fig. 2) shows high between and within year variability, especially in the late-1970s to mid-1980s. There was an increasing trend from the mid-1970s that peaked in 1982 and CPUE subsequently fluctuated but declined to the lowest rate observed in the 1997. Catch rate increased marginally in 1998 and again in 1999 (based solely on Canadian data). The model suggests that for the whole time period, catch rates were generally higher in winter and best in Subarea 2, based on the coefficients in Table 8.

For the "days fished" standardisation, the regression was also significant ($p < 0.05$), explaining 55% of the variation in catch rates (Table 10). The standardised catch rate index (Table 11, Fig. 2) also shows high between and within year variability prior to the 1990's. The catch rate was relatively stable to 1984 and, with the exception of an anomalous increase in 1987, declined by about 50% by 1988. Between 1988 and 1995 the index shows two cycles of increase followed by a decrease. Since 1995 the index declined gradually to the lowest rate observed in 1999. Similar to the "hours fished" index, over the whole time period, catch rates were generally higher in winter and higher in Subarea 2, based on the coefficients in Table 10.

Mortality estimates from survey data

Total mortality (Z) was calculated by age from the Canadian fall research survey data in Div. 2J,3K from 1978-99 for ages 2 to 13. The results are shown in Figure 3. A Lowess smoother has been added to the plots to help visualise trends. Most ages show little trend across time although ages 4 to 12 showed a slight increasing trend in mortality up to the late 1980's early 1990's, followed by a decrease in more recent years.

Estimates of relative mortality by cohort were obtained from a multiplicative model using the same data. The following model was used:

$\log(N_{ikt}) = \tau + \delta_k + \alpha\delta_k + \varepsilon$

where: N_{ikt} = number at age i for i= 2 to 14, or 5 to 14, belonging to cohort k in year t
τ = intercept
δ_k = cohort effect
$\alpha\delta_k$ = combined age cohort effect
ε = residuals from the fitted model

The separate slopes parameter estimates ($\alpha\delta_k$) were plotted as estimates of average total mortality experienced by a cohort over ages 2-14 or 5-14. There was a significant fit of the model to the data in both cases.

Ages 2-14

R^2=0.90, n=284

Source	DF	Type III SS	F Value	Pr > F
COHORT	31	12.50	0.38	0.9989
AGE*COHORT	32	1645.26	48.62	0.0001

Ages 5-14

R^2=0.91, n=218

Source	DF	Type III SS	F Value	Pr > F
COHORT	28	32.43	1.46	0.0758
AGE*COHORT	29	1130.83	49.24	0.0001

For the model using ages 2-14 there was a slight increase in mortality for cohorts from 1970 to 1983 followed by a decline (Fig. 4). For the model using ages 5-14 there was an increase in mortality for cohorts from 1970 to 1981 followed by a decline, particularly for the cohorts since 1990 (Fig. 4).

Virtual population analysis

The ADAPT framework (Gavaris, 1988) was used to estimate the population size at the beginning of 2000 by calibrating a virtual population analysis against the Canadian RV fall survey in Divisions 2J and 3K and the EU survey in Division 3M. A number of exploratory analyses were carried out and served to identify which data to include in the analysis. There was a general tendency for the observations to be higher than the predicted values in the early 1980s and lower than the predicted values for the early 1990s when all data (1978-1999) from the Canadian survey were used in the analysis. Accordingly, data prior to 1988 were excluded from the analyses presented here. Also, while CPUE data were available and were used in exploratory analyses, they were not considered as being reliable indices of stock abundance.

Input data were:

Catch numbers-at-age:
$C_{i,t}$ where i=2 to 15; t=1975 to 1999 (zero catch for ages 2 to 4).
Canadian Research Vessel survey abundance estimate for 2J3K
$RV_{1,i,t}$ where i=2 to 11; t=1988 to 1999
EU Research Vessel survey abundance estimate for 3M
$RV_{2,i,t}$ where i=2 to 11; t=1991 to 1999

The parameter estimated through the Adaptive framework were as follows:

1) The stock abundance (numbers) at the beginning of year 2000, $N_{i,2000}$, where i=3 to 13
2) The survey catchabilities:
   $K_{1,i}$, where i=2 to 11 for the Canadian Research Vessel fall survey in 2J3K
   $K_{2,i}$, where i=2 to 11 for the EU survey in 3M

The following structure was imposed:

1) Natural mortality was assumed to be 0.2 for all ages
2) The fishing mortality for ages 13-15 in 1999 calculated as average of 11-12. The fishing mortality on the oldest age (15) in all other years was set equal to the average F for ages 12-14.
3) No "plus" group for ages.
4) No error in the catch numbers-at-age.

The objective function was defined as:

$$SS = \Sigma_{s,i,t} \left(\ln (RV_{s,i,t}) - \ln (K_{s,i} N_{i,t}) \right)^2$$

where s (survey identifier)= 1,2 , i = 2 to survey maximum age and t spans over the range of years for each survey s.

Results

The results of this analysis are presented in Annex 1. The relative error in the parameter estimates of abundance ranged from 26% to 53%, ages 5 to 9 having the lowest relative error (31% or less). The relative bias ranged from 4% to 15%, most ages having a bias <7%. The matrix of correlation of parameters shows values that are relatively low (generally less than 0.2). The fishing mortality, also presented in Annex 1, have been declining in recent years and are currently relatively low in comparison to the high values reached in the early-1990s.

Implied survey catchabilities. From the results of this analysis, it is possible to calculate the catchability of the Canadian survey in relation to the virtual population analysis. These results are given in Table 12. These results suggest that the catchability for older ages (6-11) has changed by a factor of 3 between the two periods. This could be due to fish moving out of the survey area (because of climatic changes, for instance) or an increase of natural mortality (which is not accounted for in the underlying VPA). There are indications that the catchability for certain ages (e.g. 6 and 7) could be returning to their pre-1988 level, and the recent warming of bottom temperature experienced over the Grand Banks may in part explain that return. It remains unclear how this effect influenced the estimates of population size for 2000 and how to account for that effect in the years of projection. For these reasons, the results presented herein should be interpreted with caution.

Alternative formulation. While the approach taken above suggests a change in catchability over time, the results are entirely dependent upon the value of natural mortality assumed for the analysis. In order to evaluate the effect of this assumption, we used an ADAPT formulation whereby natural mortality was assumed constant for younger ages, but expressed as a parameter to be estimated by the model for the older age groups. Natural mortality here is meant to capture all factors affecting removals from the population and would include, for instance, emigration of older ages to greater depths outside the area occupied by the fishery. The formulation was as follows:

Input data were:

Catch numbers-at-age:
   $C_{i,t}$ where I=2 to 12; t=1975 to 1999
Canadian Research Vessel survey abundance estimate for 2J3K
   $RV_{1,i,t}$ where i=2 to 9; t=1978 to 1999
EU Research Vessel survey abundance estimate for 3M
   $RV_{2,i,t}$ where i=2 to 10; t=1991 to 1999

The parameter estimated through the Adaptive framework were as follows:

1) The stock abundance (numbers) at the beginning of year 2000, $N_{i,2000}$, where i=3 to 11
2) A single constant, say M_{9+}, for natural mortality M for ages 9+ in all years.
3) The survey catchabilities:
   $K_{1,i}$, where i=2 to 9 for the Canadian Research Vessel fall survey in 2J3K
   $K_{2,i}$, where i=2 to 10 for the EU survey in 3M

The following structure was imposed:

5) Natural mortality was assumed to be 0.2 for ages 2 to 8.
6) The fishing mortality for age 11 in 1999 calculated as average of 9-10. The fishing mortality on the oldest age (12) was set equal to the average F for ages 10-11.
7) No "plus" group for ages.
8) No error in the catch numbers-at-age.

The objective function was defined as:

$$SS = \Sigma_{s,i,t} \left(\ln(RV_{s,i,t}) - \ln(K_{s,i} N_{i,t}) \right)^2$$

where s (survey identifier)= 1,2 , i = 2 to survey maximum age and t spans over the range of years for each survey s.

The results of this analysis are presented in Annex 2. Natural mortality for ages 9-12 was estimated as 0.54 from this analysis. The relative error in the parameter estimates of abundance ranged from 29% to 60%, ages 5 to 9 having the lowest relative error (33% or less). The relative bias ranged from 6% to 17%, most ages having a bias <8%. The matrix of correlation of parameters shows values that are relatively large (many being in the 0.5 to 0.8 range). Trends in fishing mortality are presented in Annex 2. While the large correlation coefficients suggest that the resulting population estimates are largely dependent upon our knowledge of M, the resulting biomass (5+) follows relatively well the 5+ biomass from the Canadian surveys, a feature that was not present in the previous analysis (with natural mortality fixed at 0.2).

The relatively large values for the correlation between parameter estimates suggest that the resulting model should not be used to make absolute projections without taking into account this correlation.

General. While the direction of the change in recruitment and population abundance is obvious from these analyses, these results may be affected by factors that cannot be taken into account in traditional analyses such as the ones presented here. In particular, we are concerned with the possible effect of the conversion of the Canadian survey indices to Campelen equivalent for very young ages and with the apparent change in survey catchability over time. Also, as the data available could be equally well explained with very different values for population dynamic parameters such as natural mortality, it is not possible to estimate without ambiguity the actual population mechanisms at play.

Table 1A. Catches and TAC's of Greenland halibut in SA 2 + Div. 3KLMNO, 1960-2000. Includes some estimated catches for years 1984 and later. TAC's from 1995 onward set by NAFO Fisheries Commission.

Year	Catch (tons) SA2+Div. 3KL	Catch (tons) SA2+Div. 3KLMNO	TAC
60	938	995	
61	741	786	
62	588	624	
63	1602	1621	
64	3928	4252	
65	9501	10069	
66	19244	19276	
67	25644	26525	
68	31986	32392	
69	36520	37241	
70	36402	36839	
71	24654	24834	
72	29822	30038	
73	28944	29291	
74	27123	27588	40000
75	28681	28814	40000
76	24599	24611	30000
77	31941	32048	30000
78	38532	39070	30000
79	34069	34104	30000
80	32642	32867	35000
81	30682	30754	55000
82	26214	26278	55000
83	27839	27861	55000
84	24809	26711	55000
85	18610	20347	75000
86	15878	17976	100000
87	30938	32442	100000
88	19086	19215	100000
89	19496	20034	100000
90	22237	47454	50000
91	26868	65008	50000
92	35160	63193	50000
93	29070	62455	50000
94		51029	25000
95		15272	27000
96		18840	27000
97		19858	27000
98		19946	27000
99		24232	33000
00			35000

Table 1B. Catches of Greenland halibut by Division, 1977-99.

Year	Div. 2G	Div. 2H	Div. 2J	Div. 3K	2+3K	Div. 3L	Div. 3M	Div. 3N	Div. 3O	3LMNO	Total reported	Total estimated
1977	1778	1524	8237	13446	24985	6956	42	3	62	7063	32048	
1978	1899	1207	3723	24107	30936	7596	528	6	4	8134	39070	
1979	577	1623	3415	19843	25458	8610	12	18	6	8646	34104	
1980	36	444	1466	17923	19869	12773	141	75	9	12998	32867	
1981	1799	2141	1358	16472	21770	8912	3	49	20	8984	30754	
1982	370	8984	5931	6794	22079	4135	2	56	6	4199	26278	
1983	111	5671	6028	11374	23184	4655	7	12	3	4677	27861	
1984	214	4663	6368	8432	19677	5132	43	12	9	5196	24873	26711
1985	193	2358	6724	5775	15050	3560	184	35	1	3780	18830	20347
1986	455	1564	6823	4237	13079	2799	49	8	4	2860	15939	17976
1987	2700	2631	12464	6860	24655	6283	307	173	0	6763	31418	32442
1988	2068	2463	1971	6389	12891	6195	48	75	6	6324	19215	19215
1989	837	1821	2952	7840	13450	6046	491	38	9	6584	20034	20034
1990	2809	1225	2845	4579	11458	10779	3040	1287	17	15123	26581	47454
1991	3715	2252	3045	2229	11241	15627	3426	4192	37	23282	34523	65008
1992	1373	235	476	3883	5967	29193	14902	7132	425	51652	57619	63193
1993	963	405	214	2398	3980	25092	8282	14693	644	48711	52691	62455
1994[a]	1045	210	203	1032	2490	18257	12741	14138	3403	48539	51029	51029
1995[a]	1109	412	375	641	2537	5843	3454	2948	490	12735	15272	15272
1996[a]	598	621	1063	2544	4826	4487	783	934	367	6571	11397	18840
1997[a]	365	619	1734	2658	5376	9227	1965	2958	332	14482	19858	19858
1998[a]	362	351	1863	1400	3976	10214	3385	2112	259	15970	19946	19946
1999[a]	65	103	1340	1940	3448	13084	4136	3185	379	20784	24232	24232

Table 2. Greenland halibut landings (tons) by year and country for Subarea 2 and Divisions 3KL only, from 1960-93. Does not include catches from Div. 3MNO. Data from 1960-90 from Stat Bull summary 1960-90 (1995), 1991-93 from annual Stat Bull.

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Canada	660	741	586	776	1757	8082	16209	16604	13322	11553	10706	9408	8952	6840	5745	7807
FRG	278	-	-	10	35	-	355	42	4	202	13	-	86	707	515	622
Poland	-	-	-	691	1834	939	1114	3296	5806	5406	8266	5234	6986	9060	7105	8447
Iceland	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-
Norway	-	-	-	-	-	1	-	-	-	36	647	-	1389	501	117	-
USSR(Russia)	-	-	-	125	302	479	242	4287	8732	9268	7384	9094	10183	8652	9650	9439
Romania	-	-	-	-	-	-	-	-	-	40	228	7	120	80	-	-
GDR	-	-	-	-	-	-	1324	1415	4122	10014	9158	909	402	1681	2701	2025
Denmark-F	-	-	-	-	-	-	-	-	-	-	-	-	970	950	4	-
Spain	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
UK	-	-	2	-	-	-	-	-	-	-	-	-	731	201	1112	62
Denmark-G	-	-	-	-	-	-	-	-	-	-	-	-	-	65	2	
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	207	161	231
France(M)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
France(SPM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	48
Japan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	938	741	588	1602	3928	9501	19244	25644	31986	36520	36402	24654	29822	28944	27123	28681

Year

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Canada	24692	29940	31774	24125	19248	19031	17283	12277	8213	13450	8451	11976	9121	6418	6967	4452
FRG/ Deu	1022	15	55	-	57	2	9	482	15	1	43	5	-	8	45	-
Poland	5215	1813	203	1806	1111	5258	943	460	177	1001	904	360	-	-	-	-
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	3	8	1	-	-	15	18	1	-	-	-	8	933	1531	-	-
USSR(Russia)	5632	1961	238	3325	1471	937	440	149	770	6716	1063	1058	1313	2753	22	-
Romania	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GDR	1636	178	316	1350	2487	2587	2498	1850	1868	3268	2246	1727	12	-	-	-
Denmark-F	268	-	-	-	-	-	-	193	451	2877	740	703	508	608	255	14
Spain	-	4	-	-	-	-	-	-	-	107	15	13	492	4787	23264	22682
UK	53	110	22	-	1	-	3	-	-	-	-	-	-	4	9	-
Denmark-G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Portugal	-	38	21	16	1818	-	2612	2940	3107	1390	4118	3168	8250	8768	2129	346
France(M)	-	-	-	-	-	-	-	-	-	-	-	596	-	-	-	-
France(SPM)	5	1	-	-	7	-	-	-	-	-	-	-	-	-		-
Japan	3	-	12	60	14	-	1003	258	1277	2128	1506	478	1608	1903	2469	1576
Other	-	1	-	-	-	9	-	-	-	-	-	-	-	-	-	2
Total	38532	34069	32642	30682	26214	27839	24809	18610	15878	30938	19086	20092	22237	26780	35160	29072

Table 3A. Canadian catches of Greenland halibut in SA 2+Div.3KLMNO in 1998.

	Gillnet+Longline								Otter Trawl				
	2G	2H	2J	3K	3L	3N	3O		2J	3K	3L	3O	**Total**
Jan							13						**13**
Feb						1	33						**34**
Mar							20						**20**
Apr							34			1	1		**36**
May	64		15	95	119				13	2		1	**309**
Jun	148		344	375	196				4	4			**1071**
Jul		48	473	577	50				2	14			**1164**
Aug	111	210	307	275	96								**999**
Sep	20	93	122	49	84								**368**
Oct	19		2	8	54								**83**
Nov					8								**8**
Dec													**0**
Total	**362**	**351**	**1263**	**1379**	**607**	**1**	**100**		**19**	**21**	**1**	**1**	**4105**
			Div. Totals								**Gear Totals**		
1998	**2G**	**2H**	**2J**	**3K**	**3L**	**3N**	**3O**		**GN**	**OT**	**LL**		
	362	**351**	**1282**	**1400**	**608**	**1**	**101**		**3956**	**42**	**107**		

Table 3B. Canadian catches of Greenland halibut in SA 2+Div. 3KLMNO in 1999.

	Gillnet+Longline								Otter Trawl				
	2G	2H	2J	3K	3L	3N	3O		2J	3K	3O		**Total**
Jan							32					32	**32**
Feb							34					34	**34**
Mar							27					27	**27**
Apr				3	36		13					52	**52**
May			25	211	147							383	**383**
Jun			216	362	158		21		37	29		823	**823**
Jul	4	18	438	622	90		3				1	1176	**1176**
Aug	61	74	317	512	117							1081	**1081**
Sep		11	54	176	121							362	**362**
Oct				3	14				7	7		31	**31**
Nov				15								15	**15**
Dec													
Total	**65**	**103**	**1050**	**1904**	**683**		**130**		**44**	**36**	**1**	**4016**	**4016**
			Div. Totals								**Gear Totals**		
1999	**2G**	**2H**	**2J**	**3K**	**3L**	**3N**	**3O**		**GN**	**OT**	**LL**		
	65	**103**	**1094**	**1940**	**683**	**0**	**131**		**3870**	**81**	**65**		

Table 4. Catches of Greenland halibut in SA2+Div. 3KLMNO during 1999 by country and division.

	Div. 2G	Div. 2H	Div. 2J	Div. 3K	Div. 3L	Div. 3M	Div. 3N	Div. 3O	Total
Canada	65	103	1094	1938	683			131	4014
Japan					2376	42	2		2420
Portugal					2722	602	603	67	3994
Spain					4288	3197	1366	172	9023
Russia					1686	206	1214	11	3117
France			246		791	89			1126
Faroe Islands					538				538
Total	65	103	1340	1938	13084	4136	3185	381	24232

Data are as reported by each contracting party.

No surveillance or observer estimates are included.

Table 5. Catch numbers at age (000s) matrix for Greenland halibut catches by all countries for Subarea 2+ Div. 3KLMNO from 1975-99.

Age (yrs)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
4													
5	334	17	534	2982	2386	209	863	269	701	902	1983	280	137
6	2819	610	5012	8415	8727	2086	4517	2299	3557	2324	5309	2240	1902
7	5750	3231	10798	8970	12824	9150	9806	6319	9800	5844	5913	6411	11004
8	4956	5413	7346	7576	6136	9679	11451	5763	7514	7682	3500	5091	8935
9	3961	3769	2933	2865	1169	5398	4307	3542	2295	4087	1380	1469	2835
10	1688	2205	1013	1438	481	3828	890	1684	692	1259	512	471	853
11	702	829	220	723	287	1013	256	596	209	407	159	244	384
12	135	260	130	367	149	128	142	256	76	143	99	140	281
13	279	101	116	222	143	53	43	163	106	106	87	70	225
14	136	32	30	109	92	14	29	80	85	58	48	56	168
15	65	19	21	57	83	9	21	63	68	77	21	37	106
16	43	1	25	53	61	2	14	33	9	29	14	23	57
17	45	1	8	39	48	1	5	16	13	19	2	1	18
Total	20910	16489	28186	33817	32587	31572	32343	21082	25125	22937	19029	16533	26904

Age (yrs)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4		0	95	220	1064	1010	5395	323	190	335	552	297
5	296	181	1102	2862	4180	9570	16500	1352	1659	1903	3575	2149
6	3186	1988	6758	7756	10922	15928	15815	2342	5197	4169	5407	5625
7	8136	7480	12632	13152	20639	17716	11142	3201	6387	7544	5787	8611
8	4380	4273	7557	10796	12205	11918	6739	2130	1914	3215	3653	3793
9	1288	1482	4072	7145	4332	4642	3081	1183	956	1139	1435	1659
10	465	767	2692	3721	1762	1836	1103	540	504	606	541	623
11	201	438	1204	1865	1012	1055	811	345	436	420	377	343
12	105	267	885	1216	738	964	422	273	233	246	161	306
13	107	145	434	558	395	401	320	251	143	137	92	145
14	62	49	212	271	214	113	161	85	60	57	33	88
15	53	20	89	124	91	45	45	55	21	23	14	44
16	12	1	14	17	24	20	9	47	6	8	3	13
17	2	1	3	11	6	4	0	15	2	0	0	5
Total	18292	17093	37751	49712	57585	65223	61542	12140	17707	19800	21629	23702

Table 6. Catch biomass (tons) at age matrix for Greenland halibut catches by all countries for Subarea 2+ Div. 3KLMNO from 1975-99.

Age (yrs)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	203	10	326	1816	1453	108	338	141	289	340	1127	98	50
6	2142	464	3809	6396	6633	1375	2701	1572	2237	1355	3977	1308	1120
7	5491	3086	10312	8566	12247	7951	7737	5630	8438	4827	5564	5200	9199
8	5898	6441	8742	9015	7302	10163	11279	6512	8867	8450	4340	5600	10365
9	6258	5955	4634	4527	1847	6207	5341	4958	3787	5967	2331	2321	4508
10	3730	4874	2238	3177	1063	4823	1513	3015	1542	2443	1147	999	1817
11	1895	2237	594	1952	774	1591	629	1419	630	1070	468	704	1082
12	454	877	439	1236	501	348	497	889	301	499	367	543	1012
13	1082	394	451	863	556	167	204	734	537	477	423	345	1039
14	619	147	137	496	419	64	171	466	515	331	293	341	920
15	387	112	123	340	492	47	172	471	495	526	154	280	706
16	303	6	181	381	437	14	121	286	79	245	128	224	445
17	352	7	64	304	380	10	51	183	145	181	28	12	179
Total	28814	24611	32048	39070	34104	32867	30754	26278	27861	26711	20347	17976	32442
Accepted catch (t)	28814	24611	32048	39070	34104	32867	30754	26278	27861	26711	20347	17976	32442
Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Age (yrs)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	0	0	17	54	307	234	1058	93	46	69	126	75
5	107	72	373	1096	1797	3517	5438	491	597	639	1333	770
6	1813	1116	3693	4591	6299	8708	8132	1244	2812	2040	2936	3000
7	6550	5735	9677	10932	16364	14337	8778	2587	5312	5816	4689	7108
8	5094	4622	8454	13255	15056	14382	7946	2560	2433	3726	4394	4752
9	2139	2457	6549	12937	7866	8021	5240	2081	1722	1966	2518	2779
10	1030	1716	5850	9159	4338	4240	2502	1320	1249	1427	1272	1425
11	605	1313	3437	6171	3161	3165	2425	1076	1372	1283	1166	990
12	414	1031	3303	5037	2931	3821	1591	1042	900	971	645	1074
13	543	714	2037	2975	2016	1933	1561	1228	707	698	471	645
14	382	293	1229	1743	1319	648	960	504	352	334	197	459
15	403	143	644	982	650	325	333	380	147	150	91	270
16	111	8	130	163	201	168	64	346	46	68	23	100
17	25	10	26	100	58	39	0	134	20	0	2	45
Total	19215	19230	45421	69194	62362	63540	46029	15085	17714	19186	19861	23492
Accepted catch (t)	19215	20034	47454	65008	63193	62455	51029	15272	18840	19858	19946	24226
Ratio	1.00	0.96	0.96	1.06	0.99	1.02	0.90	0.99	0.94	0.97	1.00	0.97

Table 7. Commercial Greenland halibut mean weights at age (kg) for Subarea 2 and Div. 3KL (1975-88) and SA2+Div. 3KLMNO (1989-99).

Age (yrs)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
2													
3													
4													
5	0.609	0.609	0.609	0.609	0.609	0.514	0.392	0.525	0.412	0.377	0.568	0.350	0.364
6	0.760	0.760	0.760	0.760	0.760	0.659	0.598	0.684	0.629	0.583	0.749	0.584	0.589
7	0.955	0.955	0.955	0.955	0.955	0.869	0.789	0.891	0.861	0.826	0.941	0.811	0.836
8	1.190	1.190	1.190	1.190	1.190	1.050	0.985	1.130	1.180	1.100	1.240	1.100	1.160
9	1.580	1.580	1.580	1.580	1.580	1.150	1.240	1.400	1.650	1.460	1.690	1.580	1.590
10	2.210	2.210	2.210	2.210	2.210	1.260	1.700	1.790	2.230	1.940	2.240	2.120	2.130
11	2.700	2.700	2.700	2.700	2.700	1.570	2.460	2.380	3.010	2.630	2.950	2.890	2.820
12	3.370	3.370	3.370	3.370	3.370	2.710	3.510	3.470	3.960	3.490	3.710	3.890	3.600
13	3.880	3.880	3.880	3.880	3.880	3.120	4.790	4.510	5.060	4.490	4.850	4.950	4.630
14	4.560	4.560	4.560	4.560	4.560	4.420	5.940	5.850	6.060	5.730	6.130	6.090	5.480
15	5.920	5.920	5.920	5.920	5.920	5.040	8.060	7.530	7.310	6.850	7.160	7.640	6.670
16	7.140	7.140	7.140	7.140	7.140	7.020	8.710	8.680	8.600	8.330	8.920	9.810	7.850
17	7.890	7.890	7.890	7.890	7.890	10.100	9.580	11.500	11.300	9.570	11.800	10.100	9.840

Age (yrs)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2					0.090	0.062	0.038				0.058	0.145
3			0.090	0.126	0.175	0.134	0.080		0.161	0.120	0.119	0.176
4			0.181	0.244	0.289	0.232	0.196	0.288	0.242	0.206	0.228	0.253
5	0.363	0.400	0.338	0.383	0.430	0.368	0.330	0.363	0.360	0.336	0.373	0.358
6	0.569	0.561	0.546	0.592	0.577	0.547	0.514	0.531	0.541	0.489	0.543	0.533
7	0.805	0.767	0.766	0.831	0.793	0.809	0.788	0.808	0.832	0.771	0.810	0.825
8	1.163	1.082	1.119	1.228	1.234	1.207	1.179	1.202	1.272	1.159	1.203	1.253
9	1.661	1.657	1.608	1.811	1.816	1.728	1.701	1.759	1.801	1.727	1.754	1.675
10	2.216	2.237	2.173	2.461	2.462	2.309	2.268	2.446	2.478	2.355	2.351	2.287
11	3.007	2.997	2.854	3.309	3.122	2.999	2.990	3.122	3.148	3.053	3.095	2.888
12	3.925	3.862	3.731	4.142	3.972	3.965	3.766	3.813	3.856	3.953	4.010	3.509
13	5.091	4.919	4.691	5.333	5.099	4.816	4.882	4.893	4.953	5.108	5.132	4.456
14	6.203	6.000	5.805	6.437	6.173	5.742	5.963	5.952	5.881	5.893	5.884	5.195
15	7.644	7.041	7.257	7.928	7.145	7.176	7.430	6.902	6.857	6.608	6.445	6.131
16	9.187	7.547	9.006	9.724	8.243	8.511	7.545	7.451	7.918	8.183	7.269	7.481
17	11.444	9.659	10.050	9.433	9.490	9.823	9.456	9.089	8.361	8.290	8.218	8.623

Table 8. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Greenland halibut in NAFO SA2 + Div. 3KLMNO. Effort is HOURS fished. (1999 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............. 0.771
MULTIPLE R SQUARED..... 0.594

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	7.06E2	7.06E2	
REGRESSION	61	1.86E2	3.05E0	16.341
Cntry|Gear|TC	19	3.76E1	1.98E0	10.587
Division	11	1.09E1	9.89E-1	5.292
Month	7	7.35E0	1.05E0	5.622
Year	24	2.56E1	1.06E0	5.698
RESIDUALS	682	1.27E2	1.87E-1	
TOTAL	744	1.02E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	-0.801	0.215	744
Division	9				
Month	22				
Year	75				
1	3123	1	-0.211	0.157	9
	3126	2	-0.126	0.168	8
	10127	3	1.051	0.187	8
	11125	4	0.232	0.134	16
	11126	5	-0.127	0.205	6
	11127	6	0.375	0.125	17
	14124	7	0.476	0.080	96
	14126	8	0.739	0.114	23
	14127	9	0.450	0.104	35
	15126	10	0.316	0.202	6
	16127	11	0.263	0.090	51
	19124	12	-0.323	0.097	102
	19125	13	-0.041	0.106	75
	19126	14	0.276	0.121	28
	20125	15	0.335	0.189	7
	20126	16	-0.092	0.145	12
	20127	17	0.006	0.097	37
	27125	18	0.216	0.105	24
	34125	19	0.528	0.161	17
2	1	20	0.268	0.092	33
	2	21	0.175	0.090	36
	3	22	-0.013	0.083	47
	4	23	-0.027	0.081	50
	5	24	0.167	0.084	44
	6	25	0.179	0.079	51
	7	26	0.031	0.071	69
	8	27	0.103	0.065	86
	10	28	-0.257	0.069	76
	11	29	-0.041	0.067	85
	12	30	0.087	0.072	69

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
3	21	31	0.022	0.084	52
	23	32	0.016	0.065	109
	31	33	-0.226	0.079	108
	32	34	-0.147	0.088	181
	33	35	-0.451	0.105	85
	34	36	-0.215	0.111	61
	35	37	-0.235	0.143	21
4	76	38	-0.075	0.226	11
	77	39	0.089	0.217	19
	78	40	0.305	0.235	18
	79	41	0.110	0.231	10
	80	42	0.336	0.238	12
	81	43	0.144	0.226	15
	82	44	0.403	0.220	19
	83	45	0.351	0.213	24
	84	46	0.284	0.215	23
	85	47	0.081	0.216	21
	86	48	-0.190	0.215	24
	87	49	0.099	0.207	33
	88	50	-0.270	0.216	22
	89	51	-0.106	0.220	22
	90	52	-0.044	0.219	26
	91	53	-0.330	0.214	51
	92	54	-0.459	0.213	100
	93	55	-0.256	0.216	84
	94	56	-0.402	0.218	100
	95	57	-0.301	0.232	21
	96	58	-0.482	0.225	23
	97	59	-0.602	0.225	24
	98	60	-0.417	0.233	34
	99	61	-0.313	0.368	2

LEGEND FOR AVOVA RESULTS:

CGT CODES:

3123 = Can(NFLD)	TC 3	|	15126 = Norway	TC 6
3125 = Can(NFLD)	TC 5	|	16127 = Poland	TC 7
3126 = "	TC 6	|	19124 = Spain	TC 4
10127 = Former FRG	TC 7	|	19125 = "	TC 5
11125 = Former DDR	TC 5	|	19126 = "	TC 6
11126 = "	TC 6	|	20125 = Former USSR	TC 5
11127 = "	TC 7	|	20126 = "	TC 6
14124 = Japan	TC 4	|	20127 = "	TC 7
14126 = "	TC 6	|	27125 = Can(M)	TC 5
14127 = "	TC 7	|	34125 = Russia	TC 5

All of the above CGT are Stern Trawlers

DIVISION CODES:

21 = 2G, 22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L
33 = 3M, 34 = 3N, 35 = 3O

Table 9. Standardized catch rate index for Greenland halibut in NAFO SA2+ Div. 3KLMNO from a multiplicative model utilizing HOURS FISHED as a measure of effort. (1999 based on preliminary data).

PREDICTED CATCH RATE

	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1975	-0.8013	0.0461	0.481	0.102	28814	59843
1976	-0.8766	0.0245	0.451	0.070	24611	54514
1977	-0.7121	0.0193	0.534	0.074	32048	60067
1978	-0.4964	0.0219	0.661	0.097	39070	59099
1979	-0.6915	0.0299	0.542	0.093	34104	62951
1980	-0.4651	0.0223	0.682	0.101	32867	48193
1981	-0.6570	0.0195	0.564	0.078	30754	54555
1982	-0.3986	0.0153	0.731	0.090	26278	35925
1983	-0.4507	0.0134	0.695	0.080	27861	40089
1984	-0.5173	0.0126	0.650	0.073	26711	41065
1985	-0.7206	0.0149	0.530	0.064	20347	38377
1986	-0.9916	0.0136	0.405	0.047	17976	44430
1987	-0.7022	0.0137	0.540	0.063	32442	60034
1988	-1.0709	0.0148	0.374	0.045	19215	51440
1989	-0.9069	0.0140	0.440	0.052	20034	45506
1990	-0.8450	0.0117	0.469	0.051	47454	101201
1991	-1.1318	0.0111	0.352	0.037	65008	184623
1992	-1.2601	0.0107	0.310	0.032	63193	203985
1993	-1.0574	0.0119	0.379	0.041	62455	164722
1994	-1.2034	0.0129	0.327	0.037	51029	155822
1995	-1.1024	0.0203	0.361	0.051	15272	42310
1996	-1.2831	0.0165	0.302	0.039	18840	62414
1997	-1.4034	0.0167	0.268	0.035	19858	74205
1998	-1.2179	0.0209	0.321	0.046	19946	62041
1999	-1.1144	0.1031	0.342	0.107	27000	78908

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.138

Table 10. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Greenland halibut in NAFO SA2 + Div. 3KLMNO. Effort is DAYS fished. (1999 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............ 0.742
MULTIPLE R SQUARED..... 0.550

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	1.90E3	1.90E3	
REGRESSION	62	1.95E2	3.15E0	14.710
Cntry|Gear|TC	20	5.39E1	2.69E0	12.577
Division	11	1.45E1	1.32E0	6.167
Month	7	1.85E1	2.64E0	12.321
Year	24	2.15E1	8.97E-1	4.189
RESIDUALS	746	1.60E2	2.14E-1	
TOTAL	809	2.26E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	2.050	0.238	809
Division	9				
Month	22				
Year	75				
1	3123	1	-0.525	0.161	10
	3126	2	-0.116	0.179	8
	9125	3	0.458	0.132	21
	11125	4	-0.079	0.140	18
	11126	5	-0.295	0.243	5
	11127	6	0.154	0.142	16
	14124	7	0.461	0.090	91
	14126	8	0.552	0.140	19
	14127	9	0.420	0.116	30
	15126	10	0.286	0.235	5
	16127	11	0.166	0.105	46
	17126	12	-0.299	0.104	77
	19124	13	-0.292	0.102	101
	19125	14	-0.182	0.104	111
	19126	15	0.405	0.132	28
	20125	16	0.314	0.217	6
	20126	17	-0.367	0.169	10
	20127	18	-0.247	0.109	35
	27125	19	0.132	0.134	16
	34125	20	0.481	0.160	15
2	1	21	0.322	0.092	39
	2	22	0.268	0.090	41
	3	23	0.041	0.081	59
	4	24	0.099	0.080	60
	5	25	0.303	0.082	54
	6	26	0.204	0.079	60
	7	27	0.147	0.077	65
	8	28	0.184	0.068	91
	10	29	-0.195	0.073	76
CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
	11	30	-0.072	0.071	86
	12	31	0.050	0.075	78
3	21	32	0.123	0.100	43
	23	33	0.070	0.076	100
	31	34	-0.272	0.093	97
	32	35	-0.214	0.101	233
	33	36	-0.673	0.115	98
	34	37	-0.388	0.116	104
	35	38	-0.368	0.151	23
4	76	39	-0.152	0.249	9
	77	40	-0.062	0.239	15
	78	41	-0.044	0.272	9
	79	42	-0.012	0.260	8
	80	43	0.107	0.277	8
	81	44	-0.270	0.253	12
	82	45	0.103	0.239	18
	83	46	-0.030	0.229	25
	84	47	0.064	0.235	21
	85	48	-0.154	0.241	17
	86	49	-0.354	0.241	16
	87	50	-0.095	0.229	27
	88	51	-0.543	0.235	21
	89	52	-0.351	0.243	19
	90	53	-0.338	0.240	24
	91	54	-0.472	0.234	45
	92	55	-0.578	0.232	99
	93	56	-0.345	0.233	86
	94	57	-0.322	0.234	108
	95	58	-0.594	0.243	33
	96	59	-0.613	0.237	42
	97	60	-0.680	0.238	41
	98	61	-0.682	0.235	98
	99	62	-0.674	0.396	2

LEGEND FOR AVOVA RESULTS:

CGT CODES:

3123 = Can(NFLD)	TC 3	16127 = Poland	TC 7
3125 = Can(NFLD)	TC 5	17126 = Portugal	TC 6
3126 = "	TC 6	19124 = Spain	TC 4
9125 = Fra (SPM)	TC 5	19125 = "	TC 5
11125 = Former DDR	TC 5	19126 = "	TC 6
11126 = "	TC 6	20125 = Former USSR	TC 5
11127 = "	TC 7	20126 = "	TC 6
14124 = Japan	TC 4	20127 = "	TC 7
14126 = "	TC 6	27125 = Can(M)	TC 5
14127 = "	TC 7	34125 = Russia	TC 5
15126 = Norway	TC 6		

All of the above CGT are Stern Trawlers

DIVISION CODES:

21 = 2G, 22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L
33 = 3M, 34 = 3N, 35 = 3O

Table 11. Standardized catch rate index for Greenland halibut in NAFO SA2+ Div. 3KLMNO from a multiplicative model utilizing DAYS FISHED as a measure of effort. (1999 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1975	2.0502	0.0564	8.408	1.971	28814	3427
1976	1.8982	0.0347	7.301	1.349	24611	3371
1977	1.9881	0.0265	8.021	1.299	32048	3996
1978	2.0064	0.0357	8.132	1.523	39070	4805
1979	2.0379	0.0408	8.371	1.674	34104	4074
1980	2.1575	0.0360	9.457	1.779	32867	3475
1981	1.7799	0.0292	6.504	1.105	30754	4728
1982	2.1530	0.0193	9.493	1.312	26278	2768
1983	2.0203	0.0163	8.326	1.060	27861	3346
1984	2.1139	0.0167	9.141	1.177	26711	2922
1985	1.8959	0.0207	7.336	1.050	20347	2774
1986	1.6965	0.0215	6.007	0.878	17976	2993
1987	1.9555	0.0203	7.788	1.105	32442	4166
1988	1.5074	0.0193	4.978	0.689	19215	3860
1989	1.6993	0.0184	6.033	0.815	20034	3321
1990	1.7120	0.0149	6.122	0.744	47454	7752
1991	1.5777	0.0138	5.355	0.626	65008	12139
1992	1.4720	0.0142	4.817	0.571	63193	13118
1993	1.7051	0.0148	6.079	0.736	62455	10273
1994	1.7281	0.0153	6.219	0.767	51029	8205
1995	1.4560	0.0202	4.726	0.669	15272	3231
1996	1.4370	0.0173	4.644	0.608	18840	4057
1997	1.3698	0.0175	4.341	0.573	19858	4574
1998	1.3681	0.0161	4.337	0.549	19946	4599
1999	1.3765	0.1182	4.156	1.389	27000	6497

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.156

Table 12. Catchability coefficients implied from the ADAPT analysis.

Qs	2	3	4	5	6	7	8	9	10	11
1978	2.52	2.27	2.20	1.74	2.04	1.64	1.25	1.03	1.79	2.98
1979	1.54	0.94	0.58	0.97	1.20	0.98	0.66	0.59	1.06	1.62
1980	0.53	0.64	0.47	0.69	1.17	0.94	0.64	0.65	1.18	2.83
1981	1.90	1.54	0.74	0.69	0.86	1.10	0.85	0.91	1.17	1.86
1982	0.62	1.30	1.30	1.24	0.77	1.07	2.26	2.01	1.79	2.49
1983	0.45	1.36	1.35	1.49	1.45	1.41	1.84	1.61	0.77	1.20
1984	0.51	1.10	1.75	2.25	1.58	1.56	1.27	1.46	2.14	2.02
1985	1.08	0.80	1.04	1.89	1.89	1.54	1.27	1.11	1.53	1.40
1986	1.03	1.31	1.55	1.70	2.88	2.57	1.30	1.12	0.87	1.40
1987	0.71	2.53	1.41	1.37	1.55	2.35	1.83	1.31	1.03	0.92
1988	0.58	1.17	1.67	2.08	1.34	1.60	1.09	0.66	0.48	0.70
1989	0.71	1.74	2.29	1.92	1.92	1.22	0.60	0.47	0.28	0.40
1990	0.26	0.63	2.16	1.86	1.54	1.04	0.31	0.18	0.21	0.37
1991	0.46	0.36	1.13	0.98	0.79	0.35	0.13	0.08	0.07	0.08
1992	1.72	1.41	0.93	0.52	0.40	0.27	0.05	0.01	0.02	0.00
1993	2.98	5.57	2.12	0.51	0.22	0.14	0.08	0.02	0.00	0.01
1994	1.89	2.22	1.54	0.74	0.15	0.10	0.06	0.01	0.01	0.00
1995	3.77	1.49	0.63	0.84	0.29	0.07	0.04	0.03	0.02	0.02
1996	3.55	3.10	1.43	1.08	0.49	0.21	0.09	0.13	0.09	0.07
1997	2.88	3.81	2.72	1.63	1.19	0.76	0.43	0.23	0.16	0.15
1998	0.74	1.92	2.20	1.59	1.26	1.28	0.55	0.23	0.21	0.16
1999	0.62	0.90	2.01	2.33	1.96	1.30	0.62	0.21	0.15	0.08
2000										
			(2-5)	**1.28**					**(6-11)**	**1.46**
78-87	1.09	1.38	1.24	1.40	1.54	1.52	1.31	1.18	1.33	1.87
88-99	1.68	2.03	1.74	1.34	0.96	0.70	0.34	0.19	0.14	0.17
			(2-5)	**1.70**					**(6-11)**	**0.42**

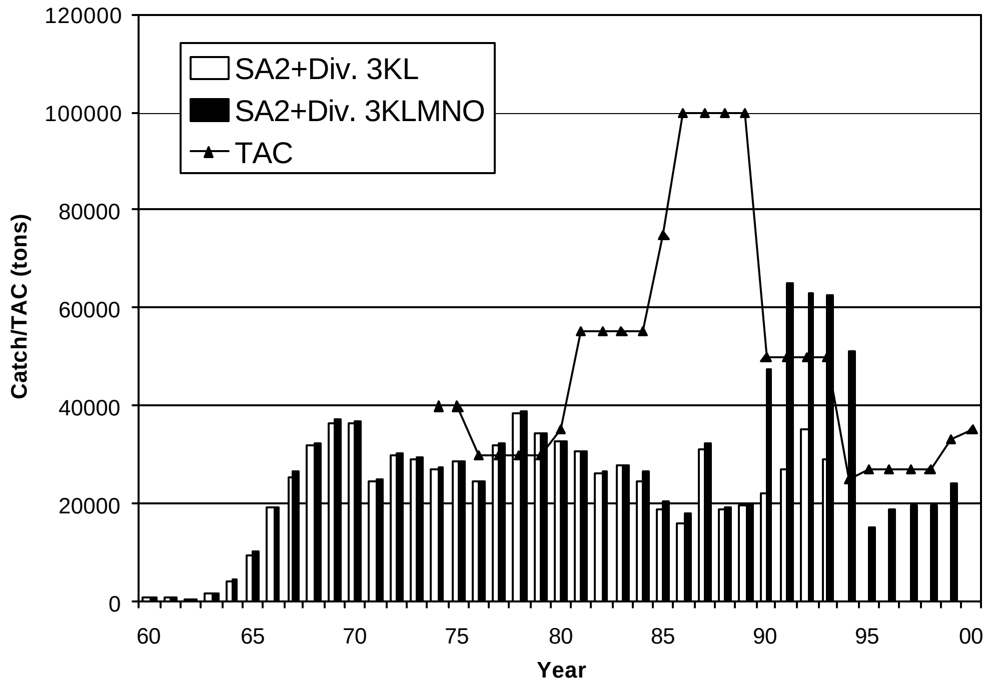


Fig. 1. Catches before and after the expansion of the stock area to include Div. 3MNO for Greenland halibut overlaid with annual TACs.

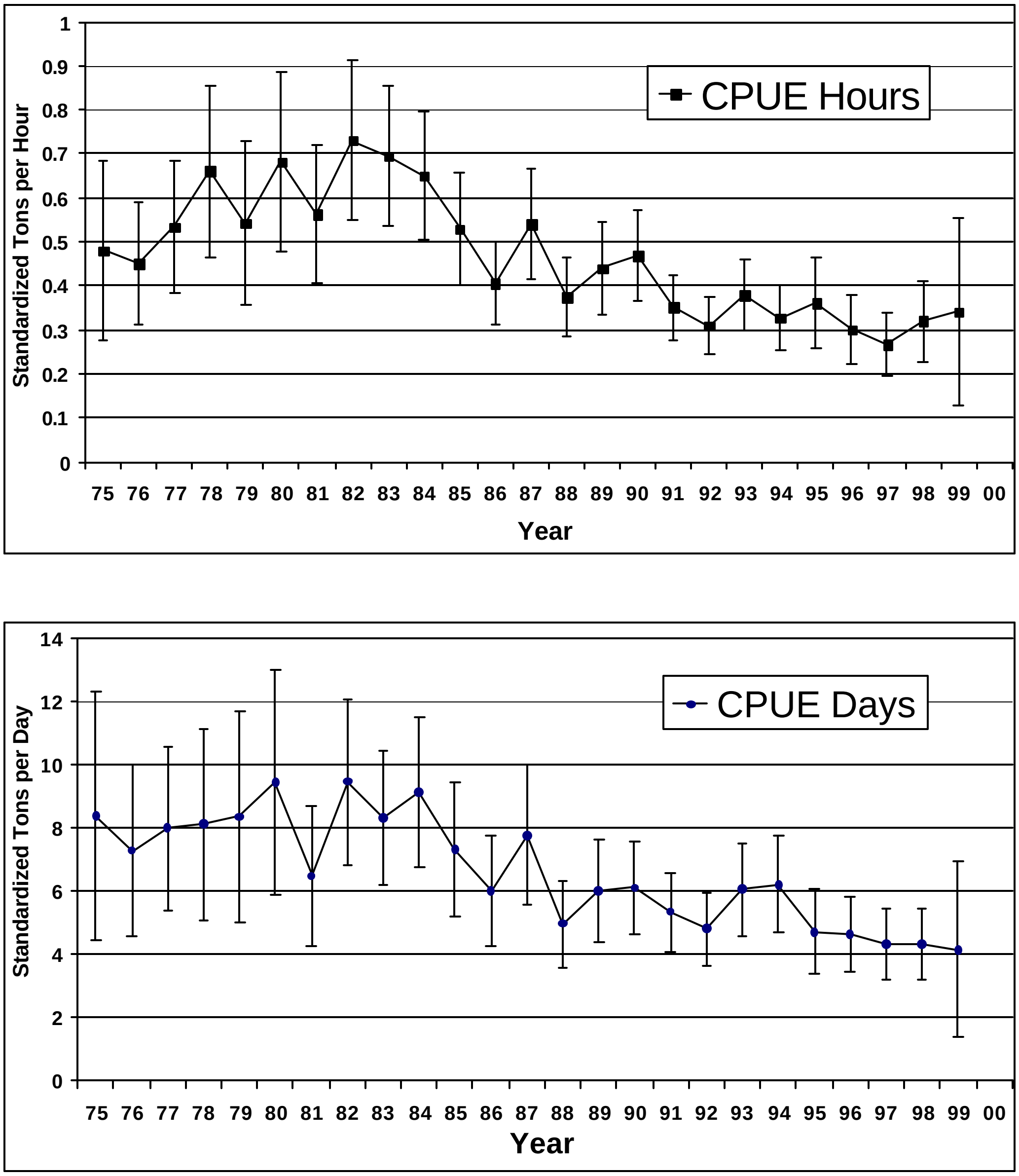


Fig. 2. Standardized CPUE with approximate 95% confidence intervals for Greenland Halibut in SA2 + Div. 3KLMNO from 1975-1999 (preliminary) utilizing effort in HOURS fished (upper panel) and DAYS fished.

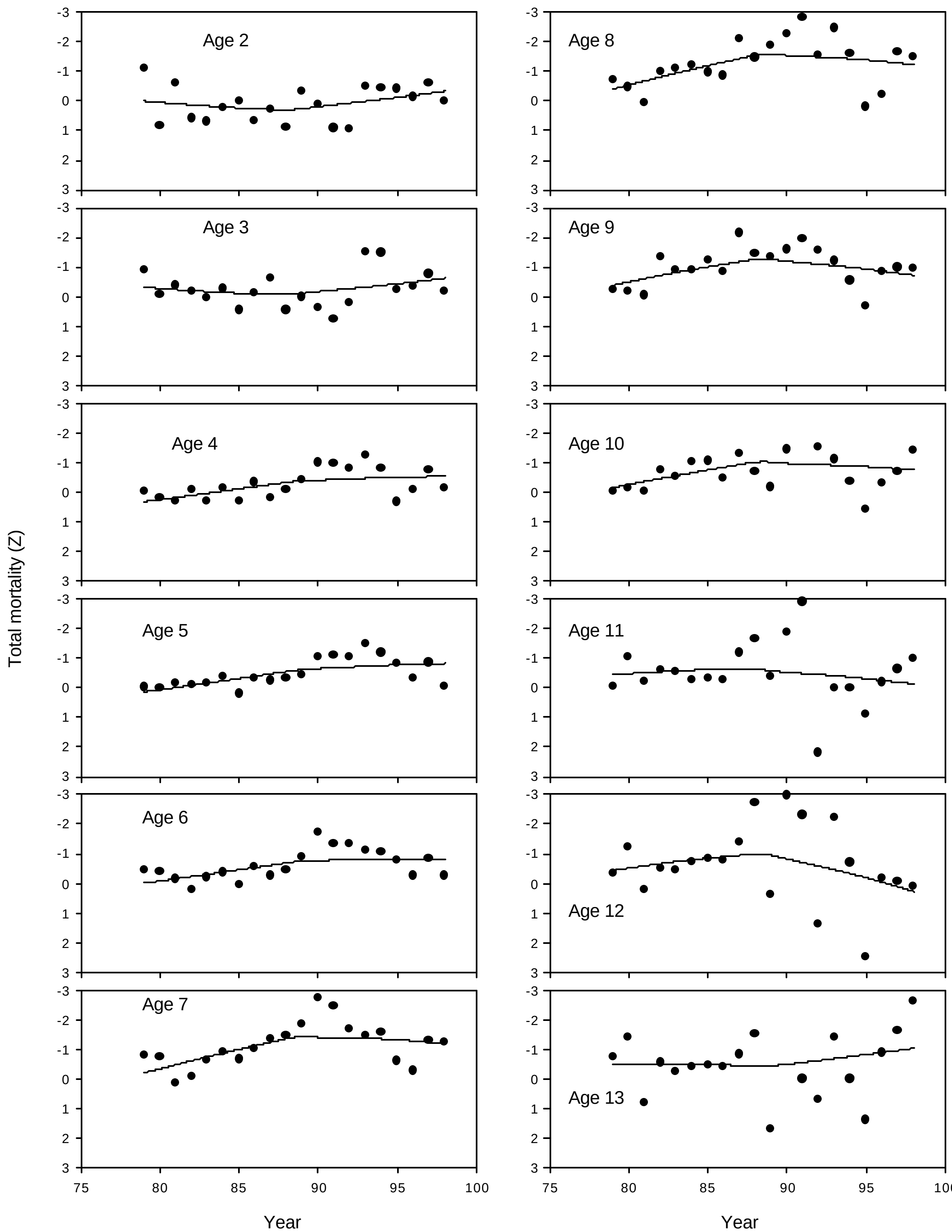


Fig. 3 Total mortality estimates at age for Greenland halibut ages 2-13 from Canadian fall surveys in Div. 2J3K during 1978-98.

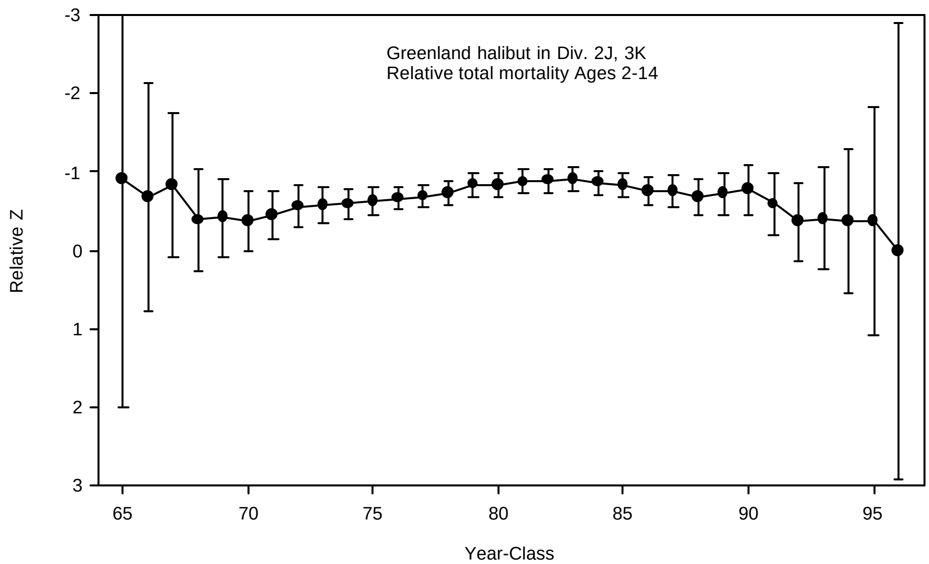


Fig. 4A Trend in relative total mortality of Greenland halibut for ages 2-14 in Divisions 2J, 3K combined from the 1965-97 cohorts. Data from Campelen surveys conducted during 1978-99.

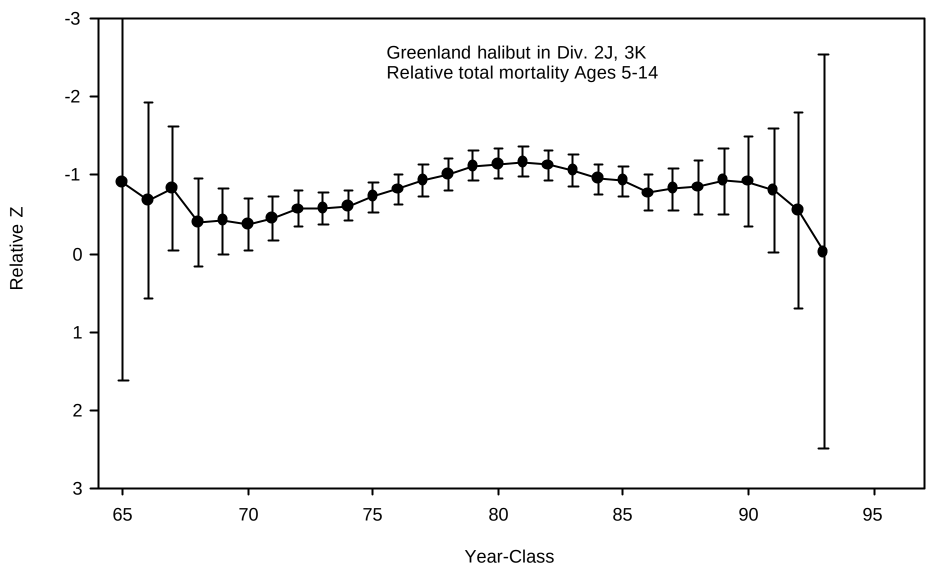


Fig. 4B Trend in relative total mortality of Greenland halibut for ages 5-14 in Divisions 2J, 3K combined from the 1965-93 cohorts. Data from Campelen surveys conducted during 1978-99.

Annex 1 - ADAPT Run - Assuming constant natural mortality (0.2) for all ages in all years

THURSDAY, JUNE 8, 2000 7:54:20.680 PM
APL Ver. 2.0.00
ADAPT_W Ver. 2.1
File Name: GH2-3 - 2000 A1

CATCH
Years: 1975 to 1999
Ages: 2 to 15

Canadian survey from 1988 to 99, ages 2 to 11 (time of year 0.85)

EU 3M from 1991 to 1999, ages 2 to 11 (time of year 0.55)

Plus Group : No plus group

Population initial values:

3	4	5	6	7	8	9	10	11	12	13
500000	60000	50000	30000	15000	10000	5000	4000	3000	2000	2000

F ratios
F for ages 13-14-15 in 1999 calculated from ages 11-12.
F for Age 15 calculated for other years as average of 12-14

Natural Mortality
0.2

Estimates for parameters (log scale)

PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
1.17E1	5.33E-1	0.045	5.93E-3	0.001
1.20E1	3.81E-1	0.032	5.81E-3	0.000
1.24E1	3.13E-1	0.025	5.68E-3	0.000
1.23E1	2.74E-1	0.022	5.26E-3	0.000
1.16E1	2.58E-1	0.022	3.82E-3	0.000
1.06E1	2.78E-1	0.026	-9.32E-4	0.000
9.96E0	2.78E-1	0.028	-2.95E-3	0.000
9.19E0	3.11E-1	0.034	-8.23E-3	-0.001
8.21E0	3.42E-1	0.042	-1.20E-2	-0.001
7.25E0	3.63E-1	0.050	-1.23E-2	-0.002
6.93E0	4.49E-1	0.065	-3.21E-2	-0.005
-6.73E0	2.24E-1	-0.033	-5.61E-3	0.001
-6.57E0	2.17E-1	-0.033	-5.12E-3	0.001
-6.59E0	2.12E-1	-0.032	-4.64E-3	0.001
-6.77E0	2.09E-1	-0.031	-4.26E-3	0.001
-7.08E0	2.08E-1	-0.029	-3.96E-3	0.001
-7.32E0	2.09E-1	-0.029	-3.04E-3	0.000
-8.07E0	2.12E-1	-0.026	-1.50E-3	0.000
-8.84E0	2.15E-1	-0.024	6.02E-4	0.000
-9.22E0	2.18E-1	-0.024	2.51E-3	0.000
-9.41E0	2.22E-1	-0.024	4.93E-3	-0.001
-5.13E0	2.86E-1	-0.056	-6.24E-3	0.001
-4.81E0	2.55E-1	-0.053	-6.27E-3	0.001
-3.99E0	2.49E-1	-0.062	-6.19E-3	0.002
-3.25E0	2.44E-1	-0.075	-5.63E-3	0.002
-2.53E0	2.42E-1	-0.095	-5.22E-3	0.002
-2.13E0	2.43E-1	-0.114	-4.34E-3	0.002
-2.14E0	2.46E-1	-0.115	-2.71E-3	0.001
-2.23E0	2.50E-1	-0.112	-1.78E-4	0.000
-2.67E0	2.55E-1	-0.096	2.30E-3	-0.001
-3.43E0	2.60E-1	-0.076	5.15E-3	-0.002

Parameters in linear scale

	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
N 3,2000	1.24E5	6.63E4	0.533	1.84E4	0.148
N 4,2000	1.65E5	6.28E4	0.381	1.29E4	0.078
N 5,2000	2.48E5	7.77E4	0.313	1.36E4	0.055
N 6,2000	2.17E5	5.95E4	0.274	9.30E3	0.043
N 7,2000	1.04E5	2.69E4	0.258	3.86E3	0.037
N 8,2000	3.95E4	1.10E4	0.278	1.49E3	0.038
N 9,2000	2.12E4	5.90E3	0.278	7.59E2	0.036
N10,2000	9.80E3	3.04E3	0.311	3.92E2	0.040
N11,2000	3.68E3	1.26E3	0.342	1.71E2	0.047
N12,2000	1.41E3	5.12E2	0.363	7.58E1	0.054
N13,2000	1.02E3	4.59E2	0.449	7.04E1	0.069
CANq2	1.19E-3	2.67E-4	0.224	2.33E-5	0.020
CANq3	1.40E-3	3.04E-4	0.217	2.58E-5	0.018
CANq4	1.38E-3	2.92E-4	0.212	2.46E-5	0.018
CANq5	1.15E-3	2.41E-4	0.209	2.04E-5	0.018
CANq6	8.46E-4	1.76E-4	0.208	1.50E-5	0.018
CANq7	6.64E-4	1.39E-4	0.209	1.25E-5	0.019
CANq8	3.13E-4	6.62E-5	0.212	6.54E-6	0.021
CANq9	1.44E-4	3.10E-5	0.215	3.43E-6	0.024
CANq10	9.88E-5	2.16E-5	0.218	2.60E-6	0.026
CANq11	8.19E-5	1.82E-5	0.222	2.43E-6	0.030
EUq2	5.93E-3	1.69E-3	0.286	2.05E-4	0.035
EUq3	8.19E-3	2.09E-3	0.255	2.15E-4	0.026
EUq4	1.85E-2	4.60E-3	0.249	4.57E-4	0.025
EUq5	3.87E-2	9.45E-3	0.244	9.36E-4	0.024
EUq6	7.93E-2	1.92E-2	0.242	1.91E-3	0.024
EUq7	1.19E-1	2.88E-2	0.243	2.98E-3	0.025
EUq8	1.18E-1	2.89E-2	0.246	3.23E-3	0.027
EUq9	1.07E-1	2.68E-2	0.250	3.33E-3	0.031
EUq10	6.94E-2	1.77E-2	0.255	2.41E-3	0.035
EUq11	3.25E-2	8.44E-3	0.260	1.26E-3	0.039

VPA using analytical bias adjusted parameters (linear scale)

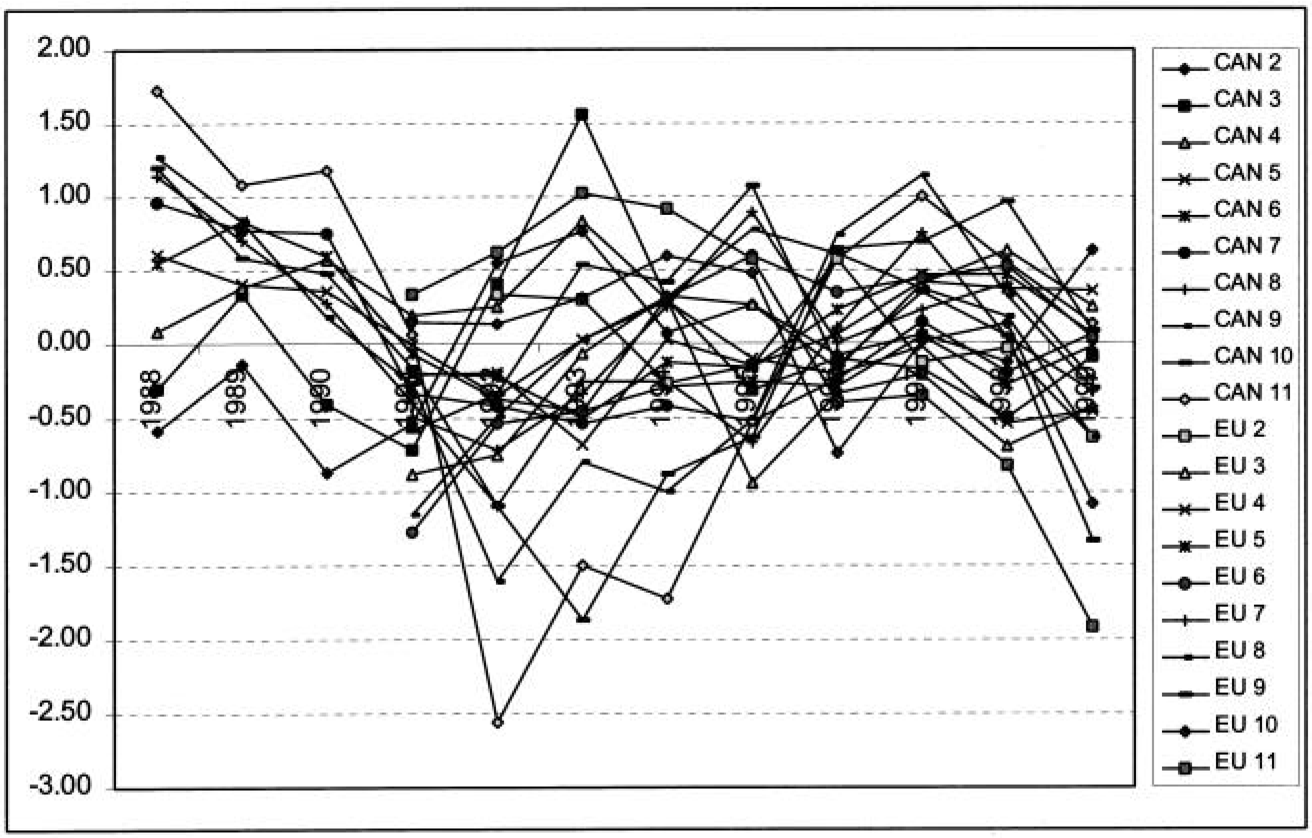
N	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1975	125136	107315	66853	52300	33521	24883	15381	9611	4112	2173	642	553	257	150
1976	83709	102453	87862	54735	42518	24903	15204	8149	4326	1857	1149	404	204	90
1977	86874	68535	83881	71935	44798	34260	17477	7598	3306	1576	780	707	240	138
1978	83409	71126	56112	68676	58413	32160	18364	7740	3595	1798	1092	521	475	170
1979	63889	68290	58233	45940	53536	40245	18276	8259	3771	1657	825	565	228	291
1980	77682	52308	55911	47677	35460	35974	21448	9462	5709	2654	1098	541	334	105
1981	100466	63600	42826	45776	38846	27150	21232	8914	2947	1287	1266	784	395	261
1982	105209	82254	52072	35063	36699	27733	13444	7188	3455	1614	823	909	603	298
1983	102798	86138	67344	42633	28464	27972	17025	5855	2725	1326	788	445	597	421
1984	113795	84164	70523	55137	34272	20099	14120	7225	2739	1610	898	577	269	412
1985	122469	93167	68907	57740	44328	25963	11210	4722	2280	1118	952	606	377	168
1986	135778	100269	76279	56417	45483	31508	15940	6039	2627	1407	772	690	418	265
1987	153016	111166	82093	62452	45937	35217	20029	8485	3624	1727	932	506	502	292
1988	128339	125279	91015	67212	51007	35893	18962	8416	4405	2200	1069	511	214	260
1989	109094	105075	102570	74517	54761	38887	22072	11587	5730	3187	1620	780	322	119
1990	94235	89319	86028	83977	60846	43040	25108	14227	8151	4001	2215	1086	508	220
1991	100482	77153	73128	70434	67759	43725	23901	13775	7992	4260	2195	1022	501	227
1992	105305	82267	63168	59872	55083	48486	23997	9924	4911	3221	1821	715	340	169
1993	127608	86217	67355	51717	45248	35272	21245	8767	4254	2442	1730	831	234	88
1994	169042	104476	70588	55145	33730	22773	13082	6792	3043	1841	1057	558	322	91
1995	293675	138400	85538	57793	30342	13497	8705	4705	2809	1503	783	487	173	120
1996	466990	240441	113312	70033	46096	22730	8173	5213	2789	1814	921	396	175	66
1997	427676	382339	196856	92772	55840	33056	12875	4971	3408	1830	1093	544	196	90
1998	226720	350151	313033	161172	74237	41957	20282	7652	3046	2245	1120	674	323	110
1999	129390	185623	286679	256289	128729	55903	29138	13317	4974	2007	1498	772	469	234
2000	100000	105935	151975	234713	207891	100317	38015	20439	9408	3511	1335	952	502	305

F	2	3	4	5	6	7	8	9	10	11	12	13	14	15		F(8-12)
1975	0.000	0.000	0.000	0.007	0.097	0.293	0.435	0.598	0.595	0.437	0.263	0.798	0.855	0.638	1975	0.466
1976	0.000	0.000	0.000	0.000	0.016	0.154	0.494	0.702	0.810	0.668	0.286	0.320	0.190	0.265	1976	0.592
1977	0.000	0.000	0.000	0.008	0.131	0.424	0.614	0.548	0.409	0.167	0.203	0.199	0.148	0.183	1977	0.388
1978	0.000	0.000	0.000	0.049	0.173	0.365	0.599	0.519	0.575	0.579	0.459	0.626	0.291	0.458	1978	0.546
1979	0.000	0.000	0.000	0.059	0.198	0.429	0.458	0.169	0.151	0.211	0.221	0.325	0.580	0.376	1979	0.242
1980	0.000	0.000	0.000	0.005	0.067	0.327	0.678	0.966	1.290	0.540	0.137	0.114	0.047	0.100	1980	0.722
1981	0.000	0.000	0.000	0.021	0.137	0.503	0.883	0.748	0.402	0.247	0.132	0.062	0.084	0.093	1981	0.482
1982	0.000	0.000	0.000	0.008	0.072	0.288	0.631	0.770	0.757	0.517	0.417	0.220	0.158	0.265	1982	0.618
1983	0.000	0.000	0.000	0.018	0.148	0.484	0.657	0.560	0.327	0.190	0.112	0.304	0.170	0.195	1983	0.369
1984	0.000	0.000	0.000	0.018	0.078	0.384	0.895	0.953	0.696	0.325	0.193	0.226	0.271	0.230	1984	0.612
1985	0.000	0.000	0.000	0.039	0.141	0.288	0.419	0.386	0.283	0.170	0.122	0.172	0.151	0.148	1985	0.276
1986	0.000	0.000	0.000	0.005	0.056	0.253	0.431	0.311	0.220	0.212	0.222	0.118	0.160	0.167	1986	0.279
1987	0.000	0.000	0.000	0.002	0.047	0.419	0.667	0.456	0.299	0.280	0.401	0.663	0.456	0.507	1987	0.421
1988	0.000	0.000	0.000	0.005	0.071	0.286	0.293	0.184	0.124	0.106	0.115	0.261	0.383	0.253	1988	0.164
1989	0.000	0.000	0.000	0.003	0.041	0.237	0.239	0.152	0.159	0.164	0.200	0.228	0.183	0.204	1989	0.183
1990	0.000	0.000	0.000	0.015	0.130	0.388	0.400	0.377	0.449	0.400	0.574	0.574	0.608	0.585	1990	0.440
1991	0.000	0.000	0.000	0.046	0.135	0.400	0.679	0.831	0.709	0.650	0.922	0.901	0.888	0.903	1991	0.758
1992	0.000	0.000	0.000	0.080	0.246	0.625	0.807	0.647	0.499	0.422	0.585	0.917	1.146	0.883	1992	0.592
1993	0.000	0.000	0.000	0.227	0.487	0.792	0.940	0.858	0.637	0.638	0.931	0.747	0.748	0.808	1993	0.801
1994	0.000	0.000	0.000	0.397	0.716	0.762	0.823	0.683	0.505	0.655	0.574	0.974	0.785	0.778	1994	0.648
1995	0.000	0.000	0.000	0.026	0.089	0.302	0.313	0.323	0.237	0.290	0.481	0.822	0.769	0.691	1995	0.329
1996	0.000	0.000	0.000	0.026	0.133	0.368	0.297	0.225	0.221	0.306	0.325	0.502	0.469	0.432	1996	0.275
1997	0.000	0.000	0.000	0.023	0.086	0.288	0.320	0.290	0.218	0.290	0.284	0.323	0.383	0.330	1997	0.280
1998	0.000	0.000	0.000	0.025	0.084	0.165	0.221	0.231	0.217	0.204	0.172	0.163	0.120	0.151	1998	0.209
1999	0.000	0.000	0.000	0.009	0.049	0.186	0.155	0.147	0.148	0.208	0.254	0.231	0.231	0.231	1999	0.183

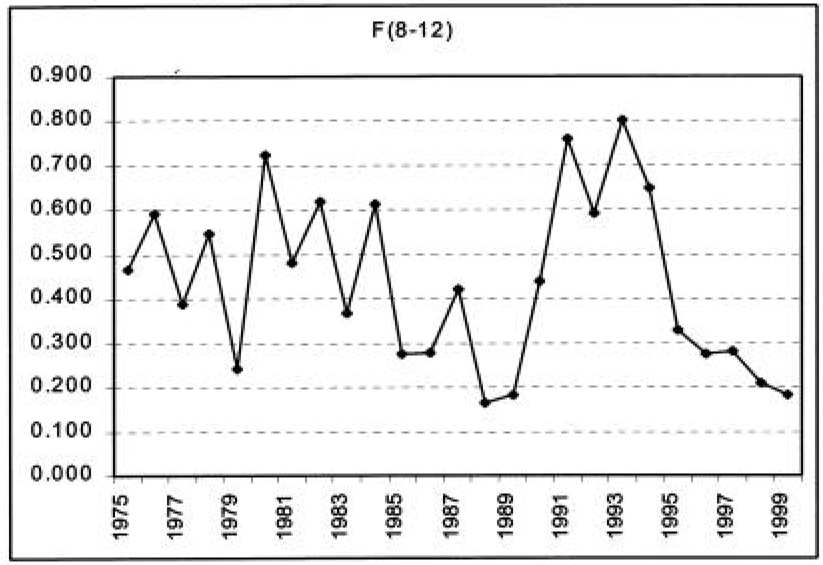
Correlation of parameter estimates

```
1.00  0.12  0.12  0.11  0.10  0.10  0.09  0.08  0.04  0.04  0.04-0.27-0.07-0.06-0.05-0.04-0.03-0.03-0.03-0.02-0.02-0.31-0.08-0.07-0.05-0.04-0.04-0.03-0.03-0.02-0.02
      1.00  0.15  0.14  0.13  0.13  0.12  0.10  0.06  0.05  0.05-0.24-0.22-0.08-0.06-0.05-0.05-0.04-0.04-0.03-0.03-0.27-0.25-0.08-0.07-0.05-0.05-0.04-0.04-0.03-0.03
            1.00  0.16  0.15  0.15  0.14  0.12  0.08  0.06  0.06-0.22-0.21-0.19-0.07-0.06-0.05-0.05-0.04-0.04-0.03-0.26-0.23-0.21-0.08-0.06-0.06-0.05-0.05-0.04-0.04
                  1.00  0.17  0.16  0.15  0.13  0.09  0.07  0.07-0.21-0.20-0.18-0.17-0.06-0.06-0.05-0.05-0.04-0.04-0.24-0.22-0.20-0.19-0.07-0.06-0.06-0.05-0.04-0.04
                        1.00  0.17  0.16  0.14  0.10  0.08  0.08-0.20-0.19-0.17-0.16-0.15-0.06-0.06-0.05-0.05-0.05-0.23-0.21-0.19-0.18-0.17-0.07-0.06-0.06-0.05-0.05
                              1.00  0.17  0.15  0.11  0.10  0.10-0.19-0.18-0.16-0.15-0.15-0.16-0.07-0.06-0.06-0.05-0.22-0.20-0.18-0.17-0.16-0.17-0.07-0.07-0.06-0.06
                                    1.00  0.17  0.13  0.12  0.13-0.18-0.17-0.15-0.14-0.14-0.15-0.17-0.08-0.07-0.07-0.20-0.19-0.17-0.16-0.16-0.16-0.18-0.08-0.07-0.07
                                          1.00  0.16  0.16  0.17-0.16-0.15-0.13-0.13-0.13-0.15-0.17-0.19-0.09-0.09-0.17-0.16-0.15-0.14-0.14-0.16-0.18-0.20-0.10-0.09
                                                1.00  0.20  0.21-0.11-0.10-0.10-0.10-0.11-0.13-0.17-0.20-0.21-0.11-0.08-0.11-0.10-0.11-0.12-0.14-0.17-0.21-0.23-0.12
                                                      1.00  0.19-0.09-0.09-0.08-0.08-0.10-0.13-0.18-0.23-0.26-0.30-0.07-0.09-0.08-0.09-0.10-0.14-0.18-0.23-0.28-0.32
...
```

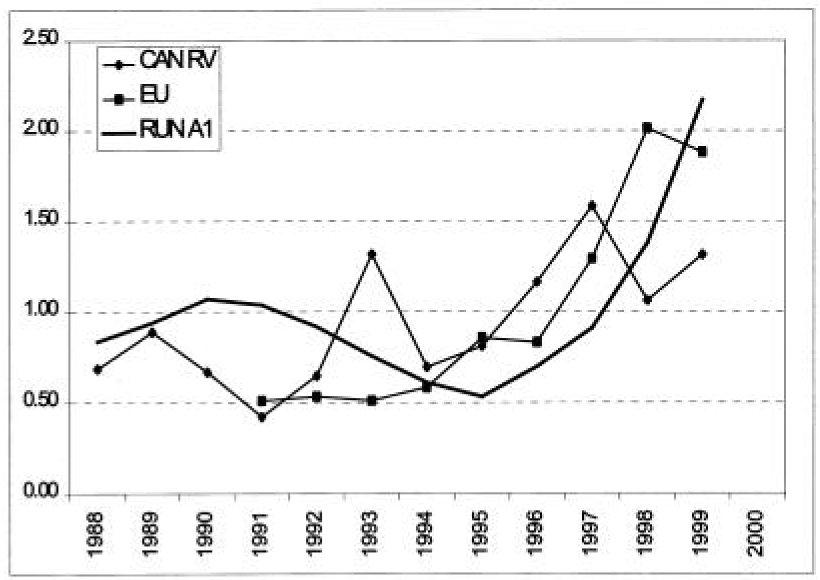
Residuals



Annual fishing mortality for ages 8-12.



Comparison between the 5+ VPA-biomass and 5+ biomass from the two research survey indices.



Annex 2 - ADAPT RUN 2 - M estimated for ages 9-12.

File Name: GH2-3 - 2000 A2

CATCH
Years: 1975 to 1999
Ages: 2 to 12

Canadian survey from 1978 to 99, ages 2 to 9 (time of year 0.85)
EU 3M from 1991 to 1999, ages 2 to 10 (time of year 0.55)

Plus Group : No plus group

Population initial values:

3	4	5	6	7	8	9	10	11
60000	60000	50000	50000	40000	30000	20000	10000	5000

F ratios
F for ages 11 in 1999 calculated from ages 9-10.
F for Age 12 calculated for other years as average of 10-11

Natural Mortality
0.2 for ages 2-8, estimated for ages 9+

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

Estimates for parameters (log scale)

PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
1.23E1	5.38E-1	0.044	2.26E-2	0.002
1.26E1	3.97E-1	0.032	2.25E-2	0.002
1.30E1	3.37E-1	0.026	2.25E-2	0.002
1.28E1	3.03E-1	0.024	2.24E-2	0.002
1.21E1	2.90E-1	0.024	2.21E-2	0.002
1.12E1	3.07E-1	0.027	2.06E-2	0.002
1.06E1	3.17E-1	0.030	1.99E-2	0.002
9.56E0	3.50E-1	0.037	1.80E-2	0.002
7.17E0	5.96E-1	0.083	-1.93E-2	-0.003
-6.15E-1	4.34E-2	-0.070	-3.18E-3	0.005
-7.44E0	2.18E-1	-0.029	-2.19E-2	0.003
-7.21E0	2.19E-1	-0.030	-2.19E-2	0.003
-7.29E0	2.21E-1	-0.030	-2.20E-2	0.003
-7.34E0	2.26E-1	-0.031	-2.25E-2	0.003
-7.50E0	2.35E-1	-0.031	-2.31E-2	0.003
-7.71E0	2.60E-1	-0.034	-2.38E-2	0.003
-8.41E0	2.93E-1	-0.035	-2.33E-2	0.003
-8.93E0	3.10E-1	-0.035	-2.24E-2	0.003
-5.63E0	3.18E-1	-0.056	-2.33E-2	0.004
-5.20E0	2.88E-1	-0.055	-2.28E-2	0.004
-4.35E0	2.81E-1	-0.065	-2.29E-2	0.005
-3.58E0	2.77E-1	-0.077	-2.29E-2	0.006
-2.87E0	2.82E-1	-0.098	-2.35E-2	0.008
-2.55E0	3.01E-1	-0.118	-2.47E-2	0.010
-2.78E0	3.38E-1	-0.122	-2.53E-2	0.009
-2.97E0	3.72E-1	-0.125	-2.40E-2	0.008
-3.41E0	4.00E-1	-0.117	-2.03E-2	0.006

Parameters in linear scale

	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
N3,2000	2.28E5	1.23E5	0.538	3.82E4	0.168
N4,2000	2.90E5	1.15E5	0.397	2.93E4	0.101
N5,2000	4.32E5	1.45E5	0.337	3.42E4	0.079
N6,2000	3.69E5	1.12E5	0.303	2.53E4	0.068
N7,2000	1.75E5	5.08E4	0.290	1.12E4	0.064
N8,2000	7.00E4	2.15E4	0.307	4.73E3	0.068
N9,2000	3.94E4	1.25E4	0.317	2.76E3	0.070
N10,2000	1.42E4	4.97E3	0.350	1.13E3	0.079
N11,2000	1.30E3	7.75E2	0.596	2.06E2	0.158
M9+	5.41E-1	2.34E-2	0.043	-1.21E-3	-0.002
CANq2	5.86E-4	1.28E-4	0.218	1.11E-6	0.002
CANq3	7.39E-4	1.62E-4	0.219	1.54E-6	0.002
CANq4	6.83E-4	1.51E-4	0.221	1.68E-6	0.002
CANq5	6.52E-4	1.47E-4	0.226	1.92E-6	0.003
CANq6	5.52E-4	1.30E-4	0.235	2.49E-6	0.005
CANq7	4.48E-4	1.16E-4	0.260	4.43E-6	0.010
CANq8	2.23E-4	6.54E-5	0.293	4.37E-6	0.020
Canq9	1.33E-4	4.12E-5	0.310	3.42E-6	0.026
EUq2	3.58E-3	1.14E-3	0.318	9.74E-5	0.027
EUq3	5.49E-3	1.58E-3	0.288	1.02E-4	0.019
EUq4	1.29E-2	3.61E-3	0.281	2.14E-4	0.017
EUq5	2.78E-2	7.72E-3	0.277	4.34E-4	0.016
EUq6	5.66E-2	1.59E-2	0.282	9.13E-4	0.016
EUq7	7.77E-2	2.34E-2	0.301	1.61E-3	0.021
EUq8	6.22E-2	2.10E-2	0.338	1.97E-3	0.032
EUq9	5.11E-2	1.90E-2	0.372	2.31E-3	0.045
EUq10	3.32E-2	1.32E-2	0.400	1.97E-3	0.060

VPA using analytical bias adjusted parameters (linear scale)

Population Numbers

	2	3	4	5	6	7	8	9	10	11	12
1975.00	305550	184274	111503	85308	54101	29117	23457	16416	6740	2277	482
1976.00	293447	250163	150871	91291	69542	41750	18666	14748	6613	2670	807
1977.00	337166	240254	204816	123523	74727	56386	31268	10423	5789	2225	942
1978.00	273730	276048	196703	167689	100649	56660	36449	18997	3896	2613	1130
1979.00	304622	224112	226009	161047	134599	74815	38312	23027	8912	1213	985
1980.00	308821	249403	183487	185041	129699	102327	49710	25842	12517	4823	493
1981.00	302781	252841	204194	150226	151310	104305	75527	31990	11021	4459	2053
1982.00	281415	247896	207009	167180	122216	119804	76556	51524	15391	5744	2402
1983.00	267893	230403	202960	169485	136633	97986	92385	57480	27314	7693	2895
1984.00	202286	219333	188638	166170	138129	108654	71388	68861	31711	15368	4318
1985.00	209928	165618	179574	154444	135234	110992	83684	51523	36988	17500	8633
1986.00	188023	171675	135597	147023	124657	105928	85536	65356	28933	21130	10060
1987.00	194952	153940	140719	111017	120119	100038	80942	65438	36912	16476	12108
1988.00	154565	159613	126036	115211	90769	96628	71985	58215	35934	20830	9295
1989.00	136766	126547	130680	103189	94060	71440	71775	54984	32895	20553	11965
1990.00	111521	111974	103608	106992	84321	75214	51747	54908	30869	18558	11626
1991.00	95481	91306	91677	84827	86602	62941	50208	35560	28886	15939	9891
1992.00	151115	78173	74755	75059	66867	63910	39702	31398	15373	14022	7877
1993.00	193352	123722	64003	61204	57681	44912	33816	21555	15029	7624	7397
1994.00	259429	158303	101295	52401	41492	32923	20916	17006	9091	7369	3647
1995.00	466679	212403	129607	82934	28102	19811	16967	11081	7598	4463	3680
1996.00	769504	382085	173901	106114	66679	20895	13338	11972	5560	4015	2338
1997.00	723987	630017	312824	142378	85380	49905	11377	9196	6247	2857	2009
1998.00	388266	592750	515814	256119	114850	66141	34064	6428	4498	3180	1348
1999.00	231982	317885	485303	422313	206464	89152	48933	24597	2674	2212	1568
2000.00	100000	189931	260263	397333	343819	163960	65227	36642	13063	1094	1031

Fishing Mortality

	2	3	4	5	6	7	8	9	10	11	12
1975.00	0.000	0.000	0.000	0.004	0.059	0.245	0.264	0.367	0.384	0.495	0.440
1976.00	0.000	0.000	0.000	0.000	0.010	0.089	0.383	0.393	0.547	0.500	0.524
1977.00	0.000	0.000	0.000	0.005	0.077	0.236	0.298	0.442	0.254	0.136	0.195
1978.00	0.000	0.000	0.000	0.020	0.097	0.191	0.259	0.215	0.625	0.433	0.529
1979.00	0.000	0.000	0.000	0.016	0.074	0.209	0.194	0.068	0.072	0.359	0.216
1980.00	0.000	0.000	0.000	0.001	0.018	0.104	0.241	0.310	0.490	0.312	0.401
1981.00	0.000	0.000	0.000	0.006	0.033	0.109	0.182	0.190	0.110	0.077	0.093
1982.00	0.000	0.000	0.000	0.002	0.021	0.060	0.087	0.093	0.152	0.143	0.148
1983.00	0.000	0.000	0.000	0.005	0.029	0.117	0.094	0.053	0.033	0.036	0.035
1984.00	0.000	0.000	0.000	0.006	0.019	0.061	0.126	0.080	0.053	0.035	0.044
1985.00	0.000	0.000	0.000	0.014	0.044	0.061	0.047	0.035	0.018	0.012	0.015
1986.00	0.000	0.000	0.000	0.002	0.020	0.069	0.068	0.030	0.021	0.015	0.018
1987.00	0.000	0.000	0.000	0.001	0.018	0.129	0.130	0.058	0.030	0.031	0.030
1988.00	0.000	0.000	0.000	0.003	0.039	0.097	0.069	0.029	0.017	0.013	0.015
1989.00	0.000	0.000	0.000	0.002	0.024	0.122	0.068	0.035	0.031	0.028	0.029
1990.00	0.000	0.000	0.000	0.011	0.092	0.204	0.175	0.101	0.119	0.087	0.103
1991.00	0.000	0.000	0.000	0.038	0.104	0.261	0.269	0.297	0.181	0.163	0.172
1992.00	0.000	0.000	0.000	0.063	0.198	0.437	0.411	0.195	0.159	0.098	0.129
1993.00	0.000	0.000	0.000	0.189	0.361	0.564	0.487	0.322	0.171	0.196	0.183
1994.00	0.000	0.000	0.000	0.423	0.539	0.463	0.435	0.264	0.170	0.153	0.161
1995.00	0.000	0.000	0.000	0.018	0.096	0.196	0.149	0.148	0.096	0.105	0.101
1996.00	0.000	0.000	0.000	0.017	0.090	0.408	0.172	0.109	0.124	0.150	0.137
1997.00	0.000	0.000	0.000	0.015	0.055	0.182	0.371	0.173	0.133	0.209	0.171
1998.00	0.000	0.000	0.000	0.016	0.053	0.101	0.126	0.335	0.168	0.165	0.167
1999.00	0.000	0.000	0.000	0.006	0.031	0.112	0.089	0.091	0.352	0.222	0.287

Correlation matrix of parameters

1.00	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.26	0.25	-0.33	-0.23	-0.23	-0.23	-0.23	-0.24	-0.25	-0.26	-0.38	-0.19	-0.18	-0.17	-0.18	-0.19	...
0.19	1.00	0.26	0.27	0.29	0.30	0.31	0.32	0.35	0.33	-0.38	-0.37	-0.31	-0.31	-0.31	-0.33	-0.34	-0.34	-0.38	-0.37	-0.24	-0.23	-0.23	-0.26	...
0.20	0.26	1.00	0.32	0.33	0.35	0.37	0.37	0.41	0.38	-0.41	-0.41	-0.41	-0.36	-0.37	-0.38	-0.40	-0.40	-0.39	-0.38	-0.37	-0.27	-0.27	-0.30	...
0.21	0.27	0.32	1.00	0.37	0.38	0.40	0.41	0.46	0.43	-0.44	-0.44	-0.44	-0.44	-0.41	-0.43	-0.44	-0.45	-0.40	-0.40	-0.39	-0.38	-0.31	-0.34	...
0.22	0.29	0.33	0.37	1.00	0.42	0.44	0.45	0.50	0.47	-0.47	-0.47	-0.47	-0.47	-0.48	-0.47	-0.49	-0.49	-0.41	-0.41	-0.40	-0.39	-0.40	-0.37	...
0.23	0.30	0.35	0.38	0.42	1.00	0.48	0.49	0.55	0.51	-0.50	-0.50	-0.50	-0.51	-0.52	-0.54	-0.53	-0.54	-0.42	-0.42	-0.41	-0.41	-0.42	-0.46	...
0.24	0.31	0.37	0.40	0.44	0.48	1.00	0.53	0.61	0.56	-0.53	-0.53	-0.54	-0.54	-0.56	-0.58	-0.61	-0.59	-0.44	-0.44	-0.43	-0.43	-0.44	-0.49	...
0.24	0.32	0.37	0.41	0.45	0.49	0.53	1.00	0.63	0.56	-0.55	-0.55	-0.55	-0.56	-0.58	-0.61	-0.63	-0.65	-0.44	-0.44	-0.44	-0.43	-0.45	-0.51	...
0.26	0.35	0.41	0.46	0.50	0.55	0.61	0.63	1.00	0.53	-0.63	-0.63	-0.64	-0.65	-0.67	-0.71	-0.75	-0.77	-0.44	-0.47	-0.47	-0.48	-0.52	-0.60	...
0.25	0.33	0.38	0.43	0.47	0.51	0.56	0.56	0.53	1.00	-0.61	-0.63	-0.64	-0.66	-0.68	-0.72	-0.76	-0.76	-0.42	-0.41	-0.40	-0.40	-0.42	-0.47	...
-0.33	-0.38	-0.41	-0.44	-0.47	-0.50	-0.53	-0.55	-0.63	-0.61	1.00	0.54	0.54	0.55	0.56	0.59	0.62	0.62	0.44	0.42	0.40	0.39	0.41	0.45	...
-0.23	-0.37	-0.41	-0.44	-0.47	-0.50	-0.53	-0.55	-0.63	-0.63	0.54	1.00	0.55	0.56	0.57	0.60	0.63	0.64	0.42	0.42	0.41	0.40	0.41	0.46	...
-0.23	-0.31	-0.41	-0.44	-0.47	-0.50	-0.54	-0.55	-0.64	-0.64	0.54	0.55	1.00	0.57	0.58	0.61	0.64	0.65	0.41	0.41	0.41	0.40	0.42	0.46	...
-0.23	-0.31	-0.36	-0.44	-0.47	-0.51	-0.54	-0.56	-0.65	-0.66	0.55	0.56	0.57	1.00	0.59	0.62	0.65	0.66	0.40	0.41	0.41	0.40	0.42	0.47	...
-0.23	-0.31	-0.37	-0.41	-0.48	-0.52	-0.56	-0.58	-0.67	-0.68	0.56	0.57	0.58	0.59	1.00	0.64	0.67	0.68	0.41	0.41	0.41	0.41	0.43	0.49	...
-0.24	-0.33	-0.38	-0.43	-0.47	-0.54	-0.58	-0.61	-0.71	-0.72	0.59	0.60	0.61	0.62	0.64	1.00	0.71	0.72	0.42	0.43	0.43	0.43	0.45	0.51	...
-0.25	-0.34	-0.40	-0.44	-0.49	-0.53	-0.61	-0.63	-0.75	-0.76	0.62	0.63	0.64	0.65	0.67	0.71	1.00	0.76	0.44	0.45	0.44	0.44	0.47	0.53	...
-0.26	-0.34	-0.40	-0.45	-0.49	-0.54	-0.59	-0.65	-0.77	-0.76	0.62	0.64	0.65	0.66	0.68	0.72	0.76	1.00	0.44	0.45	0.45	0.45	0.48	0.55	...
-0.38	-0.38	-0.39	-0.40	-0.41	-0.42	-0.44	-0.44	-0.44	-0.42	0.44	0.42	0.41	0.40	0.41	0.42	0.44	0.44	1.00	0.37	0.34	0.32	0.32	0.34	...
-0.19	-0.37	-0.38	-0.40	-0.41	-0.42	-0.44	-0.44	-0.47	-0.41	0.42	0.42	0.41	0.41	0.41	0.43	0.45	0.45	0.37	1.00	0.34	0.32	0.32	0.35	...
-0.18	-0.24	-0.37	-0.39	-0.40	-0.41	-0.43	-0.44	-0.47	-0.40	0.40	0.41	0.41	0.41	0.41	0.43	0.44	0.45	0.34	0.34	1.00	0.32	0.32	0.35	...
-0.17	-0.23	-0.27	-0.38	-0.39	-0.41	-0.43	-0.43	-0.48	-0.40	0.39	0.40	0.40	0.40	0.41	0.43	0.44	0.45	0.32	0.32	0.32	1.00	0.32	0.35	...
-0.18	-0.23	-0.27	-0.31	-0.40	-0.42	-0.44	-0.45	-0.52	-0.42	0.41	0.41	0.42	0.42	0.43	0.45	0.47	0.48	0.32	0.32	0.32	0.32	1.00	0.37	...
-0.19	-0.26	-0.30	-0.34	-0.37	-0.46	-0.49	-0.51	-0.60	-0.47	0.45	0.46	0.46	0.47	0.49	0.51	0.53	0.55	0.34	0.35	0.35	0.35	0.37	1.00	...
-0.22	-0.29	-0.34	-0.38	-0.41	-0.45	-0.54	-0.57	-0.69	-0.54	0.51	0.52	0.53	0.54	0.55	0.58	0.61	0.63	0.38	0.39	0.39	0.39	0.41	0.47	...
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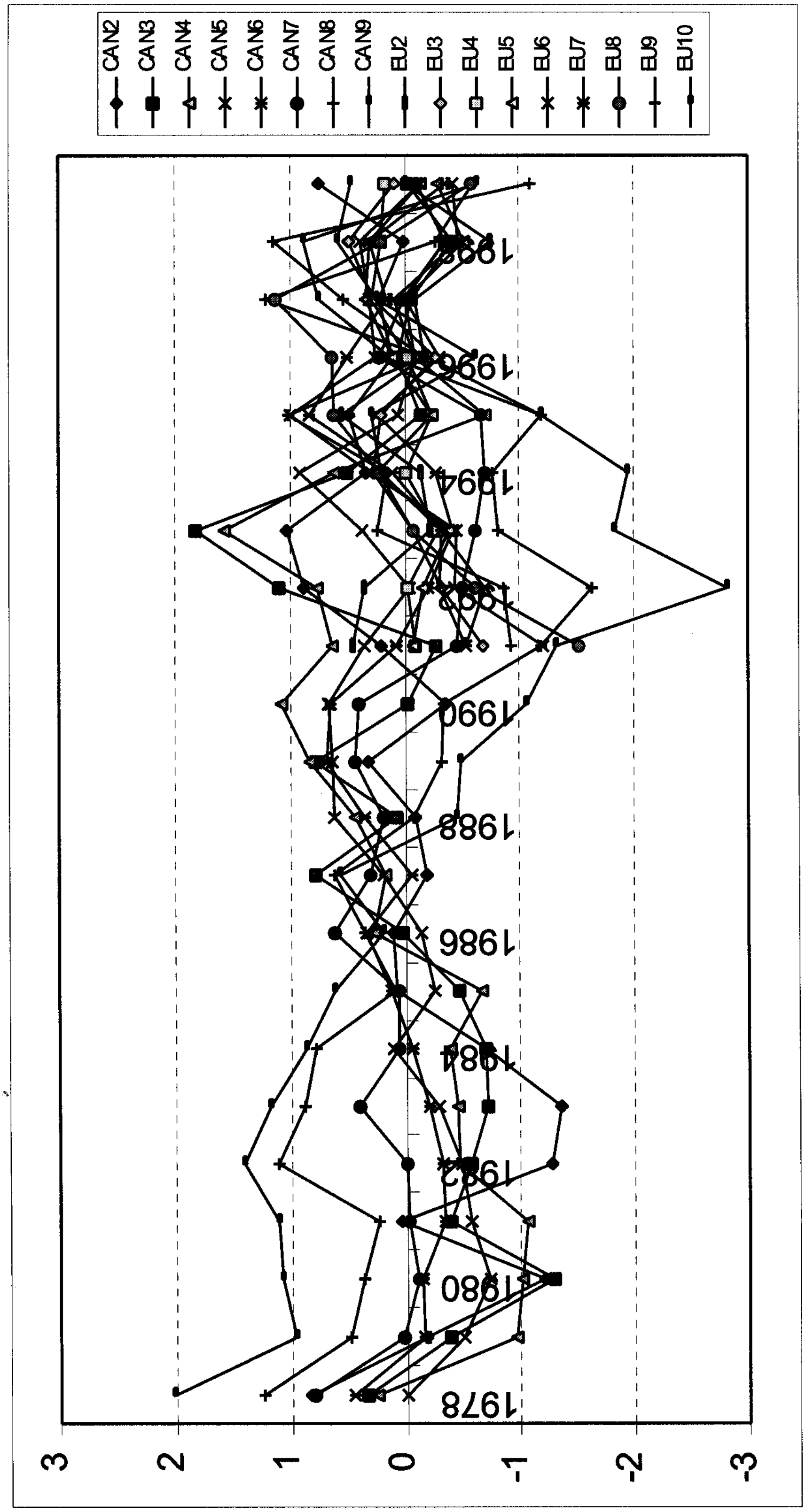
Residuals
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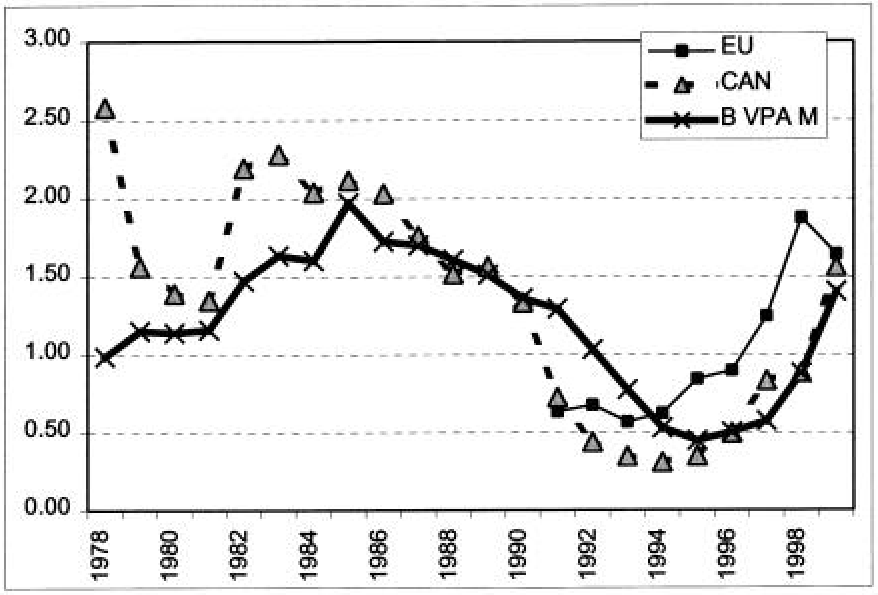
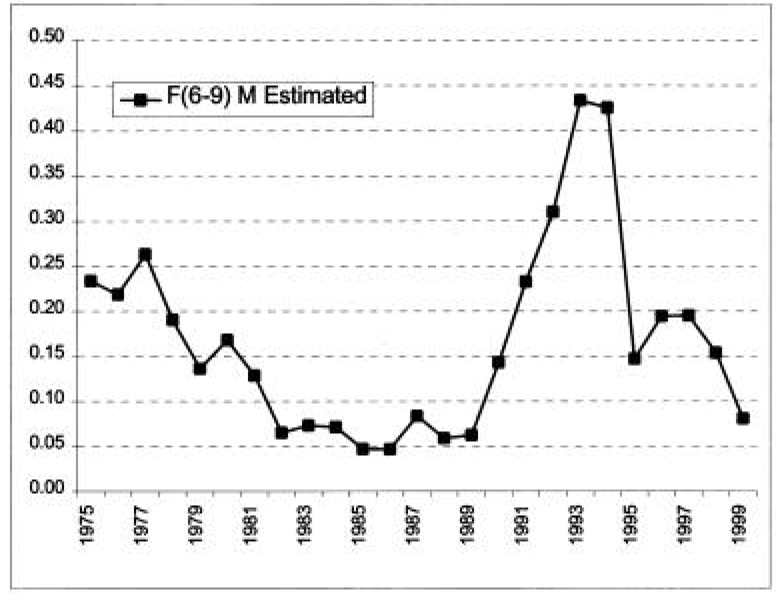


Comparison between the indices and the 5+ biomass (scaled) resulting from ADAPT RUN 2.



Comparison between the fishing mortality estimated in ADAPT RUN 2 (which estimated M for 9-12).