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Standardized Catch Rate Indices for Greenland Halibut in SA2+3KLMNO

by

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Abstract

Catch and effort data were analysed with a multiplicative model to derive a standardized catch rate index for the directed Greenland halibut otter trawl fishery in NAFO SA2+3KLMNO. Two measures of effort were used (hours fished and days fished) in separate analyses because of the lack of hours fished data for some fleets. Separate models were also run for CANADIAN FLEETS and NON-CANADIAN FLEETS because Canadian fleet operates within the 200-mile limit in Div. 2HJ+3KL while non-Canadian vessels have fished in the NAFO Regulatory area (NRA) outside the 200-mile limit in Div. 3LMNO since the mid-1980s. The results indicate that these fleets should be standardized separately, although there were some consistencies between some models in recent years. Various models suggest recent catch rates are amongst the lowest in the time series for both Canadian and non-Canadian fleets.

Introduction

Catch and effort data from directed Greenland halibut otter trawl fisheries, standardized with a multiplicative model, have been presented as information for the assessment of this resource in SA2+Div. 3KLMNO since 2001. Although the analyses have utilized all fleets within any particular standardization, it has been recognized that fleets fish in different areas within the management unit. The Canadian fleet have operated totally within the 200-mile limit in Div. 2GHJ+3KL while non-Canadian fleets have fished in the NAFO Regulatory area (NRA) since the mid-1980s primarily in Div. 3LMN. However, there was a period prior to the mid-1980s when certain non-Canadian fleets operated within the 200-mile limit. The purpose of this paper is to investigate whether there are differences in trends in standardized CPUE between these area/fleet components.

Materials and Methods

Catch and effort data from the directed fishery for Greenland halibut during the period 1975 to 2000 were obtained from ICNAF/NAFO Statistical Bulletins. These data were combined with provisional 2001-2003 NAFO STATLANT 21B data and 2003 Canadian data obtained from logbook records. The catch/effort data were analysed with a multiplicative model (Gavaris, 1980) to derive a standardized catch rate index separately for hours fished and days fished as measures of effort. The reason for the additional days fished standardization was due to the deficiency of hours-fished data within the NAFO database from two major fleets, EU-Portugal since 1992 and EU-Spain since 1995. Subsequently, within each measure of effort standardization, three analyses were considered: (a) All fleets, (b) Non-Canadian fleets since 1988, which corresponds to the entry of a principal fleet into the fishery (EU-Portugal) and (c) the Canadian fleets.

LN (CPUE) was the dependent variable in the models. Independent variables (category types) were: (1) a combination country-gear-tonnage-class category type (CGT), (2) month, (3) NAFO Division and (4) Year. Consistent with previous catch rate standardizations, individual observations with catch less than 10 tons or effort

less than 10 hours were eliminated prior to analysis for the "hours fished" models. Subsequently, within each dependent variable, categories with arbitrarily less than five observations were also eliminated, with the exception of the variable "year", which is the purpose of the standardization. For the "days fished" models the only difference in data elimination was for those observations where the effort was less than 5 days fished. When these arbitrary data selection criteria were applied, the analyses for non-Canadian fleets could only be conducted on the data from 1992 onward. Residual plots for all runs did not indicate model misspecification. An initial run of the ALL FLEETS hours fished data did not indicate problematic interaction effects and so all subsequent runs were conducted only on the four main effects noted previously.

Results and Discussion

(Model 1) ALL FLEETS 2G to 3N

For the "hours fished" standardization, the regression was significant ($p < 0.05$), explaining 57% of the variation in catch rates (Table 1). Although there was a significant year effect, there were only two years (1997 and 2002) that were significantly different from the 1975 reference year. Based on the regression coefficients, over the entire time series catch rates were better in winter, highest in Subarea 2 and lowest in Div 3M. The standardized catch rate index (Table 2; Fig. 1, upper panel) shows high between and within year variability, especially in the late-1970s to mid-1980s. There was an increasing trend in catch rate from the mid-1970s that peaked in 1982. CPUE subsequently fluctuated but declined by 60% to the lowest rate estimated in 1997. Catch rate increased from 1997 to 2000, which was the highest rate in the previous 10 years, declined to the lowest rate in the series in 2002 and increased by 17% in 2003. The increase between 1997 and 2000 is consistent with improved recruitment of several successive year-classes born between 1993-1995 (Bowering, 2001; Mahe and Bowering, 2001). The 2003 estimate is based solely on preliminary Canadian data. The percentage of otter trawl catch with reported hours fished effort utilized in the analysis, after the selection criteria were applied, ranged from 5% in 1980 to 80% in 1994 and averaged 17% since 1995.

For the "days fished" standardization, the regression was also significant ($p < 0.05$), explaining 52% of the variation in catch rates (Table 3). Similar to the "hours fished" index, over the whole time period, catch rates were generally higher in winter, highest in Subarea 2 and lowest in Div. 3M, based on the coefficients in Table 3. The standardized catch rate index (Table 4, Fig. 2 upper panel) also shows high between and within year variability prior to the 1990s. The catch rate index shows a similar trend to the hours-fished model. From the mid-1970s to the highest estimate in the series in 1982 the index increased by about 10%. Catch rate subsequently declined by 46% to 1988, with the exception of an anomalous increase in 1987. Between 1988 and 1995 the index shows two cycles of increase followed by a decrease. The index declined gradually to the second lowest value in the series in 1998. Catch rate increased sharply to 2000, which was the highest rate in the previous 13 years, then declined to the lowest rate in the series in 2002 and increased by 23% in 2003. The 2003 estimate is based on preliminary data from Canada and Statlant 21B data from Estonia which was incorporated into the model for the first time. The percentage of otter trawl catch with reported days fished effort utilized in the analysis, after the selection criteria were applied, ranged from 5% in 1980 to 85% in 1994 and averaged 33% from 1995-2002.

(Model 2) NON-CANADIAN FLEETS in the NRA (3LMN)

For the "hours fished" standardization, the regression was significant ($p < 0.05$), explaining 56% of the variation in catch rates (Table 5). Based on the regression coefficients, over the whole time period catch rates were highest in winter and drop off as the year progresses, and, were similar in 3LNO and much lower in Div. 3M. The standardized catch rate index (Table 5, Fig. 1 middle panel) increased by 22% from 1992 to 1993, the highest in the series. Catch rate then declined in each year to 1997, the lowest in the series, and then increased in sequence to 2000. The index declined substantially in 2001 and remained at that level in 2002. These values are the second lowest in the time series and are about 50% lower than the highest in the series in 1993. The percentage of otter trawl catch with reported hours fished effort utilized in the analysis, after the selection criteria were applied, ranged from 9% in 2001 to 84% in 1994 and averaged 17% since 1995.

For the "days fished" standardization, the regression was also significant ($p < 0.05$), explaining 54% of the variation in catch rates (Table 6). Similar to the "hours fished" index, over the whole time period, catch rates were generally higher in winter and dropped off as the year progresses, and, that Div. 3M catch rate was comparatively the lowest.

The standardized catch rate index (Table 6, Fig. 2 middle panel) shows a similar trend to the hours fished model. Catch rate increased from 1992 to 1993, the highest in the series, and subsequently declined by 43% to 1997. The index increased each year to 2000 then declined rapidly to 2002. The 2002 value is the lowest in the series and represented a 42% reduction from the 2000 estimate, which was comparable to the highest rate in the series in 1993. The percentage of otter trawl catch with reported days fished effort utilized in the analysis, after the selection criteria were applied, ranged from 20% in 2002 to 89% in 1994 and averaged 38% since 1995.

(Model 3) CANADIAN FLEETS (2HJ3KL inside 200-mile limit)

For the "hours fished" standardization, the regression was significant ($p < 0.05$), explaining 59% of the variation in catch rates (Table 7). Based on the regression coefficients, over the entire time series catch rates were better in late summer, highest in Div. 2H and similar but lower in Div 2J+3KL. The standardized catch rate index (Table 8, Fig. 1 lower panel) shows much within year variability. Catch rate more than doubled from the lowest value in the series in 1976 to 1978. There was a period of stability from 1978 to 1984. During this period of stability, the highest catch rates over the series were realized. Catch rate declined by 65% from 1984 to 1992 although there were some sporadic increases over this period. The 1992 value was the second lowest in the series. Between 1992 and 2001 catch rates increased gradually while doubled over this period. Catch rate declined in 2002 and again in 2003. The 2003 value is amongst the lowest in the time series. The percentage of otter trawl catch with reported hours fished effort utilized in the analysis, after the selection criteria were applied, ranged from 10% in 1976 to 99% in 2000 and averaged 83% since 1995.

For the "days fished" standardization, the regression was also significant ($p < 0.05$), explaining 56% of the variation in catch rates (Table 9). Similar to the "hours fished" index, over the whole time period, catch rates were better in late summer, highest in Div. 2H and similar but lower in Div 2J+3KL. The standardized catch rate index (Table 10, Fig. 2 lower panel) shows much within year variability. Catch rate more than doubled from the lowest value in the series in 1976 to 1978. There was a period of stability from 1978 to 1983. During this period of stability, the highest catch rates over the series were realized. Catch rate declined by 60% from 1983 to 1988 although there were some sporadic increases over this period. The 1988 value was the second lowest in the series. Catch rate increased by 85% in 1989 and was stable to 1997. Catch rate declined to the lowest value in the series in 1998 and subsequently increased each year to 2001, more than doubling over the period. Catch rate declined in 2002 and again in 2003. The 2003 value was similar to the catch rates in the stable period from 1989 to 1997. The percentage of otter trawl catch with reported days fished effort utilized in the analysis, after the selection criteria were applied, ranged from 10% in 1976 to 99% in 2002 and averaged 79% since 1995.

Summary and Conclusions

Based on differences in trends in the catch rate models between CANADIAN and NON-CANADIAN fleets for the years since 1992, it appears that separate standardizations should be considered in future. This may be related to the fact that Canadian fleets fish within the 200-mile limit and all other fleets operate in the NAFO regulatory, outside the 200 mile limit. However, despite these findings there were some consistencies between some models in recent years. Various models suggest recent catch rates are amongst the lowest in the time series for both Canadian and non-Canadian fleets. A substantial number of deficiencies exist in the NAFO database since the mid-1990s for important fleets, particularly for the typically utilized hours-fished measurement of effort. Therefore, the NAFO STATLANT 21B data should not be used as data source for models utilized for standardization CPUE for Greenland halibut.

References

Bowering, W.R. 2001. Population Trends in the Greenland halibut *(Reinhardtius hippoglossoides)* Resource of NAFO Subarea 2 and Divisions 3KLMNO based on Canadian Research Vessel Survey Results during 1978-2000. NAFO SCR Doc. 01/39, Ser. No. N4417, 42 p.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Mahe, J-C and Bowering, W.R. 2001. An Assessment of Stock Status of the Greenland Halibut Resource in NAFO Subarea 2 and Divisions 3KLMNO based on Extended Survivors Analysis. NAFO SCR Doc. 01/80, Ser. No. N4459, 18 p.

Table 1. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO SA2 + Div. 3KLMNO based on HOURS FISHED. Results are from the ALL FLEETS model (2003 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.748

MULTIPLE R SQUARED..... 0.560

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	9.08E2	9.08E2	
REGRESSION	68	1.97E2	2.89E0	15.850
Cntry|Gear|TC(1)	22	3.79E1	1.72E0	9.447
Month(2)	11	1.28E1	1.16E0	6.366
Division(3)	7	9.18E0	1.31E0	7.186
Year(4)	28	2.83E1	1.01E0	5.536
RESIDUALS	846	1.54E2	1.83E-1	
TOTAL	915	1.26E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	-0.784	0.210	915
Month	9				
Division	22				
Year	75				
1	3123	1	-0.335	0.145	10
	3126	2	-0.073	0.140	11
	9125	3	0.647	0.152	12
	10127	4	1.056	0.184	8
	11125	5	0.207	0.130	16
	11126	6	-0.125	0.201	6
	11127	7	0.356	0.122	17
	14124	8	0.327	0.065	143
	14126	9	0.694	0.111	23
	14127	10	0.338	0.090	43
	15126	11	0.240	0.198	6
	16127	12	0.255	0.087	51
	19124	13	-0.349	0.089	102
	19125	14	-0.062	0.098	75
	19126	15	0.253	0.115	28
	20125	16	0.295	0.185	7
	20126	17	-0.120	0.142	12
	20127	18	-0.029	0.094	37
	27125	19	0.247	0.098	26
	34125	20	0.422	0.154	17
	34126	21	0.067	0.113	32
	34127	22	0.040	0.147	13
2	1	23	0.234	0.081	44
	2	24	0.178	0.078	49
	3	25	-0.007	0.072	64
	4	26	0.067	0.071	67
	5	27	0.201	0.072	64
	6	28	0.143	0.068	76
	7	29	0.045	0.065	84
	8	30	0.067	0.061	95
	10	31	-0.269	0.063	88
	11	32	-0.062	0.062	96
	12	33	0.067	0.067	79
3	21	34	0.070	0.081	52
	23	35	-0.005	0.062	122
	31	36	-0.248	0.072	128
	32	37	-0.198	0.077	295
	33	38	-0.481	0.094	94
	34	39	-0.233	0.099	70
	35	40	-0.265	0.135	21
4	76	41	-0.067	0.223	11
	77	42	0.077	0.214	19
	78	43	0.291	0.231	18
	79	44	0.106	0.227	10
	80	45	0.322	0.235	12
	81	46	0.129	0.223	15
	82	47	0.391	0.217	19
	83	48	0.350	0.210	24
	84	49	0.300	0.212	23
	85	50	0.091	0.213	21
	86	51	-0.149	0.212	24
	87	52	0.130	0.204	33
	88	53	-0.242	0.213	22
	89	54	-0.054	0.217	22
	90	55	-0.003	0.215	26
	91	56	-0.285	0.211	51
	92	57	-0.413	0.208	102
	93	58	-0.215	0.211	84
	94	59	-0.370	0.212	102
	95	60	-0.167	0.225	21
	96	61	-0.354	0.219	23
	97	62	-0.476	0.219	24
	98	63	-0.272	0.226	34
	99	64	-0.247	0.219	49
	100	65	-0.062	0.222	19
	101	66	-0.275	0.213	32
	102	67	-0.525	0.215	47
	103	68	-0.356	0.220	22

LEGEND FOR ANOVA RESULTS:

CGT CODES: All are Stern Trawlers

3123 = Can(NFLD)	TC 3	16127 = Poland	TC 7
3125 = Can(NFLD)	TC 5	19124 = Spain	TC 4
3126 = "	TC 6	19125 = "	TC 5
9125 = Fra(SPM)	TC 5	19126 = "	TC 6
10127 = Former FRG	TC 7	20125 = Former USSR	TC 5
11125 = Former DDR	TC 5	20126 = "	TC 6
11126 = "	TC 6	20127 = "	TC 7
11127 = "	TC 7	27125 = Can(M)	TC 5
14124 = Japan	TC 4	34125 = Russia	TC 5
14126 = "	TC 6	34126 = "	TC 6
14127 = "	TC 7	34127 = "	TC 6
15126 = Norway	TC 6		

DIVISION CODES:

21 = 2G, 22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L

33 = 3M, 34 = 3N, 35 = 3O

Table 2. Standardized CPUE for Greenland halibut in NAFO SA2+ Div. 3KLMNO based on a multiplicative model based utilizing HOURS FISHED as a measure of effort. Results are from the ALL FLEETS model (2003 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1975	-0.7837	0.0443	0.489	0.102	28814	58873	9.1
1976	-0.8506	0.0234	0.463	0.070	24611	53206	9.5
1977	-0.7068	0.0180	0.536	0.072	32048	59842	17.2
1978	-0.4926	0.0207	0.663	0.095	39070	58965	6.7
1979	-0.6777	0.0282	0.549	0.092	34104	62167	9.5
1980	-0.4613	0.0210	0.684	0.099	32867	48082	5.1
1981	-0.6543	0.0182	0.564	0.076	30754	54493	12.6
1982	-0.3932	0.0145	0.734	0.088	26278	35795	34.5
1983	-0.4333	0.0125	0.706	0.079	27861	39465	31.6
1984	-0.4832	0.0119	0.672	0.073	26711	39761	33.4
1985	-0.6922	0.0140	0.545	0.064	20347	37367	27.9
1986	-0.9324	0.0127	0.429	0.048	17976	41947	22.4
1987	-0.6542	0.0128	0.566	0.064	32442	57322	35.8
1988	-1.0254	0.0141	0.390	0.046	19215	49241	20.7
1989	-0.8373	0.0131	0.471	0.054	20034	42516	11.3
1990	-0.7867	0.0110	0.496	0.052	47454	95642	8.5
1991	-1.0691	0.0103	0.374	0.038	65008	173717	10.9
1992	-1.1970	0.0093	0.329	0.032	63193	191809	59.3
1993	-0.9985	0.0104	0.402	0.041	62455	155518	60.4
1994	-1.1534	0.0110	0.344	0.036	51029	148405	80.4
1995	-0.9506	0.0175	0.420	0.055	15272	36378	13.8
1996	-1.1378	0.0145	0.349	0.042	18840	54037	14.6
1997	-1.2596	0.0146	0.309	0.037	19858	64339	14.2
1998	-1.0556	0.0180	0.378	0.050	19946	52788	19.3
1999	-1.0306	0.0147	0.388	0.047	24226	62430	26.9
2000	-0.8456	0.0161	0.467	0.059	34177	73251	11.1
2001	-1.0588	0.0121	0.378	0.041	38232	101210	12.1
2002	-1.3084	0.0127	0.294	0.033	34062	115769	21.4
2003	-1.1393	0.0120	0.349	0.038	35151	100840	7.6

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.124

Table 3. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO SA2 + Div. 3KLMNO based on DAYS FISHED. Results are from the ALL FLEETS model (2003 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.722

MULTIPLE R SQUARED..... 0.522

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	2.48E3	2.48E3	
REGRESSION	71	2.25E2	3.17E0	15.113
Cntry|Gear|TC(1)	25	6.47E1	2.59E0	12.337
Month(2)	11	2.00E1	1.82E0	8.661
Division(3)	7	2.34E1	3.34E0	15.910
Year(4)	28	2.64E1	9.43E-1	4.493
RESIDUALS	983	2.06E2	2.10E-1	
TOTAL	1055	2.92E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	2.052	0.233	1055
Month	9				
Division	22				
Year	75				
1	3123	1	-0.546	0.157	10
	3126	2	-0.100	0.156	10
	9125	3	0.451	0.111	28
	11125	4	-0.078	0.135	18
	11126	5	-0.277	0.238	5
	11127	6	0.166	0.138	16
	14124	7	0.410	0.073	137
	14126	8	0.538	0.137	19
	14127	9	0.367	0.100	37
	15126	10	0.260	0.231	5
	16127	11	0.176	0.102	46
	17126	12	-0.335	0.082	123
	19124	13	-0.263	0.091	101
	19125	14	-0.158	0.092	111
	19126	15	0.423	0.124	28
	19166	16	0.355	0.180	8
	20125	17	0.324	0.213	6
	20126	18	-0.365	0.166	10
	20127	19	-0.263	0.105	35
	27125	20	0.174	0.128	17
	31126	21	0.481	0.225	5
	32127	22	-0.079	0.175	13
	34125	23	0.482	0.150	15
	34126	24	0.065	0.101	41
	34127	25	0.070	0.125	21
2	1	26	0.268	0.078	57
	2	27	0.259	0.074	67
	3	28	0.083	0.069	88
	4	29	0.177	0.070	82
	5	30	0.311	0.070	80
	6	31	0.192	0.068	84
	7	32	0.128	0.067	86
	8	33	0.155	0.063	103
	10	34	-0.229	0.065	94
	11	35	-0.100	0.064	103
	12	36	0.064	0.067	94
3	21	37	0.156	0.097	43
	23	38	0.053	0.073	110
	31	39	-0.255	0.085	113
	32	40	-0.242	0.088	405
	33	41	-0.711	0.102	111
	34	42	-0.466	0.101	133
	35	43	-0.411	0.141	23
4	76	44	-0.144	0.246	9
	77	45	-0.092	0.235	15
	78	46	-0.064	0.268	9
	79	47	-0.046	0.257	8
	80	48	0.066	0.273	8
	81	49	-0.299	0.249	12
	82	50	0.096	0.236	18
	83	51	-0.025	0.226	25
	84	52	0.074	0.232	21
	85	53	-0.147	0.238	17
	86	54	-0.327	0.238	16
	87	55	-0.078	0.226	27
	88	56	-0.526	0.232	21
	89	57	-0.320	0.239	19
	90	58	-0.313	0.236	24
	91	59	-0.450	0.230	45
	92	60	-0.552	0.227	99
	93	61	-0.331	0.228	88
	94	62	-0.312	0.227	112
	95	63	-0.518	0.236	33
	96	64	-0.542	0.231	42
	97	65	-0.622	0.232	41
	98	66	-0.636	0.228	98
	99	67	-0.384	0.231	60
	100	68	-0.182	0.230	50
	101	69	-0.439	0.228	54
	102	70	-0.679	0.232	47
	103	71	-0.470	0.245	31

LEGEND FOR ANOVA RESULTS:

CGT CODES: All are Stern Trawlers

3123 = Can(NFLD)	TC 3	16127 = Poland	TC 7		
3125 = Can(NFLD)	TC 5	19124 = Spain	TC 4		
3126 = "	TC 6	19125 = "	TC 5		
9125 = Fra(SPM)	TC 5	19126 = "	TC 6		
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11125 = Former DDR	TC 5	20126 = "	TC 6		
11126 = "	TC 6	20127 = "	TC 7		
11127 = "	TC 7	27125 = Can(M)	TC 5		
14124 = Japan	TC 4	34125 = Russia	TC 5		
14126 = "	TC 6	34126 = "	TC 6		
14127 = "	TC 7	34127 = "	TC 6		
15126 = Norway	TC 6				

DIVISION CODES:

21 = 2G, 22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L

33 = 3M, 34 = 3N, 35 = 3O

Table 4. Standardized CPUE for Greenland halibut in NAFO SA2+ Div. 3KLMNO based on a multiplicative model based utilizing DAYS FISHED as a measure of effort. Results are from the ALL FLEETS model (2003 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1975	2.0522	0.0542	8.416	1.934	28814	3424	9.1
1976	1.9079	0.0334	7.361	1.334	24611	3343	9.4
1977	1.9603	0.0248	7.791	1.220	32048	4114	17.0
1978	1.9884	0.0338	7.976	1.455	39070	4898	4.9
1979	2.0067	0.0385	8.105	1.576	34104	4208	9.3
1980	2.1181	0.0340	9.080	1.662	32867	3620	4.8
1981	1.7529	0.0273	6.324	1.039	30754	4863	12.5
1982	2.1484	0.0183	9.434	1.271	26278	2785	36.1
1983	2.0275	0.0152	8.373	1.029	27861	3328	40.4
1984	2.1264	0.0157	9.241	1.155	26711	2891	33.2
1985	1.9049	0.0195	7.390	1.027	20347	2753	27.6
1986	1.7254	0.0202	6.174	0.874	17976	2912	21.1
1987	1.9743	0.0190	7.923	1.089	32442	4095	35.4
1988	1.5262	0.0182	5.064	0.681	19215	3795	20.6
1989	1.7318	0.0171	6.223	0.811	20034	3219	11.1
1990	1.7397	0.0139	6.283	0.738	47454	7553	8.4
1991	1.6026	0.0128	5.481	0.619	65008	11861	10.7
1992	1.5004	0.0121	4.950	0.543	63193	12766	59.2
1993	1.7215	0.0124	6.174	0.685	62455	10115	61.1
1994	1.7404	0.0125	6.292	0.700	51029	8111	84.9
1995	1.5343	0.0168	5.108	0.660	15272	2990	20.9
1996	1.5101	0.0144	4.992	0.597	18840	3774	28.4
1997	1.4307	0.0146	4.611	0.555	19858	4307	26.5
1998	1.4163	0.0130	4.549	0.518	19946	4385	67.1
1999	1.6685	0.0142	5.850	0.696	24226	4141	35.6
2000	1.8703	0.0138	7.159	0.839	34177	4774	32.7
2001	1.6130	0.0130	5.538	0.630	38232	6904	28.5
2002	1.3730	0.0145	4.353	0.522	34062	7825	21.4
2003	1.5819	0.0157	5.361	0.669	35151	6557	11.4

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.138

Table 5. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO Div. 3LMNO based on HOURS FISHED. Results are from the NON-CANADIAN FLEETS model.

REGRESSION OF MULTIPLICATIVE MODEL %OF
MULTIPLE R..... 0.746
MULTIPLE R SQUARED..... 0.556

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	6.61E2	6.61E2	
REGRESSION	32	6.55E1	2.05E0	15.278
Cntry|Gear|TC	8	2.45E1	3.06E0	22.833
Month	11	9.83E0	8.94E-1	6.669
Division	3	5.92E0	1.97E0	14.724
Year	10	1.07E1	1.07E0	7.971
RESIDUALS	390	5.23E1	1.34E-1	
TOTAL	423	7.79E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	14124	INT	-0.835	0.099	423
Month	11				
Division	32				
Year	92				
1	9125	1	0.346	0.139	10
	14127	2	0.013	0.080	33
	19124	3	-0.975	0.081	101
	19125	4	-0.679	0.087	75
	19126	5	-0.410	0.107	28
	34125	6	0.229	0.136	16
	34126	7	-0.231	0.093	32
	34127	8	-0.253	0.128	13
2	1	9	0.441	0.092	31
	2	10	0.367	0.089	35
	3	11	0.245	0.085	42
	4	12	0.235	0.086	40
	5	13	0.333	0.086	39
	6	14	0.138	0.089	35
	7	15	0.121	0.091	31
	8	16	0.109	0.091	31
	9	17	0.091	0.088	35
	10	18	-0.172	0.089	33
	12	19	0.135	0.087	36
3	33	20	-0.310	0.050	93
	34	21	-0.011	0.057	69
	35	22	-0.006	0.096	21
4	93	23	0.200	0.078	64
	94	24	-0.064	0.075	98
	95	25	-0.129	0.121	19
	96	26	-0.307	0.130	14
	97	27	-0.649	0.123	17
	98	28	-0.265	0.126	32
	99	29	-0.214	0.110	46
	100	30	0.009	0.144	10
	101	31	-0.507	0.124	15
	102	32	-0.515	0.112	36

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1992	-0.8347	0.0097	0.462	0.045	56190	121651	62.7
1993	-0.6352	0.0107	0.564	0.058	57549	102108	63.3
1994	-0.8991	0.0095	0.433	0.042	48076	110988	84.2
1995	-0.9640	0.0119	0.405	0.044	12037	29689	14.5
1996	-1.1413	0.0137	0.339	0.040	12661	37319	15.0
1997	-1.4838	0.0126	0.241	0.027	13578	56337	13.7
1998	-1.0998	0.0135	0.354	0.041	15825	44744	24.2
1999	-1.0491	0.0098	0.373	0.037	20210	54216	30.7
2000	-0.8259	0.0186	0.464	0.063	23584	50833	10.6
2001	-1.3420	0.0128	0.278	0.031	29867	107554	9.4
2002	-1.3498	0.0105	0.276	0.028	27772	100682	19.9

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.109

LEGEND FOR ANOVA RESULTS:
CGT CODES: All are Stern Trawlers

9125 = Fra(SPM)	TC 5	19126 = Spain	TC 6		
14124 = Japan	TC 4	34125 = Russia	TC 5		
14127 = "	TC 7	34126 = "	TC 6		
19124 = Spain	TC 4	34127 = "	TC 7		
19125 = "	TC 5				

DIVISION CODES:
32 = 3L, 33 = 3M, 34 = 3N, 35 = 3O

Table 6. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO Div. 3LMNO based on DAYS FISHED. Results are from the NON-CANADIAN FLEETS model.

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R..... 0.724
MULTIPLE R SQUARED..... 0.524

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE	
INTERCEPT	1	1.10E3	1.10E3		
REGRESSION	35	1.13E2	3.23E0	18.17	%OF
Cntry|Gear|TC	11	4.85E1	4.41E0	24.847	
Month	11	1.67E1	1.52E0	8.562	
Division	3	1.71E1	5.69E0	32.031	--
Year	10	1.57E1	1.57E0	8.822	
RESIDUALS	577	1.02E2	1.77E-1		
TOTAL	613	1.32E3			

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	14124	INT	1.855	0.105	613
Month	9				
Division	32				
Year	92				
1	9125	1	0.022	0.110	19
	14127	2	-0.049	0.092	29
	17126	3	-0.732	0.060	123
	19124	4	-0.828	0.078	101
	19125	5	-0.651	0.073	111
	19126	6	-0.198	0.118	28
	19166	7	-0.145	0.161	8
	31126	8	0.171	0.205	5
	34125	9	0.086	0.131	15
	34126	10	-0.316	0.084	41
	34127	11	-0.308	0.110	21
2	1	12	0.393	0.089	43
	2	13	0.346	0.083	56
	3	14	0.199	0.080	67
	4	15	0.295	0.082	58
	5	16	0.372	0.082	58
	6	17	0.161	0.085	50
	7	18	0.092	0.089	42
	8	19	0.126	0.088	43
	10	20	-0.182	0.086	47
	11	21	-0.081	0.086	48
	12	22	0.138	0.084	51
3	33	23	-0.495	0.052	110
	34	24	-0.239	0.049	130
	35	25	-0.132	0.103	23
4	93	26	0.150	0.086	70
	94	27	0.105	0.083	108
	95	28	-0.217	0.115	31
	96	29	-0.257	0.113	34
	97	30	-0.405	0.114	32
	98	31	-0.283	0.094	92
	99	32	-0.073	0.104	57

CATEGORY	CODE	#	COEF	ERR	OBS
4	100	33	0.133	0.109	42
	101	34	-0.218	0.111	39
	102	35	-0.420	0.117	36

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	S.E.	RETRANSFORMED MEAN	S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1992	1.8548	0.0109	6.946	0.725	56190	8089	62.6
1993	2.0048	0.0095	8.076	0.787	57549	7126	64.1
1994	1.9596	0.0081	7.725	0.693	48076	6224	89.0
1995	1.6375	0.0110	5.590	0.585	12037	2153	23.5
1996	1.5975	0.0104	5.372	0.546	12661	2357	35.5
1997	1.4503	0.0100	4.637	0.463	13578	2928	30.0
1998	1.5714	0.0081	5.240	0.470	15825	3020	80.8
1999	1.7817	0.0089	6.464	0.607	20210	3127	41.1
2000	1.9879	0.0101	7.938	0.796	23584	2971	42.1
2001	1.6370	0.0098	5.590	0.551	29867	5343	30.5
2002	1.4350	0.0108	4.565	0.473	27772	6083	19.9

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.099

LEGEND FOR ANOVA RESULTS:
CGT CODES: All are Stern Trawlers

9125 = Fra(SPM)	TC 5	19126 = Spain	TC 6
14124 = Japan	TC 4	19166 = "	TC 6
14127 = "	TC 7	31126 = Latvia	TC 6
17126 = Portugal	TC 6	34125 = Russia	TC 5
19124 = Spain	TC 4	34126 = "	TC 6
19125 = "	TC 5	34127 = "	TC 7

DIVISION CODES:
32 = 3L, 33 = 3M, 34 = 3N, 35 = 3O

Table 7. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO Div. 2HJ3KL based on HOURS FISHED. Results are from the CANADIAN FLEETS model (2003 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	2.38E2	2.38E2	
REGRESSION	44	5.02E1	1.14E0	7.243
Cntry|Gear|TC	3	7.96E-1	2.65E-1	1.686
Month	11	3.97E0	3.61E-1	2.291
Division	3	1.08E0	3.61E-1	2.295
Year	27	2.55E1	9.46E-1	6.010
RESIDUALS	218	3.43E1	1.57E-1	
TOTAL	263	3.23E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	-1.186	0.306	263
Month	9				
Division	22				
Year	76				
1	3123	1	-0.215	0.144	10
	3126	2	0.110	0.146	11
	27125	3	0.142	0.097	25
2	1	4	-0.239	0.149	11
	2	5	-0.173	0.151	12
	3	6	-0.485	0.133	18
	4	7	-0.386	0.126	24
	5	8	-0.193	0.127	21
	6	9	-0.135	0.112	29
	7	10	-0.143	0.101	34
	8	11	0.081	0.093	37
	10	12	-0.244	0.129	15
	11	13	-0.331	0.137	14
	12	14	-0.137	0.161	9
3	23	15	-0.154	0.095	68
	31	16	-0.245	0.100	113
	32	17	-0.147	0.115	49
4	77	18	0.300	0.338	5
	78	19	0.946	0.329	8
	79	20	0.950	0.370	3
	80	21	1.101	0.315	12
	81	22	0.998	0.318	12
	82	23	0.981	0.322	10
	83	24	0.981	0.309	18
	84	25	1.114	0.316	12
	85	26	0.617	0.315	13
	86	27	0.506	0.334	7
	87	28	0.815	0.342	5
	88	29	0.095	0.357	4
	89	30	0.577	0.335	6
	90	31	0.530	0.315	12
	91	32	0.249	0.310	15

CATEGORY	CODE	#	COEF	ERR	OBS
4	92	33	0.069	0.309	20
	93	34	0.121	0.320	15
	94	35	0.181	0.356	4
	95	36	0.283	0.407	2
	96	37	0.234	0.326	8
	97	38	0.610	0.330	7
	98	39	0.510	0.410	2
	99	40	0.472	0.414	2
	100	41	0.557	0.324	9
	101	42	0.780	0.313	17
	102	43	0.341	0.319	11
	103	44	0.195	0.304	22

LEGEND FOR ANOVA RESULTS:
CGT CODES: All are Stern Trawlers
3123 = Can(NFLD) TC 3
3125 = Can(NFLD) TC 5
3126 = " TC 6
27125 = Can(M) TC 5
DIVISION CODES:
21 = 2G, 22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L

Table 8. Standardized CPUE for Greenland halibut in NAFO 2HJ3KL based on a multiplicative model based utilizing HOURS FISHED as a measure of effort. Results are from the CANADIAN FLEETS model (2003 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1976	-1.1861	0.0933	0.315	0.094	767	2432	9.5
1977	-0.8863	0.0452	0.436	0.092	2866	6572	20.9
1978	-0.2400	0.0338	0.837	0.153	3951	4720	30.0
1979	-0.2359	0.0708	0.825	0.216	5183	6283	35.4
1980	-0.0854	0.0276	0.980	0.162	3946	4027	42.5
1981	-0.1878	0.0258	0.885	0.142	6155	6952	55.8
1982	-0.2053	0.0222	0.872	0.129	8143	9342	73.4
1983	-0.2050	0.0177	0.874	0.116	7085	8108	87.4
1984	-0.0722	0.0195	0.997	0.139	6070	6088	90.4
1985	-0.5694	0.0198	0.606	0.085	4847	7994	91.2
1986	-0.6804	0.0300	0.540	0.093	1896	3512	73.7
1987	-0.3710	0.0421	0.731	0.149	2465	3371	85.6
1988	-1.0913	0.0533	0.354	0.081	629	1778	38.8
1989	-0.6088	0.0376	0.578	0.111	988	1710	21.2
1990	-0.6559	0.0233	0.555	0.084	2402	4327	75.9
1991	-0.9368	0.0240	0.419	0.065	3254	7766	68.1
1992	-1.1170	0.0202	0.351	0.050	2502	7136	50.2
1993	-1.0647	0.0307	0.367	0.064	1034	2814	87.7
1994	-1.0049	0.0529	0.386	0.088	575	1490	96.5
1995	-0.9027	0.0912	0.419	0.124	632	1508	56.2
1996	-0.9518	0.0314	0.411	0.072	1043	2536	81.0
1997	-0.5763	0.0352	0.598	0.111	1017	1702	94.7
1998	-0.6765	0.0926	0.525	0.157	46	88	63.0
1999	-0.7144	0.0966	0.505	0.153	81	161	81.5
2000	-0.6288	0.0308	0.568	0.099	1285	2261	99.3
2001	-0.4061	0.0237	0.713	0.109	1833	2573	99.2
2002	-0.8446	0.0274	0.459	0.076	1784	3889	98.7
2003	-0.9908	0.0158	0.399	0.050	3710	9307	72.2

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.192

Table 9. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE for Greenland halibut in NAFO 2HJ3KL based on DAYS FISHED. Results are from the CANADIAN FLEETS model (2003 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R..... 0.749
MULTIPLE R SQUARED..... 0.562

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	6.39E2	6.39E2	
REGRESSION	44	4.31E1	9.79E-1	5.239
Cntry|Gear|TC	3	1.82E0	6.08E-1	3.253
Month	11	5.38E0	4.90E-1	2.620
Division	3	1.19E0	3.97E-1	2.126
Year	27	1.88E1	6.97E-1	3.732
RESIDUALS	180	3.36E1	1.87E-1	
TOTAL	225	7.16E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	1.565	0.345	225
Month	9				
Division	22				
Year	76				
1	3123	1	-0.503	0.161	10
	3126	2	-0.008	0.171	10
	27125	3	-0.001	0.127	17
2	1	4	-0.243	0.171	11
	2	5	-0.124	0.184	9
	3	6	-0.490	0.151	17
	4	7	-0.451	0.149	20
	5	8	-0.104	0.146	18
	6	9	-0.023	0.134	24
	7	10	0.023	0.124	24
	8	11	0.119	0.107	35
	10	12	-0.289	0.151	13
	11	13	-0.386	0.160	12
	12	14	-0.237	0.206	7
3	23	15	-0.239	0.121	57
	31	16	-0.320	0.128	102
	32	17	-0.293	0.144	41
4	77	18	0.221	0.381	4
	78	19	0.803	0.374	6
	79	20	1.045	0.405	3
	80	21	1.071	0.355	8
	81	22	0.913	0.359	9
	82	23	0.893	0.359	9
	83	24	0.833	0.349	14
	84	25	1.140	0.354	10
	85	26	0.615	0.353	11
	86	27	0.564	0.397	4
	87	28	1.101	0.453	2
	88	29	-0.048	0.393	4
	89	30	0.560	0.390	4
	90	31	0.380	0.349	11
	91	32	0.380	0.342	15
	92	33	0.087	0.342	19
	93	34	0.351	0.358	14
	94	35	0.312	0.392	4
	95	36	0.319	0.448	2
	96	37	0.305	0.360	8
	97	38	0.609	0.364	7
	98	39	-0.140	0.555	1
	99	40	0.214	0.458	2
	100	41	0.515	0.363	8
	101	42	0.779	0.348	15
	102	43	0.408	0.353	11
	103	44	0.213	0.341	18

LEGEND FOR ANOVA RESULTS:

CGT CODES: All are Stern Trawlers

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
9125 = Fra(SPM)	TC 5	19125 = "	TC 5
10127 = Former FRG	TC 7	19126 = "	TC 6
11125 = Former DDR	TC 5	20125 = Former USSR	TC 5
11126 = "	TC 6	20126 = "	TC 6
11127 = "	TC 7	20127 = "	TC 7
14124 = Japan	TC 4	27125 = Can(M)	TC 5
14126 = "	TC 6	34125 = Russia	TC 5
14127 = "	TC 7	34126 = "	TC 6

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

Table 10. Standardized CPUE for Greenland halibut in NAFO 2HJ3KL based on a multiplicative model based utilizing DAYS FISHED as a measure of effort. Results are from the CANADIAN FLEETS model (2003 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	FLEET CATCH	EFFORT	% OF CATCH IN THIS ANALYSIS
1976	1.5652	0.1192	4.949	1.663	767	155	9.5
1977	1.7862	0.0692	6.330	1.641	2866	453	20.4
1978	2.3686	0.0533	11.424	2.609	3951	346	29.0
1979	2.6102	0.0931	14.259	4.262	5183	363	35.4
1980	2.6359	0.0466	14.976	3.205	3946	263	40.0
1981	2.4780	0.0441	12.804	2.666	6155	481	55.0
1982	2.4584	0.0304	12.642	2.195	8143	644	73.2
1983	2.3980	0.0269	11.923	1.946	7085	594	85.6
1984	2.7054	0.0291	16.194	2.751	6070	375	89.6
1985	2.1800	0.0281	9.581	1.600	4847	506	90.4
1986	2.1288	0.0626	8.947	2.210	1896	212	71.5
1987	2.6662	0.1182	14.890	4.985	2465	166	84.1
1988	1.5173	0.0686	4.839	1.249	629	130	38.8
1989	2.1253	0.0646	8.907	2.233	988	111	18.2
1990	1.9451	0.0327	7.558	1.359	2402	318	75.4
1991	1.9447	0.0341	7.550	1.387	3254	431	68.1
1992	1.6520	0.0308	5.643	0.986	2502	443	49.5
1993	1.9161	0.0466	7.291	1.560	1034	142	86.7
1994	1.8770	0.0679	6.936	1.782	575	83	96.5
1995	1.8846	0.1131	6.833	2.241	632	92	56.2
1996	1.8702	0.0418	6.981	1.416	1043	149	81.0
1997	2.1737	0.0464	9.434	2.015	1017	108	94.7
1998	1.4254	0.2178	4.095	1.816	46	11	34.8
1999	1.7792	0.1202	6.127	2.068	81	13	81.5
2000	2.0800	0.0438	8.601	1.786	1285	149	98.4
2001	2.3440	0.0345	11.252	2.078	1833	163	97.2
2002	1.9727	0.0373	7.752	1.487	1784	230	98.7
2003	1.7781	0.0219	6.430	0.950	3710	577	70.5

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.235

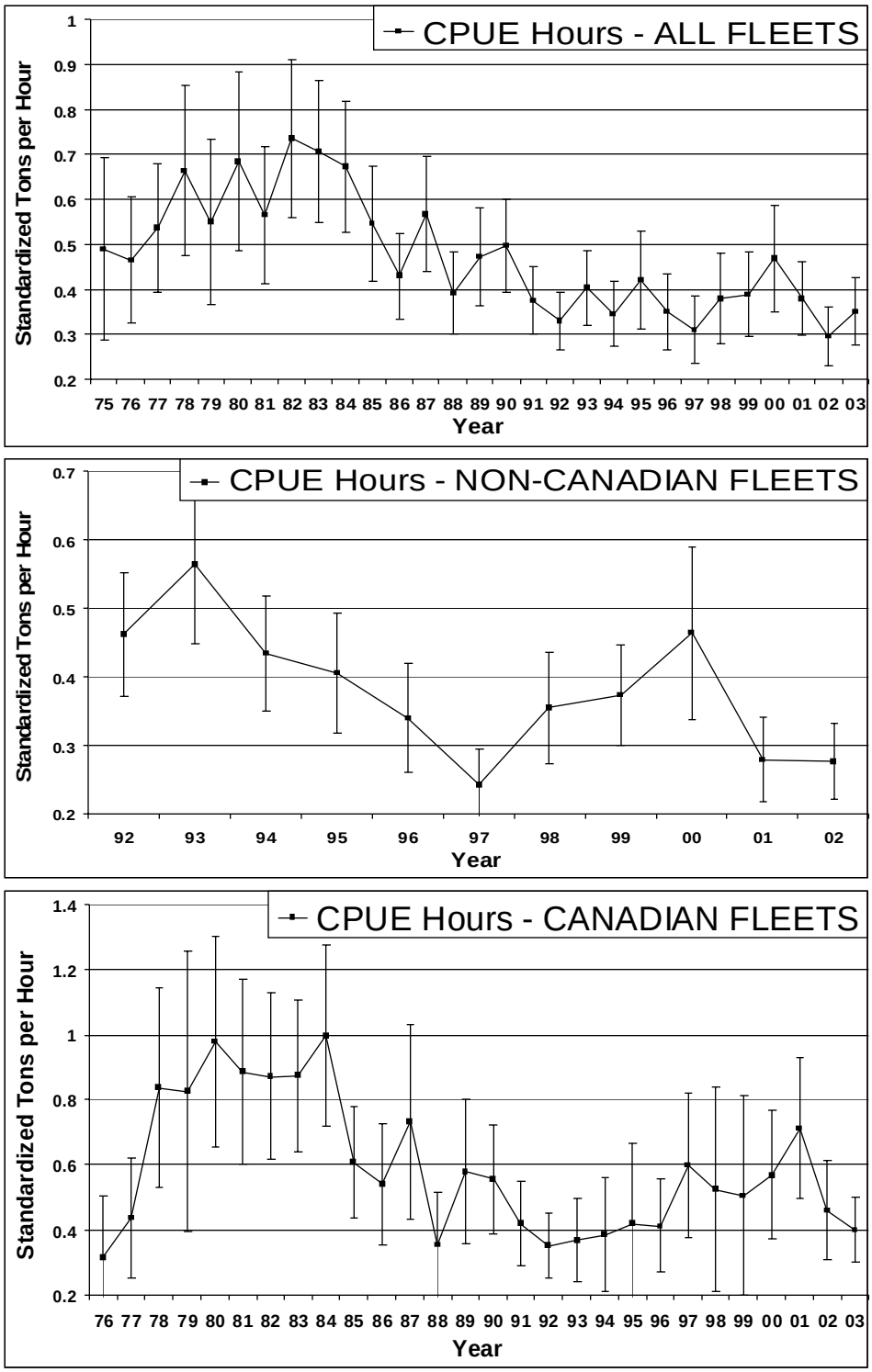

Fig. 1. Standardized Mean CPUE ± 2 standard errors for Greenland Halibut in SA2 + Div. 3KLMNO utilizing effort in HOURS fished. Upper panel is from the ALL FLEETS model, middle panel from NON-CANADIAN FLEETS model and lower panel from CANADIAN FLEETS model.

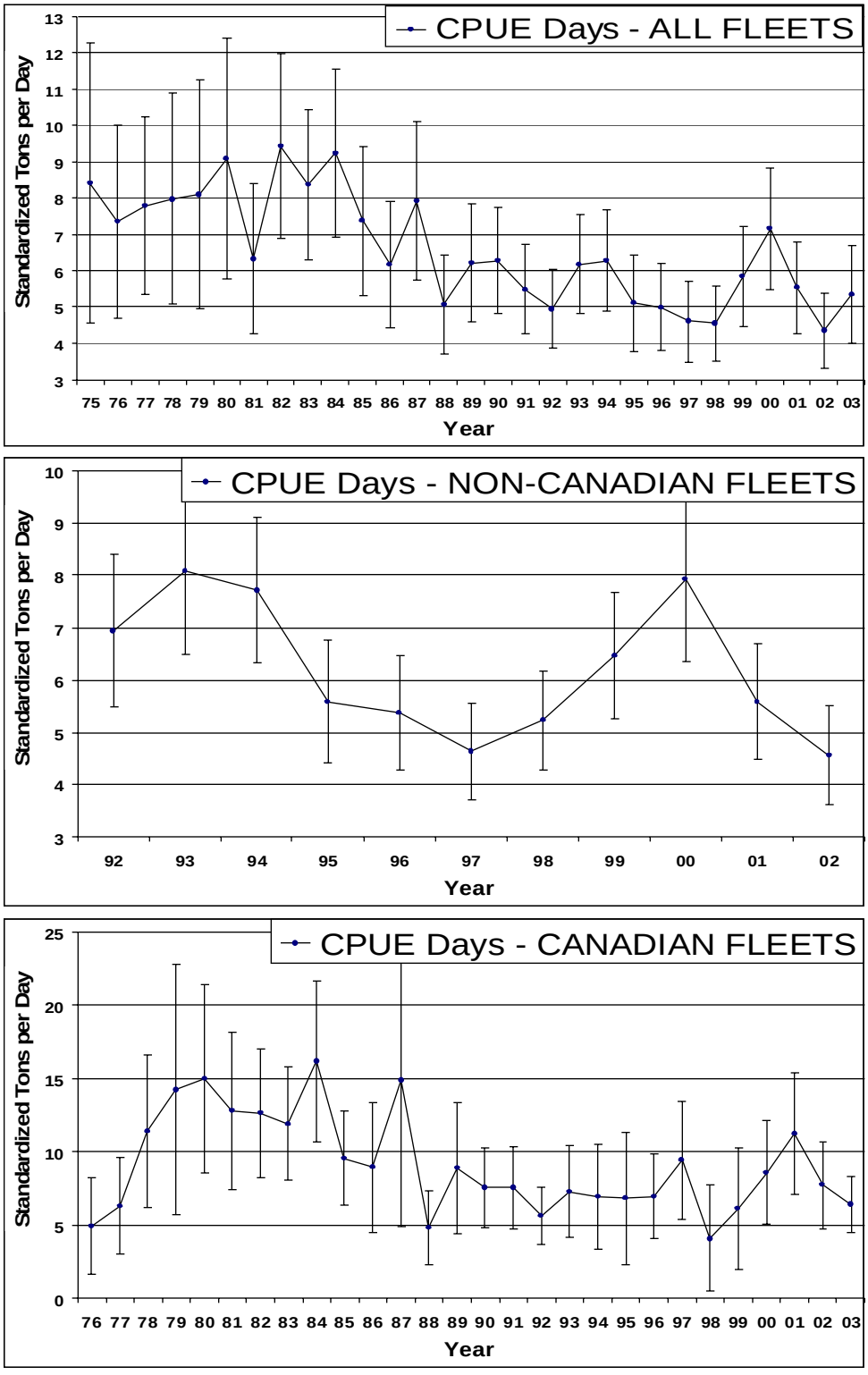

Fig. 2. Standardized Mean CPUE ± 2 standard errors for Greenland Halibut in SA2 + Div. 3KLMNO utilizing effort in DAYS fished. Upper panel is from the ALL FLEETS model, middle panel from NON-CANADIAN FLEETS model and lower panel from CANADIAN FLEETS model.