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

by

D. Power

Science Branch, Department of Fisheries and Oceans
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Abstract

Catch and effort data were analyzed with a multiplicative model to derive a standardized catch rate index for Greenland halibut 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. The results indicate the lowest catch rate in the time series was experienced in 1997 for hours fished and 1998 for days fished. The hours fished and days fished indices increased to 10 and 15 year highs respectively by 2000, consistent with improved recruitment, but have since declined to their former low levels. It is uncertain whether the catch rate index is representative of stock abundance because fleets fish in different areas of the stock. The Canadian fleet operates within the 200-mile limit in Div. 2J+3KL while foreign vessels fish in the NAFO Regulatory area outside the 200-mile limit primarily in Div. 3LMN.

Introduction

A catch rate standardization based on commercial fishery data is presented for the assessment of Greenland halibut in SA2+3KLMNO.

Materials and Methods

Catch and effort data from the directed fishery for Greenland halibut during the period 1975 to 1999 were obtained from ICNAF/NAFO Statistical Bulletins and were combined with provisional 2000-2001 NAFO STATLANT 21B data and 2002 Canadian data. The catch/effort data were analyzed with a multiplicative model (Gavaris, 1980) to derive a standardized catch rate index for hours fished, as has been done in the last few assessments of this stock. A second standardization was conducted for days fished due to missing hours-fished data from two major fleets, 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 standardizations, individual observations with catch less than 10 tons or effort less than 10 hours were eliminated prior to analysis for the "hours fished" model. Subsequently, categories within each factor where there were less than five observations in the database were also eliminated. For the "days fished" model the only difference in was that observations with effort less than 5 days fished were eliminated prior to analysis.

Results and Discussion

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 (1992 and 1997) 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, but has subsequently declined to 2002. 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 2002 estimate, based solely on preliminary Canadian data is amongst the lowest in the time series.

For the “days fished” standardization, the regression was also significant ($p < 0.05$), explaining 54% 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. 1 lower panel) also shows high between and within year variability prior to the 1990’s. 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 12%. Catch rate subsequently declined by 47% 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. Since 1995 the index declined gradually to the lowest rate observed in 1998. Catch rate increased sharply to 2000, which was the highest rate in the previous 15 years, but has subsequently declined to 2002. The 2002 estimate, based solely on preliminary Canadian data is amongst the lowest in the time series.

It is uncertain whether the catch rate index is representative of stock abundance because fleets fish in different areas of the stock. The Canadian fleet currently operates within the 200-mile limit in Div. 2J3KL while foreign fleets fish in the NAFO Regulatory area outside the 200-mile limit primarily in Div. 3LMN.

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.*, No. 39, Serial 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.*, No. 80, Serial No. N4459, 18 p.

Table 1. 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. (2002 based on preliminary Canadian data).

REGRESSION OF MULTIPLICATIVE MODEL
 MULTIPLE R..... 0.754
 MULTIPLE R SQUARED..... 0.568

 ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	8.13E2	8.13E2	
REGRESSION	66	1.91E2	2.89E0	15.712
Cntry Gear TC(1)	21	3.79E1	1.80E0	9.806
Month(2)	11	1.34E1	1.22E0	6.611
Division(3)	7	8.87E0	1.27E0	6.886
Year(4)	27	2.54E1	9.42E-1	5.119
RESIDUALS	789	1.45E2	1.84E-1	
TOTAL	856	1.15E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry Gear TC	3125	INT	-0.806	0.213	856
Month	9				
Division	22				
Year	75				
1					
	3123	1	-0.245	0.154	9
	3126	2	-0.159	0.165	8
	9125	3	0.709	0.159	12
	10127	4	1.069	0.185	8
	11125	5	0.212	0.132	16
	11126	6	-0.124	0.202	6
	11127	7	0.365	0.124	17
	14124	8	0.351	0.069	129
	14126	9	0.702	0.112	23
	14127	10	0.358	0.092	43
	15126	11	0.256	0.200	6
	16127	12	0.256	0.088	51
	19124	13	-0.352	0.092	102
	19125	14	-0.071	0.101	75
	19126	15	0.263	0.117	28
	20125	16	0.308	0.187	7
	20126	17	-0.114	0.143	12
	20127	18	-0.022	0.095	37
	27125	19	0.256	0.099	26
	34125	20	0.447	0.155	17
	34126	21	0.193	0.144	22
2					
	1	22	0.276	0.084	41
	2	23	0.217	0.082	46
	3	24	0.017	0.075	61
	4	25	0.086	0.074	63
	5	26	0.228	0.076	58
	6	27	0.166	0.072	68
	7	28	0.035	0.068	77
	8	29	0.085	0.063	90
	10	30	-0.265	0.066	84
	11	31	-0.040	0.064	93
	12	32	0.079	0.070	74
3					
	21	33	0.066	0.082	52
	23	34	0.003	0.064	118
	31	35	-0.252	0.075	123
	32	36	-0.195	0.081	253
	33	37	-0.479	0.098	92
	34	38	-0.235	0.103	70
	35	39	-0.267	0.138	21
4					
	76	40	-0.057	0.224	11
	77	41	0.083	0.215	19
	78	42	0.293	0.232	18
	79	43	0.115	0.228	10
	80	44	0.321	0.236	12

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
		81	0.131	0.224	15
		82	0.397	0.218	19
		83	0.360	0.211	24
		84	0.308	0.214	23
		85	0.101	0.214	21
		86	-0.147	0.213	24
		87	0.131	0.205	33
		88	-0.239	0.214	22
		89	-0.051	0.218	22
		90	-0.003	0.217	26
		91	-0.286	0.212	51
		92	-0.420	0.209	102
		93	-0.203	0.212	84
		94	-0.356	0.214	101
		95	-0.189	0.227	21
		96	-0.372	0.221	23
		97	-0.487	0.221	24
		98	-0.289	0.228	34
		99	-0.320	0.225	49
		100	-0.076	0.223	19
		101	-0.291	0.214	32
		102	-0.402	0.239	11

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 2. Standardized catch rate index for Greenland halibut in NAFO SA2+ Div. 3KLMNO from a multiplicative model utilizing HOURS FISHED as a measure of effort. (2001 based on preliminary data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM		RETRANSFORMED		CATCH	EFFORT	
	MEAN	S.E.	MEAN	S.E.			
1975	-0.8058		0.0452	0.479	0.101	28814	60169
1976	-0.8630		0.0239	0.457	0.070	24611	53840
1977	-0.7225		0.0187	0.527	0.072	32048	60757
1978	-0.5133		0.0214	0.649	0.094	39070	60170
1979	-0.6909		0.0290	0.542	0.092	34104	62971
1980	-0.4850		0.0216	0.668	0.098	32867	49211
1981	-0.6744		0.0189	0.553	0.076	30754	55574
1982	-0.4085		0.0148	0.723	0.088	26278	36324
1983	-0.4461		0.0129	0.697	0.079	27861	39949
1984	-0.4983		0.0122	0.662	0.073	26711	40341
1985	-0.7053		0.0144	0.538	0.064	20347	37835
1986	-0.9528		0.0131	0.420	0.048	17976	42786
1987	-0.6747		0.0133	0.555	0.064	32442	58479
1988	-1.0450		0.0144	0.383	0.046	19215	50186
1989	-0.8572		0.0135	0.462	0.053	20034	43346
1990	-0.8089		0.0113	0.486	0.052	47454	97728
1991	-1.0923		0.0107	0.366	0.038	65008	177676
1992	-1.2256		0.0099	0.320	0.032	63193	197276
1993	-1.0092		0.0111	0.397	0.042	62455	157127
1994	-1.1615		0.0119	0.341	0.037	51029	149564
1995	-0.9944		0.0184	0.402	0.054	15272	37994
1996	-1.1783		0.0152	0.335	0.041	18840	56248
1997	-1.2930		0.0153	0.299	0.037	19858	66493
1998	-1.0953		0.0189	0.363	0.050	19946	54908
1999	-1.1262		0.0176	0.352	0.047	24226	68735
2000	-0.8822		0.0168	0.450	0.058	34177	75948
2001	-1.0964		0.0128	0.364	0.041	38232	105042
2002	-1.2075		0.0230	0.324	0.049	30531	94221

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.128

Table 3. 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. (2002 based on preliminary Canadian data).

REGRESSION OF MULTIPLICATIVE MODEL						REGRESSION COEFFICIENTS					
MULTIPLE R			MULTIPLE R SQUARED			CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
0.733			0.538					8	0.189	0.065	97
-----								10	-0.222	0.068	88
ANALYSIS OF VARIANCE								11	-0.069	0.066	99
-----								12	0.095	0.070	89
SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE		(3)	21	0.157	0.098	43	
INTERCEPT	1	2.35E3	2.35E3				23	0.055	0.075	108	
REGRESSION	69	2.24E2	3.25E0	15.472			31	-0.268	0.089	109	
Cntry Gear TC(1)	24	6.34E1	2.64E0	12.575			32	-0.246	0.094	355	
Month(2)	11	2.12E1	1.92E0	9.161			33	-0.723	0.107	109	
Division(3)	7	2.35E1	3.36E0	16.000		(4)	34	-0.480	0.106	130	
Year(4)	27	2.33E1	8.64E-1	4.111			35	-0.416	0.145	23	
RESIDUALS	918	1.93E2	2.10E-1				76	-0.136	0.246	9	
TOTAL	988	2.77E3					77	-0.090	0.236	15	
-----								78	-0.068	0.269	9
								79	-0.041	0.257	8
								80	0.063	0.274	8
								81	-0.298	0.250	12
								82	0.097	0.236	18
								83	-0.025	0.226	25
								84	0.076	0.232	21
								85	-0.144	0.238	17
								86	-0.335	0.238	16
								87	-0.084	0.226	27
								88	-0.529	0.232	21
								89	-0.319	0.240	19
								90	-0.315	0.237	24
								91	-0.449	0.231	45
								92	-0.559	0.228	99
								93	-0.340	0.228	88
								94	-0.323	0.228	112
								95	-0.529	0.236	33
								96	-0.555	0.232	42
								97	-0.636	0.232	41
								98	-0.654	0.229	98
								99	-0.434	0.232	60
								100	-0.206	0.231	50
								101	-0.467	0.229	54
								102	-0.540	0.258	11
REGRESSION COEFFICIENTS						LEGEND FOR ANOVA RESULTS:					
CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS	CGT CODES: All are Stern Trawlers					
Cntry Gear TC	3125	INT	2.031	0.235	988	3123 = Can(NFLD)	TC 3	19124 = Spain	TC 4		
Month	9					3125 = Can(NFLD)	TC 5	19125 = "	TC 5		
Division	22					3126 = "	TC 6	19126 = "	TC 6		
Year	75					9125 = Fra (SPM)	TC 5	19166 = SpainPai rTrawl	TC 6		
(1)	3123	1	-0.531	0.157	10	11125 = FormerDDR	TC 5	20125 = Former USSR	TC 5		
	3126	2	-0.124	0.175	8	11126 = "	TC 6	20126 = "	TC 6		
	9125	3	0.475	0.113	28	11127 = "	TC 7	20127 = "	TC 7		
	11125	4	-0.082	0.137	18	14124 = Japan	TC 4	27125 = Can(M)	TC 5		
	11126	5	-0.276	0.239	5	14126 = "	TC 6	31126 = Latvia	TC 6		
	11127	6	0.166	0.139	16	14127 = "	TC 7	34125 = Russia	TC 5		
	14124	7	0.419	0.077	123	15126 = Norway	TC 6	34126 = "	TC 6		
	14126	8	0.549	0.137	19	16127 = Poland	TC 7	34127 = "	TC 7		
	14127	9	0.375	0.102	37	17126 = Portugal	TC 7	34127 = "	TC 7		
	15126	10	0.272	0.232	5						
	16127	11	0.172	0.103	46						
	17126	12	-0.313	0.085	123						
	19124	13	-0.253	0.093	101						
	19125	14	-0.143	0.094	111						
	19126	15	0.433	0.126	28						
	19166	16	0.357	0.181	8						
	20125	17	0.327	0.214	6						
	20126	18	-0.364	0.166	10						
	20127	19	-0.264	0.106	35						
	27125	20	0.177	0.128	17						
	31126	21	0.518	0.227	5						
	34125	22	0.508	0.152	15						
	34126	23	0.187	0.114	31						
	34127	24	0.002	0.171	9						
2	1	25	0.322	0.081	53						
	2	26	0.312	0.077	63						
	3	27	0.121	0.071	84						
	4	28	0.208	0.072	78						
	5	29	0.346	0.073	74						
	6	30	0.217	0.071	77						
	7	31	0.144	0.071	78						

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

Table 4. Standardized catch rate index for Greenland halibut in NAFO SA2+ Div. 3KLMNO from a multiplicative model utilizing DAYS FISHED as a measure of effort. (2002 based on preliminary Canadian data).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM	RETRANSFORMED		S.E.	CATCH	EFFORT
	MEAN	S.E.	MEAN			
1975	2.0309	0.0550	8.236	1.906	28814	3498
1976	1.8947	0.0338	7.264	1.325	24611	3388
1977	1.9406	0.0255	7.637	1.212	32048	4196
1978	1.9625	0.0345	7.771	1.432	39070	5028
1979	1.9903	0.0393	7.971	1.565	34104	4278
1980	2.0936	0.0346	8.859	1.635	32867	3710
1981	1.7334	0.0281	6.200	1.033	30754	4961
1982	2.1281	0.0186	9.244	1.255	26278	2843
1983	2.0054	0.0157	8.189	1.021	27861	3402
1984	2.1072	0.0161	9.064	1.145	26711	2947
1985	1.8865	0.0199	7.255	1.020	20347	2805
1986	1.6956	0.0206	5.992	0.856	17976	3000
1987	1.9473	0.0196	7.712	1.074	32442	4207
1988	1.5017	0.0186	4.941	0.671	19215	3889
1989	1.7122	0.0175	6.102	0.803	20034	3283
1990	1.7162	0.0142	6.136	0.730	47454	7733
1991	1.5820	0.0131	5.369	0.613	65008	12108
1992	1.4714	0.0128	4.808	0.543	63193	13145
1993	1.6908	0.0131	5.986	0.683	62455	10433
1994	1.7080	0.0133	6.090	0.699	51029	8380
1995	1.5017	0.0178	4.943	0.656	15272	3089
1996	1.4760	0.0152	4.824	0.593	18840	3906
1997	1.3950	0.0155	4.448	0.551	19858	4464
1998	1.3773	0.0139	4.373	0.514	19946	4561
1999	1.5971	0.0155	5.444	0.675	24226	4450
2000	1.8253	0.0148	6.842	0.831	34177	4995
2001	1.5639	0.0140	5.270	0.622	38232	7254
2002	1.4910	0.0272	4.867	0.797	30531	6273

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.142

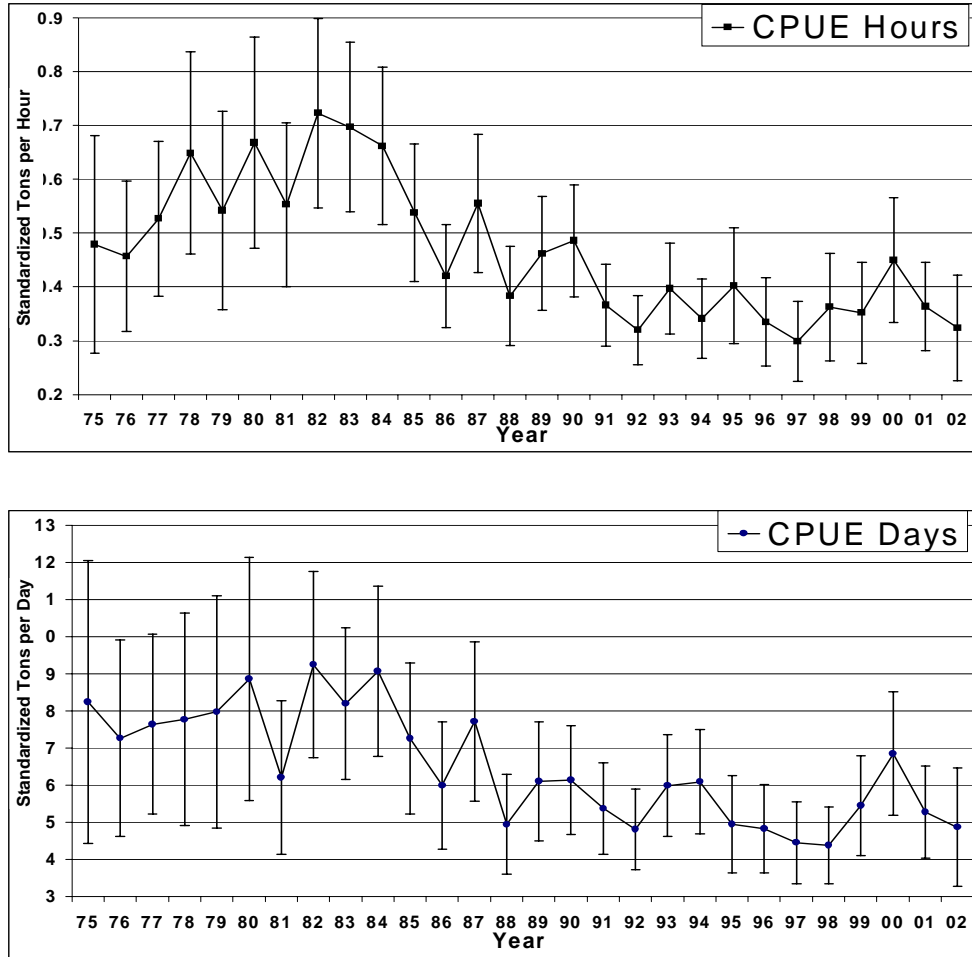


Fig. 1. Standardized Mean CPUE \pm 2 standard errors for Greenland Halibut in SA2 + Div. 3KLMNO from 1975-2002 (preliminary) utilizing effort in HOURS fished (upper panel) and DAYS fished.