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

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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. Since 2005, the index increased rapidly and peaked at the highest rate in the series in 2008, an increase of about 250%, then declined 60% thereafter by 2010. The catch rate remained stable to 2013 then almost doubled in 2014 and remained at this level in 2015. It is difficult to accept that this index is reflective of stock dynamics, particularly since the recent scale of the CPUE relative to the entire series and rapid changes in trend are unprecedented. Further investigation is warranted to understand these changes.

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. Based on differences in trends in the catch rate models between CANADIAN and NON-CANADIAN fleets for the years since 1992, separate standardizations were conducted since 2004 (Power, 2004). 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.

Materials and Methods

Catch and effort data from the Canadian otter trawl fishery directed for Greenland halibut during the period 1975 to 2002 were obtained from the NAFO STATLANT 21B database and combined with data from 2003-2016 from Canada (N) logbook (ZIFF) records. The catch/effort data were analysed with a General Linear Model using SAS Version 9.3 PROC GLM (SAS, 2011) to derive a standardized catch rate index based on an hours-fished measure of effort. Ln (CPUE) was the dependent variable in the model. 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 (e.g. Power, 2004), individual observations with catch less than 10 tons or effort less than 10 hours were eliminated prior to analysis. 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. After the selection criteria were applied, the percentage of otter trawl catch with hours fished effort utilized in the analysis ranged from 9.5% in 1976 to 99.1% in 2007, and averaged over 90% since 2007.

Results and Discussion

The ANOVA results and parameter estimates (Table 1) resulted in a significant regression (P <0.01) explaining 69% of the variation in catch rates. Residual plots (Fig. 1) did not indicate model misspecification. Based on the regression coefficients, over the entire time series, catch rates are generally better in late spring/summer and higher in Div. 2H. The divisional coefficients also suggest catch rate decreases from north to south. The fishing power of the large trawlers (TC 7) is the highest with no significant difference between single and twin trawls.

The standardized catch rate series on the log (ln) scale (Table 2, Fig. 2) shows much between-year variability. CPUE more than doubled from 1976 to 1978 then showed a period of stability to 1984. CPUE declined by about two-thirds to 1992 although there were some sporadic increases over this period. The 1992 value was near the lowest in the series then was relatively stable to 2005. Within a five year period, the index increased rapidly and peaked at the highest rate in the series in 2008, an increase of about 250%, then declined 55% thereafter by 2010. The catch rate remained stable to 2013 then almost doubled in 2014 and remained near this level to 2016, amongst the highest in the time series.

It is difficult to accept that this index is reflective of stock dynamics, particularly since the recent scale, and, the rapid changes in trend from 2005 to 2010 are unprecedented. It would be important to investigate a finer spatial scale disaggregation of the data set for a long a series as possible in an attempt to understand the nature of the rapid changes in the recent period compared to the past.

References

Power, D. 2004. Standardized Catch Rate Indices for Greenland Halibut in SA2+3KLMNO. NAFO SCR. Doc. 04/37, Serial No. N4988, 15p.

SAS (2011). The data analysis for this paper was generated using SAS/STAT software, Version 9.3 of the SAS System for Windows. Copyright © 2011 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Table 1. ANOVA results and regression coefficients from a SAS GLM model utilized to derive a standardized CPUE index for Greenland halibut in NAFO Div. 2HJ3KL. Analysis is based on HOURS FISHED from the Canadian ottertrawl fleet (2016 based on preliminary data).

GLM ANOVA MULTIPLICATIVE MODEL USING 2HJ3KL Canadian DATA to 2016

Main Effects Model

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
MO	12	1 2 3 4 5 6 7 8 10 11 12 90
DIV	4	23 31 32 220
CGT	7	3123 3124 3126 3127 3857 27125 31250
YEAR	41	77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 760

Number of Observations Read	458
Number of Observations Used	458

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	60	181.0422098	3.0173702	14.60	<.0001
Error	397	82.0695440	0.2067243		
Corrected Total	457	263.1117538			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.688081	-69.22278	0.454669	-0.656821

Source	DF	Type III SS	Mean Square	F Value	Pr > F
CGT	6	26.87267987	4.47877998	21.67	<.0001
YEAR	40	54.98295782	1.37457395	6.65	<.0001
MO	11	9.49541624	0.86321966	4.18	<.0001
DIV	3	13.80083069	4.60027690	22.25	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-1.163113559B	0.33883135	-3.43	0.0007
CGT 3123	-0.640466155B	0.11463826	-5.59	<.0001
CGT 3124	-0.191562776B	0.20179983	-0.95	0.3431
CGT 3126	0.115944007B	0.12193482	0.95	0.3422
CGT 3127	0.508220417B	0.09581581	5.30	<.0001
CGT 3857	0.650848513B	0.11666149	5.58	<.0001
CGT 27125	0.104760059B	0.11030814	0.95	0.3428
CGT 31250	0.000000000B	.	.	.
YEAR 77	0.316337277B	0.38428376	0.82	0.4109
YEAR 78	0.886103615B	0.36856659	2.40	0.0167
YEAR 79	0.849556945B	0.42097308	2.02	0.0443
YEAR 80	1.084150114B	0.35338268	3.07	0.0023
YEAR 81	0.823288160B	0.35470885	2.32	0.0208
YEAR 82	0.895787062B	0.36140423	2.48	0.0136
YEAR 83	0.889079953B	0.34699548	2.56	0.0108
YEAR 84	1.018658891B	0.35364266	2.88	0.0042
YEAR 85	0.603431450B	0.35486956	1.70	0.0898
YEAR 86	0.341228645B	0.37406542	0.91	0.3622

Table 1 (continued)

Parameter	Estimate	Standard Error	t Value	Pr > |t|
YEAR 87	0.853455948B	0.38547464	2.21	0.0274
YEAR 88	0.008097426B	0.40134449	0.02	0.9839
YEAR 89	0.478450942B	0.37683172	1.27	0.2049
YEAR 90	0.483135666B	0.35332779	1.37	0.1723
YEAR 91	0.128334623B	0.34772914	0.37	0.7123
YEAR 92	0.105305992B	0.34520678	0.31	0.7605
YEAR 93	0.211993733B	0.35577375	0.60	0.5516
YEAR 94	0.315002990B	0.40041219	0.79	0.4319
YEAR 95	0.476223833B	0.45982095	1.04	0.3010
YEAR 96	0.281835294B	0.36518725	0.77	0.4407
YEAR 97	0.629732754B	0.37060961	1.70	0.0901
YEAR 98	0.252953904B	0.46135160	0.55	0.5838
YEAR 99	0.138718392B	0.46370000	0.30	0.7650
YEAR 100	0.448148385B	0.36338943	1.23	0.2182
YEAR 101	0.658542393B	0.34964546	1.88	0.0604
YEAR 102	0.245123635B	0.35783433	0.69	0.4937
YEAR 103	0.183409944B	0.34020113	0.54	0.5901
YEAR 104	0.195181758B	0.34432936	0.57	0.5711
YEAR 105	0.249672804B	0.34590377	0.72	0.4708
YEAR 106	0.909021947B	0.36576677	2.49	0.0134
YEAR 107	1.355012344B	0.38038683	3.56	0.0004
YEAR 108	1.488047575B	0.38717628	3.84	0.0001
YEAR 109	1.332029590B	0.36364919	3.66	0.0003
YEAR 110	0.668291012B	0.35033477	1.91	0.0572
YEAR 111	0.739875887B	0.35469338	2.09	0.0376
YEAR 112	0.573994311B	0.35324860	1.62	0.1050
YEAR 113	0.700797167B	0.35588266	1.97	0.0496
YEAR 114	1.238555705B	0.35983708	3.44	0.0006
YEAR 115	1.164294496B	0.36828273	3.16	0.0017
YEAR 116	1.433613070B	0.36913036	3.88	0.0001
YEAR 760	0.000000000B	.	.	.
MO 1	-0.042729409B	0.13734278	-0.31	0.7559
MO 2	0.095213509B	0.14247976	0.67	0.5044
MO 3	-0.041884628B	0.12742317	-0.33	0.7426
MO 4	0.096392108B	0.11291299	0.85	0.3938
MO 5	0.224766963B	0.11252156	2.00	0.0464
MO 6	0.254093097B	0.10170917	2.50	0.0129
MO 7	0.092903306B	0.09627460	0.96	0.3351
MO 8	0.099770011B	0.09467162	1.05	0.2926
MO 10	-0.184321969B	0.12566291	-1.47	0.1432
MO 11	-0.438691371B	0.12942409	-3.39	0.0008
MO 12	-0.024819406B	0.12607276	-0.20	0.8440
MO 90	0.000000000B	.	.	.
DIV 23	-0.086668018B	0.09265070	-0.94	0.3501
DIV 31	-0.470179567B	0.09540751	-4.93	<.0001
DIV 32	-0.540150717B	0.10254909	-5.27	<.0001
DIV 220	0.000000000B	.	.	.

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the nor mal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

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

3123 =	Can(NFLD)	Otter Trawl	TC 3
3124 =	"	"	TC 4
3125 =	"	"	TC 5
3126 =	"	"	TC 6
3127 =	"	"	TC 7
3857 =	"	Twin Otter Trawl	TC 7
27125 =	Can(M)	Otter Trawl	TC 5

DIVISION CODES:
22 = 2H, 23 = 2J, 31 = 3K, 32 = 3L

Table 2. Standardized CPUE for Greenland halibut in NAFO 2HJ3KL based on a SAS GLM model utilizing HOURS FISHED as a measure of effort. Results are from the CANADIAN OTTERTRAWL fleet (2016 based on preliminary data).

The GLM Procedure
Least Squares Means

YEAR	LNCPUE LSMEAN	Standard Error	Pr > |t|
77	-1.03188569	0.21651119	<.0001
78	-0.46211935	0.17370490	0.0081
79	-0.49866602	0.27524793	0.0708
80	-0.26407285	0.13858641	0.0574
81	-0.52493480	0.13312297	<.0001
82	-0.45243590	0.16354065	0.0059
83	-0.45914301	0.12893340	0.0004
84	-0.32956407	0.15022402	0.0288
85	-0.74479151	0.15348812	<.0001
86	-1.00699432	0.18419347	<.0001
87	-0.49476702	0.21979842	0.0249
88	-1.34012554	0.24107521	<.0001
89	-0.86977202	0.20150814	<.0001
90	-0.86508730	0.14561478	<.0001
91	-1.21988834	0.12514320	<.0001
92	-1.24291697	0.11455163	<.0001
93	-1.13622923	0.13919123	<.0001
94	-1.03321997	0.24291271	<.0001
95	-0.87199913	0.33604960	0.0098
96	-1.06638767	0.17526396	<.0001
97	-0.71849021	0.18794311	0.0002
98	-1.09526906	0.33115655	0.0010
99	-1.20950457	0.33323790	0.0003
100	-0.90007458	0.16603653	<.0001
101	-0.68968057	0.12626335	<.0001
102	-1.10309933	0.15156952	<.0001
103	-1.16481302	0.09974566	<.0001
104	-1.15304121	0.11653541	<.0001
105	-1.09855016	0.10998977	<.0001
106	-0.43920102	0.16172048	0.0069
107	0.00678938	0.18791061	0.9712
108	0.13982461	0.20118097	0.4874
109	-0.01619337	0.15331933	0.9159
110	-0.67993195	0.12431105	<.0001
111	-0.60834708	0.12443482	<.0001
112	-0.77422865	0.12135051	<.0001
113	-0.64742580	0.12630476	<.0001
114	-0.10966726	0.13502247	0.4172
115	-0.18392847	0.15334145	0.2311
116	0.08539011	0.15267211	0.5763
760	-1.34822296	0.33379651	<.0001

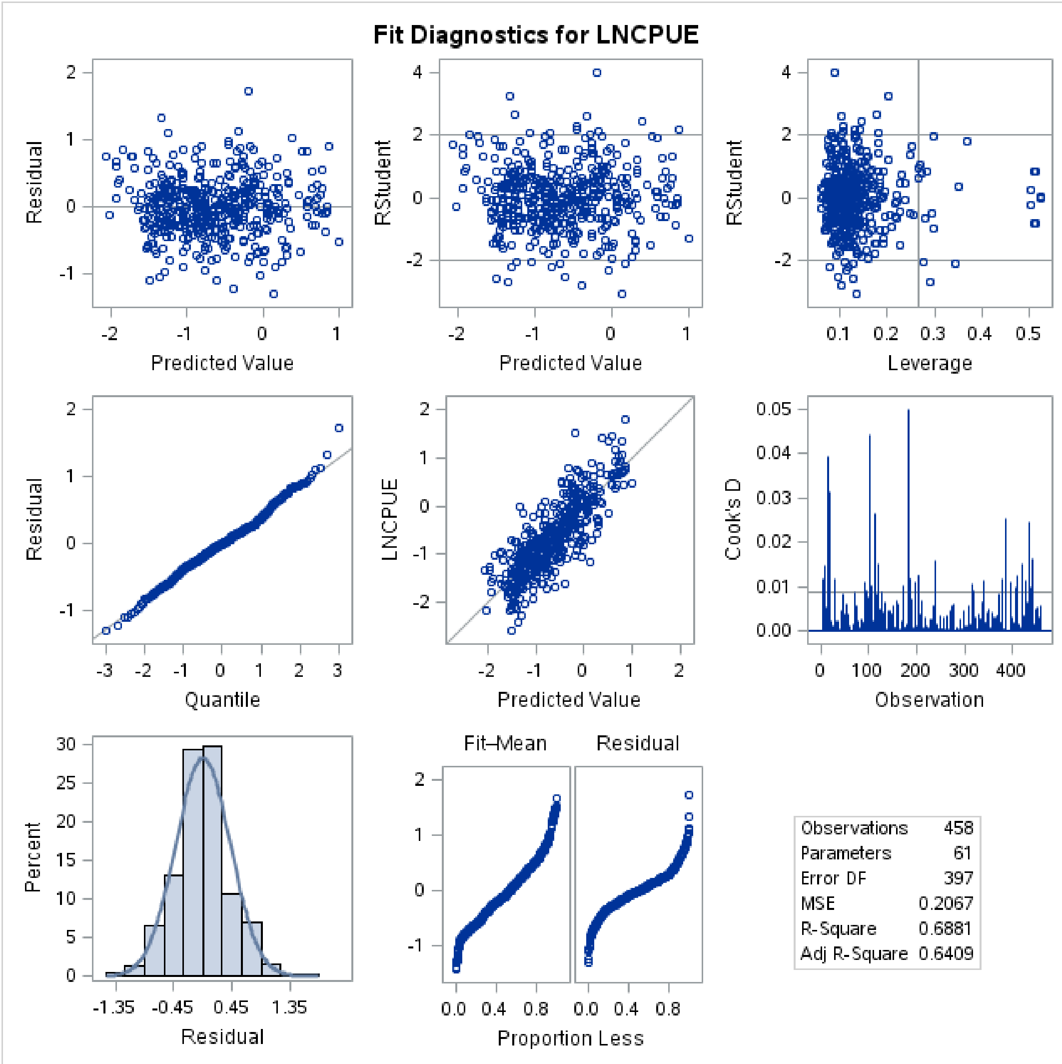

Fig. 1. Diagnostic plots from SAS PROC GLM

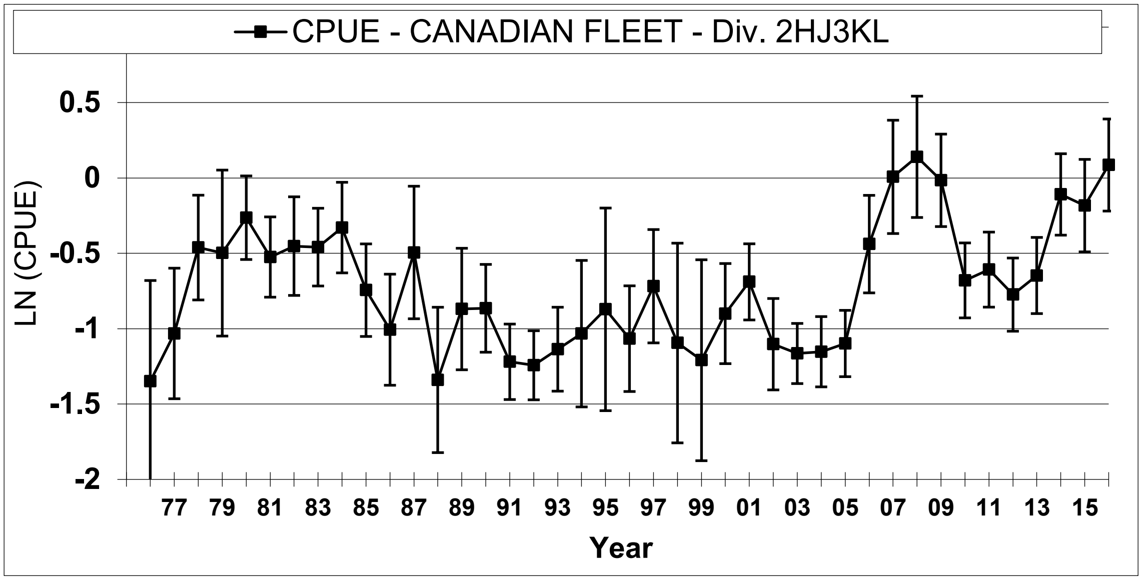

Fig. 2. Standardized Least Square Mean CPUE ± 2 standard errors for Greenland Halibut in Div. 2HJ3KL utilizing effort in HOURS fished from the CANADIAN OTTERTRAWL FLEET. (SAS GLM)