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Standardized CPUE Indices for Greenland Halibut in NAFO Divisions 3LMNO Based on Spanish Commercial Catch Rates

by

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Abstract

Standardized CPUE series using a Generalized Linear Model for Greenland halibut in Div. 3LMNO, based on catch and effort data from the Spanish trawl fleet since 1991 are presented. Fixed factors considered in the model were: year, month, vessel, Division and depth and the interactions analysed were: Division – depth and month – Division. All the factors and interactions analyzed are significant. The total proportion of variance explained by this model was 40%. The results indicate a decrease trend in the catch rate index in recent years from highest values in 2000.

Introduction

The Spanish Greenland halibut fishery in Div. 3LM Regulatory area is performed by bottom trawlers since 1990 (Junquera *et al*., 1992). From about 1993 the activity of this fleet has been spread to the south, into Div. 3N and 3O shelf edge, where at present a significant proportion of this fleet effort is displayed (Junquera *et al*., 2000). Greenland halibut is the main resource for Spanish fleet in NAFO Regulatory Area and Spanish catches represent more than 40% of the total catches of this stock during last years.

The objective of this study is to standardize CPUE series for Greenland halibut in Div. 3LMNO based on catch and effort data recollected by scientific observers onboard the Spanish trawl fleet since 1991. Since Greenland halibut is the target species of the fleet analysed here, the standardized CPUE data can be considered as an index of the fishable biomass of this stock.

Material and Methods

1- Catch and effort data.

Records of catch and effort data from the Spanish Greenland halibut fishery was collected in Div. 3LMNO by scientific observers from the national sampling program since 1991. While those records varied in coverage over the years, it is assumed that the available data are representative of the fishery, considering that the Spanish fleet catches constitute the major component of the total Greenland halibut catch in the Regulatory Area. Data were recorded and analyzed on a haul by haul basis. Catch in kilograms per hour (CPUE) was the unit measure selected to standardize the series.

Since the database of records contain data from different fleets directed to several species, as a first step, an analysis was carried out to select the hauls directed to Greenland halibut. For this purpose, the hauls where the catches of Greenland halibut plus Grenadiers were bigger than total catches of any other species present in the catches were selected.

For standardization analyses, nominal CPUE was estimated as the Greenland halibut catch per hour. The nominal CPUE distribution showed a highly skewed distribution departing from a normal distribution. Since to apply a GLM the response variable distribution must belong to the exponential family, the nominal CPUE data was transformed logarithmically to get a normal distributed response variable. Figure 1 shows the frequency histogram of CPUE and the log transformed CPUE data and Fig. 2 presents the qq plot of transformed distribution, which shows how normal is the variable analysis.

2- Standardizing method.

A Generalized Linear Model (McCullagh and Nedler, 1983) has been applied to log(CPUE) data. This method is appropriate for standardizing indices, as it can explain the variability due to year abundance and other factors in the standardization procedures of CPUE data. The observed log(CPUE) values are fitted to a linear function of fixed factors and interactions. The theoretical background of the generalized linear models has been developed by Nelder and Wedderburn (1972). Those models are generalizations of the common linear regression models to situations where the response is discrete or varies in other ways from the standard linear models assumptions.

The Gaussian model formulation with an identity function to link the linear factor components and the error distributions have been used, as it proved to fit adequately to the observed data. To observe the significant of the variables of the model a F test has been used. Fixed factors considered in the model were: year, month, vessel, Division and depth. The interactions analysed are: Division – depth and month – Division. The Divisions used have been Div. 3LMNO and the depths were divided in depth intervals of 100 in 100 meters up to 1 400 and it was formed a group with the depths of more than 1400 meters.

Results

The results of the regression analysis used to determine the specifications for standardizing CPUE series are listed in Table 1. The residual deviance column is the variability of the data unexplained by each step model. In this case, the largest proportion of the variance (22%) is explained by the factor 'vessel'. All the factors and interactions analyzed were significant as we can see in Table 1. The total proportion of variance explained by this model was 40%. Division was the individual factor that has more interactions with the others factors, in order to explore other possible interactions, plots of different variable interactions were analysed, Figure 3 presents the plots for the interactions (Division and deep and Division and month) used in the final model. Table 2 shows that the correlation between the observed variables and the correlation is almost non-existent. Table 3 presents parameters values for year factor with their Standard Deviations and significance; in this analysis all years were significant.

Figure 4 present the residuals deviance versus the fitted values, where a clear pattern of residuals cannot be observed. Figure 5 shows the values of the observed Log(CPUE) *versus* fitted values, it can observe that the values fitted well in the middle of the distribution but the fit is poorer for the extreme values, tends to overestimate the observations with low log(CPUE) and sub-estimate the observations with high log(CPUE). Figure 6 shows that the residuals follow the expected linear pattern of the qq-plot, although the extreme values slightly departure from normality.

The Greenland halibut standardized CPUE series, scaled to the first year of the analysis (1991), with their confidential intervals ($\pm$ 1.96 times the standard error) is illustrated in Fig. 7 and the values are presented in Table 3. The values for the different years vary around 15% up and down respect to the value of the year 1991. The standard deviation is similar for all years except for 1995 where the Spanish fleet fished very few months for what there are very few data. There is not a clear trend in the series, the maximum values of the index were reached in 1996 and 2000 (14%) and the minimum in 1998 (21%). During last years, the values have decreased from the maximum of 2000 (14% higher than the reference year) to 2003 (10% lower than 1991).

References

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Table 1.- Summary of the results of analysis for standardizing CPUE data using a Generalized Linear Model for Greenland halibut in Div. 3LMNO (1991-2003). Two points designates factors interactions.

	Df	Deviance	Resid.Df	Resid.Dev	F	Pr(>F)	Accumulated % of total Deviance
NULL			40030	10439.3			
Year	12	753.00	40018	9686.3	396.25	<2.2E-16	7
Month	11	610.60	40007	9075.7	350.53	<2.2E-17	13
Vessel	56	2260.00	39951	6815.7	254.847	<2.2E-18	35
Division	3	233.60	39948	6582.1	491.625	<2.2E-19	37
Depth	13	88.00	39935	6494.2	42.731	<2.2E-20	38
Division:Depth	32	110.10	39903	6384.1	21.727	<2.2E-21	39
Month:Division	32	70.20	39871	6313.9	13.854	<2.2E-22	40

Table 2.- Correlation table between factors.

	Year	Month	Depth
Year	1.00	-0.03	-0.06
Month	-0.03	1.00	-0.09
Depth	-0.06	-0.09	1.00

Table 3.- Parameters values for year factor with their Standard Deviations and significance.

	Estimate	Std.Error	t-value	Pr(>|t|)
(Intercept)	5.098103	0.231328	22.038	<2E-16
1991	0	-	-	-
1992	0.118646	0.010266	11.557	<2E-16
1993	-0.027983	0.011392	-2.456	0.014036
1994	-0.116946	0.011716	-9.982	<2E-16
1995	-0.157377	0.046053	-3.417	0.000633
1996	0.135031	0.018745	7.204	5.97E-13
1997	0.076106	0.0208	3.659	0.000254
1998	-0.212935	0.020349	-10.464	<2E-16
1999	-0.159972	0.02276	-7.029	2.12E-12
2000	0.140758	0.016895	8.331	<2E-16
2001	0.059773	0.01868	3.2	0.001376
2002	0.079333	0.019623	4.043	0.0000529
2003	-0.104954	0.023779	-4.414	0.0000102

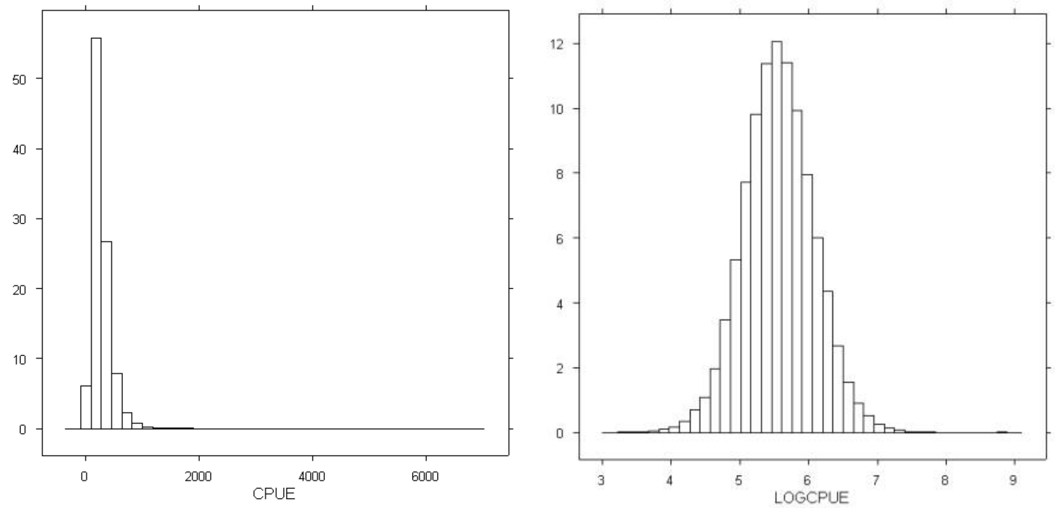

Fig. 1. Frequency histogram of CPUE and the log transformed CPUE data.

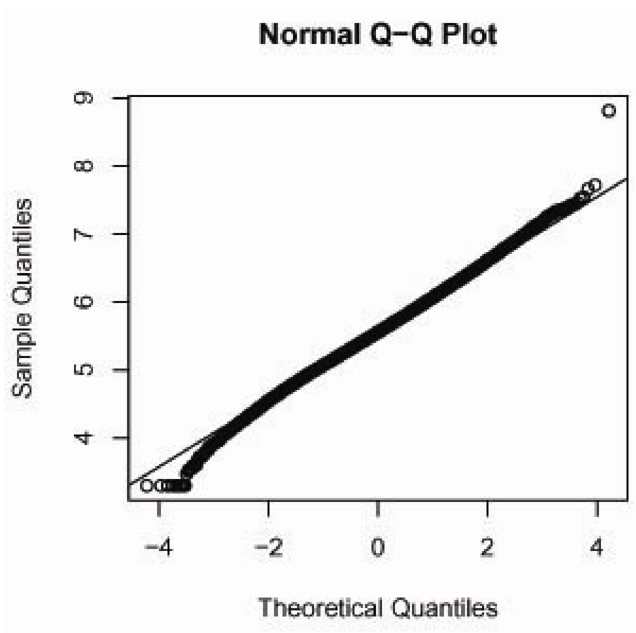

Fig. 2. Normal quantile-quantile plot of Log(CPUE) data.

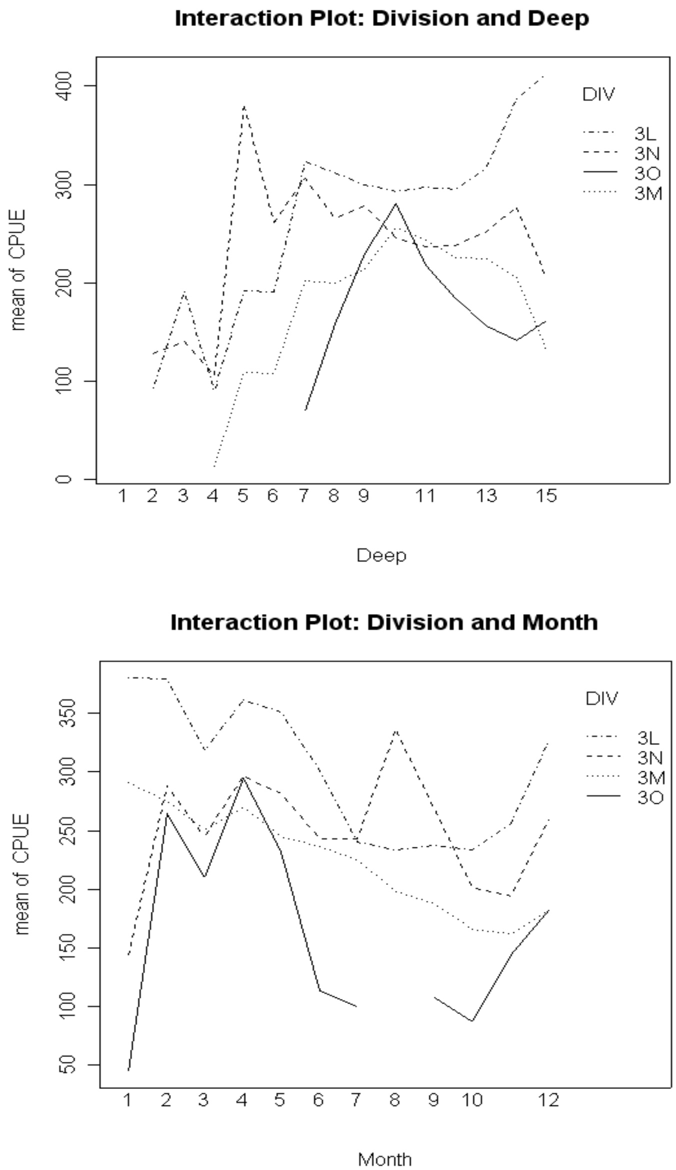

Fig. 3. Interaction plots between the factors Division and deep and Division and month.

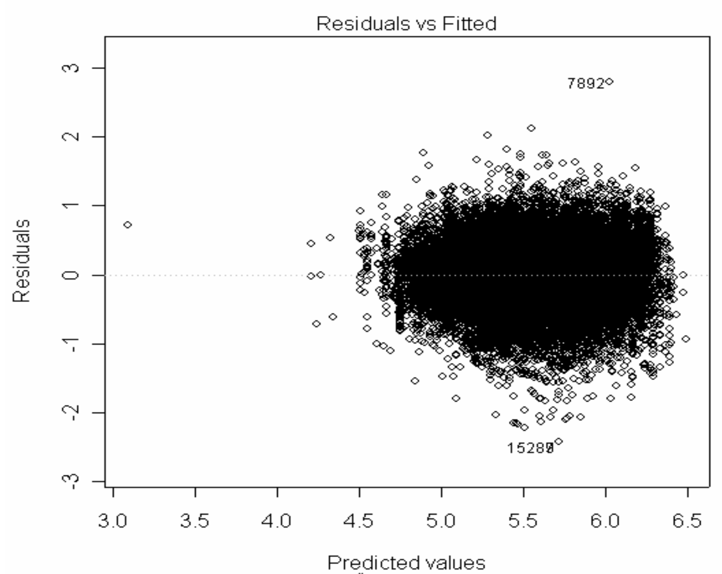

Fig. 4. Plot of the residuals deviance *versus* the fitted values.

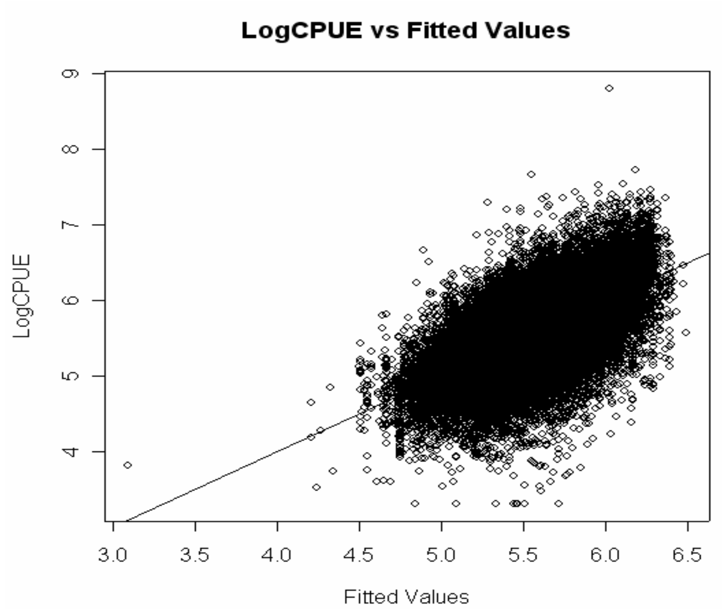

Fig. 5. Log(CPUE) values *versus* fitted values

Fig. 6. Normal quantile-quantile plot of the residuals.

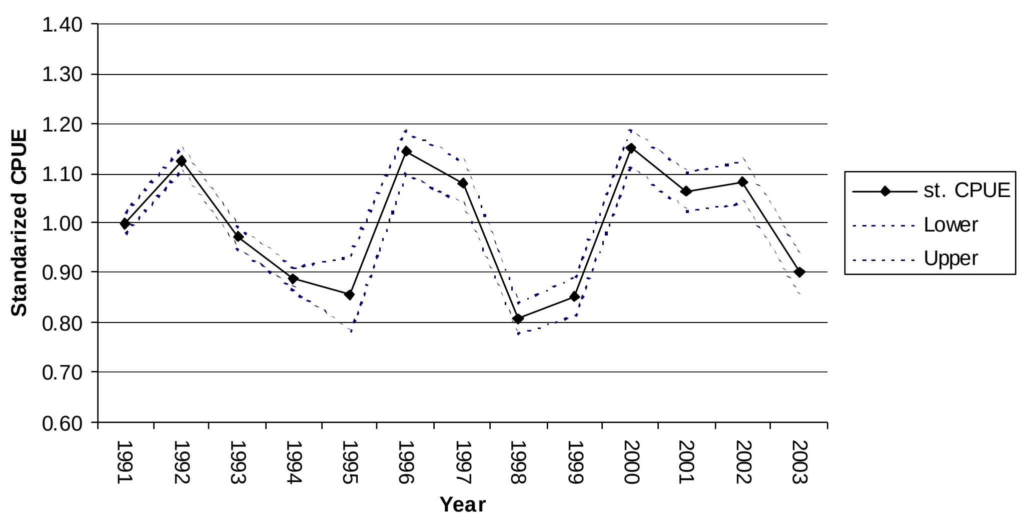

Fig. 7. Standardized CPUE series (1991-2003) +-1.96 Standard errors for Greenland halibut in Div. 3LMNO.