STANDARDIZED CPUE OF BLUEFIN TUNA (*THUNNUS THYNNUS*) CAUGHT BY MOROCCAN TRAPS FOR THE PERIOD 1986- 2014

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SUMMARY

*Relative abundance index of bluefin tuna (*Thunnus thynnus*) caught by the Moroccan traps in the Atlantic area close to the Strait of Gibraltar was updated up to 2014. The annual Standardized index was estimated through a General Linear Modeling (GLM) approach under a negative binomial error distribution assumption. A remarkable increase of the index has been observed since 2012, reflecting probably an improvement of the EABFT stock spawning biomass.*

RÉSUMÉ

*L'indice d'abondance relative du thon rouge (*Thunnus thynnus*) capturé par des madragues marocaines dans la zone atlantique proche du détroit de Gibraltar a été actualisé jusqu'en 2014. L'indice standardisé annuel a été estimé par le biais d'une approche de modélisation linéaire généralisée (GLM) en postulant une distribution d'erreur binomiale négative. Une augmentation considérable de l'indice a été observée depuis 2012, témoignant probablement d'un accroissement de la biomasse du stock reproducteur de EABFT.*

RESUMEN

*Se actualizó hasta 2014 el índice de abundancia relativa de atún rojo (*Thunnus thynnus*) capturado por almadrabas marroquíes en el área cercana al estrecho de Gibraltar. El índice estandarizado anual se estimó mediante un enfoque GLM con un supuesto de distribución de error binomial negativo. Se ha observado un aumento importante del índice desde 2012, lo que probablemente refleja una mejora en la biomasa reproductora del stock de EABFT.*

KEYWORDS

Bluefin tuna, Relative abundance, Atlantic Moroccan traps, GLM

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1. Introduction

The Moroccan traps relative abundance index has been traditionally used for VPA - calibrating purposes at the EABFT Stock Assessment Sessions (Anon. 2013, 2011, 2009).

The purpose of this document is to update previously reported information on bluefin tuna standardized catch rates for Moroccan traps (Abid *et al*., 2007, Abid *et al*., 2009, Abid and Idrissi, 2011 and Abid & Faraj, 2014)

In order to implement Rec. [08.05], Rec. [10.04] and Rec. [12-03] the Moroccan Administrations set up a *quota-by-gear* system, starting in 2009. As a result, the traps were forced to release previously caught fish once the awarded quota was reached. The estimated number of released fish, reported by the traps operators since 2009 was included in the data base for the current analysis.

2. Material and Methods

2.1 Description of data source

The annual catch data in number of bluefin tuna as well as the number of fish released were obtained from traps operators. For the purpose of updating the relative abundance index for the Moroccan traps, the data used concerned only 4 traps for which the longest time series data are available.

2.2 Size/age range of fish

This index is applied to spawners whose size ranged from 200 to 280 cm CFL, which correspond to fish aged 10+ years (Abid *et al*, 2013) **(Figure 1).** This is consistent with studies which demonstrated that the individuals of these age groups are fully selected by Spanish traps.

2.3 Management regulation

The Moroccan trap fishery remained stable for many years both in terms of the geographic location of traps as well as their technical characteristics. Nevertheless, with the significant reduction in quota since 2010 coupled with the higher number of BFT entering the traps, during the month of May, the fishing season of Moroccan traps has become shorter and has not been longer than 3 weeks in the four last years (25^{th} April -15^{th} May).

In order to take into account the effect of the recent management regulation on the catch rates, an estimation of the total number of fish released by each trap was obtained from the traps operators to be included in the total catch in number standardisation **(Figure 2).** As it was assumed in the previous analyses, the fishing effort of traps for the whole season was considered to be the same over the whole time series.

2.4 Model standardisation

A Generalized Linear Modeling (GLM) approach (McCullagh and Nelder, 1989) was applied with total catch in number as the response variable and the year and *trap* as the explanatory factors, under a negative binomial error distribution assumption (Ortiz de Urbina *et al*, 2007).

3. Results

Deviance analysis results are reported in **Table 1**. Based on its statistical significance as well as the percentage of the deviance explained by each factor, the final model for CPUE in number of fish for the whole fishing season included both factors *year* and *trap*. The selected model explains about 67% of the variability in the response variable. The factor *Year* explains roughly about 58% against 8.75% for *the Trap* factor.

Diagnostic plots (residuals *vs* fitted values and cumulative normalized residual plots) are shown in **Figure 3**. In general, residual patterns are not far from expected under the negative binomial error distribution assumption, which suggests a reasonably good fit.

Annual standardized relative abundance index with corresponding 95% confidence limit, the coefficients of variation, as well as the nominal CPUEs are reported in **Table 2.** Trend of the annual standardized index is shown in **Figure 4**. The remarkable increase in the index since 2011 would probably due to the improvement of the EABFT SSB.

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Table 1. Deviance analysis results. BFT catch in number. Moroccan Traps. 1986- 2014. Δ deviance refers to change in deviance; % deviance: percent of deviance explained with respect to the null model; p-value: χ^2 probability between consecutive models.

Model factors	*residual df*	*residual deviance*	*Δ deviance*	*% deviance*	*p-value*
null	96	310.94			
Year	68	129.57	181.365	58.33	<2.2e-16***
Trap	65	102.38	27.196	8.75	5.355e-06***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 2. GLM estimated standardized relative abundance indices, with corresponding 95% upper and lower confidence limit, nominal CPUE and coefficient of variation (CV %). BFT catch in number. Moroccan Traps. 1986- 2014.

Year	*No.CPUE*	*Std.CPUE*	*Upper*	*Lower*	*CV*
1986	680.0	1962.80	6433.95	598.79	8.42%
1987	516.0	1489.60	4886.53	454.09	8.76%
1988	1291.0	3725.74	12199.03	1137.89	7.72%
1989	974.0	1113.18	2613.54	474.14	6.51%
1990	295.5	421.08	771.26	229.89	5.36%
1991	966.0	1800.92	3290.69	985.61	4.26%
1992	177.5	255.43	468.81	139.17	5.88%
1993	261.8	353.80	648.42	193.05	5.53%
1994	320.8	435.29	797.22	237.68	5.32%
1995	169.3	261.37	479.65	142.43	5.86%
1996	369.7	426.57	846.91	214.85	6.07%
1997	889.0	1073.92	2127.57	542.08	5.22%
1998	1309.3	1780.47	3525.33	899.23	4.85%
1999	788.0	1116.41	2211.63	563.56	5.19%
2000	1003.8	1298.08	2372.55	710.21	4.46%
2001	2271.5	3632.88	6635.60	1988.94	3.88%
2002	1498.0	2890.30	5279.76	1582.24	4.00%
2003	844.8	1834.58	3352.15	1004.04	4.25%
2004	387.5	579.33	1060.21	316.56	5.07%
2005	1031.5	1765.14	3225.36	966.01	4.27%
2006	803.8	1249.32	2283.54	683.51	4.49%
2007	1409.3	2422.15	4424.97	1325.84	4.09%
2008	787.0	1166.68	2132.64	638.24	4.54%
2009	1002.3	1351.18	2469.51	739.29	4.44%
2010	840.7	1205.37	2386.99	608.68	5.13%
2011	668.5	1054.29	1927.42	576.69	4.61%
2012	1475.3	2065.48	4088.38	1043.50	4.75%
2013	5366.0	6978.12	13806.09	3527.01	4.07%
2014	2981	4390.35	8687.20	2218.80	4.30%

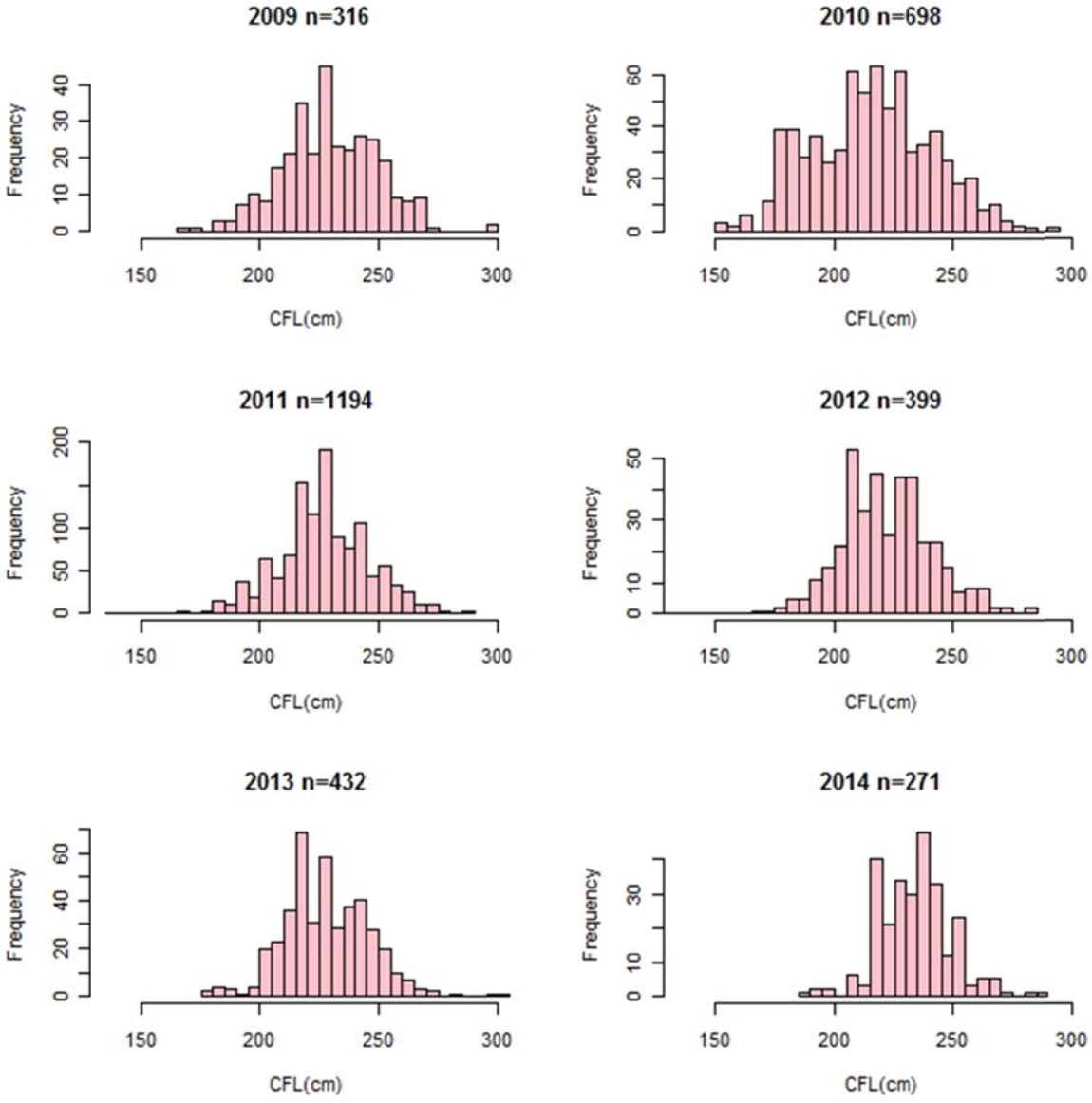

Figure 1. The annual size frequencies of BFT catch by Moroccan Atlantic traps, 2009-2014.

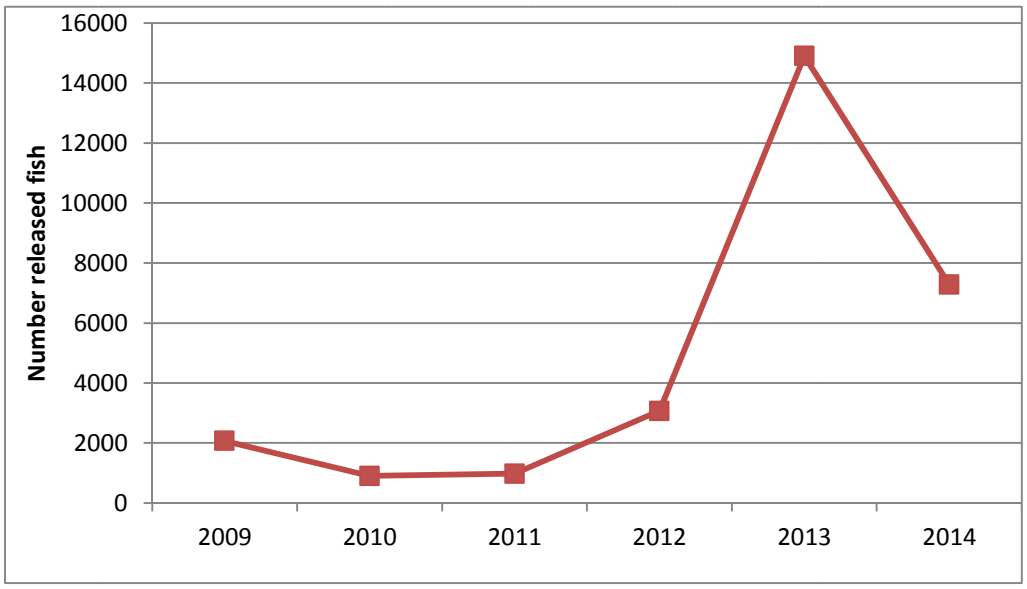

Figure 2. The number of fish released by the four Moroccan Atlantic traps included in the GLM analysis, 2009-2014.

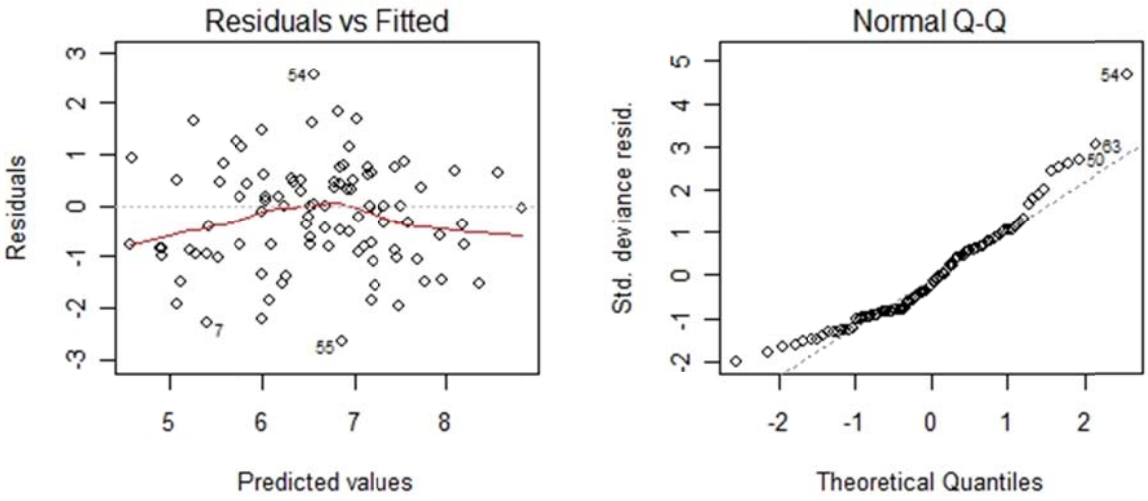

Figure 3. Diagnostic plots: residuals *vs* fitted values and cumulative normalized residual plot.

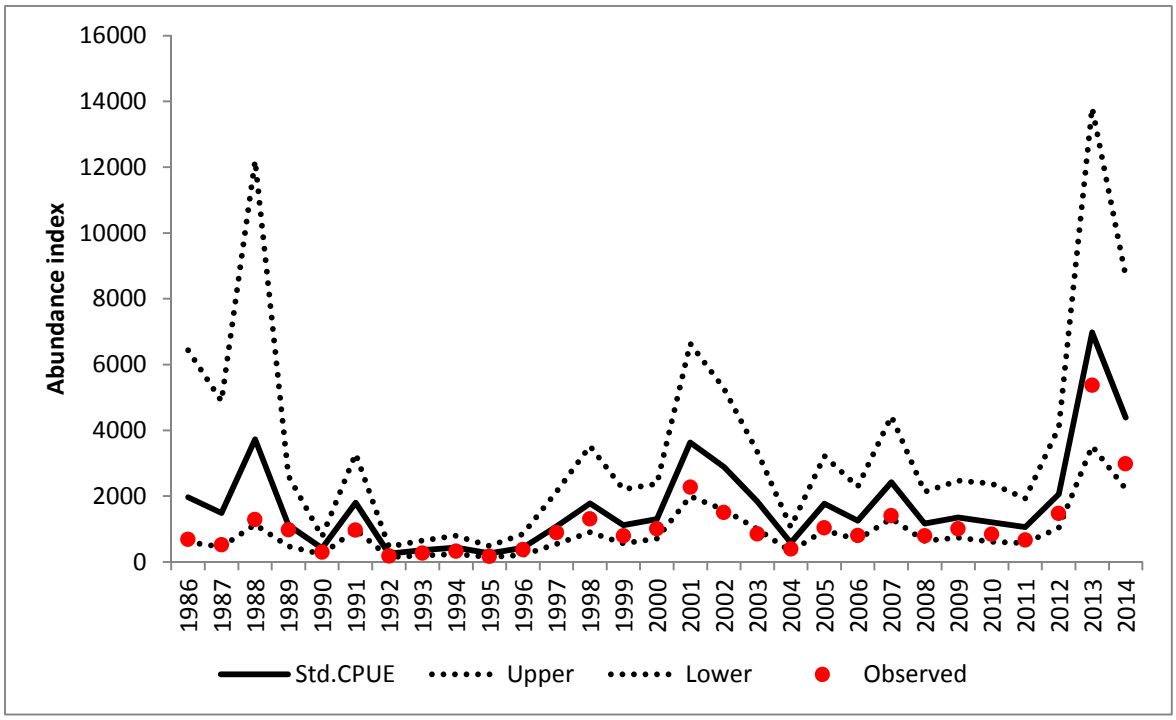

Figure 4. Estimated standardized relative abundance index and corresponding 95% confidence limits Moroccan traps, 1986- 2014.