

## STANDARDIZED CATCH RATES OF ALBACORE (*THUNNUS ALALUNGA* BONNATERRE, 1788) IN THE SPANISH RECREATIONAL FISHERY IN THE WESTERN MEDITERRANEAN IN THE PERIOD 2005-2019

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### SUMMARY

*Catch and effort data from the Spanish recreational fishery in the Balearic Sea (Western Mediterranean) were analysed to estimate an index of relative abundance for albacore for the years 2005-2019. Standardized catch per unit effort (CPUE) in number were estimated through a General Linear Mixed Modeling (GLMM) approach under a negative binomial (NB) error distribution assumption. Nominal catch rates and a standardized abundance index are presented along with estimates of 95% confidence limits of the predicted means. These indices show an upward trend from the start of the series 2005 peaking in 2013; followed by a decrease until 2015. For the latest four-year period (2016-2019), the index shows a relatively stable trend fluctuating around a level two times lower than the maximum abundance recorded in the time series.*

### RÉSUMÉ

*Les données de prise et d'effort de la pêche récréative espagnole opérant dans la mer des Baléares (Méditerranée occidentale) ont été analysées pour estimer un indice d'abondance relative pour le germon pour les années 2005-2019. Des captures par unité d'effort (CPUE) standardisées en nombre ont été estimées par le biais d'une approche de modélisation linéaire généralisée mixte (GLMM) en postulant une distribution d'erreur binomiale négative (NB). Des taux de capture nominaux et un indice d'abondance standardisé sont présentés avec des estimations des limites de confiance de 95% des moyennes prédites. Ces indices affichent une tendance à la hausse depuis le début de la série en 2005, avec un pic en 2013 suivi d'un recul jusqu'en 2015. Pour la dernière période de quatre ans (2016-2019), l'indice affiche une tendance relativement stable fluctuant autour d'un niveau deux fois inférieur à celui de l'abondance maximale enregistrée dans la série temporelle.*

### RESUMEN

*Se analizaron los datos de captura y esfuerzo de la pesquería de recreo española en el mar Balear (Mediterráneo occidental) para estimar un índice de abundancia relativa de atún blanco para los años 2005- 2019. Las capturas por unidad de esfuerzo (CPUE) estandarizadas en número se estimaron mediante un enfoque de modelación lineal mixto generalizado (GLMM) bajo un supuesto de distribución de error binomial negativo (NB). Se presentan las tasas de captura nominal y un índice de abundancia estandarizado junto con estimaciones de los límites de confianza del 95 % de las medias predichas. Estos índices muestran una tendencia al alza desde el inicio de la serie 2005, con un máximo en 2013, seguida de una disminución hasta 2015. Para el último período de cuatro años (2016- 2019), los índices muestran una tendencia relativamente estable que fluctúa alrededor de un nivel dos veces inferior a la abundancia máxima registrada en la serie temporal.*

### KEYWORDS

*Thunnus alalunga, Western Mediterranean Sea, CPUE, recreational fishery*

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## 1. Introduction

Albacore (*Thunnus alalunga*, Bonnaterre, 1788) is a migratory species distributed worldwide between latitudes 50°N and 40°S in the three major oceans (i.e., Atlantic, Indian and Pacific) and in the Mediterranean Sea (Collette and Nauen, 1983). This species is targeted by the Spanish recreational fishery in the Balearic Sea (Western Mediterranean) mainly in June and July, when they are reproductively active (Saber *et al.*, 2015).

The main goal of this study is to estimate the standardized catch per unit effort (CPUE) of albacore caught during its spawning season using the data collected in the fishing tournaments of the Spanish recreational fishery.

## 2. Material and methods

### 2.1. Data collection

Data used in this study were obtained from 23 fishing tournaments of the recreational fishery targeting mainly albacore in June-July for 15 years (2005-2019). The fishing area is located in the Balearic Sea (Western Mediterranean) (**Figure 1**). Further details on the fishing tournaments and fishing characteristics can be found in Saber *et al.* (2015).

Information on the fishing location, the catch (biomass in number of fish and in weight), the size composition of the catch and the number of vessels and rods was collected. Strait fork length (SFL) and round weight (RW) were measured to the nearest 0.1 cm and to the nearest 0.1 kg, respectively. In 2005 and 2006 observers on sports vessels monitored the catch and recorded fish that were not retained. The observers reported that no albacore were discarded during any of the tournaments. In the subsequent years up to 2012, six or seven surveys in each fishing tournament were conducted at landing and also showed that no albacore were discarded.

### 2.2. Catch ratios (CPUE)

A filter was applied to the data in order to use only positive fishing sets. The fishing effort was measured by the number of fishing rods. CPUE observations were expressed in terms of number of fish/ number of rods. **Table 1** summarizes the number of sets for albacore, the total catch by number and kg and effort per year.

Nominal catch rates (number of fish per rod) were standardized through a General Linear Mixed Modeling (GLMM) approach under a negative binomial (NB) error distribution assumption. The NB generalized linear mixed model was parameterized as a rate model in which the fishing effort (number of rods) was implemented as an offset, which reflects the total effort by set over which the count response (number of fish) was generated. The statistically significant factors were: year and the interaction year:month. The interaction year:month was implemented as a random effect. The model fit assessment was based on simulated residuals plots (R DHARMA package; Hartig, 2019). Annual standardized indices were based on least-squares means (SAS Institute, 2012; Hartig, 2019).

The analyses were conducted, and the graphs designed by using R statistical software (R Core Team, 2017). Among others, packages MASS (Venables and Ripley, 2002), DHARMA (Hartig, 2019), emmeans (Lenth, 2018), and ggplot2 (Wickham, 2016) were of particular help.

## 3. Results and discussion

A total of 1282 trips were recorded during the period (2005-2019). A total of 8238 fish of six species were caught; in decreasing order according to the number of individuals caught: albacore (92.0%), skipjack *Katsuwonus pelamis* (6.5%), bluefin tuna *Thunnus thynnus* (0.7), Mediterranean spearfish *Tetrapturus belone* (0.5%), dolphinfish *Coryphaena hippurus* (0.2%) and little tunny *Euthynnus alletteratus* (0.1%). Note here that since 2007 bluefin tuna landings are prohibited. In total, 7515 albacore were measured of the 7580 caught. Their sizes ranged between 55.5 and 105.5 cm SLF (mean  $\pm$  SD = 71.2  $\pm$  7.3 cm).

As regards the adequacy of the model fit, in general, the Q-Q plot (residual uniformity) were very close to linear and, the formal test (K-S) was not statistically significant. The dispersion plot and corresponding test indicates no evidence of dispersion (either over or under). The plots of the standardized quantile residuals against the

explanatory variables in the model were quite flat, i.e., no identifiable patterns were showed. The estimated annual abundance indices, associated standard errors, corresponding coefficients of variation, and the upper and lower limits of a 95% confidence interval (based on a normal approximation) are given in **Table 2** and **Figure 2**.

These indices show an upward trend from the start of the series (2005) peaking in 2013; followed by a decrease until 2015. For the latest four-year period (2016-2019), the index shows a relatively stable trend fluctuating around a level two times lower than the maximum abundance recorded in the time series.

## Acknowledgments

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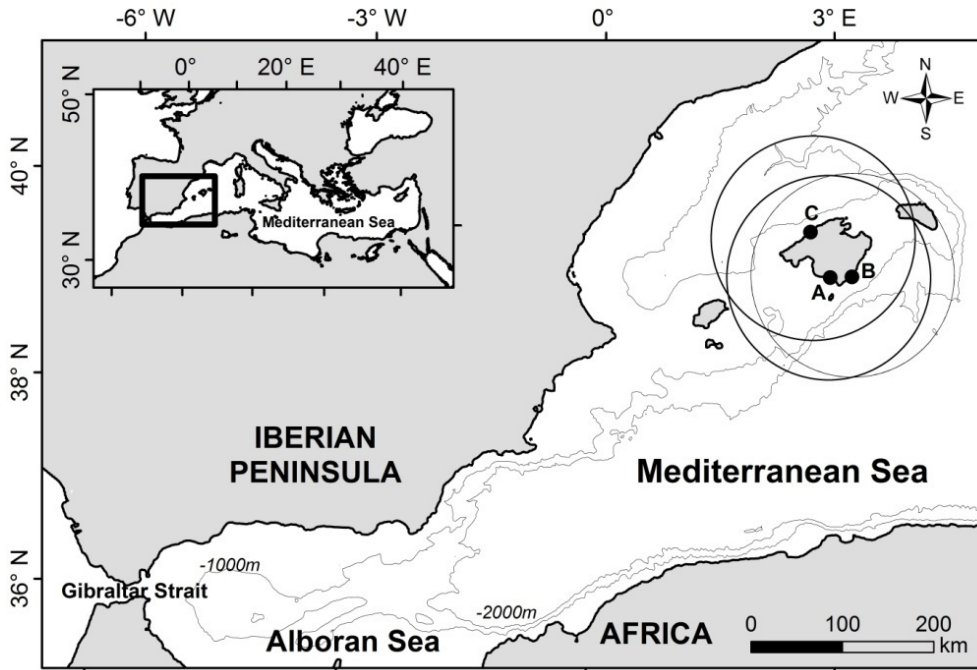
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**Table 1.** Number of sets for albacore, total catch by number and kg and effort from the fishing recreational tournaments in the Western Mediterranean Sea (2005-2019).

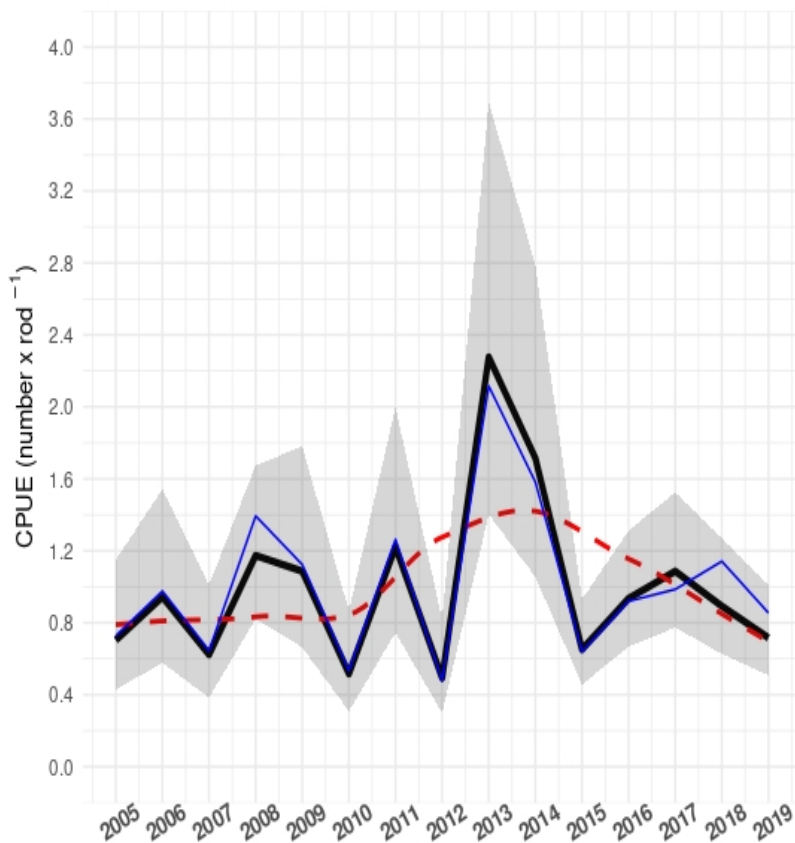
Year	Sets	Catch (n)	Catch (kg)	Effort (rod <sup>-1</sup> )	Nominal CPUE (N rod <sup>-1</sup> )	Nominal CPUE (kg rod <sup>-1</sup> )
2005	64	326	2337.20	448	0.73	5.22
2006	59	403	2195.00	413	0.98	5.31
2007	101	456	3041.54	707	0.64	4.30
2008	73	712	4559.27	511	1.39	8.92
2009	51	401	2783.59	357	1.12	7.80
2010	39	146	1205.60	273	0.53	4.42
2011	57	360	2793.70	285	1.26	9.80
2012	56	187	1488.98	392	0.48	3.80
2013	68	804	6134.88	380	2.12	16.14
2014	68	598	4366.71	378	1.58	11.55
2015	65	291	2218.40	455	0.64	4.88
2016	93	599	4945.60	651	0.92	7.60
2017	111	766	6515.40	777	0.99	8.39
2018	104	831	6563.90	728	1.14	9.02
2019	117	700	5769.70	819	0.85	7.04

**Table 2.** Nominal and standardized catch per unit effort (CPUE) (n ALB\*rod<sup>-1</sup>).

Year	Nominal CPUE	Standardized CPUE	std.err	lower.cl	upper.cl	cv
2005	0.73	0.70	0.18	0.43	1.15	0.25
2006	0.98	0.94	0.24	0.58	1.54	0.25
2007	0.64	0.62	0.15	0.38	1.01	0.25
2008	1.39	1.17	0.21	0.82	1.68	0.18
2009	1.12	1.09	0.27	0.66	1.78	0.25
2010	0.53	0.52	0.14	0.31	0.87	0.26
2011	1.26	1.22	0.31	0.75	2.00	0.25
2012	0.48	0.49	0.13	0.30	0.82	0.26
2013	2.12	2.28	0.56	1.40	3.69	0.25
2014	1.58	1.71	0.42	1.05	2.79	0.25
2015	0.64	0.65	0.12	0.46	0.93	0.18
2016	0.92	0.94	0.16	0.67	1.31	0.17
2017	0.99	1.09	0.19	0.77	1.52	0.17
2018	1.14	0.89	0.16	0.63	1.27	0.18
2019	0.85	0.72	0.13	0.51	1.01	0.17



**Figure 1.** The Western Mediterranean Sea showing the fishing grounds of recreational fishery (circles around the base ports) during the fishing tournaments. Base ports: A, S'Estanyol; B, Cala D'Or; C, Sóller.



**Figure 2.** Standardized CPUE and corresponding 95% confidence limits (normal approximation) for albacore from the recreational Spanish fishery in the Western Mediterranean Sea (2005-2019). Solid black line, standardized CPUE; solid blue line, nominal CPUE; dotted red line, loess fit.