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CATCH RATES AND CATCH STRUCTURES OF THE BALFEGÓ PURSE SEINE FLEET IN BALEARIC WATERS FROM 2000 TO 2015; THREE YEARS OF SIZE FREQUENCY DISTRIBUTION BASED ON VIDEO THECNIQUES

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SUMMARY

This study standardized the daily catch of the Balfegó joint fishing fleet from 2003 to 2015 and updated the unstandardized CPUE of the Balfegó purse seiners: both series are contrasted with the Japanese longline standardized CPUE series. The results showed that the unstandardized series is the only one that correlates with the Japanese index (r = 0,92). The age structure estimated from video techniques measured over the period 2013-2015 is consistent, showing that at the end of May in the Balearic grounds the fully recruited age is 11 years. The results were indicative that the 2002 year class was stronger than the 2003 or 2004 classes. We conclude that the unstandardized CPUE series of Balfegó vessels are a reliable abundance index of the ABFT eastern population and should be considered in the next assessment. Nevertheless, at present this statement should not be inferred to purse seiners' catch rates from other Mediterranean regions.

RÉSUMÉ

Cette étude a standardisé la prise quotidienne de la flottille de pêche conjointe de Balfegó de 2003 à 2015 et mis à jour la CPUE non standardisée des senneurs de Balfegó : les deux séries sont comparées aux séries de CPUE standardisées des palangriers japonais. Les résultats ont montré que la série non standardisée est la seule qui soit en corrélation avec l'indice japonais (r = 0,92). La structure démographique estimée à partir des techniques vidéo pendant la période 2013-2015 est cohérente, montrant que l'âge de plein recrutement, à la fin du mois de mai dans les zones Baléares, est de 11 ans. Les résultats indiquaient que la classe d'âge de 2002 était plus forte que les classes d'âge de 2003 ou de 2004. Nous concluons que les séries non standardisées de CPUE des navires de Balfegó constituent un indice d'abondance fiable de la population de thon rouge de l'Atlantique Est et qu'elles devraient être considérées dans la prochaine évaluation. Néanmoins, cette affirmation ne devrait pas à l'heure actuelle s'appliquer aux taux de capture des senneurs provenant d'autres régions méditerranéennes.

RESUMEN

Este estudio estandarizaba la captura diaria de la flota pesquera conjunta de Balfegó desde 2003 hasta 2015 y actualizaba la CPUE no estandarizada de los cerqueros de Balfegó: ambas series se comparan con la serie de CPUE estandarizada del palangre japonés. Los resultados demostraron que la serie no estandarizada es la única que se corresponde con el índice japonés (r = 0,92). La estructura por edad estimada por medio de técnicas de vídeo para el periodo 2013-2015 es coherente, demostrando que a finales de mayo en los caladeros baleares la edad de pleno reclutamiento es 11 años. Los resultados eran indicativos de que la clase anual de 2002 es más fuerte que las clases de 2003 o 2004. Se concluye que las series de CPUE no estandarizadas de los buques de Balfegó son un índice de abundancia fiable de la población oriental de atún rojo del Atlántico y deberían considerarse en la próxima evaluación. No obstante, actualmente esta afirmación no debería aplicarse a las tasas de captura de cerqueros de otras regiones del Mediterráneo.

KEYWORDS

Bluefin tuna, Stock abundance, Mediterranean,
CPUE standardization, Catch at age, Video techniques

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Introduction

The upcoming assessment of Atlantic bluefin tuna will be improved by incorporating better-quality data and by enhancing their spatial representativeness. It should be borne in mind that the eastern stock of ABFT is mostly harvested in Mediterranean waters. In 2013, according to the catches reported and recorded in the ICCAT data base, 65.6 % of the eastern stock was harvested in the Mediterranean Sea and 92% of it was caught by purse seiners. Despite this, all the indices used for the eastern stock comes from Atlantic fisheries due to the length of their time series. However, the historical time series are losing spatial representativeness or continuity. The Spanish bait boat and trap fisheries are losing continuity, the Spanish traps data is being replaced by a mix index; Moroccan traps + Spanish traps and entirely Moroccan in the most recent years. Consequently, the third historical fishery index, the Japanese longline fishery data, is becoming unique and essential because of its length and continuity. Although fishing patterns and areas of this fishery have changed in recent years, the abundance indices of this fishery are still very reliable as a result of the continuous improvement in the standardization of catch rates (Kimoto 2014). Nevertheless, it has been strongly recommended to develop reliable indices for other major fisheries such as the Mediterranean purse seiners (Kimoto 2014, Gordoa 2014).
For several years the annual catch rates of Balfegó purse seiners have been presented (Gordoa 2014; Gordoa 2013; Gordoa 2012; Gordoa 2010) with the aim of being accepted and included as an additional index of the ABFT eastern stock. However, it has been systematically rejected because the index was not standardized. Thus, in this study the daily catch of the Balfegó joint fishing fleet from 2003 to 2015 was standardized and the unstandardized CPUE of Balfegó purseiners was updated, both series representing exclusively the catch harvested in Balearic waters. We contrast both series with the Japanese longline standardized CPUE series (Kimoto *et al* 2014), a reference index of the eastern stock and also a reference for assessing the reliability and representativeness of the estimated indices in Balearic waters. Additionally, the CPUE of Tunisian purse seiners (Raffik and Missaoui, 2015) were also included to contrast the temporal dynamic of ABFT catch rates in Balearic waters with those from the Central Mediterranean.

Material and Methods

The Balfegó purse seiners' annual catch rates are estimated by dividing the total catch (kg) of the Balfegó vessels by the total number of days in the Balearic fishing ground over the period 2000-2015. This CPUE series are not standardized and we split it into two: the first one over the whole spawning fishing season (Balfegó index 1) and the second considering the period until the 8th of June (Balfegó index 2), which is more representative of the fishing season in the most recent years (**Table 1**) (more details in Gordoa 2010). The particularity of these two vessels is the consistency of their fishing spawning ground, always the Balearic waters during the study period.

More detailed data is reported since 2006, the daily catch, haul by haul, for the whole Balfegó joint fishing fleet. For this study the data has been completed since 2003 with a total of 262 hauls. The daily catch per vessel has been used for the CPUE standardization for the period 2003 -2015.

In the CPUE standardization, fishing year, vessel, month and average individual weight were preliminarily considered as main effects. The effect of an aerial survey was not considered because it was forbidden in June, which at that time was the main or even the only month of active fishing in the spawning ground.

Ln CPUE = Intercept + Main effects (month, vessel, BFT weight, year) + error

where Ln CPUE indicates the natural logarithm of daily catch rate per vessel. The final model only included the effects which were significant ($p<0.001$). Subsequently, the annual standardized CPUE was compared with the standardized CPUE of the Japanese longline fleet and the Balfegó unstandardized CPUE series.

The length frequency distribution of catches from 2013 to 2015 was based on the individual length estimated by video techniques carried out by Spanish fisheries inspectors at the time of transferring tuna from the transport vessels to the fattening facilities. The measured subsample represented 17.9% of the tuna transferred in 2013 and 20% in 2014 and 2015. The annual catch at age was estimated by applying the inverse of the von Bertalanffy growth length at age equation estimated by Cort (1991) for the East Atlantic - Mediterranean stock and adopted by ICCAT (2010).

Additionally and independently, the annual average individual weight was estimated from the skipper's estimation of tuna size of each haul over the period 2003-2015. In order to assess the reliability of this time series, the annual individual weight estimated over the last three years was compared with the most precise estimations measured by video techniques. These estimations were also compared with the annual individual weight recently reported for Tunisian purse seine fleet (Raffik and Missaoui, 2015).

Results

Annual Catch Rates (CPUE)

The results of the GLM model with the above-mentioned possible effects showed that none were significant except the year (**Table 2a**). Accordingly, the GLM was reduced to the year effect (**Table 2b**): this model merely explained 22% of CPUE variability (R=0.56). The standardized CPUE of the Balfegó joint fishing fleet and the non-standardized CPUE of the Balfegó vessels (**Figure 1**) only showed similar trends in the last three years. The trend of the standardized indices was unreliable and was not observed in any other fishery. Accordingly, with standardized values, CPUE has declined since 2003, reaching the minimum value in 2012, and by 2013 the index was slightly above the one estimated in 2003.

The CPUE of updated and split Japanese longline series were used as the reference of ABFT abundance index. Both series correlated significantly with the unstandardized Balfegó CPUE series (**Table 3**), with a notable correlation between Balfegó index 2 and the Japanese split standardized series (r=0.92). In contrast, the standardized Balfegó index does not correlate with the Japanese LL index and should be rejected as a reliable abundance index. This index is estimated from the haul-by-haul data base, so there is no information of days at sea without catch. Consequently, fishing effort is underestimated and inversely proportional to abundance: less abundance implies more searching time and more fishing days without catch and consequently the index overestimate catch rates.

The fact that the Balfegó unstandardized index and the Japanese standardized ones are highly correlated, despite their differences (geographical and seasonal coverage) but also because of them, mutually reinforce each other as reliable indices of ABFT population. Thus, we presume that the Balearic spawning ground is an optimal spatio-temporal site to take the pulse of the ABFT eastern population as revealed by the purse seiners' catch rates. At present, and with the available knowledge, we cannot extend this statement to purse seiners' catch rates of other Mediterranean regions.

The results of electronic tagging deployed in the Atlantic region are indicative that their spawning migration never reaches the Eastern Mediterranean (e.g. Block *et al*., 2001; Block *et al*., 2005; Stockesbury *et al*., 2011; Wilson *et al*., 2011), and tags deployed in the Levantine Sea did not leave the Mediterranean (Demetrio *et al*., 2003; Demetrio *et al.* 2005), so there are no grounds for considering that catch rates of purse seiners in the Levantine Sea are representative of the Eastern Atlantic population. Thus far, all the tuna tagged during the spawning season in the Balearic spawning grounds migrate to the Atlantic after spawning (Demetrio 2005; Aranda *et al*., 2013), so we consider that most of the Balearic spawners come from the Atlantic feeding grounds. With regard to the Central Mediterranean spawning ground, we cannot discard a mix of spawners: from Atlantic feeding grounds, as revealed by the presence of tuna tagged in the Atlantic (Block *et al*., 2001; Block *et al*., 2005; Stockesbury *et al*., 2011) and also spawners that might not leave the Mediterranean (Demetrio *et al*., 2005). Briefly, all these results showed that the eastern spawners did not leave the Mediterranean, the western all of them and an undetermined fraction of spawners in the central region. Nevertheless, we presume that a fraction of spawners in the western can also be Mediterranean residents, but a minor fraction as to date none has been observed. We strongly recommended deploying tags on tuna caught by purse seiners (spawning schools) in the three Mediterranean areas for the purpose of determining the fraction of spawners of Atlantic grounds in each region.

Catch Structure

The catch at age of the Balfegó joint fishing fleet over the period 2013-2015, based on video technique measurements, revealed a consistent age structure with modal age around 11 years (**Figure 2**). There is a notable strength of the 2002 year class (modal age in 2013 and 2014). In contrast, in the Japanese longline fleet the 2003 class was considered the strongest. The left side of the age distribution (upward trend) is indicative of the age selectivity pattern recruited to the Balearic spawning ground at the beginning of the spawning season. The catch age structure at the beginning of the spawning season should not be inferred to the whole spawning season because the arrival of spawners is sequential and by size, the bigger ones are the first arriving in and leaving the Mediterranean (Rodriguez-Roda 1964).

The annual average individual weight estimated visually by Balfegó skippers is slightly biased, higher than the weight estimated from video camera measurements (**Figure 3**). Nevertheless, the trends of both estimations are similar while the average weight of the Tunisian fleet showed differences in trends and weights, with much smaller individuals.

Conclusions

The results showed that the unstandardized CPUE series of Balfegó vessels are indicative of the relative abundance of ABFT spawners in Balearic grounds and also a reliable abundance index of the ABFT eastern population. Nevertheless, at present the same cannot be inferred to purse seiners' catch rates from other Mediterranean regions and should be rejected for the Levantine Sea.

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Table 1. Annual profile of purse seiners regulatory measures in the Mediterranean and Balfegó fishing season in Balearic grounds.

Year	**Start of closure period**	**Aerial survey**	**Minimum size (kg.)**	**First and last fishing dates**
2000	16 July	Forbidden in June	6.4	
2001	16 July	Forbidden in June	6.4	
2002	16 July	Forbidden in June	6.4	
2003	16 July	Forbidden in June	6.4	1 June- 9 July
2004	16 July	Forbidden in June	6.4	1 June - 30 June
2005	16 July	Forbidden in June	10	12 June -3 July
2006	16 July	Forbidden in June	10	4 June - 11 July
2007	1 July	Forbidden in June	10	2 June - 30 June
2008	1 July (closed by 23 June)	Forbidden	30	2 June - 21 June
2009	15 June (+5)	Forbidden	30	21 May - 13 June
2010	15 June (closed by 8 June)	Forbidden	30	24 May - 8 June
2011	15 June	Forbidden	30	22 May - 9 June
2012	15 June	Forbidden	30	18 May - 26 May
2013	25 June	Forbidden	30	26 May - 2 June
2014	25 June	Forbidden	30	26 May - 27 May
2015	25 June	Forbidden	30	26 May - 1 June

Table 2. Statistical results from GLM analysis for CPUE of Balfegó joint fishing fleet in the period between 2003-2015, a) complete model (R^2 = 0,25) and b) final model (R^2 = 0,22).

(a) Complete Model

Effect	SS	DF	MS	F	p
year	44.36	12	3.70	3.97	<0.0001
vessel	7.35	11	0.67	0.72	0.72
month	1.96	2	0.98	1.06	0.35
Avg. W	1.37	1	1.37	1.48	0.23
Error	219	235	0.93		

(b) Final model

Effect	SS	DF	MS	F	p
year	63.81	12	5.32	5.77	<0.0001
Error	229	249	0.92		

Table 3. Correlation between Japanese abundance index and Balfegó CPUE series standardized and unstandardized.

	Balfegó S1	*Balfegó S2*	*Std Balfegó fleet*
Std. LL JP	0.80**	0.84**	0.38
Std LL Jp split	0.89**	0.92**	0.52
Std Balfegó fleet	0.69*	0.72*	
Balfegó S2	0.99**		

****(p<0,001) *(p<0,001)**

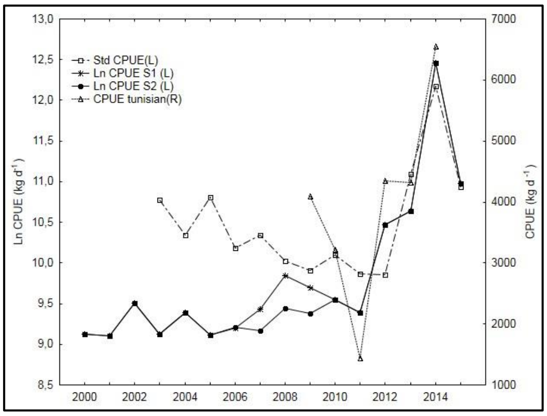

Figure 1. CPUE Mediterranean purse seiners series: western-Med unstandardized (Balfegó S1 and S2), western-Med standardized (Std CPUE) and Central-Med (CPUE Tunisian).

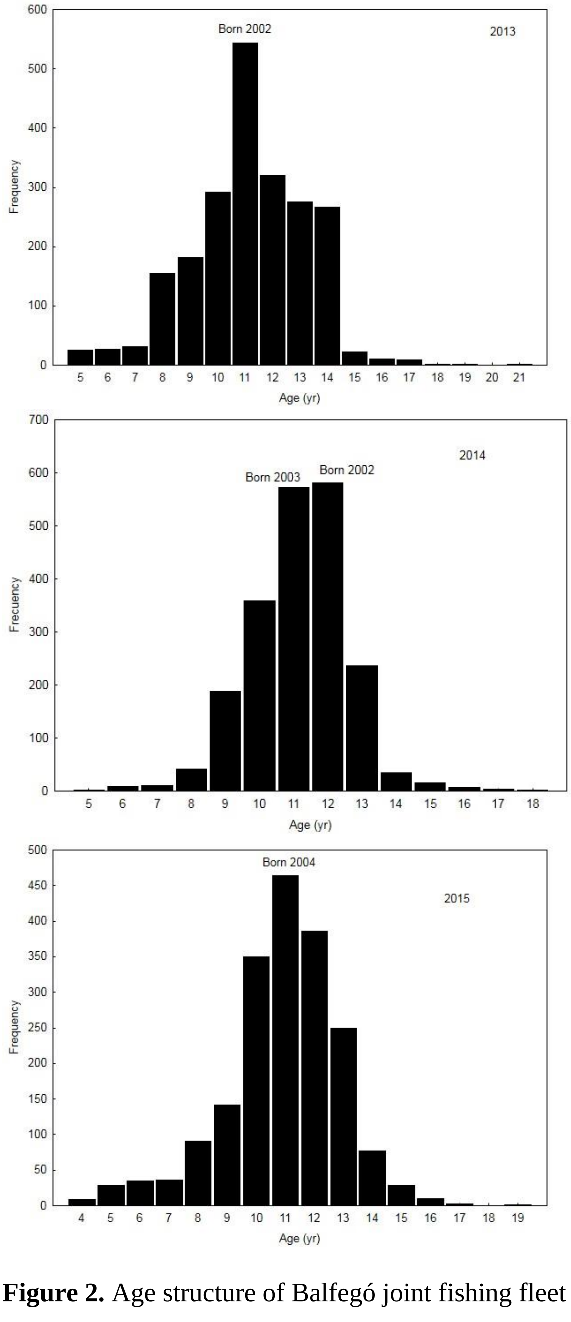

Figure 2. Age structure of Balfegó joint fishing fleet catch (2013-2015).

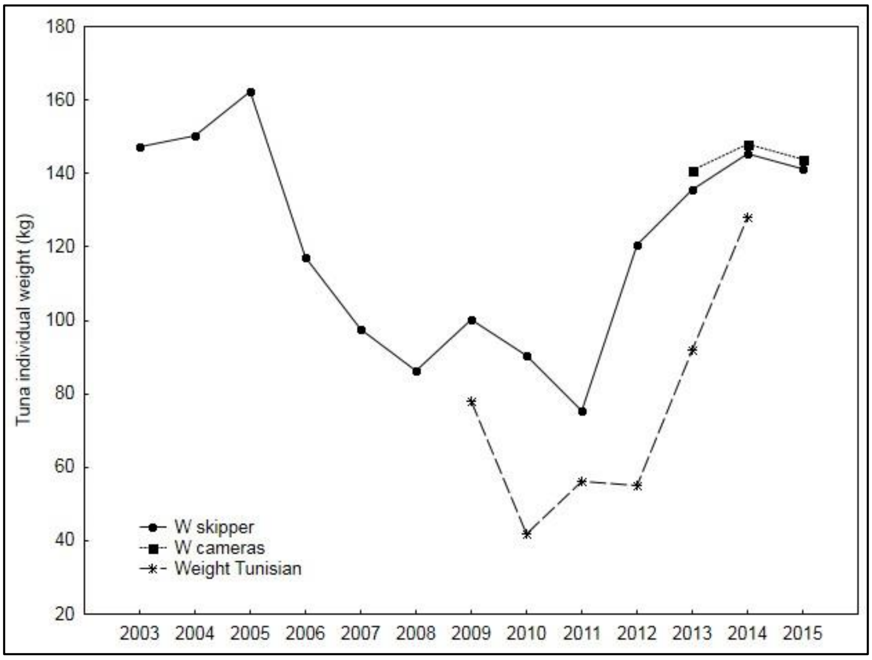

Figure 3. Annual individual weight of ABFT caught by the Balfegó joint fishing fleet in Balearic grounds and by Tunisian purse seiners in the Central Mediterranean region.