AGE AND GROWTH OF MEDITERRANEAN ALBACORE

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SUMMARY

This study presents age and growth parameters of albacore Thunnus alalunga *from the Mediterranean Sea, derived on the basis of dorsal fin spine section readings. 379 specimens were collected during the period 2003 – 2016 in the Southern Ionian Sea and Ligurian Sea in the framework of different research programs funded by the EU and the Italian Government. The albacore length ranged between 22 cm and 99 cm FL. New growth parameters estimates were compared with other studies carried out in the past on Mediterranean albacore.*

RÉSUMÉ

*Cette étude présente les paramètres d'âge et de croissance du germon (*Thunnus alalunga*) de la Méditerranée, calculés sur la base de lectures de sections de l'épine de la nageoire dorsale. 379 spécimens ont été recueillis entre 2003 et 2016 dans le Sud de la mer Ionienne et dans la mer de Ligure dans le cadre de différents programmes de recherche financés par l'UE et le gouvernement italien. La taille du germon oscillait entre 22 et 99 cm FL. De nouvelles estimations de paramètres de croissance ont été comparées avec d'autres études sur le germon de la Méditerranée réalisées par le passé.*

RESUMEN

En este estudio se presentan los parámetros de crecimiento y edad del atún blanco (Thunnus alanlunga) del mar Mediterráneo, calculados a partir de las lecturas de la sección de la espina de la aleta dorsal. Se recogieron 379 ejemplares durante el periodo 2003 a 2016 en el mar de Liguria y el mar Jónico meridional en el marco de diferentes programas de investigación financiados por la UE y por el gobierno italiano. La talla del atún blanco osciló entre 22 cm FL y 99 cm FL. Se compararon las nuevas estimaciones de parámetros de crecimiento con otros estudios sobre atún blanco del Mediterráneo realizados en el pasado.

KEYWORDS

Thunnus alalunga, albacore, age, growth, Mediterranean

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1. Introduction

Albacore *Thunnus alalunga* (Bonnaterre, 1788) is widely distributed in tropical and temperate waters, including the Mediterranean Sea. In the ICCAT area three different stocks has been identified and are separately managed: North Atlantic, South Atlantic and Mediterranean. About the Mediterranean stock, the distribution of albacore fisheries and catches in the Mediterranean shows higher traditional activities in the Tyrrhenian Sea, around Sicily, Ionian, Adriatic, Aegean Sea and Balearic Islands area; in the last 10 years total Mediterranean catches ranges from 1,500 to more than 6,000 tons, without any evident trend. The Italian albacore fishery is the most important in the area and produces the main bulk of the catches. Age and growth parameters are fundamental in the process for the assessment of the status of the fished stocks. Some studies were published in the past investigating these parameters, on the basis of the analysis of hard parts, such as scales (Arena, 1990; Arena *et al.*, 1980; Cefali *et al*., 1986; Megalofonou, 1990; Megalofonou *et al*., 2003) and spines (Megalofonou, 2000; Quelle *et al.*, 2011). In the framework of different projects on large pelagic fish funded by EU and Italian Government we had the opportunity to collect samples in order to investigate some aspects of the biology of the albacore *T. alalunga* along the Italian coasts. The main objectives of this study is to extrapolate a growth function for the Mediterranean albacore that could be useful for management purposes.

2. Material and methods

A total of 379 albacore dorsal fin spines were collected in the central and north western Mediterranean Sea. Two different sets of samples were available:

- 300 spines collected by scientific observers directly onboard Sicilian vessels using albacore longline in Southern Ionian Sea on August 2003;
- 79 spines collected at landing in the Ligurian Sea over a period of 10 years (2006-2016) from specimens caught by SSD targeting albacore, as by-catch of the swordfish longline fishery and a small sample of YOY (8 specimens) collected on August 2015 by SPS fishery targeting anchovies and sardine.

The dorsal fin spines were prepared following the methodology described by Bard and Compean-Jimenez (1980). Sections (0.5 mm thick) were obtained using an ISOMET low speed saw; three consecutive cross cuts were made starting from the base of each spine condyle. Sections were later analysed under a dissection stereo microscope, both in reflected and transmitted light. All sections were photographed and images were digitalized for later analysis.

Three different age readings were carried out for each section by two experienced independent readers; only the coincident age estimates were considered as valid and used for subsequent analysis.

The traditional Von Bertalanffy model was applied and growth performance indexes ($\Phi' = \ln k + 2\ln L_\infty$) were calculated to compare the results of the present VBGF with other studies in the Mediterranean Sea.

3. Results

A total of 379 albacore spines were processed: details of the samples are reported in **Table 1**. The length/frequency distribution of the analyzed specimens divided by sampling area is shown in **Figure 1**. The Ligurian sample has a mean length (75.5 cm FL) higher than the Ionian one (64.9 cm FL); this difference between the two areas is due to the different selectivity pattern of the gear used. Out of 379 specimens sampled, 307 spines (81%) had at least three coincident readings of the four performed; the Ligurian sample, composed by larger specimen, had a lower agreement (62 out of 79; 78.5%) than the Ionian one (245 out of 300 - 81.7%); this is due to the fact that in larger specimens the interpretation of growth bands is more difficult and the variability in age readings, also if performed by trained researcher, could be higher. The estimated ages ranged between 0 and 10 years for the Ligurian sample and 1 to 7 years from the Ionian sample. The age/length key derived by age readings is reported in **Table 2**, along with numbers, mean FL at age and SD for each age group. The VBGF were the following:

$$L_\infty = 89.24,\ k = 0{,}31 \text{ and } t_0 = -1.49$$

The derived growth curve is reported in **Figure 2.**

4. Discussion and conclusion

The wide range of sizes analyzed in our sample has allowed to extrapolate a growth curve that includes individuals from 0 to at least 10 years old. The presence of YOY during summer in 2015 in the Ligurian Sea was probably due to the rise of the SST which extraordinary hot in that year. These environmental factors probably has favored the reproductive activity, bringing to the presence of a large amount of juveniles and therefore to a very abundant cohort, as has been observed for BFT (Di Natale *et al.,* 2016).

The albacore shows a very fast growth in the first year of life, when it reaches and exceeds 50 cm FL (in the early months it grows at a speed similar to that of a BFT; in fact it was possible to find YOY of the two species schooling together at the end of summer months. After this phase, the growth rate slows down considerably, in the interval between 2 to 5 years (**Figure 2**) raising again in the following ages. This may be related to the achievement of sexual maturity. All the curves obtained in the past in the Mediterranean are very similar, although age determination has been performed following different methods (scales or fin ray spines). In **Table 3** and **Table 4** a comparison among the results obtained during this study and other studies carried out in the past in the Mediterranean Sea is reported, both for the mean FL at age and the VBGF parameters, while all the available von Bertalanffy growth curves for the Mediterranean are shown in **Figure 3**.

The growth curve that mostly differs from the others is that published by Arena (1980); it was obtained studying increments on scales, which probably underestimates the ages, and has the smallest size range.

Other data that might be helpful to implement the observations on age and growth of the Mediterranean albacore are published in Di Natale *et al.,* (2011), reporting data from samples collected in the southern Italian seas. Even if authors didn't extrapolated a growth curve, readings of the dorsal spine sections of a large number of specimens are available in the text; ages appear to be underestimated if compared with other studies and more similar to the results obtained by Arena (1980).

However, considering all the studies known so far in the literature, there are no individuals aged older than 11 years (95cm FL), although we know that larger specimens belonging to the Mediterranean population were captured. This is due to a possible lack in sampling activities or it could be linked to the readability of spine sections. As far as age determination and growth band interpretation is concerned, the reading of albacore spine sections is difficult (i.e. much more than in BFT) and this is particularly true for the oldest specimens.

The main problems are:

1. the correct interpretation of multiple bands (double or triple bands) that are frequently observed in sections.

2. the possibility that in older individuals some bands could be reabsorbed in the central vascularized part of the spine (just like it happens in BFT), which could cause underestimation of ages; this could also explain the presence of an "inflection" in growth ratio observed between ages 2 and 5 that may be related to the "loss" of a growth band due to reabsorption.

3. the difficulty in reading and interpretation of spine sections from large individuals (i.e. in the present study the largest individuals of the sample (99 cm FL) was discarded given that spine sections were absolutely unreadable).

Taking into account these considerations, it is possible that the maximum age of the Mediterranean albacore might be greater than it has been estimated so far. Although otoliths are normally used in studies on age and growth of many tuna species and also for Pacific albacore (Wells *et al.,* 2013), for the Mediterranean this was done as a limited extent. As suggested also by Davies *et al*. (2008), it would be useful to perform age estimation using both otoliths and spines, trying to solve the problems in the interpretation of growth bands and to better understand the growth patterns of the Mediterranean albacore.

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Table 1. Main characteristics of the studied material.

Area	Sampling period	N	FL (cm) min-max	Fishing gears
Ligurian Sea	20/06/2006 to 16/09/2016 (summer months)	79	22 - 99	SSD SWO LL SPS
S. Ionian Sea	02 August 2003 – 04 August 2003	300	51 - 82	ALB LL

Table 2. Age/length key derived by the analysis of the first fin dorsal ray.

	Age (years)										
FL(cm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
22	2										
23	1										
24	1										
32	2										
33	1										
37	1										
52		2									
53		8									
54		12									
55		10									
56		14									
57		8									
58		3									
59		2	4	1							
60			7	1							
61		1	3	3							
62			11	4							
63		1	15	2							
64			8	3							
65			8	3	1	1					
66			8	7	4	1					
67			3	6	5	1					
68			2	6	7	3					
69			1		13	1					
70				2	5	4					
71					1	3					
72				2	4	2					
73					5	3					
74					2	4					
75					3	2		1			
76						2	1				
77					1		3	1			
78					1	2		1	1		
79							2	1			
80						1		3			
81						1	1		1		
82							4	2		1	
83						1					
84								1	1	1	1
85								2			

86								1	2		
87								1	1		
88								1			
89								1	1		
90								1		1	
91										1	1
92											1
93								1			
94											
95										1	
Total	8	61	70	40	52	32	11	18	7	5	3
Mean FL at age	28.4	55.6	63.4	65.6	70.1	72.7	79.5	83.3	84.4	88.4	89.0
Standard deviation	5.9	2.0	2.3	3.2	3.0	4.2	2.4	4.9	3.8	5.3	4.4

Table 3. Mean FL at age derived from different studies in the Mediterranean Sea.

Age	Present study	Arena 1980	Megalofonou 2000	Megalofonou *et al.* 2003	Quelle *et al.* 2011	Di Natale *et al.* 2011
0	28.4	38.3	40	-	-	-
1	55.6	45	59.5	56.6	56.7	58.1
2	63.4	66.3	65.8	65.4	63	67.0
3	65.6	75.4	69.8	69.4	64.1	74.0
4	70.1	78.1	74.4	74.3	70.5	82.6
5	72.7	-	79.3	78.2	74.3	98.0
6	79.5	-	81.2	82.8	78.3	-
7	83.3	-	85.5	-	81.6	-
8	84.4	-	92	-	84.5	-
9	88.4	-	-	-	87	-
10	89.0	-	-	-	88.7	-
11	-	-	-	-	92	-

Table 4. Von Bertalanffy growth parameters and growth performance indexes (Φ') of albacore in the Mediterranean Sea.

Authors	Methods	L_∞	k	t_0	Φ'
Present study	Spines	89.24	0.31	-1.49	7.82
Arena (1980)	Scales	98.50	0.41	-0.63	8.3
Megalofonou (2000)	Spines	94.70	0.26	-1.35	7.7
Megalofonou,*et al.* (2003)	Scales	86.00	0.37	-0.76	7.9
Karakulak *et al*. (2011)	Spines	93.20	0.30	-1.21	7.8

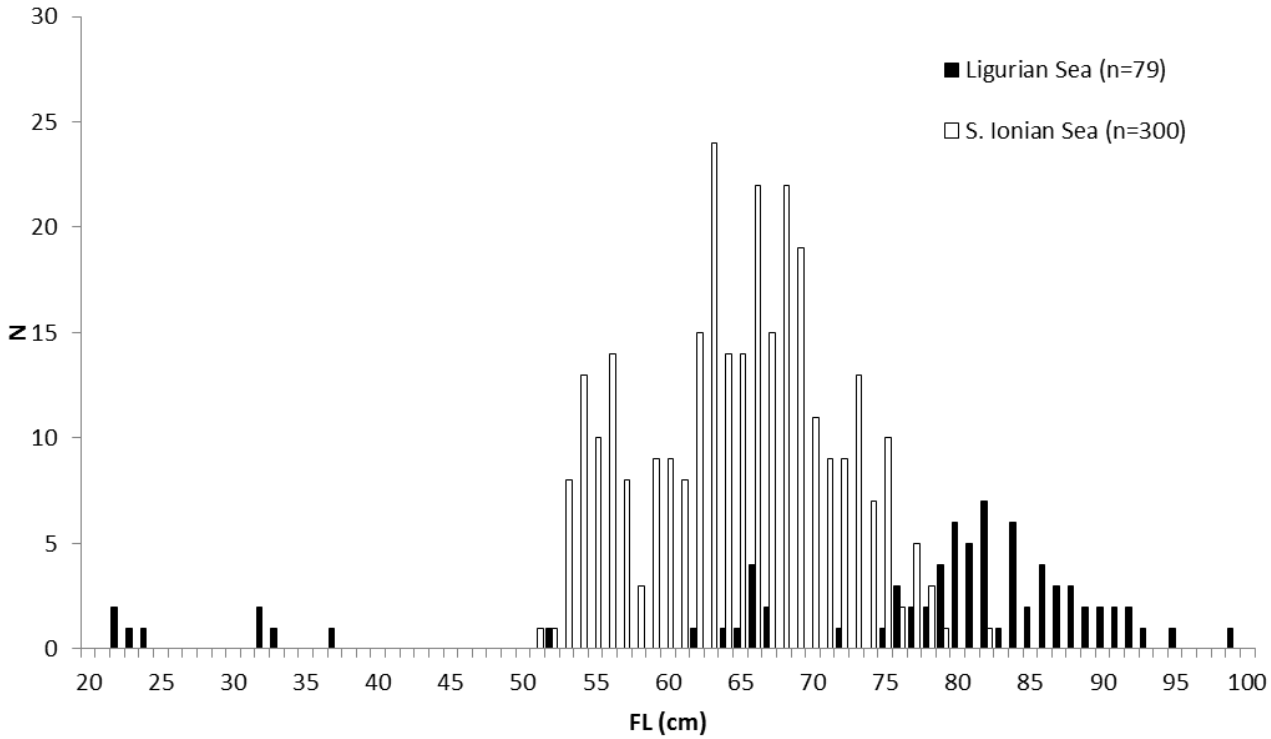

Figure 1. Length frequency distribution of total albacore samples separated by area.

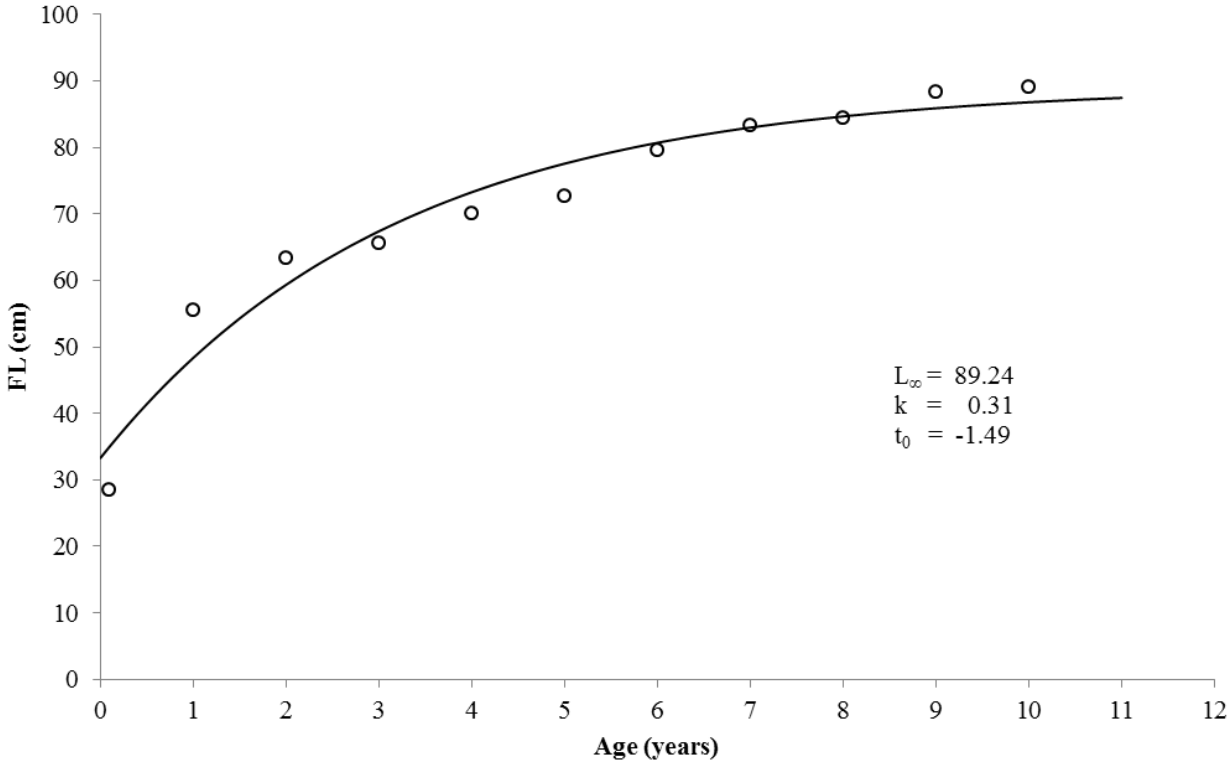

Figure 2. Proposed VBGF for the Mediterranean albacore; dots represent mean lengths at age.

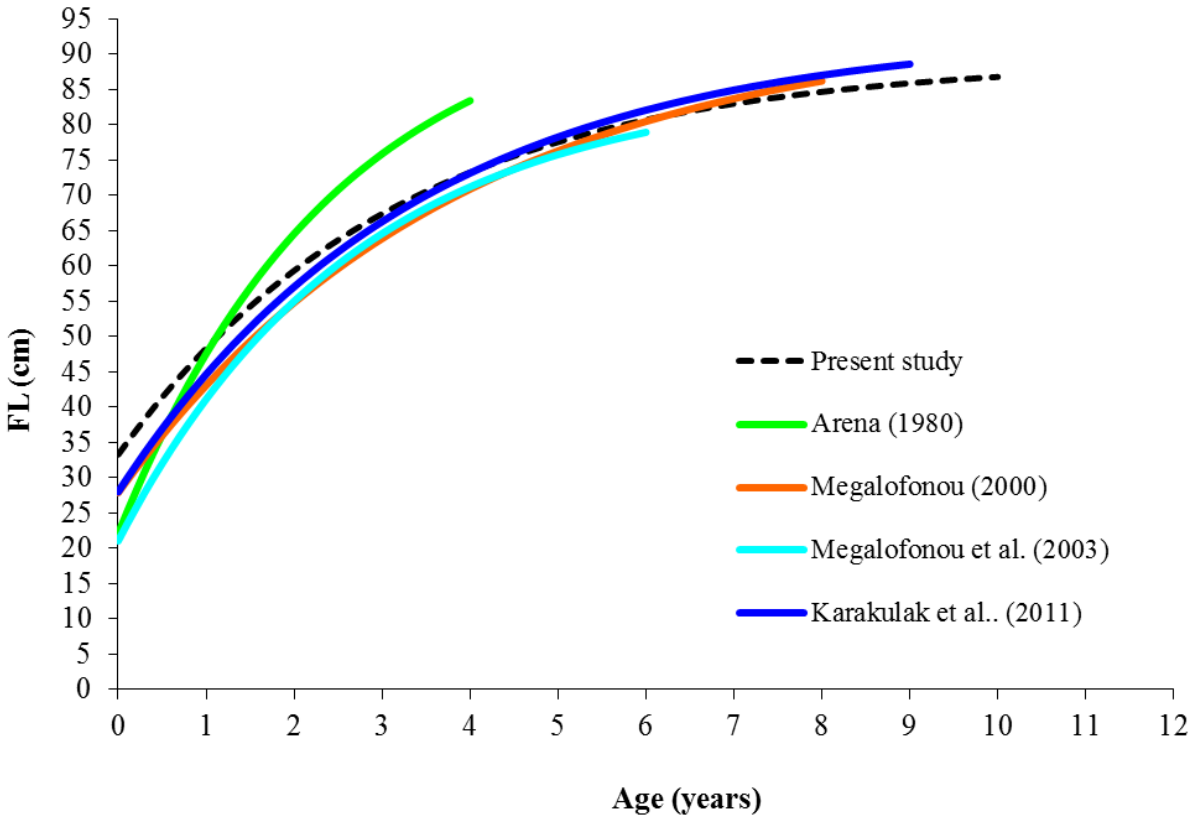

Figure 3. Von Bertalanffy growth curves for the Mediterranean Sea.