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Age and growth of Mediterranean albacore

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Estimated ages of 1136 individual albacore *Thunnus alalunga* (57–92 cm L_F) from the Aegean and Ionian Sea ranged from 1^+ to 9 years. Males grew faster and reached a greater size and age than females. No significant differences were found in the mean lengths at estimated ages between the two sampling areas. The von Bertalanffy growth model was fitted to mean lengths of estimated ages of individual fish and estimated growth parameters for the combined sexes were: L_∞=94·7 cm, K=0·258, to= − 1·354 years. Significant differences were found when the Mediterranean albacore growth parameters were compared with those determined for Atlantic Ocean albacore. It is not possible to determine if the differences in growth rates for the two populations are phenotypic or genotypic at the present time.

Key words: age; growth; spine sections; validation; albacore; Mediterranean.

INTRODUCTION

Albacore *Thunnus alalunga* (Bonnaterre, 1788), inhabit the tropical and temperate waters of all oceans including the Mediterranean Sea and is considered among the most important commercial tuna species in world landings. For management purposes, albacore have been separated into north and south stocks in the Atlantic, divided at 5° N latitude, by international management authorities. In addition, it has been accepted that the albacore in the Mediterranean Sea can be treated as a separate stock for management purposes (ICCAT, 1996).

The distribution of albacore in the Mediterranean Sea is discontinuous. There are higher concentrations in the Tyrrhenian, Ionian, Adriatic, and Aegean Sea where the exploited stocks consist mostly of individuals with fork lengths of <90 cm (Cefali *et al*., 1986; Megalofonou, 1990). The fishery for albacore, even though it is recent in the Mediterranean in comparison with other large pelagic fisheries, has developed rapidly since the early 1980s, peaking at 4100 tonnes in 1985 (ICCAT, 1996). The Italian and Greek fisheries for albacore are the most important in the area and produce the bulk of the catches. In Greece, fishing takes place mainly in the northern Aegean Sea from the end of August until November with long lines and troll lines. In Italy, albacore fishing is practised in the Ionian, southern Adriatic and Tyrrhenian Sea with long lines and drift nets from September to December. In the area of the Tyrrhenian Sea albacore fishing is also conducted during April through to August.

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Despite the high commercial value of this species and the significance of this large predator of the open sea, relatively little is known about its population biology. The existing literature on the biology of albacore is predominately on Atlantic fish. There have been several attempts to estimate age and growth of albacore in the Atlantic and Pacific ocean using various hard parts such as spiniform fin rays, vertebrae and otoliths (Partlo, 1955; Figueras, 1957; Bard & Compeán-Jimenez, 1980; Beamish, 1981; Gonzáles-Garcés & Fariña-Perez, 1983; Laurs *et al*., 1985; Fernandez, 1992; Lee & Yeh, 1993). The comparative analysis of the three different calcified structures suggested that the fin rays are the most appropriate for aging adult albacore (Fernadez, 1992). However, there are some problems with spine analysis that remain unresolved, such as the lack of validation for the observation that in some cases two annuli are formed per year. Also, there is the issue of bias in age estimation that is incorporated in analysis using back-calculated lengths, which does not account for the individual variation in growth (ICCAT, 1996).

Biological studies concerning the age and growth of the Mediterranean albacore are rare (Arena *et al*., 1980; Cefali *et al*., 1986; Megalofonou, 1990). In those studies ages were estimated by counting the annuli of scales and modal analysis of length frequencies. Some preliminary data suggest that it might not be correct to assume the same life-history characteristics exist for Atlantic and Mediterranean albacore. The growth rate of fish is an essential component of models used in stock assessment of fish populations and small variations in growth rates can have significant impact on the outcomes of the population analysis. This is especially important when it is unclear if the stocks of the fish that are targeted by the fishery are different. In this study, which is part of a more extensive study of albacore biology and population dynamics in the Mediterranean Sea, the age and growth of Mediterranean albacore were estimated using dorsal fin spines and tagging experiments. The objectives of this study were to determine the growth rate and life span of Mediterranean albacore and test the null hypothesis that there is no difference between the life history characteristics of Atlantic and Mediterranean albacore.

MATERIALS AND METHODS

SAMPLING SCHEME

Albacore ($n=1136$) of all size categories were obtained from the Greek and Italian fishing fleets operating in the Aegean Sea and the Gulf of Taranto, respectively. Sampling was carried out during the period 1989–1993, in September, October and November of each year. The bulk of the activities of the commercial albacore fisheries take place in the two areas at that time. Most of the specimens were sampled from landings at the island of Alonisos in the northern Aegean Sea and in the fishing port of Porto Cesareo in the Gulf of Taranto in southern Italy. A few specimens were obtained during tagging campaigns for large pelagic species carried out in the Gulf of Taranto (Fig. 1).

For each fish, the first spiniform ray of the first dorsal fin, fork length (L_F), round weight (W_R), sex, as well as date and place of capture were collected. Length measurements were made to the nearest centimetre and weight was measured to the nearest gram. Sex was determined, when it was possible, by visual inspection and gonad samples were preserved in Bouin's solution for histological examination or confirmation.

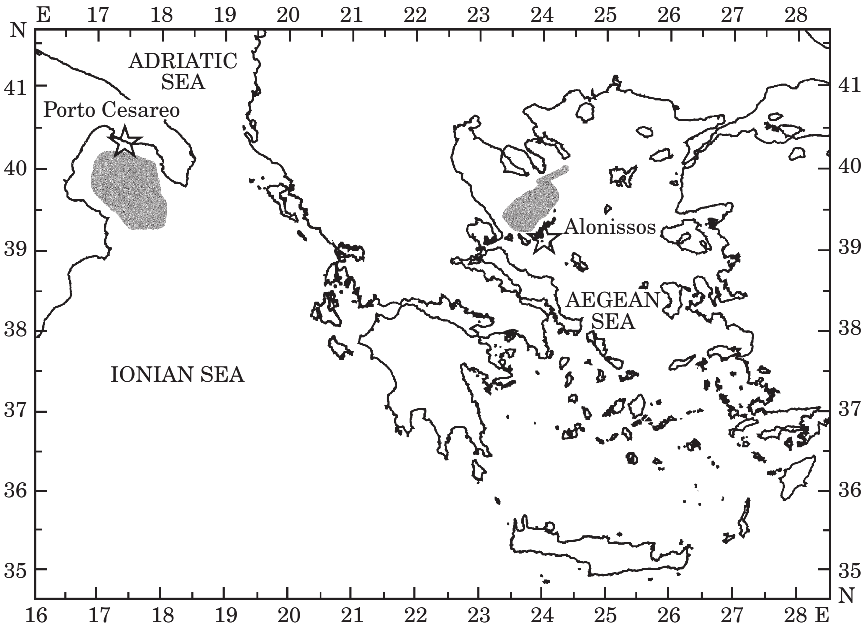


FIG. 1. Map of study area in the Mediterranean Sea showing approximate geographic distribution of fishing grounds and sampling sites (☆) of albacore *Thunnus alalunga*, in the Aegean and Ionian Seas.

AGE ESTIMATION

Three cross sections of *c.* 0·7 mm thick were obtained from each spine at the point near the condyle (Gonzáles-Garcés & Fariña-Perez, 1983) using a low-speed saw and diamond wafering blades. The sections were mounted with a synthetic resin on glass slides and viewed under transmitted light using a Leitz Diaplan binocular microscope equipped with an image analyzer Quantimet 500 Plus.

Growth bands observed under the above optical conditions were distinguished. Translucent zones, assumed to be indicative of slow growth, were separated by opaque zones, assumed to represent fast growth. Previous papers indicate that translucent zone on spines of Pacific and Atlantic tunas are often present in clusters or groups of two or more (Chi & Yang, 1973; Cayré & Diouf, 1983; Compeán-Jimenez & Bard, 1983; Cort, 1991; Fernandez, 1992) and have been interpreted as representing annual events. A single translucent band, or tight cluster of bands and the associated opaque band was assumed to represent 1 year of growth in this study. In most cases, two translucent bands appeared together. Bands were considered to be double if the distance between them was less than the distance to the preceding and following translucent band. Translucent bands were counted as an annulus if they were continuous around the perimeter of the spine section.

The total number of translucent bands in spine sections was recorded in order to assign an estimated age to each albacore and build a size-age key. Two readings of each spine were made independently by one reader. When there was disagreement between counts of translucent bands, spines were read for a third time. If agreement could not be reached, those spines were not included in the analysis.

VALIDATION

An attempt to validate the aging method, and specifically the observation that multiple translucent bands represent annual events, was performed by analysing the spines of albacore tagged and injected with oxytetracycline (OTC) during tagging cruises carried

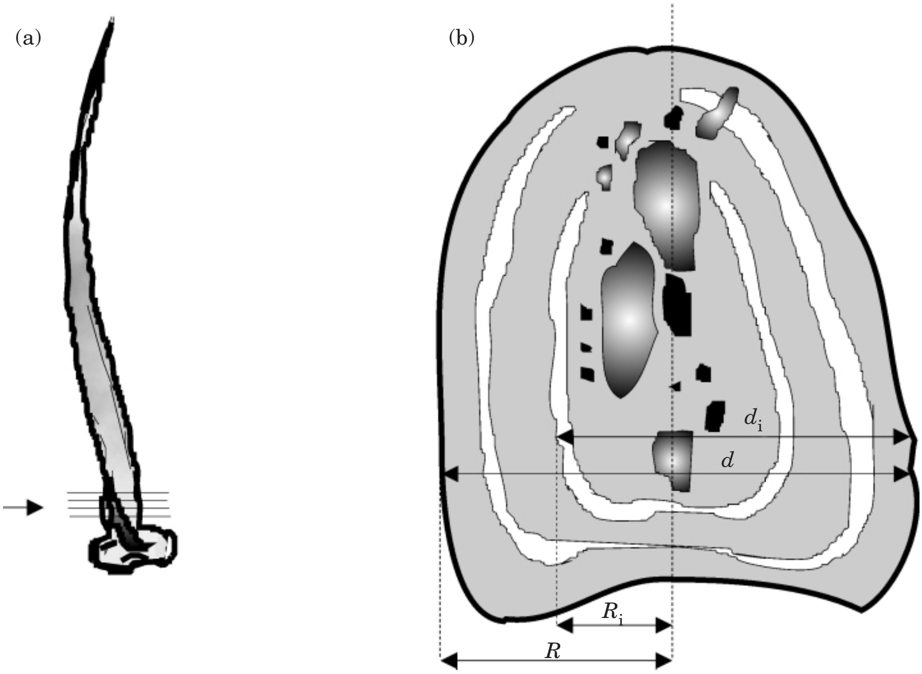


FIG. 2. Schematic diagram of the first dorsal fin spine from albacore *Thunnus alalunga*. Position of sections removed from the first spine (a), and a thin cross section of the spine showing the measurements taken (b). d, Diameter of the spine; d_i, distance from the outside edge of translucent band i to the opposite edge of the cross section; R, radius of the spine, R_i, radius of the i translucent band).

out in the Gulf of Taranto (De Metrio *et al*., 1997). Spine sections of five recaptured specimens were observed under the microscope with a UV light system, Leitz Ploemopak (3 lambda) with filter type D, in a darkened room. Once the OTC mark was identified, the filter was changed gradually to white light and the number of translucent bands formed after the OTC mark was counted.

BACK CALCULATION

To estimate previous growth history of albacore by back calculation, the relationship between the radius of the spine and fork length was studied. Linear and curvilinear equations were tested using regression analysis. The radius of the spine was defined as the distance between the estimated centre of the cross section and the edge of the section (Compeán-Jimenez & Bard, 1983). To avoid errors that result from the loss of material from the vascularized core, which makes it difficult to establish the exact centre, measurements were made from the outside edge of each ring to the opposite edge of the cross section (Cayré & Diouf, 1983). These distances were converted into radii (R_I) with the formula: $R_I = d_I - d/2$ where R=radius of the ring i, d=diameter of the spine and d_I=distance from the outside edge of translucent band i to the opposite edge of the cross section (Fig. 2). Back calculations of fork length-at estimated age were obtained using the formula of Tesch (1971) and Ricker (1975).

GROWTH

Estimates of theoretical growth in length were obtained by fitting the von Bertalanffy growth model to the mean lengths at estimated ages, using the Sparre (1987) method. Theoretical growth in weight was obtained by converting length to weight using the length–weight relationship for albacore. Linear regression was used to determine

TABLE I. Mean, standard deviation (S.D.), and range of fork lengths (L_F) by area and sex for albacore *Thunnus alalunga*, sampled in the Mediterranean Sea from 1989 to 1993

Area	Sex	Sample size	L_F (cm) Mean	S.D.	Min	Max
Aegean	Males	338	72·6	4·8	63·0	89
	Females	154	68·6	3·9	58·5	82
	Combined	603	71·8	5·0	58·5	92·0
Ionian	Males	139	68·0	4·6	60·0	84·0
	Females	137	66·2	3·6	57·0	84·0
	Combined	533	68·9	4·6	57·0	84·0

length–weight relationships. Differences between sexes were tested with tests of homogeneity of slopes and intercepts. The hypothesis of isometric growth (Ricker, 1975) was tested with a t-test.

Mean growth rate was also calculated directly from the lengths of tagged-recovered fish by the formula: growth rate$=(L_2-L_1)\,.\,(t_2-t_1)^{-1}$, where L_1=fish length during tagging at time t_1 and L_2=fish length during recapture at time t_2 (King, 1995).

The quantity $\Phi'=\ln k+2\ln L_\infty$, was computed (Sparre *et al.*, 1989) to compare albacore growth parameters of this study with those estimated in other studies from the Atlantic.

RESULTS

AGE ESTIMATION

Of 1136 albacore sampled, sex was determined in 768 specimens (Table I). Age estimations from spine sections were obtained from a total of 1087 albacore, ranging from 57 to 92 cm L_F (Fig. 3). Only 49 spines that represent 4·3% of the sample were considered unreadable and rejected from the analysis. Spine sections were eliminated because either the bands were too broad and diffuse to determine their number and location accurately or, annuli bands near the centre of the spine were not visible due to loss of material by vascularization.

The length frequency distributions, as well as the age estimates, showed that there were more larger and older albacore sampled in the Aegean Sea than in the Gulf of Taranto. Specifically, the Aegean samples were dominated by the age groups 3 and 4, while the age groups 2 and 3 were dominant in the Ionian Sea. Estimated age group 3 was the most abundant year class in both areas. No specimens equal to or younger than 1 year old (age group 0) were observed. Fish that had already completed their first year of life (age group 1) were quite rare. Estimated ages ranged between 1^+ to 9 years. Especially, the estimated ages for males ranged between 2^+ to 7^+ years while the range for females was from 1^+ to 6^+ years (Fig. 3).

No significant differences were found in the mean lengths at estimated ages between the two sampling areas (F=0·843 and P>0·05). However, in all seas sampled, males grew faster and reached a greater size and age than females.

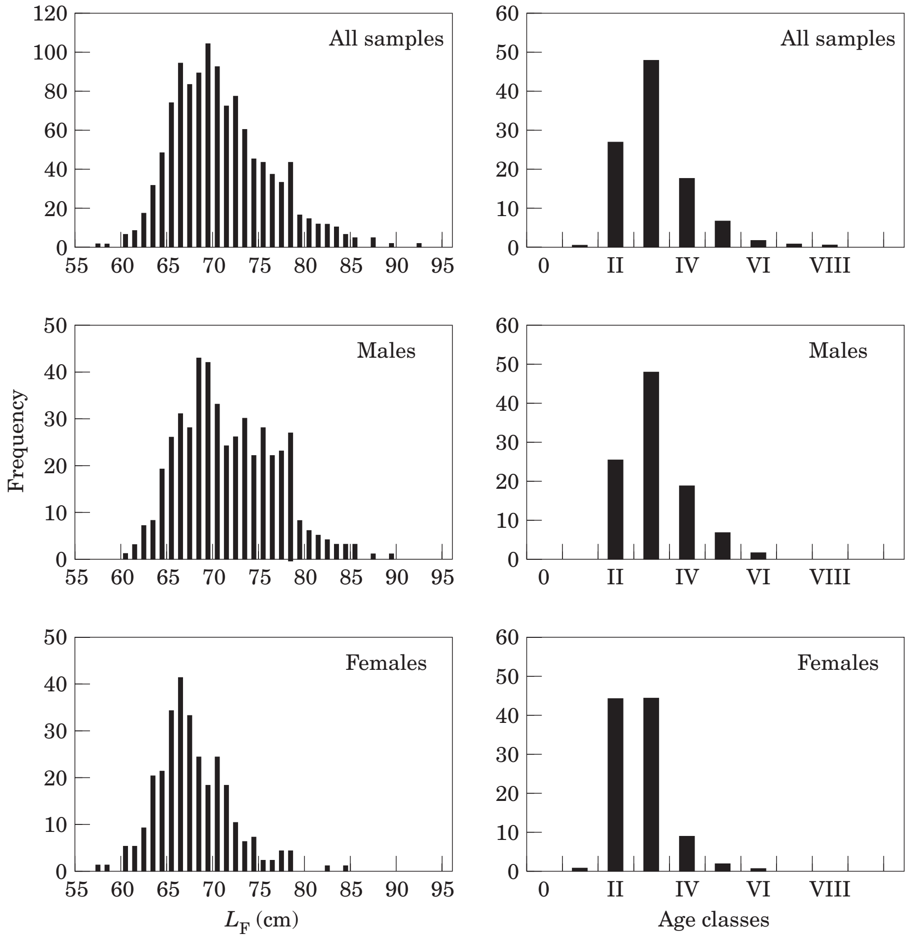


FIG. 3. Fork length and age frequency distributions of albacore *Thunnus alalunga*, sampled in the Mediterranean Sea, 1989–1993.

LENGTH–WEIGHT RELATIONSHIPS

Fork length and round weight data were recorded for 998 albacore ranging from 57 to 92 cm L_F and 3·4 to 13·4 kg W_R. Conversion equations for lengths (cm) and weights (kg) did not differ between sexes. The two sexes of albacore had similar slopes and intercepts (F_b=0·02, P=0·876; F_a=3·64, P=0·056) therefore a pooled length–weight regression (Fig. 4) was developed with the equation:

$$W_R = 5{\cdot}312 \times 10^{-5} \times L_F^{2{\cdot}74} \; (r^2 = 0{\cdot}86;\ n = 998;\ P < 0{\cdot}05)$$

The slope of the regression line was significantly different from 3·00 indicating allometric growth (t-test; t=12·2, P<0·05).

BACK CALCULATION

A significant linear relationship (Fig. 5) was found between spine radius and fork length. However, because of the restricted size range, and especially the

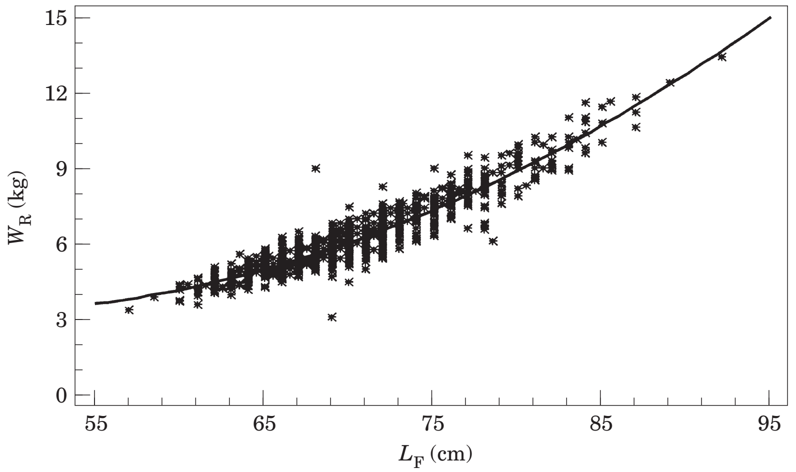


FIG. 4. Fork length–round weight relationship of albacore *Thunnus alalunga*, sampled in the Mediterranean Sea, 1989–1993. $n=998$.

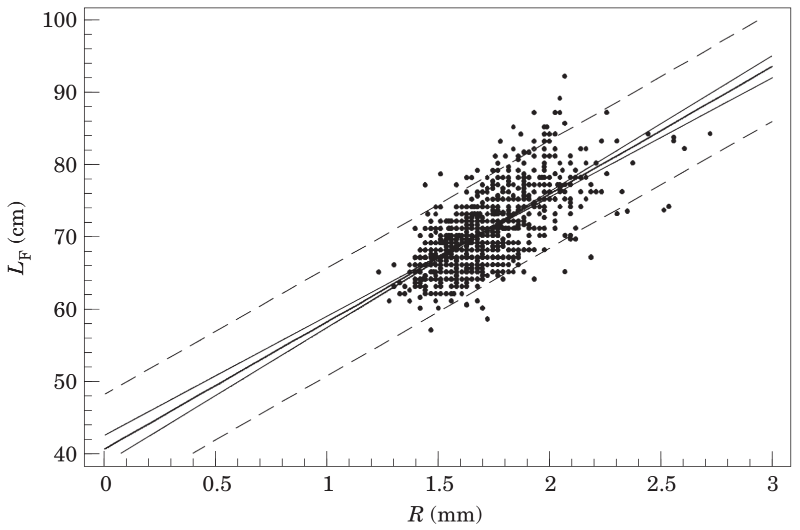


FIG. 5. Relationship between fork length (L_F) and spine radius (R) of the first dorsal fin for albacore *Thunnus alalunga,* sampled in the Mediterranean, 1989–1993. $n=1087$.

lack of small or young individuals, the results should be viewed with caution. The correlation coefficient of 0·68 indicates a moderately strong relationship between the variables. The equation found is:

$$L_F=41{\cdot}6+17{\cdot}4R\ (r^2=0{\cdot}45;\ n=1087;\ P<0{\cdot}01)$$

Previous studies showed that the relationship between size of fish and spine radius in albacore could be statistically significant (Bard & Compeán-Jimenez, 1980; Gonzáles-Garcés & Fariña-Perez, 1983). The main reason to attempt back calculation of the length at age is because of the absence of young albacore in the sample. However, the average size at formation of the first band obtained from that analysis seem to be very high (59·5 cm). That is possibly due to the high value of the intercept obtained in the regression analysis for the relationship between length of fish and spine radius. In addition, the disappearance of the first annulus due to the vascularization of the core central area of the spine in the older specimens creates problems in measurement and interpretation. For these reasons, back calculation was not used for the von Bertalanffy growth analysis.

GROWTH PARAMETERS AND EQUATION

Because of the difficulty in obtaining fish of the 0-age class, the first mode from the size frequency distribution was used from the sample from the Tyrrhenian Sea and the observations of Arena *et al*. (1980). Mean lengths at estimated ages were determined by sex as well as with both sexes combined and the von Bertalanffy growth model was fitted to these with 95% CI (Tables II and III; Fig. 6). The von Bertalanffy equation for the theoretical growth of albacore in length for sexes combined was:

$$L_t = 94{\cdot}7\ [1 - e^{(-0{\cdot}258)(t+1{\cdot}354)}]$$

The growth parameters of albacore from the Mediterranean and Atlantic as well as the calculated quantity Φ' present significant differences. The growth parameters of the Mediterranean fish give the lowest Φ' value (Table IV).

VALIDATION

From a total of 480 albacore tagged and injected with OTC, seven were recaptured during 1991–1995. Length and weight measurements as well as spines and other hard parts were recovered from five fish, which had been at liberty from 305 to 1157 days. Mean growth ranged from 1·9 to 4·1 cm year^{-1} (Table V).

A clear OTC mark was visible in all spine sections. In two of the samples, which had been at liberty for a period of 2 and 3 years, the number of annuli beyond the OTC mark in their spines (Fig. 7) was consistent with the number of years at liberty. However, in the case of fish that were at liberty less than 1 year, no annuli were identified after the OTC mark. The number of annuli that formed while the fish were at liberty never produced an overestimate of age.

DISCUSSION

Spines were chosen for age estimation of albacore because of the advantages they present compared with other hard parts (Beamish, 1981; Gonzáles-Garcés & Fariña-Perez, 1983; Fernadez, 1992). Also, spines are easily accessible for sampling since their extraction does not interfere with the market value of the fish.

Although, translucent bands are clearly distinct on the spine sections, it is difficult to establish the number of translucent bands that formed per year. The formation of the translucent bands, which are interpreted to represent an annual mark, probably could be the result of several causes including migration, spawning or other physiological and environmental events. These factors can

TABLE II. Mean observed fork lengths at age and those predicted by the von Bertalanffy model for albacore *Thunnus alalunga*, sampled in the Mediterranean Sea from 1989 to 1993. Round weights at age derived from the conversion of the predicted fork lengths using the length–weight relationship

Estimated age group	Mean observed fork length (cm)			Predicted by von Bertalanffy model					
				Fork length (cm)			Round weight (kg)		
	Males	Females	Combined	Males	Females	Combined	Males	Females	Combined
0	40·0	40·0	40·0	42·3	41·0	43·1	1·5	1·4	1·6
1	59·5	(2) 59·5	(2) 59·5	55·3	56·5	54·8	3·2	3·4	3·1
2	(91) 65·9	(117) 65·1	(280) 65·8	64·8	65·6	63·9	4·9	5·1	4·7
3	(219) 70·0	(123) 68·1	(520) 69·8	71·7	70·9	70·9	6·4	6·3	6·3
4	(109) 74·9	(25) 72·1	(195) 74·4	76·7	73·9	76·3	7·8	7·0	7·6
5	(38) 79·1	(5) 76·3	(72) 79·3	80·4	75·7	80·5	8·8	7·5	8·9
6	(7) 81·1	(2) 79·4	(13) 81·2	83·1	76·8	83·7	9·7	7·8	9·9
7	(1) 89·0	—	(4) 85·5	85·1	77·4	86·2	10·3	8·0	10·7
8	—	—	(1) 92·0	86·6	77·7	88·1	10·8	8·0	11·3

TABLE III. Summary of parameter estimates for the von Bertalanffy growth equation on fork length (cm) of albacore *Thunnus alalunga*, caught in the Mediterranean Sea

Sex	Parameter	Estimate	S.D.	95% CI	
				Lower	Upper
Sexes combined	L_∞	94·67	6·36	79·09	110·25
SSD=63·03	K	0·258	0·07	0·07	0·44
	t_o	− 1·354	0·64	− 2·92	0·22
Males	L_∞	90·46	5·92	75·24	105·69
SSD=51·72	K	0·314	0·09	0·07	0·56
	t_o	− 1·012	0·58	− 2·49	0·47
Females	L_∞	78·23	3·17	69·42	87·05
SSD=34·74	K	0·540	0·15	0·13	0·95
	t_o	− 0·375	0·39	− 1·47	0·72

SSD, sum squares differences.

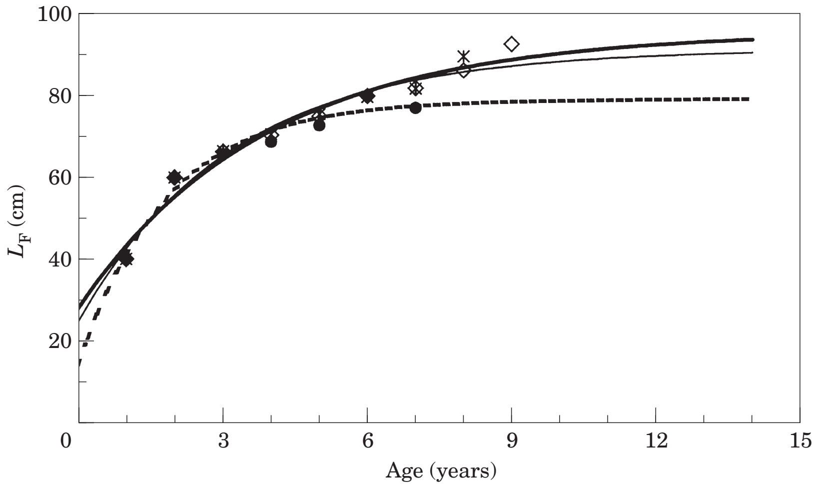


FIG. 6. Mean fork lengths at estimated ages and von Bertalanffy growth curves for sexed and unsexed albacore *Thunnus alalunga*, from the Mediterranean Sea. ●, Females; *, males; ◇, males and females.

work either separately or in combination to affect the physiology and growth of albacore. Bard & Compeàn-Jimenez (1980) reported that the translucent bands were formed in pairs on a yearly basis and referred to them as doublets. However, Gonzáles-Garcés & Fariña-Perez (1983) suggested that the interpretation of two translucent bands is accurate for estimating albacore age for the first year of its life but less certain for older age categories.

The marks on spines of the Mediterranean albacore also appeared to be formed in pairs or in groups of translucent bands. However, the space between members of bands varied, and in some cases there appeared to be a wide translucent band. These wide, single, translucent bands were also counted as

TABLE IV. Comparison of growth parameters of Atlantic and Mediterranean albacore *Thunnus alalunga*, estimated by different authors using spines ($\Phi' = \ln K + 2 \ln L_\infty$)

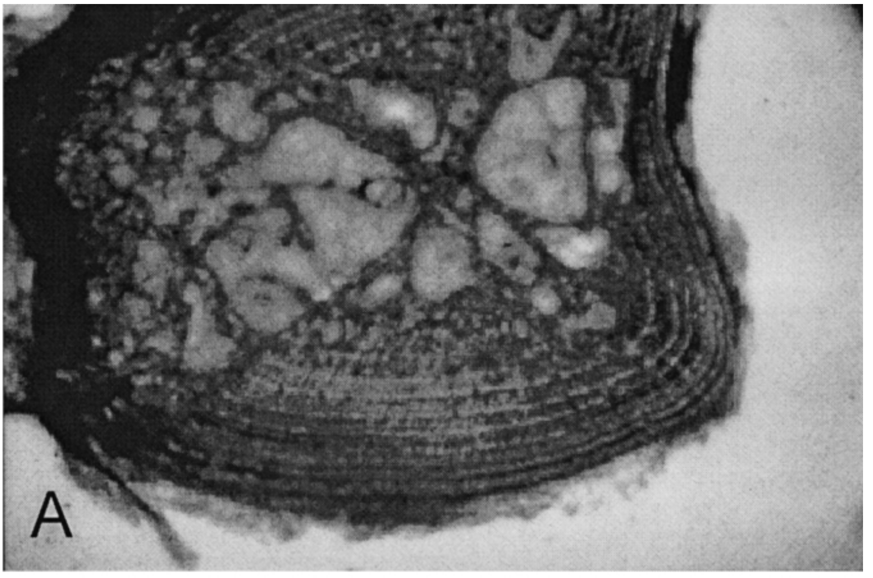
Author	Growth parameters L_∞	K	t_o	Area	Φ'
Compeán-Jimenez & Bard (1983)	124·7	0·228	−0·98	North Atlantic	8·173
Gonzáles-Garcés & Fariña-Perez (1983)	140·1	0·129	−1·57	North Atlantic	7·835
Fernadez (1992)	125·0	0·170	−1·12	North Atlantic	7·885
Lee & Yeh (1993)	142·2	0·145	−0·67	South Atlantic	7·983
Present study	94·7	0·258	−1·35	Mediterranean	7·746

TABLE V. Estimated mean growth in fork length (cm year^{-1}) and number of translucent bands after the oxytetracycline (OTC) mark in spine sections of five Mediterranean albacore *Thunnus alalunga*, marked and recaptured in the Ionian Sea during tagging experiments from 1990 to 1995

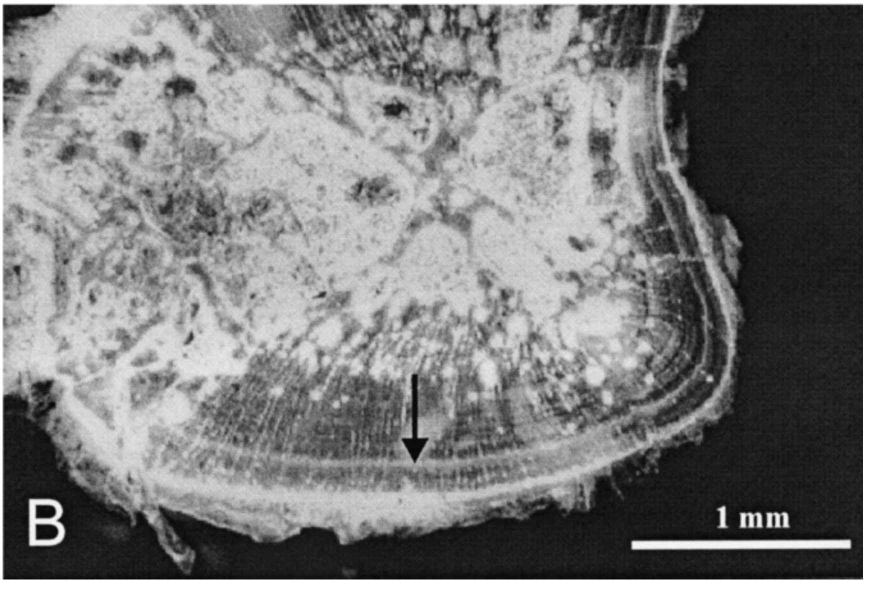
Tag no.	Tagging date	Recapture date	Days at liberty	Length at tagging (L_F, cm)	Length at recapture (L_F, cm)	Mean annual growth (cm year^{-1})	Number of bands after OTC mark
N.5262	7/10/1991	7/12/1994	1157	71	77·0	1·9	3
N.00220	17/10/1993	27/10/1995	740	66	70·5	2·2	2
N.00330	22/11/1994	4/10/1995	316	70	72·5	2·9	0
N.00377	22/11/1994	30/09/1995	312	67	70·5	4·1	0
N.05158	6/12/1994	7/10/1995	305	71	73·5	3·0	0

year-marks. It was considered that, in the case of the doublets, the first band formation was completed when albacore arrived in the Gulf of Taranto and the north Aegean Sea at the end of August while the second band formation began when albacore left these areas during late winter. This timing should not be considered as precise as the dates were conditioned by the period of fishing, and the fishery was not pursued after December. The first translucent band that is suggested as the August translucent band often appeared at the margin of the spines and it was visible only after the period of the autumn growth of albacore had started. Previous studies have noted that temperate tunas that undergo long distance migrations could register two growth bands each year and band formation could be a function of bioenergetic stress associated with migration (Bard & Compeán-Jimenez, 1980; Compeán-Jimenez & Bard, 1983). Given that the migration pattern of albacore in the Mediterranean Sea is unknown further research is necessary to identify migrations as probable, primary causes of growth band formation.

The results of the age estimates from spine sections are in reasonable agreement with the estimates performed from scales in earlier studies for Mediterranean albacore (Arena *et al*., 1980; Cefali *et al*., 1986; Megalofonou, 1990). The individual length-at age estimates suggested a high degree of variation in growth rate. Estimates of growth parameters indicated that males



(a)



(b)

FIG. 7. Sectioned spine of a marked albacore *Thunnus alalunga*, from the Mediterranean Sea viewed under a microscope with (a) transmitted light and (b) UV light. The arrow indicates the OTC mark on the spine of the albacore that was recaptured after 1157 days at liberty.

reach a larger asymptotic size than females. The value of $L_{\infty}=78{\cdot}2$ cm for females, although low, seems acceptable considering that during 10 years sampling, few females exceeded 80 cm L_F. The difference in sizes of males and females, with males being larger, is well documented both in the Atlantic and Mediterranean sea (Beardsley, 1971; Megalofonou, 1990). The observed

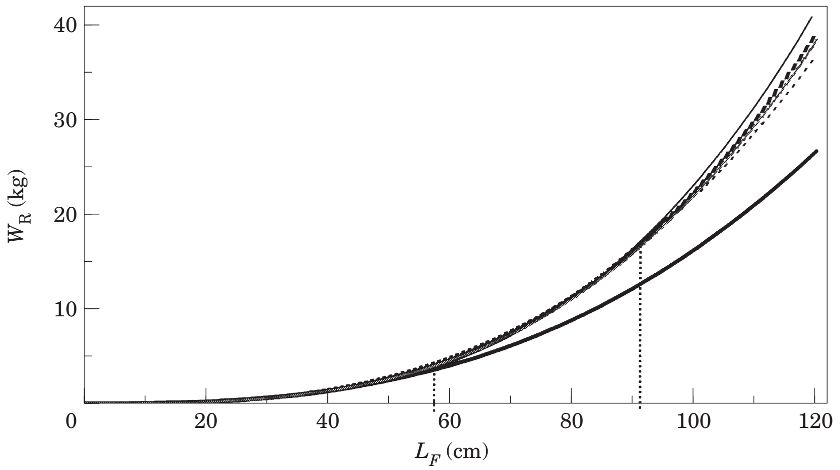


FIG. 8. Comparison of fork length–round weight relationships computed by several authors for albacore *Thunnus alalunga*, from the Mediterranean Sea and Atlantic Ocean. Range of data from 57 to 92 cm L_F. ▬, Present study; ——, Beardsley (1971); ▬ ▬ ▬, Sandiango (1993); – – –, Mejuto & Gonzáles-Garcés (1985); ——, Penney (1994).

differential life span for males and females can play a significant role in population dynamic model outputs. Such differential life spans have been observed also in bluefin tuna *Thunnus thynnus* (L.) (Hurley & Iles, 1983). Present results suggest a maximum life span of at least 9 years for albacore in the Mediterranean which is much lower compared with the maximum life span of 13 years in the Atlantic Ocean (Bard, 1974; Lee & Yeh, 1993).

A comparison of von Bertalanffy parameters in the Mediterranean with four similar studies in the Atlantic yield a significant difference in growth rates (Table IV). It has been observed that albacore in the Mediterranean do not reach the asymptotic length that is achieved by albacore in the Atlantic Ocean and the mean lengths per age class for Mediterranean fish are smaller, especially for larger and presumably older fish. Moreover, the length-weight relationship of Mediterranean albacore differs from those found for Atlantic albacore (Beardsley, 1971; Mejuto & Gonzáles-Garcés, 1985; Sandiango, 1993; Penney, 1994). It is observed that at a given length, Atlantic albacore are heavier than the Mediterranean ones (Fig. 8).

Much of the evidence used to evaluate the reliability of the observed differences in growth and to reject the hypothesis that there is no difference between the life history characteristics of Atlantic and Mediterranean albacore has come from the comparison of the growth of tagged fishes. The Ortiz de Zarate *et al.* (1996) study used OTC marking and tagging to validate the spine ageing method. However, it is possible to compare directly the growth of tagged fish in the Atlantic (Ortiz de Zarate *et al.*, 1996) with the tagged fish in the Mediterranean Sea because exactly the same tagging methods and measurements were made in both instances. This comparison, based on a linear approximation to the growth curve, is considered valid because both size composition and times at liberty between the two studies were comparable. On that basis, these data

TABLE VI. Comparison of means of growth in fork length (cm year^{-1}) observed in tagged albacore *Thunnus alalunga*, being at liberty for a period from 10 to 36 months in the Atlantic Ocean and Mediterranean Sea

Area and authors	Size group (L_F, cm)	Time at liberty (months)	Number of samples	Mean growth (cm year^{-1})	S.D.
Atlantic Ocean	57–63	11–27	7	12·2	6·2
Ortiz de Zarate *et al.* (1996)					
	64–69	11–13	14	10·6	2·3
Mediterranean Sea	66–71	10–36	5	2·8	0·8
present study					

prove that the measured growth is different in the two areas and Mediterranean albacore show slower growth rates (Table VI).

These findings constitute also a verification of the spine aging method used in both areas hence the differences observed by the age estimations are confirmed by the tagging data. In fact two independent methods leads to the same conclusion. Several authors have noted the importance of validation of age estimates and techniques. Beamish & McFarlane (1983) stated that successful validation must prove that the fish is not older or younger than estimated, as well as showing that the growth zone identified as an annulus forms approximately once a year. The number of OTC marked and recaptured Mediterranean fish and their time at liberty are not sufficiently large to permit a complete study of growth at this time. Moreover, only fish at liberty for more than 1 year can be used to validate the translucent band periodicity as an annual event. Nevertheless, important data were obtained which support the assumption that counts of the translucent bands in the spines of the Mediterranean albacore ranging in length between 66 and 77 cm can be used to estimate their age and growth.

These results encourage the efforts for further study. Analysis of hard parts from OTC tagged fish in marking experiments could provide significant advances in albacore age assessment and validation. Besides, the information on migrations and the ability to estimate directly the age and growth of the albacore will give new insight into the fundamental biology of the fish. The findings that the length-weight relationships, growth rate and life span of the Mediterranean albacore are significantly different from those of the Atlantic population challenges all of those engaged in the science and policy of fisheries management. It is not possible at this time to know if the differences are phenotypic or genotypic. For that reason it is important and appropriate that studies on stock resolution using the most contemporary techniques of molecular genetics be conducted.

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