

Some biological parameters of bullet tuna *Auxis rochei* from the Algerian coasts

Date soumission 16 mars 2025
Date acceptation 07 avril 2025

Khadra FERHANI^{1*}, Samia BENSMAIL¹, Chalabia CHABET DIS¹, Said Chaouki CHAKOUR²

k.ferhani@cnrdpa.dz

Abstract

This study presents basic data on the bullet tuna, *Auxis rochei*, sampled from the central region of Algerian waters between February and December 2015. The sex ratio, males to females, was 1:1.05. The gonado-somatic index (GSI) values calculated for females and males indicated that the reproductive season occurred between June and September, with a peak in July for both sexes. An isometric relationship between fork length and weight was found for females ($b = 2.95$). However, positive allometric growth was observed for both grouped sexes and males, with b values of 3.53 and 3.29, respectively. The von Bertalanffy growth parameters estimated via modal progression analysis using Bhattacharya were $L_{\infty} = 58.3$ cm, $K = 0.3$ y⁻¹ and $t_0 = -0.36$. Mortality estimates were $M = 0.358$ y⁻¹ and $Z = 1.71$ y⁻¹ and $F = 1.35$ y⁻¹ with an exploitation rate of $E = 0.78$.

Key words: *Auxis rochei*, GSI, growth parameters, mortality, Algerian basin

¹ Centre National de Recherche et de Développement de la Pêche et de l'Aquaculture

² Université de Jijel Mohammed Seddik Benyahia, Jijel, Algérie

Introduction

Three main small tuna species are found in Algerian landings: *Auxis rochei* (bullet tuna), *Sarda sarda* (Atlantic bonito), and *Euthynnus alletteratus* (little tunny). The bullet tuna, *Auxis rochei*, called melva by Algerian fishermen, is the most frequently caught species. Annual catches increased from 391 tons in 2004 to 731.7 tons in 2020, representing 54.8% of the total catches of small tuna species landed in Algeria (FAO, 2023).

Auxis species are the smallest members of the tribe Thunnini, the true tunas. *Auxis rochei* reaches a fork length (FL) of 600 mm (Collette and Aadland, 1996). Studies on the biology of *A. rochei* exploited in the Mediterranean Sea are limited and include those by Bök and Oray (2001) and Kahraman *et al.* (2011) in Turkish waters, De La Serna *et al.* (2005), Palandri *et al.* (2009) and Sabatés and Recasens (2001) in Spanish waters, Hattour (2009) in Tunisia and Campo (2006) in Italian waters. The diet of this species was also studied in Algerian waters by Ferhani *et al.* (2017). However, in Algeria, no recent data is available about bullet tuna.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) has identified the bullet tuna as one of the target species in its 2022–2024 research program agenda (Year Research Program for Small Tunas SMTYP), because of the great need to study these species and determine their stock status (ICCAT, 2022). In this context, the aim of this study is to provide preliminary information on reproductive season, length-weight relationship, growth and mortality parameters of *Auxis rochei* (Risso, 1810).

Material and methods

Samples of bullet tuna were collected monthly from landings along the central region of the Algerian coast (Southwest of the Mediterranean Sea). The sampling was carried out from February to December 2015.

All fish were measured to the total (TL, mm), fork (FL, mm) and standard (SL, mm) lengths, weighed to the nearest 0.01 g (total and gutted weight). Sex and maturation stages were also determined.

Sex ratio and gonadosomatic index (GSI)

The sex ratio was given as males: females (M:F), calculated as the total number of males divided by the total number of females. Statistical differences in the means of fork length between males and females were assessed using t-test.

The maturity stages were determined by visual examination of the gonads using the maturity key of Rey *et al.* (1984) and which includes six stages. The gonadosomatic index (GSI) was calculated according to the formula:

$$GSI = \frac{\text{Gonad weight}}{\text{Body total weight}} * 100$$

Length weight relationship

The length-weight relationships ($WT=aFL^b$) were established for males, females, and both sexes combined. To determine if b significantly differs from the expected value for isometric growth ($b = 3$), A t-test was conducted for comparison. A statistically significant difference of b from 3 indicates an allometric growth, either positive or negative. Isometric growth is considered when b is not statistically different from 3 (Schwartz, 1996).

Growth and mortality parameters

For the study of growth and exploitation, the data collected were combined with previous data carried out in the Algerian coast, because, the migratory behavior of the bullet tuna made its sampling difficult or even absent for a few months (Larbi and Mecellah, 2008). Length frequency data obtained were used to estimate growth parameters via the modal progression analysis of Bhattacharya and Gulland and Holt plot using FISAT software (Gulland and Holt, 1959; Bhattacharya, 1967; Pauly, 1984; Gayanilo *et al.*, 2005). The growth curve was represented by the von Bertalanffy growth function.

$$FL = L_{\infty} (1 - e^{-k(t-t_0)})$$

where FL is the fork length (in cm) at the age t (in years), L_{∞} is the asymptotic length, K is the body growth rate coefficient (years⁻¹) and t_0 is the time when length would have been zero on the modeled growth trajectory.

Mortality rates

The total (Z), natural (M), and fishing (F) mortality rates crucial for implementing exploitation models, are estimated using methods and equations whose principles are described below.

The total mortality Z was estimated from the length-converted catch curves (Pauly, 1984). The natural mortality was calculated using the formula of (Djabali *et al.*, 1994):

$$\log_{10} M = 0.0278 - 0.1172 \log_{10} L_{\infty} + 0.5092 \log_{10} k$$

From the value of total and the natural mortality, the value of fishing mortality (F) was estimated from the following formula: $F = Z - M$

Results

Sex ratio and GSI

The results obtained in this part were calculated from a sample composed of 51 males and 54 females. The fork length of males ranged from 31.7 to 45 cm with a mean FL of 37.07 ± 0.76 cm. The lengths of females ranged between 33.2 and 43.5 cm with a mean FL of 36.74 ± 0.53 cm. There is no significant difference between the mean lengths of males and females (t-test, $P > 0.05$). The sex-ratio males to females was 1:1.05.

The macroscopic observation of the male and female gonads locates the beginning of the reproductive period in late spring and late summer. Immature fish (stage 2) were found remarkably in the winter and autumn. Bullet tuna gonads at stage 5 (mature or spawning) were observed in June, July and August for both sexes (Figure 1).

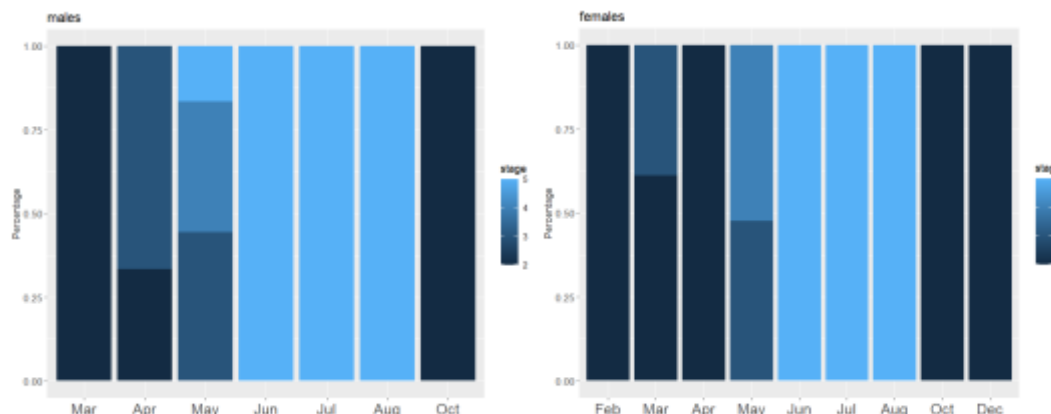


Figure 1. Progression of sexual maturity stages for males and females of *Auxis rochei* in the Algerian coasts.

The gonadosomatic index (GSI) was calculated for all individuals; the maximum value for females was found to be 6.94 for an individual of 40.5 cm (FL) (sampled in 30/07/15); for males, the maximum value was 16.73 for an individual to 43.7 cm (FL), (sampled in 30/07/15).

The temporal evolution of GSI highlights the main spawning period, for this species, the peak of GSI is in July for females and males. The reproductive period is extended from May until September for both sexes (Figure 2).

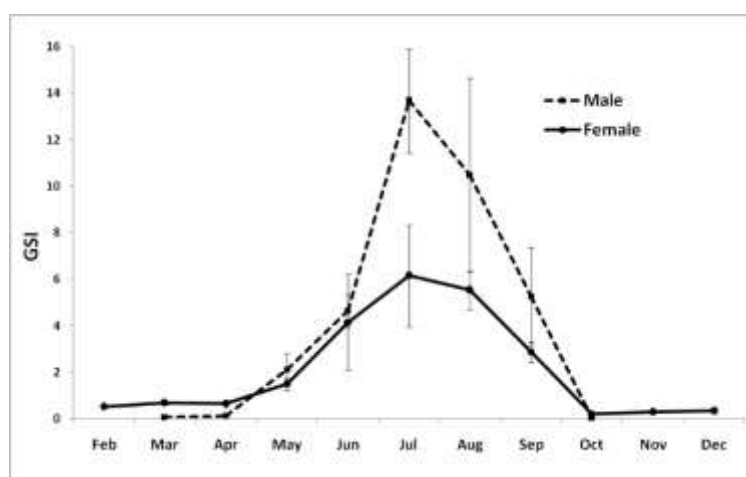


Figure 2. Evolution of GSI, per sex, of *Auxis rochei* from the Algerian coasts.
Length weight relationship

The bullet tuna length – weight relationship was calculated based on the fork length and total weight of 110 individuals. The bullet tuna length-weight relationships are represented by Figure 3. The females exhibited an isometric growth ($b = 2.956$, t-test, $P > 0.05$). However, a positive allometric growth was deduced from the males and both sexes with, respectively, $b = 3.2973$ and $b = 3.5378$. A strong positive relationship between fork length and total weight of bullet tuna was interpreted by the high values of coefficient of determination R^2 .

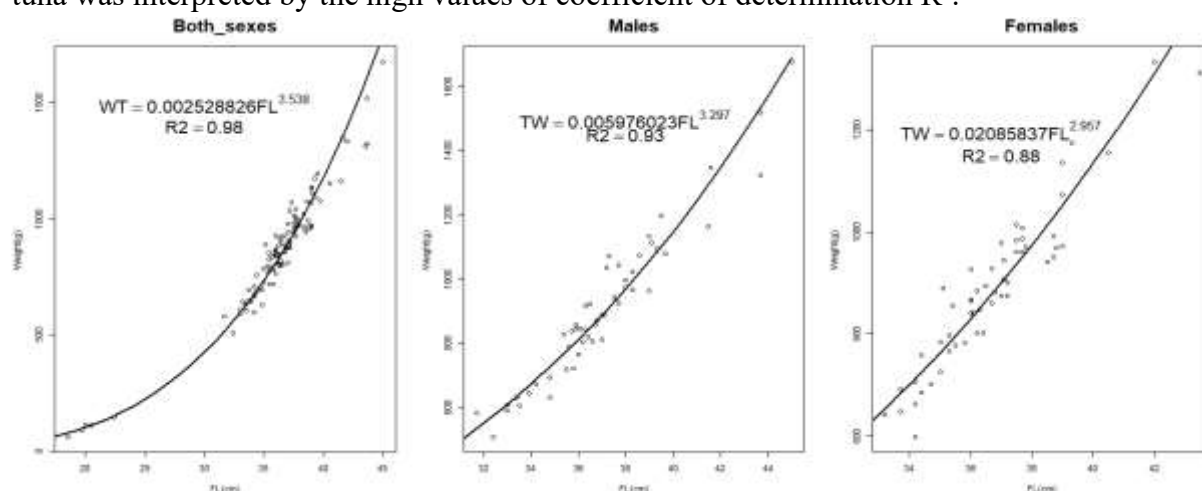


Figure 3. Length-weight curves of bullet tuna *Auxis rochei* captured in the Algerian coasts.
Growth and mortality parameters

Length frequency distribution of *A. rochei* collected from the Algerian basin is presented in Figure 4. The minimum and the maximum measured fork lengths were 18.5 cm and 49 cm respectively. The mean fork length calculated is 40.03 ± 0.62 cm.

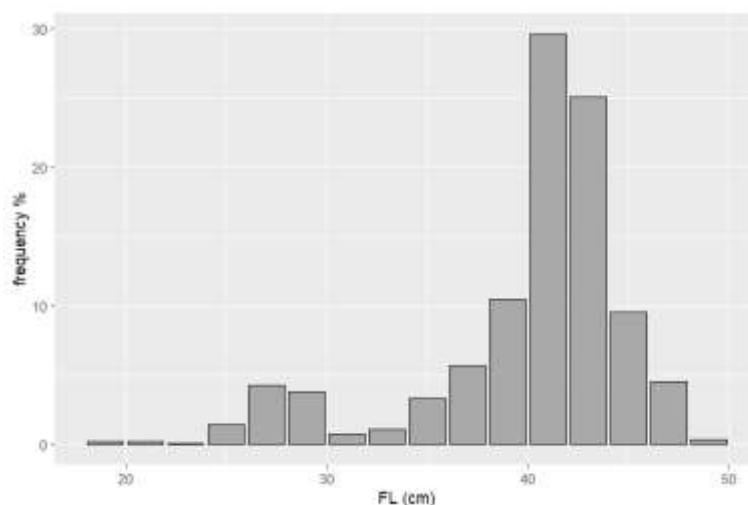


Figure 4. Length-frequency distribution of bullet tuna *Auxis rochei*.

The growth parameters and exploitations indices are summarized in Table 1. Equation result of growth was the following: Both sexes: $FL = 58.3 (1 - e^{-0.3(t+0.36)})$

The total mortality (Z) is 1.71 year^{-1} , the natural mortality (M) equal to 0.358 year^{-1} and the fishing mortality (F) is 1.35 year^{-1} .

Table 1. Growth parameters and exploitation indices of *Auxis rochei* from the Algerian basin.

Growth parameters			Exploitation indices (y^{-1})			
L_{∞} (cm)	K(year^{-1})	t_0 (year)	Z	M	F	$E=F/Z$
58.3	0.3	-0.36	1.71	0.358	1.35	0.78

Discussion

The bullet tuna *Auxis rochei* (Risso, 1810) - is a species belonging to the Scombridae family that holds commercial interest mainly for artisanal fisheries. Due to the limited number of studies on its biological parameters, this study contributes to identify some biological parameters like reproduction season, sex-ratio, and to estimate growth parameters (L_{∞} , K and t_0), and mortality coefficients (Z, M and F).

Regarding the study of reproduction, overall, the distribution of males and females is nearly equal in this sample (sex-ratio=1:1.05). The reproductive season

resulting from the GSI evolution occurs mainly between June and September, with a

peak in July for both sexes. These results are similar to those found by Palandri *et al.* (2009) in the Ligurian Sea, Macías *et al.* (2005) from the southwestern Spanish Mediterranean and Hattour (2009) in the Tunisian waters.

An isometric relationship between fork length and weight was found in this study for females ($b=2.9$). However, positive allometric growth for males and both sexes of bullet tuna was observed with b equal to 3.2, 3.5, respectively, which indicates that the body becomes more round as it increases in length. These values are close

to those obtained by De la Serna *et al.* (2005) and Palandri *et al.* (2009). By contrast, values obtained in this study are higher than the reported values in Kahraman *et al.* (2011) and Hattour (2009). The von Bertalanffy growth parameters estimated (using FL) were $L_{\infty} = 58.3$ cm, $K = 0.3 \text{ y}^{-1}$, and $t_0 = -0.36 \text{ y}^{-1}$. The growth parameters of this species, previously estimated in the Mediterranean, Atlantic, and Indian Oceans, revealed L_{∞} values ranging between 42.3 and 57.4 cm (Bök and Oray, 2001; Valeiras *et al.*, 2008; Palandri *et al.*, 2009; Hattour, 2009; Jasmine *et al.*, 2013). However, a study conducted in Spanish Mediterranean waters by De La Serna *et al.* (2005) report an L_{∞} value higher than the one found in this study. According to FishBase, the values of k range from 0.1 to 0.7 in the western Mediterranean Sea. Additionally, Kahraman *et al.* (2011) estimated a very low K value for bullet tuna collected from the Turkish Mediterranean coast ($K = 0.181 \text{ y}^{-1}$).

The mortality estimates were $M = 0.358 \text{ y}^{-1}$, $Z = 1.71 \text{ y}^{-1}$, and $F = 1.35 \text{ y}^{-1}$, with an exploitation rate of $E = 0.78$, highlighting the need for appropriate management measures to ensure continued exploitation at sustainable levels.

The results of this study provide valuable insights for applying stock assessment methods to *Auxis rochei*, given that Algerian waters (Postel, 1964) are suggested as possible spawning sites. Bullet tuna hold economic importance for both artisanal and commercial fisheries in the Mediterranean Sea, highlighting the need for further studies on their biology and exploitation to provide a comprehensive assessment of stock status.

Références bibliographiques

Bhattacharya C.G. (1967). A simple method of resolution of a distribution into Gaussian components. *Biometrics*. 23, 115-135.

Bök T. and Oray I.K. (2001). Age and growth of bullet tuna *Auxis rochei* (Risso, 1810) in Turkish waters. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 52, 708-718.

Campo D. (2006). Comparative study of the trophic ecology of *Auxis rochei* (Risso, 1810), *Euthynnus alletteratus* (Rafinesque, 1810), *Sarda sarda* (Bloch, 1793) and of the young-of-the-year of *Thunnus thynnus* (Linnaeus, 1758) (Perciformes, Scombridae) in the southern Tyrrhen. s.l. : PhD thesis in Evolutionary Biology and Marine Ecology, Università di Pisa. Italy. 30,3, 220 p.

Collette B.B. and Aadland C.R. (1996). Revision of the frigate tunas (Scombridae, *Auxis*), with descriptions of two new subspecies from the eastern Pacific. *Fishery Bulletin*. 94(3), 423-441.

De la Serna J.M., Ortiz de Urbina J.M., Alot E., Garcia S. and Rioja P. (2005). Biological parameters of bullet tuna (*Auxis rochei*) observed in the Spanish Mediterranean fisheries. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 58(2), 517-526.

Djabali F., Mehailia A., Koudil M. and Brahmi B. (1994). Empirical equations for the estimation of natural mortality in Mediterranean teleosts. *Naga, the ICLARM Quarterly*. 16, 35-37.

FAO (2023) GFCM capture production (1970-2020). <https://www.fao.org/gfcm/data/capture-production>.

Ferhani K., Hemida F. and Chakour S.C. (2017). Contribution à l'étude du régime alimentaire de la melva (*Auxis rochei*) de la côte algérienne. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 73(8), 2688-2694.

Gayanilo Jr F.C., Sparre P. and Pauly D. (2005). FAO-ICLARM Outils d'évaluation des stocks II (FiSAT II). Version révisée. Guide d'utilisation. FAO Série informatique. Pêche. No. 8, Version révisée. Rome, FAO.

Gulland J.A. and Holt S.J. (1959). Estimation of growth parameters for data at unequal time intervals. *ICES Journal of Marine Science*. 25(1), 47-49.

Hattour A. (2009). Les thons mineurs tunisiens : Etude biologique et pêche. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 64 (7), 2230-2271.

ICCAT. (2022). Rapport du Comité Permanent pour la Recherche et les Statistiques (SCRS), Madrid, Espagne / hybride, 26 - 30 septembre 2022, 383 pp.

Jasmine S., Rohit P., Abdussamad E.M., Koya K.P., Joshi K.K., Kemparaju S., Prakasan D., Elayathu M.N.K., Sebastine Manju. (2013). Biology and fishery of the bullet tuna, *Auxis rochei* (Risso, 1810) in Indian waters. *Indian Journal of Fisheries*. 60(2), 13-20.

Kahraman A.E., Göktürk D. and Karakulak F.S. (2011). Age and growth of bullet tuna, *Auxis rochei* (Risso), from the Turkish Mediterranean coasts. *African Journal of Biotechnology*. 10(15), 3009-3013.

Larbi M.A. and Mecellah M.R. (2008). Contribution à l'étude de la famille des Scombridae (Ostéichthyens, Perciformes) statistiques des débarquements et estimation du niveau d'exploitation de deux espèces cibles. Mémoire d'ingénieur. Pêche et Aquaculture. Alger : USTHB.

Macías D., Gómez-Vives M.J. and De la Serna J.M. (2005). Some reproductive aspects of bullet tuna (*Auxis rochei*) from the south western Spanish Mediterranean. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 58(2), 484-495.

Palandri G., Lanteri L., Garibaldi F. and Orsi Relini L. (2009). Biological parameters of bullet tuna in the Ligurian Sea. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 64(7), 2272-2279.

Pauly D. (1984). Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part II). *ICLARM Fishbyte*. 2(1), 17-19.

Postel E. (1964). Les thonidés d'Afrique du Nord. In Proc. Symp. Scombroid Fishes, Part I. Mar. Biol. Assoc. India, Symp. Ser Vol. 1, pp. 211-220.

Rey J.C., Alot E. and Ramos A. (1984). Synopsis biológica del bonito, *Sarda sarda* (Bloch), del Mediterraneo y Atlantico Este. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 20, 469-502.

Sabatés A. and Recasens L. (2001). Seasonal distribution and spawning of small tunas (*Auxis rochei* and *Sarda sarda*) in the northwestern Mediterranean. *Scientia Marina*. 65(2), 95-100.

Schwartz D. (1996). Méthodes statistiques à l'usage des medecins et des biologistes. Paris: Flammarion Medecine-Sciences.

Valeiras X., Macías D., Gómez M.J., Lema L., García-Barcelona S., Ortiz de Urbina J.M. and De la Serna J.M. (2008) Age and growth of bullet tuna (*Auxis rochei*) in the Western Mediterranean Sea. *Collective Volume of Scientific Papers of International Commission for the Conservation of Atlantic Tunas*. 62(5), 1629-1637.