



CHAPTER 2.1.10.1: ATLANTIC BONITO	AUTHORS: B. MOURATO, T. BARRETO AND F. LUCENA-FRÉDOU	LAST UPDATE: June 2021 Original: English
----------------------------------------------	---------------------------------------------------------------------	---------------------------------------------------------

2.1.10.1 Description of Atlantic bonito (BON)

1. Names

1.a. Classification and Taxonomy

Species name: *Sarda sarda* (Bloch, 1793)

ICCAT species code: BON

ICCAT names: Atlantic bonito (English), Bonito (Spanish), Bonite à dos rayé (French).

According to Collette and Nauen (1983), Atlantic bonito is classified as follows:

- Phylum: Chordata
- Subphylum: Vertebrata
- Superclass: Gnathostomata
- Class: Osteichthyes
- Subclass: Actinopterygii
- Order: Perciformes
- Suborder: Scombroidei
- Family: Scombridae
- Genus: *Sarda*
- Species: *Sarda sarda*

1.b. Common names

List of vernacular names used by different countries according to ICCAT, FAO and Fishbase (www.fishbase.org). The list of countries is not exhaustive and some local names might not be included.

Albania: Palamiti.

Algeria: Bonite, Bonite à dos rayé, Palamita, Rsela.

Angola: Bonito, Sarda, Sarrajão, Serrajão, Serralhão.

Argentina: Bonito.

Azores Islands: Atlantic bonito, Bonito, Serra.

Benin: Kpokoukpokou.

Brazil: Bonito, Bonito-atlântico, Cavala, Sarda, Sarrajão, Serra, Serra-comum, Serra-de-escama, Serra-sarda.

Bulgaria: Lakerda, Palamud, Turuk.

Cabo Verde: Bonito, Bonito do Atlântico, Bonito-de-lombo-listado, Sarrajão.

China Main: 狐鯷.

Colombia: Bonito.

Croatia: Palamida, Polanda.

Cuba: Bonito.

Denmark: Pelamide, Rygstribet pelamide.

Finland: Sarda.

Former USSR: Atlanticheskaya pelamida, Lacherda, Pelamida.

France: Bonite à dos rayé, Bonicou, Boniton, Boussicon, Boussicou, Conite, Pélamide, Pelamide commun, Pelamido.

Germany: Bonito, Pelamide, Unechter Bonito.

Greece: Ρίκι, Τουλίπι, Τορνέττα, Παλαμίδα, Ντορίκι, Doriki, Koini, Palamida, Palamída, Ternata, Toriki, Touliki.

Guinea: Koko.

Iceland: Rákungur.

Israel: Sarda.

Italy: Bonnicou, Cavaritu imperiali, Paamia, Paamie, Palameit, Palametiedde, Palametto, Palamia, Palamida, Palamide, Palamidu, Palamita, Palamito, Palamitu, Palamitu maiaticus, Palammete, Palammete cuvarita, Paramira, Parantuni, Pelamida, Pilamitu, Pirantuni, Pisantuni, Sangulu, Scurma, Sgamiru, Sgonfietto, Strombo, Tombarello, Tunnacchiu, Tunnareiu.

Japan: Hagatsuo, Kigsungegatsuo.

Lebanon: Ghazâl.

Libya: منخطط, Balamit, Blamto, Mghatat.

Madeira Island: Cerda, Serrajão, Serralhão.

Malta: Palamia, Palamit, Palamita, Plamitu, Plamtu.

Marshall Islands: Loj, Looj.

Martinique: Bonite.

Mauritania: Bonite, Bonite à dos rayé, Bonito, Doulou doulou, Pélamide.

Mexico: Bonito del Atlántico.

Monaco: Palamida, Paramida, Piramida.

Morocco: Bonito, Cerda.

Namibia: Atlantiese bonito, Bonito, Pelamide.

Netherlands: Atlantische boniter, Bonito.

Norway: Pelamide, Stripet pelamide.

Poland: Pelamida.

Portugal: Bonito, Bonito-do-Atlântico, Sarrajão, Serra.

Romania: Lacherda, Palamida, Pelamida.

Russian Fed: пеламида атлантическая.

Senegal: Bonite à dos rayé, Dullu dullu, Kiri kiri, wal.

Sierra Leone: Bonito.

Slovenia: Palamida.

South Africa: Atlantic bonito, Atlantiese bonito, Katonkel.

Spain: Bonito, Bonito atlántico, Bonito del Atlántico, Bonitol, Bonítol, Bonitu, Cerda, Sierra.

Sweden: Pelamida, Pelamide, Ryggstrimmig pelamid.

Syria: Palamet.

Trinidad Tobago: Bonito.

Tunisia: Balamit, Palamid, Rsela, Toumbrel.

Türkiye: Altiparmak, Çingenepalamudu, Kestanapalamudu, Palamut, Palamut torik, Palamutvonozu, Piçuta, Sivri, Torik, Zindandelen.

UK: Atlantic bonito, Belted bonito, Bonito, Pelamid, Short finned tunny, Stripe-backed pelamis.

Ukraine: Pelamida.

Uruguay: Bonito.

USA: Atlantic bonito, Bloater, Bone jack, Bonito, Boston mackerel, Common bonito, Skipjack.

Venezuela: Cabaña blanca, Cabaña cariba, Cabaña de dientes.

2. Identification



Figure 1. Drawing of an adult *Sarda sarda* (by A. López, 'Tokio').

Characteristics of *Sarda sarda* (see Figure 1 and Figure 2)

Atlantic bonito is a small tuna species. In the Atlantic Ocean, maximum length was reported at 91.4 cm fork length and maximum weight at 5.4 kg. In the Black Sea, maximum length is 85 cm fork length and 5 kg weight (Collette and Nauen, 1983).

Colour:

- Back and upper sides steel blue, silvery below.
- 5-11 longitudinal oblique dorsal dark stripes running forward and downward (with a greater angle than in other species of *Sarda*).
- Dorsal and caudal dusky. Pectoral pale. Other fins more or less silvery.

External:

- Body elongate and slightly compressed.
- Body completely covered with very small scales except on the well-developed corselet.
- Caudal peduncle slender, with a well-developed lateral keel between two smaller keels on each side.
- First dorsal fin long, nearly reaches second dorsal.
- First dorsal fin: 20-23 spines.
- Dorsal finlets: usually 8.
- Anal fin: 14-17 rays.
- Anal finlets usually 7.
- Pectoral fin rays: 23-26, usually 24-25.
- Gill rakers on first arch: 16-23.
- The mouth is moderately large.
- 16-26 conical teeth in upper jaw, 12 to 24 in lower. No teeth on tongue.
- Lamellae of olfactory rosette 22-33.
- Intrapelvic process small and bifid.
- Length of fin base 29.1 to 33% of fork length.

Internal:

- Swim bladder absent.
- Spleen large and prominent in ventral view.
- Liver with elongate left and right lobe and short middle lobe.
- No cutaneous artery.
- Vertebrae: 50-55.

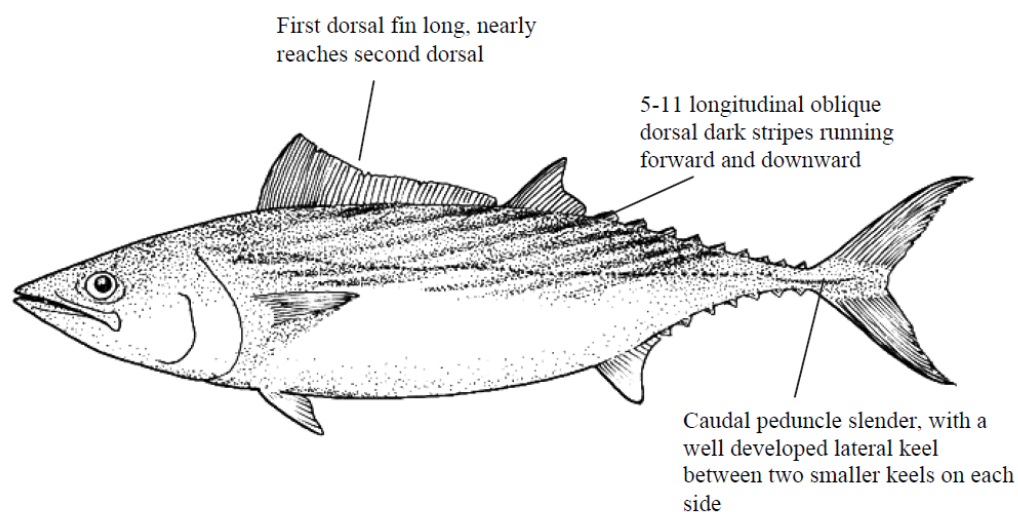


Figure 2. Synthesis of the most outstanding characteristics of *Sarda sarda* (by A. López, 'Tokio').

3. Distribution and population ecology

3.a. Geographical distribution

Atlantic bonito is distributed in the tropical and subtropical Atlantic Ocean, in the Gulf of Mexico, and in the Mediterranean and Black Seas (Collette and Nauen, 1983). In the eastern Atlantic, it is distributed from Oslo (Norway) to Port Elizabeth (South Africa). In the Northwest Atlantic, Atlantic bonito occurs from Nova Scotia to Florida, is present in the northern Gulf of Mexico and apparently absent from most of the Caribbean Sea (Collette and Nauen, 1983). Off the South America Atlantic coast, the species is recorded from Colombia, Venezuela, and south of the Amazon River to northern Argentina.

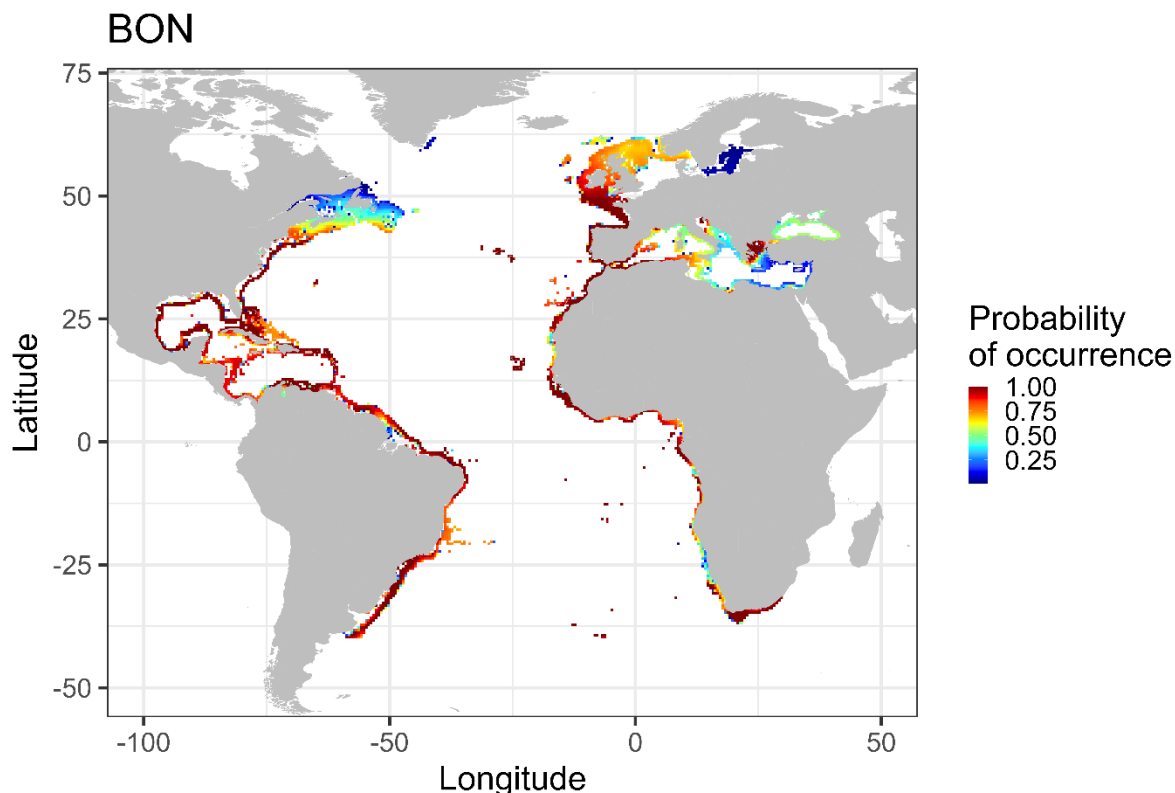


Figure 3. Geographical distribution showing the probability of occurrence of *Sarda sarda* based on data available on FishBase and aquamaps.org website.

3.b. Habitat preferences

Atlantic bonito is an epipelagic and neritic marine fish species which lives in schools along the neritic area and may enter in estuaries. It can be found from 80 to 200 meters in depth (Yoshida, 1980). This species can adapt to different temperatures from 12° to 27°C and salinities from 14 to 39 (Collette and Nauen, 1983; Bianchi *et al.*, 1999).

3.c. Migrations

In general, little is known about bonito migration patterns. Atlantic bonito migrates along the coast for large distances as proved by recaptures of tagged fish in the Black Sea and Alboran Sea (western Mediterranean Sea) (Rey *et al.*, 1984). It is known to migrate along the coast from the Atlantic to the Alboran Sea and from the Aegean to the Black Sea for spawning; after spawning, it migrates taking the opposite route (Nümann, 1954). Some studies suggest that Atlantic bonito is resident in western Mediterranean Sea throughout the year and that mature fish migrate from coastal areas to the open sea to spawn (Sabatés and Recasens, 2001). This species can carry out extensive migrations within its distribution. The average distance covered is around 2.6 km/day but can vary from 0.2 to 35.6 km/day (Rey *et al.*, 1984).

3.d. Recruitment

Knowledge of the early life stages for Atlantic bonito is very scarce. It is assumed that the larval period is short. The beginning of the juvenile period has been established arbitrarily as to sizes escaping from plankton nets, around 2 cm (Bard, 1981). Rodríguez-Roda and Di Centa (1980) have found Atlantic bonito larvae in the northeast Atlantic on the Moroccan coast. During the first life stages bonitos are not caught and juvenile life history is unknown. Immature fish first appear in fishery from around 15 cm of fork length (Zengin *et al.*, 2005).

4. Biology and life history parameters

For this manual and species, 5 stocks unit areas, previously defined by ICCAT for data collection and management purposes, were considered to summarize the results: Southwest Atlantic (SW), Northwest Atlantic (NW), Southeast Atlantic (SE), Northeast Atlantic (NE) and Mediterranean Sea (MED).

4.a. Growth

Atlantic bonito age determination and growth have been studied by different methodologies: otoliths, vertebrae, spines and size frequency. The maximum reported age is 5 years (Cayré *et al.*, 1993). The growth is extremely rapid during the first year, and slows after the fish have reached size at first maturity (approximately 40 cm FL). Most of the studies are from Mediterranean stocks and only a few are from the other parts of the Atlantic Ocean. There are several studies on growth biology of bonito in the Black Sea and western Mediterranean. Von Bertalanffy growth parameters are showed in **Table 1** for different areas.

Table 1. Growth parameters for Atlantic bonito (L_{∞} in cm, K in y^{-1} , t_0 in y). Southwest Atlantic (SW), Northeast Atlantic (NE) and Mediterranean Sea (MED).

L_{∞}	K	t_0	Locality	Reference
62.5 (FL)	0.719		MED (Spain)	Valeiras <i>et al.</i> , 2008
64.0 (FL)	0.693	-1.42	NE (Morocco)	Dardignac, 1962
64.0 (FL)	0.86		MED (Black Sea - Türkiye)	Turgan, 1958
67.8 (FL)	0.795		MED (Black Sea - Türkiye)	Nümann, 1954
68.0 (TL)	0.82	-0.39	MED (Black Sea and Sea of Marmara)	Ateş <i>et al.</i> , 2008
69.57 (FL) *	0.44	-1.33	MED (Black Sea and Sea of Marmara)	Kahraman, <i>et al.</i> , 2014
74.6 (FL) **	0.364	-1.52	MED (Black Sea and Sea of Marmara)	Kahraman, <i>et al.</i> , 2014
69.8 (FL)	0.76		MED (Northern Aegean Sea)	Cengiz, 2013.
80.6 (FL)	0.36		MED (Ionian Sea - Italy)	Santamaria <i>et al.</i> , 1998
80.9 (FL)	0.352	-1.7	MED (Strait of Gibraltar - Spain)	Rey <i>et al.</i> , 1986
81.5 (FL)	0.525		MED (Black Sea - Türkiye)	Nikolsky, 1957
95.6 (FL)	0.237	-1.24	MED (Black Sea - Bulgaria)	Nikolov, 1960
103.0 (FL)	0.132	-1.8	MED (Black Sea - Russia)	Zusser, 1954
80.87 (FL)	0.35	-1.7	NE	Rey <i>et al.</i> , 1984
80.87 (FL)	0.352	-1.7	MED (Morocco)	Rey <i>et al.</i> , 1984
95.6 (FL)	0.237	-1.24	MED (Black Sea - Bulgaria)	Kutaygil, 1967
81.5 (FL)	0.525		MED (Black Sea - Türkiye)	Mayorova and Tkacheva, 1959
74.615 (FL)	0.225	-2.74	SW (Argentina)	Hansen, 1987
73.01 (FL)	0.3075	-2.4469	NE	Baibbat <i>et al.</i> , 2020

* females

** males

4.b. Length-weight relationship

Most of the studies on length-weight relationships of *Sarda sarda* off the Atlantic Ocean are summarized in **Table 2**.

Table 2. Different Atlantic bonito length-weight relationships published. Southwest Atlantic (SW), Northeast Atlantic (NE) and Mediterranean Sea (MED).

N	a	b	r ²	Length range (cm)	Sex	Location	Reference
240	0.0003	2.83		35.0-82.0 (FL)	Mixed	MED (Italy)	Di Natale <i>et al.</i> , 2006
109	0.0004	2.18		35.0-67.0 (FL)	Mixed	MED (Italy)	Di Natale <i>et al.</i> , 2006
	0.0502	2.562	0.891	28.1-37.5 (TL)	Mixed	MED (Türkiye)	Kasapoglu and Duzgunes, 2013.
183	0.0046	2.67		41.0-48.0 (FL)	Mixed	MED (Spain)	Macías <i>et al.</i> , 2005
1608	0.0236	2.87		14.0-90.0 (FL)	Mixed	MED (Türkiye)	Kara, 1979
165	0.0148	2.97		40.0-55.0 (FL)	Mixed	MED (Spain)	Rodríguez-Roda, 1966
89	0.009	3.099	0.992	23.0-56.5 (FL)	Male	MED (Türkiye)	Kahraman <i>et al.</i> , 2014
	0.0091	3.1	0.890	33.0-67.0 (TL)	Female	MED (Croatia)	Sinovčić <i>et al.</i> , 2004
	0.0094	3.103	0.960	19.0-64.0 (FL)	Mixed	SW (Senegal)	Diouf, 1980
	0.0082	3.13	0.965	10.4-64.5 (TL)	Mixed	MED (Croatia)	Sinovčić <i>et al.</i> , 2004
878	0.0072	3.16		19.0-72.0 (FL)	Mixed	MED (Spain)	Rey <i>et al.</i> , 1984
100	0.007	3.168	0.990	25.5-63.0 (FL)	Female	MED (Türkiye)	Kahraman <i>et al.</i> , 2014
	0.0067	3.18	0.883	35.0-67.0 (TL)	Male	MED (Croatia)	Sinovčić <i>et al.</i> , 2004
	0.0051	3.18		60.5-76.5 (TL)	Mixed	NW (UK)	Coull, <i>et al.</i> , 1989.
694	0.0054	3.21		23.5-71.0 (TL)	Mixed	MED (Türkiye)	Ateş <i>et al.</i> , 2008
	0.0034	3.285	0.987	41.0-82.0 (TL)	Mixed	NW (Portugal)	Santos, <i>et al.</i> , 2002.
1168	0.0039	3.32		23.0-66.0 (FL)	Mixed	MED (Türkiye)	Oray <i>et al.</i> , 2004
238	0.0028	3.32		23.8-72.0 (TL)	Mixed	MED (Türkiye)	Cengiz, 2013
411	0.001	3.839	0.890	29.0-37.6 (TL)	Mixed	MED (Bulgaria)	Yankova <i>et al.</i> , 2011
665	0.0085	3.12		33.0-67.0 (FL)	Mixed	MED (Adriatic Sea)	Franičević <i>et al.</i> , 2005
212	0.01	3.085		17.7-63.0 (FL)	Mixed	MED (Türkiye)	Kahraman <i>et al.</i> , 2014
	0.0227	2.8773	0.9587	37.5-60.8 (FL)	Mixed	MED (Adriatic Sea)	Čikeš Keč <i>et al.</i> , 2019

TL: Total length
 FL: Fork length

4.c. Conversion factors

There is a lack of information on this topic.

4.d. Reproduction

- *Spawning*

Atlantic bonito is a multiple spawner with asynchronous oocyte development that carries out 3 or 4 spawning batches by reproductive season (Mayorova and Tkacheva, 1959; Rey *et al.*, 1984). The spawning grounds are typically in coastal areas during the warmer seasons of the year. In the Mediterranean, there are several areas of spawning: Balearic area, Algerian coasts, Sicilian coast, Aegean Sea and Black Sea (Dardignac, 1962; Rodríguez-Roda and Di Centa, 1980; Sabatés, 1990; Sabatés and Recasen, 2001; Čikeš Keč, *et al.*, 2019).

Table 3. Spawning period of the Atlantic bonito off the Atlantic Ocean and Mediterranean Sea. Northwest Atlantic (NW), Southeast Atlantic (SE) and Mediterranean Sea (MED).

Location - ICCAT	J	F	M	A	M	J	J	A	S	O	N	D	Reference
MED (East Mediterranean)													Kahraman <i>et al.</i> , 2014
MED (West Mediterranean)													Kahraman <i>et al.</i> , 2014
MED (Morocco)													Collette and Nauen, 1983
MED (Mediterranean and Morocco)													Muus and Nielsen, 1999
NW													Collette and Nauen, 1983
SE (Algeria)													Collette and Nauen, 1983
SE (Senegal)													Collette and Nauen, 1983
SE (Atlantic Morocco)													Fournestin <i>et al.</i> , 1958
MED (Spain)													Sanzo, 1932
Tropical East Atlantic													Frade and Postel, 1955
NW (USA)													Bigelow and Schroeder, 1953

- *Maturity*

Estimates of length of sexual maturity of Atlantic bonito off the Atlantic Ocean and Mediterranean Sea are summarized in the **Table 4**.

Table 4. Published Atlantic bonito maturity studies off the Atlantic Ocean and Mediterranean Sea.

Lm ₅₀ FL (cm)	Locality	Sex	Reference
36.6	MED	Female	Hattour, 2000; Saber <i>et al.</i> , 2017
39.31	MED	Unsexed	Hattour, 2000; Saber <i>et al.</i> , 2017
47.41	NE (Mauritania)	Female	Diagne <i>et al.</i> , 2017
38.56	SE (Côte d'Ivoire)	Female	Angui <i>et al.</i> , 2018
38.0	SW (Argentina)	Unsexed	Hansen, 1987
41.9	MED (Türkiye)	Unsexed	Cengiz, 2013
38.0	MED (Spain)	Males	Rey <i>et al.</i> , 1984
39.0	MED (Morocco)	Females	Rey <i>et al.</i> , 1984
42.5	MED (Türkiye)	Females	Kahraman <i>et al.</i> , 2014
36.8	MED (Türkiye)	Males	Kahraman <i>et al.</i> , 2014
39.2	NE	Females	Postel, 1955
37.0	NE	Males	Postel, 1955
40.0	NE (Morocco)	Females	Dardignac, 1962
45.0	NE (Morocco)	Males	Dardignac, 1962

- *Sex ratio*

The sex ratio has been studied for the Mediterranean and there is a 1:1 sex ratio. However, a higher presence of females in the larger length classes has been noted (Macías *et al.*, 2005).

- *Fecundity*

This species is a fish with indeterminate fecundity (Macías *et al.*, 2005). In the Mediterranean, the average fecundity is 79,432 oocytes by spawning batch, while the total annual fecundity estimates range from 304,000 and 1,150,000 oocytes (Macías *et al.*, 2005).

4.e. First life stages

Eggs and larvae

Eggs are pelagic, 1.15-1.57 mm in diameter and with a variable number (1 to 9) of oil globules (0.28-0.36 mm in diameter when single, 0.02-0.24 when multiple). The yolk is homogeneous. The hatch size is 4 mm. Larvae present pigmentation on tips of jaws, forebrain, midbrain, gut, cleithral symphysis, ventral margins of tail, usually over hypural plate area and P₂ rays (Richards, 2005).

4.f. Diet

Adult Atlantic bonito prey on schooling sardine, anchovy, mackerel and other small pelagic fishes. Main food species reported in eastern Atlantic and Mediterranean Sea: *Engraulis engrasicholus*, *Sardina pilchardus*, *Sardinella sp.*, *Spratella sprattus*, *Ammodytes cicerellus*, *Scomber scombrus*, *Scomber japonicus*, *Trachurus mediterraneus*, *Trachurus trachurus*, *Mullus barbatus*, juvenile *Sarda sarda*, *Atherina spp.*, *Boops boops* and *Caprella*, *Penaeus sp.*, *Euphausia spp.* (Yoshida, 1980). Main species reported in western Atlantic are: clupeids, *Peprilus paru*, *Leiostomus xanthurus*, *Anchoa sp.*, *Scomberomorus sp.*, *Prionotus sp.*, *Loligo sp.*, *Penaeus sp.* and squid (Bigelow and Schroeder, 1953; Boschung, 1966). Atlantic bonito searches for its food early in the morning and evening, generally in the coastal zone (Postel, 1954). The species predators are *Acanthocybium solandri*, *Coryphaena hippurus* and *Sarda sarda*.

4.g. Physiology

There is a lack of information on this topic.

4.h. Behaviour

Atlantic bonito form schools of variable dimensions. The more coastal schools are comprised of small individuals. The schools are mixed, composed of spotted tunny and auxid, or monospecifically formed of Atlantic bonito of the same size. Schooling around flotsam is observed in Senegal (Diouf, 1985). The schools can break up and original individuals from the same school and age class could be found in 2 different schools 600 miles apart (Rey, 1983).

4.i. Natural mortality

Rey (1983) have estimated natural mortality at 1.32 year⁻¹ in the Northeast Atlantic using tagging data. However, Pons *et al.* (2019a) estimated natural mortality empirically through different methods and reported a value of 0.78 year⁻¹ and 0.83 year⁻¹ for the Northeast Atlantic and Mediterranean, respectively.

4.j. Stock structure

There are no clear stock boundaries defined for small tunas species in the Atlantic Ocean. However, the SCRS considers five stocks unit areas, which were previously defined by ICCAT for data collection and management purposes: Mediterranean Sea (Med), Southwest Atlantic (SW), Southeast Atlantic (SE), Northwest Atlantic (NW) and Northeast Atlantic (NE). Rey *et al.* (1984) showed that there is mixing between Atlantic bonito populations from the western Mediterranean and the Northeast Atlantic. Recently, Viñas *et al.* (2020) found a clear genetic heterogeneity among the eastern Atlantic and Mediterranean Sea populations. The genetic isolation of Atlantic bonito was previously noted within the Mediterranean (Viñas *et al.*, 2004) and between the east Mediterranean and Black Sea (Turan, 2015) and between both sides of the Atlantic Ocean (Viñas *et al.*, 2010). These studies suggest that Atlantic bonito might have multiple stock units in the Atlantic Ocean and Mediterranean Sea.

5. Description of fisheries

Since 1950, the total reported catches of Atlantic bonito have been oscillating with an average around 30,000 t, with strong peaks along the time series, some years reaching more than 50,000 t landed (**Figure 4**). In general, most of the catch come from Mediterranean Sea, accounting for ~ 65% in average of the total landed catch between 1950 and 2019 (**Figure 4**). Landings from the Northeast Atlantic have been increasing since the mid 1990s up to the last decade with a notable increase in 2019, when almost 20,000 t were landed, becoming the most important area with 67% of the total catch in the Atlantic Ocean and Mediterranean Sea. On the other hand, landings of Atlantic bonito in the western and Southeast Atlantic are considerably lower in comparison to the Mediterranean Sea and Northeast Atlantic (**Figure 4**).

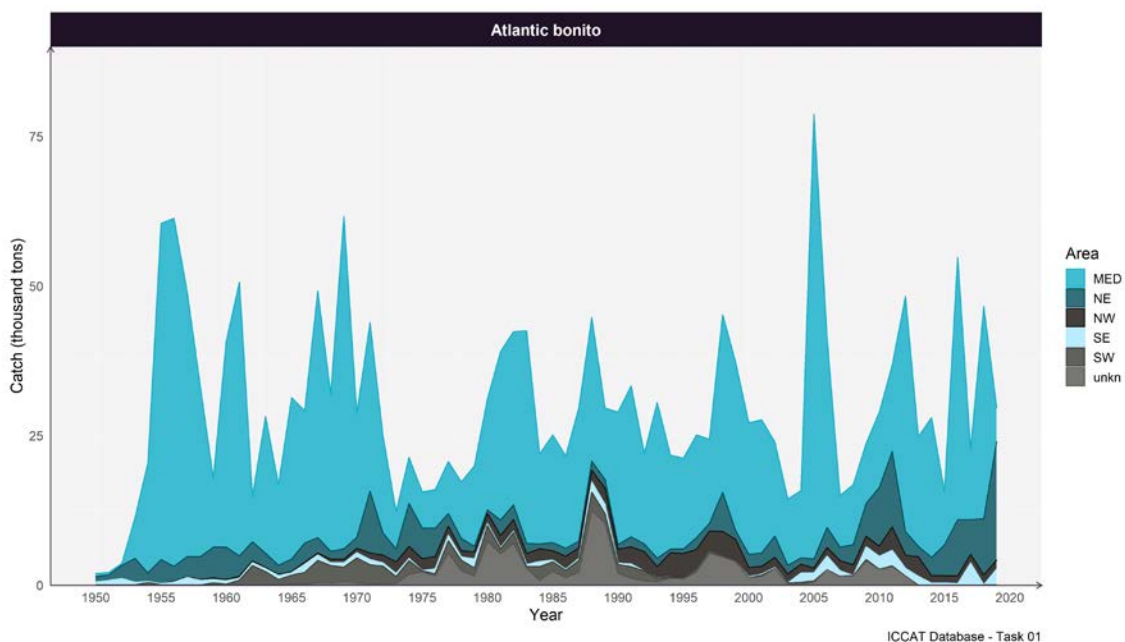


Figure 4. Catch of Atlantic bonito available in the ICCAT database by region from 1950 to 2019.

Atlantic bonito is exploited mainly by coastal fisheries and often by artisanal fisheries, including purse seiners, handlines, small-scale longlines, and a wide variety of nets, especially, gillnets and trammel nets. Most of the catch come from unknown fishing gears (**Figure 5**), particularly at the beginning of the time series in all five areas. In the Mediterranean Sea, purse seine fisheries are the most important fishing gear in terms of landings (**Figure 5**). In the Northeast Atlantic, most of the catch is under the category “others” and includes a wide variety of fishing gears, while in the Northwest Atlantic, catches are dominated by longline fisheries. In the Southeast Atlantic, gillnet fisheries are the most important with 48% of total catch in the last decade. For the Southwest Atlantic, catch reporting has decreased to extremely low levels and landings have been mainly reported by the longline fisheries in the last decade (**Figure 5**).

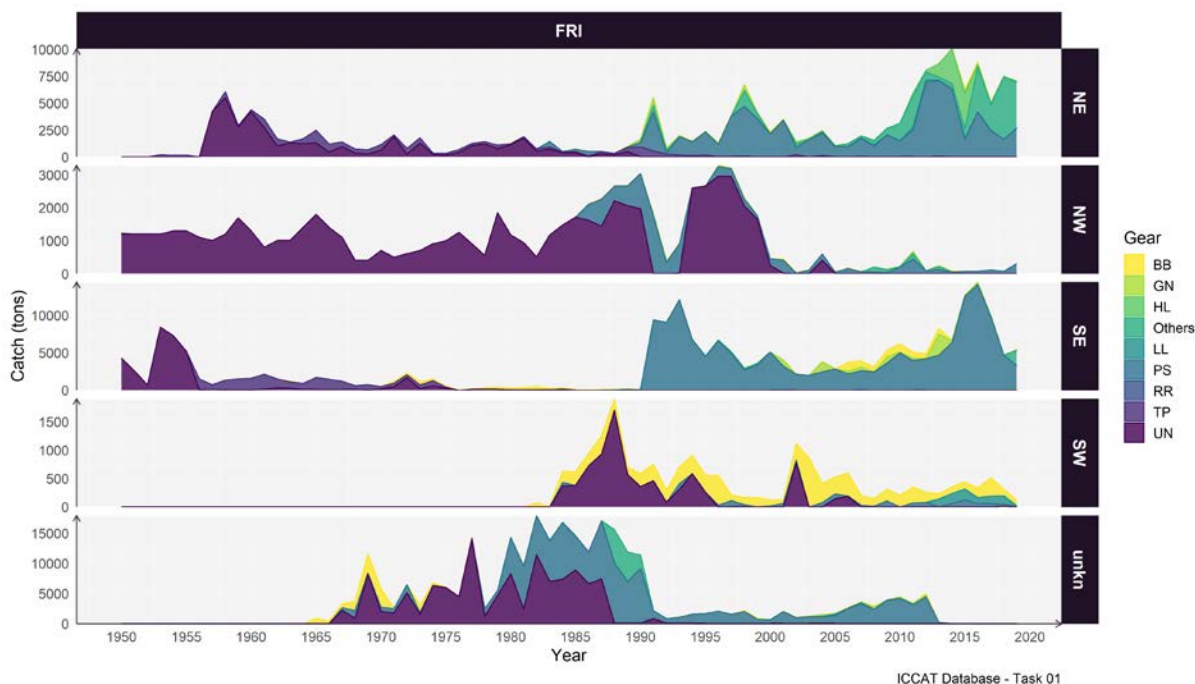


Figure 5. Total catch of Atlantic bonito by ICCAT region and fishing gear. TP: traps. RR: rod and reel. PS: purse seine. LL: longline. HL: handline. GN: gillnets. BB: baitboat. UN: unknown. Others includes: trawl (TW), trolling (TR), haul seine (HS), trammel net (TN), sport (SP), tended line (TL), and harpoon (HP).

6. Description of size composition

There are no estimates of catch-at-size or catch-at-age for Atlantic bonito. However, there is a relatively large sample size from the main fisheries available in the ICCAT Task 2 size data base. In general, size samples are not well represented throughout its distribution, with the largest number and spatial coverage of sampling in the eastern Atlantic and the Mediterranean Sea (**Figure 6**). The largest specimens of Atlantic bonito occurred in the Gulf of Mexico, but size data from the Northwest Atlantic is represented only by rod and reel with a slight recent decrease reported (Lucena-Frédou *et al.*, 2021). In the Northeast, mean sizes varied from 38 to 60 cm and is relatively stable over the overall period with an overall mean of 50 cm FL for all gears combined (**Figures 6 and 7**). Most of the data comes from gillnet, handline, trapping, trolling and trawl fisheries (Lucena-Frédou *et al.*, 2021). On the other hand, Atlantic bonito in the Mediterranean Sea presented an overall declining trend in mean size from 2000 onwards (**Figure 7**), particularly for the longline fishery (Lucena-Frédou *et al.*, 2021). Although Atlantic bonito size data in the Southeast Atlantic are very spread across time, a relatively stable trend can be observed (**Figure 7**).

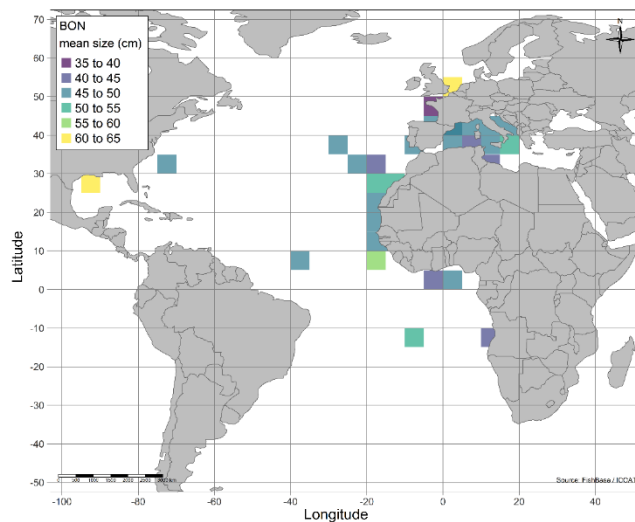


Figure 6. Mean size of Atlantic bonito, in each quadrant of 5x5° between 1979 and 2019.

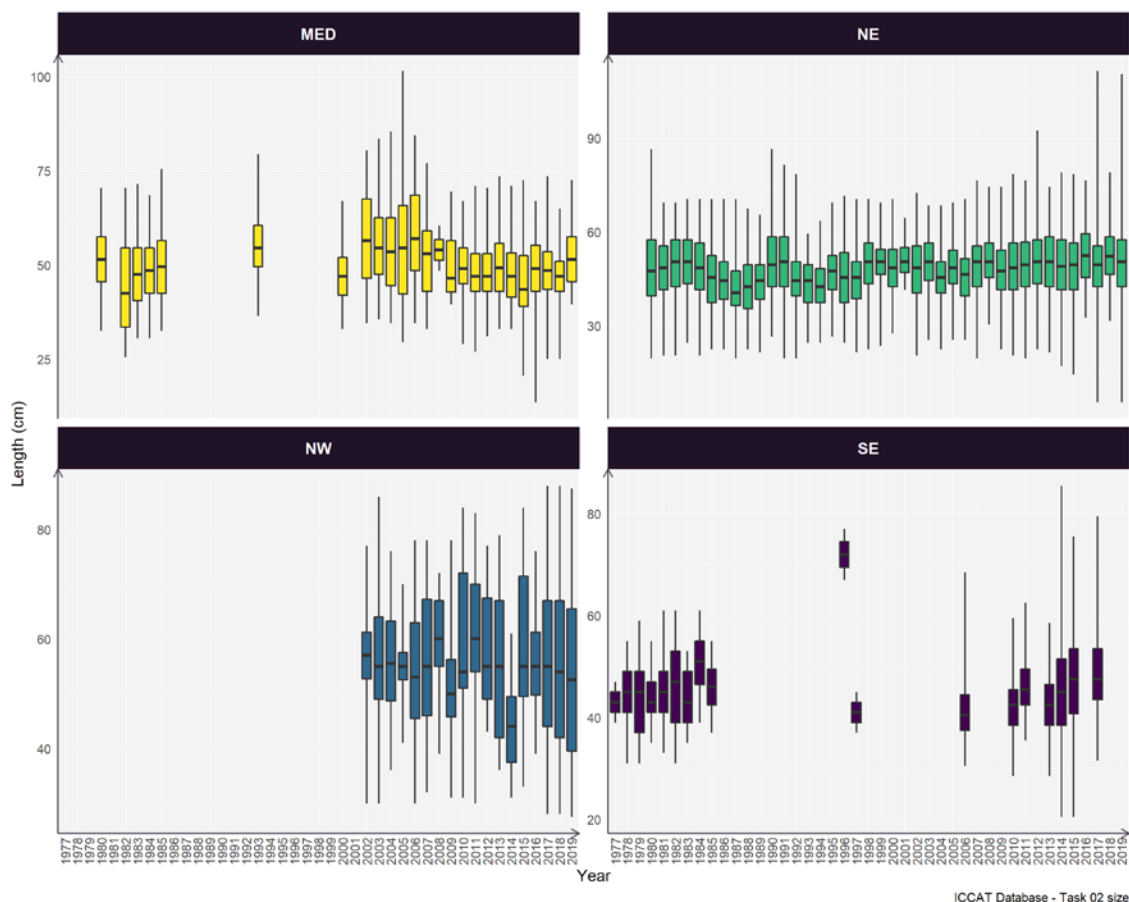


Figure 7. Length data for Atlantic bonito in the Atlantic between 1977 and 2019.

7. Stock assessment

Results from data-limited stock assessment methods showed that the stock status of Atlantic bonito in the Mediterranean and Northeast Atlantic is highly uncertain, as denoted by some conflicting results between the assessment models (Pons *et al.* 2019 a and b). Petukhova (2020) using a length-based model with Russian fishery-length data, found that Atlantic bonito in the Northeast Atlantic is experiencing overfishing with an estimation of spawning potential ratio of 0.28.

8. List of references

- Angui, K.J.P., Soro, Y., Amandé, M.J., Edoukou, A., N'Guessan, Y., N'da, K. 2018. Paramètres de reproduction de *Sarda sarda* (Bloch, 1793) du golfe de Guinée, Côte d'Ivoire. *Int J Biol Chem Sci* 12: 1320–1333.
- Ateş, C., Deval, M.C., Bok, T. 2008. Age and growth of Atlantic bonito (*Sarda sarda* Bloch, 1793) in the Sea of Marmara and Black Sea, Turkey. *J Appl Ichthyol* 24: 546–550.
- Baibbat, S., Malouli, I.M., Abid, N., Bensbai, J., Benazzouz, B. 2020. Growth and Biometry Analysis of the Atlantic Bonito (*Sarda sarda* (Bloch, 1793)), in the Southern Coast of Morocco. *Acta Sci Vet Sci* 2:7.
- Bard, F.X. 1981. Le thon germon (*Thunnus alalunga* Bonnaterre, 1788), de l'Océan Atlantique. De la dynamique des 1981 populations à la stratégie démographique. Thèse de Doctorat d'État des Sciences Naturelles présentée à l'Université Pierre et Marie Curie, Paris, 335 p.
- Bianchi, G., Carpenter, K.E., Roux, J.P., Molloy, F.J., Boyer, D., Boyer, H.J. 1999. Field guide to the living marine resources of Namibia. FAO species identification guide for fishery purposes. Rome, FAO. 265 p., 11 colour plates.

- Bigelow, H.B. and Schroeder, W.C. 1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv., Fish. Bull., 53, 577 pp.
- Boschung, H.T. 1966. The occurrence of common bonito, *Sarda sarda*, in the northern Gulf of Mexico. Trans. Am. Fish. Soc., 95: 227-228.
- Cayré, P., Amon Kothias, J.B., Diouf, T., Stretta, J.M. 1993. Biology of tuna. p. 147-244. In A. Fonteneau and J. Marcille (eds.) Resources, fishing and biology of the tropical tunas of the Eastern Central Atlantic. FAO Fish. Tech. Pap. 292. Rome, FAO. 354 p.
- Cengiz, Ö. 2013. Some biological characteristics of Atlantic bonito (*Sarda sarda*) Bloch, 1793) from Gallipoli Peninsula and Dardanelles (northeastern Mediterranean, Turkey). Turk. J. Zool. 37: 73-83.
- Čikeš Keč, V., Zorica, B., Vuletin, V. 2019. Does the Atlantic bonito, *Sarda sarda*, spawn in the eastern Adriatic Sea? Journal of the Marine Biological Association of the United Kingdom 99, 1865–1868.
- Collette, B.B. and Nauen, C.E. 1983. FAO species catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop. 125(2). 137 pp.
- Coull, K.A., Jermyn, A.S., Newton, A.W., Henderson, G.I., Hall, W.B. 1989. Length/weight relationships for 88 species of fish encountered in the North Atlantic. Scottish Fish. Res. Rep. (43):80 p.
- Dardignac, J. 1962. La bonite du Maroc Atlantique (*Sarda sarda* Bloch). Rev. Trav. Inst. Pêches Marit., 26(4): 399-406.
- Di Natale, A., Mangano, A., Celona, A., Navarra, E., Valastro, M. 2006. Atlantic bonito (*Sarda sarda*) catch composition in the Tyrrhenian Sea and in the Strait of Sicily in 2004. Collect Vol Sci Pap ICCAT. 59: 564–570.
- Diagne, A., Djimera, L., Dia, M., Meissa, B. 2017. Contribution à la biologie et la croissance de la bonite à dos rayé (*Sarda sarda*) des côtes Mauritaniennes. Collect Vol Sci Pap ICCAT 74: 266–276.
- Diouf, T. 1985. Méthode suivie au Sénégal pour l'estimation des statistiques des Tâches 1 et 2 concernant les principales espèces de thonidés (albacore, listao, patudo) de l'Atlantique est. Collect. Vol. Sci. Pap. ICCAT/Recl. Doc. Sci. CICTA/Colecc. Doc. Cient. CICAA, 23 (2): 426–32.
- Diouf, T. 1980. Pêche et biologie de trois Scombridae exploités au Sénégal: *Euthynnus alletteratus*, *Sarda sarda* et *Scomberomorus tritor*. Thèse de Doctorat 3ème cycle, Université de Bretagne Occidentale, France. 159 p.
- Fournestin, J., Dardignac, J., Maurin, C., Vincent, A., Coupè, R., Boutiere, H. 1958. Données nouvelles sur les poissons du Maroc Atlantique. Rev. Tra. Inst. Peches Marit. 22: 379 – 493.
- Frade, F. and Postel, E. 1955. Contribution à l'étude de la reproduction des scombridés et thonidés de l'Atlantique tropical. Rapp. P. - V Reun. CIESM 137: 33 – 35.
- Franičević, M., Sinovčić, G., Čikeš Keč, V., Zorica, B. 2005. Biometry analysis of the Atlantic bonito, *Sarda sarda* (Bloch, 1793), in the Adriatic Sea. Acta Adriat 46: 213–222.
- Hansen, J.E. 1987. Aspectos biológicos y pesqueros del bonito del Mar Argentino (Pisces, Scombridae, *Sarda sarda*). Collect Vol Sci Pap ICCAT, 26:441–442.
- Hattour, A. 2000. Contribution à l'étude des poissons pélagiques des eaux Tunisiennes. Thèse de Doctorat, Université de Tunis II, 327 pp.
- Kahraman, A.E., Gökürk, D., Yildiz, T., Uzer, U. 2014. Age, growth and reproductive biology of the Atlantic bonito (*Sarda sarda* Bloch, 1793) from the Turkish coast of the Black Sea and the Sea of Marmara. Turk. J. Zool. 38.
- Kara, F. 1979. Observations on growth and relationship between length and weight of *Sarda sarda* (Bloch). Inv. Pesq., 43(1): 95-105.
- Kasapoglu, N. and Duzgunes, E. 2013. Length-weight relationships of marine species caught by five gears from the Black Sea. Mediterranean Marine Science 15(1): 95-100.
- Kutaygil, N. 1967. Preliminary age analysis of *Mullus barbatus* L. and *Merluccius merluccius* L. in the Sea of Marmara and some pelagic fish of Turkey. FAO Proc. Tech. Pap. Gen. Fish. Counc. Medit. 8: 361–383.

- Lucena-Frédou, F. L., B. Mourato, T. Frédou, P. G. Lino, R. Muñoz-Lechuga, C. Palma, A. Soares, M. Pons. 2021. Review of the life history, fisheries and stock assessment for small tunas in the Atlantic Ocean. *Rev. Fish. Biol. Fish.* 31(1):1-28.
- Macías, D., Gómez-Vives, M.J., García, S., Ortiz de Urbina, J.M. 2005. Reproductive characteristics of Atlantic bonito (*Sarda sarda*) from the south western Spanish Mediterranean. *Col. Vol. Sci. Pap. ICCAT*, 58(2): 470-483.
- Mayorova, A. and Tkacheva, K.S. 1959. Distribution and conditions of reproduction of pelamid, *Sarda sarda* (Bloch), in the Black Sea according to data for the period 1956-1957. *Proc. Tech. Pap. GFCM*, 5: 509-514.
- Muus, B.J. and Nielsen, J.G. 1999. *Sea fish. Scandinavian Fishing Year Book*, Hedehusene, Denmark. 340 p.
- Nikolsky, G.V. 1957. *Spezielle Fischkunde*. VEB Deutscher Verlag der Wissenschaften. Berlin. 632 p.
- Nikolov, D.K. 1960. Biology of the bonito *Sarda sarda* (Bloch) from the Black Sea. *Trud. nauch.-issled. Inst. Rib. Prom. Varna* 3:91-115. (in Bulgarian).
- Nümann, W. 1954. Growth and migration of short-finned tuna (*Sarda sarda*) in Turkish waters. *Document technique*, 42: 377-379.
- Oray, I.K., Karakulak, F.S., Zengin, M. 2004. Report on the Turkish bonito (*Sarda sarda*) fishery in 2000/2001. *Col. Vol. Sci. Pap. ICCAT*, 56(2): 784-788.
- Petukhova, N.G. 2020. Preliminary Assessment of the Stock Status of Atlantic Bonito (*Sarda sarda*) in the Northeastern Part of the Atlantic Ocean. *Journal of Ichthyology*, 60(5), 732-741.
- Pons, M., Kell, L., Rudd, M. B., Cope, J. M., Lucena-Frédou, F. 2019a. Performance of length-based data-limited methods in a multifleet context: application to small tunas, mackerels, and bonitos in the Atlantic Ocean. *ICES Journal of Marine Science*. 76 (4) 960–973.
- Pons, M., Lucena-Frédou, F., Frédou, T., Mourato, B. 2019b. Exploration of length-based and catch-based data limited methods for small tunas. <https://www.researchgate.net/publication/334274099>
- Postel, E., 1955. Contribution à l'étude de la biologie de quelques Scombridae de l'Atlantique tropico-oriental. *Ann. Stn. Océanogr. Salammbo*, 10:168 p.
- Rey, J.C. 1983. Considerations on the migration of tunas in relation on the hydrology of the Strait of Gibraltar. *Collect. Vol. Sci. Pap.*, 18 (3):758–64.
- Rey, J.C., Alot, E., Ramos, A. 1984. Synopsis biológica del bonito, *Sarda sarda* (Bloch) del Mediterráneo y Atlántico Este. *Col. Vol. Sci. Pap. ICCAT*, 20(2): 469-502.
- Rey, J.C., Alot, E., Ramos, A. 1986. Growth of the Atlantic bonito, *Sarda sarda* (Bloch) in the Atlantic and Mediterranean area of the Strait of Gibraltar. *Inv. Pesq.*, 50(2): 179-185.
- Richards, W.J., (ed.), 2005. *Early Stages of Atlantic Fishes: An identification guide for the western central North Atlantic*. CRC Press, Taylor and Francis Group, Boca Raton, FL, 2640 pp.
- Rodríguez-Roda, J. and A. Di Centa. 1980. Área de puesta del atún, melva y bonito en las costas de España y Marruecos. *Col. Doc. Cient. ICCAT* 15 (2).
- Rodríguez-Roda, J. 1966. Estudio de la bacoreta, *Euthynnus alleteratus* (Raf.) bonito, *Sarda sarda* (Bloch) y melva, *Auxis thazard* (Lac.), capturados por las almadrabas españolas. *Inv Pesq* 30: 247–292.
- Sabatés, A. 1990. Distribution pattern of larval fish populations in the Northwestern Mediterranean. *Marine Ecology Progress Series*, 59(7), 75-82.
- Sabatés, A. and Recasens, L. 2001. Seasonal distribution and spawning of small tunas, *Auxis rochei* (Risso) and *Sarda sarda* (Bloch) in the northwestern Mediterranean. *Sci. Mar.*, 65 (2): 95-100.
- Saber, S., Ortiz de Urbina, J., Lino, P. G. 2017. Biological samples collection for growth and maturity studies EU Portugal and Spain: Northeastern Atlantic and Western Mediterranean. *ICCAT*, Madrid.
- Santamaria, N., Sion L., Cacucci M., De Metrio G. 1998. Età ed accrescimento di *Sarda sarda* (Bloch, 1793) (Pisces, Scombridae) nello Ionio Settentrionale. *Biol. Mar. Medit.* 5 (1): 721-725.
- Santos, M.N., Gaspar M.B., Vasconcelos P., Monteiro C.C. 2002. Weight-length relationships for 50 selected fish species of the Algarve coast (southern Portugal). *Fish. Res.* 59(1-2):289-295.

- Sanzo, L. 1932. Uova e primi stadi larvali di *Pelamys sarda* Cuvier e Valenc. Mem. Com. Talass. Ital. 188: 3-9 + 1 Plate.
- Sinovčić, G., Franičević, M., Zorica, B., Čikeš-Keč, V., 2004. Length–weight and length–length relationships for 10 pelagic fish species from the Adriatic Sea (Croatia). *Journal of Applied Ichthyology*, 20(2), 156-158.
- Turan, C. 2015. Microsatellite DNA reveals genetically different populations of Atlantic bonito *Sarda sarda* in the Mediterranean Basin. *Biochem Syst Ecol.* 63: 174-182.
- Turgan, G. 1958. The age determination of bonitos and pelamids. *Balik Balıkcılık* 6(3):18-20.
- Valeiras, X., Macías, D., Gómez, M.J., Lema, L., Alot, E., de la Serna, J.M., Ortiz de Urbina, J.M. 2008. Age and growth of Atlantic bonito (*Sarda sarda*) in western Mediterranean Sea. *Collect Vol. Sci. Pap. ICCAT* 62: 1649-1658.
- Viñas, J., Alvarado Bremer, J.R., Pla, C. 2004. Phylogeography of the Atlantic bonito (*Sarda sarda*) in the northern Mediterranean: the combined effects of historical vicariance, population expansion, secondary invasion, and isolation by distance. *Mol. Phylogen. Evol.* 33(1): 32-42.
- Viñas, J., Alvarado Bremer, J.R., Pla, C. 2010. Phylogeography and phylogeny of the epineritic cosmopolitan bonitos of the genus *Sarda* (Cuvier): inferred patterns of intra- and inter-oceanic connectivity derived from nuclear and mitochondrial DNA data. *J Biogeogr.* 37(3): 557-570.
- Viñas, J., Ollé, J., Hajjej, G., Macías, D., Saber, S., Lino, P.G., Muñoz-Lechuga, R., Baibbat, S.A., Habibe, B.M., Ngom Sow, F., Diaha, C., Frédou, F.L. 2020. Population genetic of Atlantic bonito in the North East Atlantic and Mediterranean. *Collect. Vol. Sci. Pap. ICCAT*, 77(9), 6-12.
- Yankova, M., Pavlov, D., Raykov, V., Mihneva, V., Radu, G. 2011. Length-weight relationships of ten fish species from the Bulgarian Black Sea waters. *Turk. J. Zool.* 35(2): 265-270.
- Yoshida, H.O. 1980. Synopsis of biological data on Bonitos of the genus *Sarda*. *FAO Fish. Synop.*, 118.
- Zengin, M., Karakulak, F.S., Oray, I.K. 2005. Investigations on bonitos (*Sarda sarda*, Bloch 1793) on the southern Black Sea coast of Turkey. *Col. Vol. Sci. Pap. ICCAT*, 58(2): 510-516.
- Zusser, S.G. 1954. Biology and fishery for bonito in the Black Sea. *Tr. VNIRO* 28:160-174.