

Study of the reproduction of Atlantic bonito (*Sarda sarda*) in South Atlantic Ocean of Morocco

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Abstract. The demographic structures of Atlantic bonito, *Sarda sarda* (Bloch, 1793), in the South Atlantic coasts of Morocco were studied from the biological sampling data of the landings coastal units targeting this species, between 2012 and 2015. In total, 2688 individuals are measured for size frequency analysis and 158 individuals for biological parameters determination. The season of reproduction was determined by the monthly evolution of the gonado-somatic index and the monthly evolution of the percentage of sexual maturity. The demographic structure of the Atlantic bonito is dominated by sizes between 45 and 52 cm and the gonado-somatic index shows that this species reproduces between May and July.

Key Words: size frequency, reproduction, gonado-somatic index, sexual maturity, sex-ratio.

Introduction. Atlantic bonito (*Sarda sarda* (Bloch, 1793)) which is a member of Scombridae is distributed in both sides of the tropical and subtropical Atlantic Ocean, in the Gulf of Mexico, and in the Mediterranean and Black Seas. In the Eastern Atlantic it is distributed from Oslo (Norway) to Port Elizabeth (South Africa), including the Mediterranean and Black Sea. In the western Atlantic off the east coast of the United States and Canada its usual northern limit is Cape Ann but also has been recorded along Nova Scotia (ICCAT Manuel, 2010 edition). Atlantic bonito is a small tuna species that feeds on small fishes, especially clupeoids such as anchovy, sardine, and sprat, and also on crustaceans (Campo et al 2006). Maximum length in the Atlantic is 91.4 cm fork length (FL) and 5.4 kg and in the Black Sea is 85 cm and 5 kg weight (Collete & Nauen 1983). Common size is 50 cm fork length and about 2 kg. Maximum published weight is 11.0 kg (IGFA 2001).

In Morocco, this species is distributed along the Atlantic Coasts, especially in the southern part of the the Atlantic coast (Abid et al 2015). Coastal fishing units, using gill net as the main gear, mainly exploit the Atlantic bonito. However, other gears catch also this species as by catch such as hand line and trawls. Indeed, other fishing vessels as ocean-going trawlers for example do not target Atlantic bonito but landed more or less significant quantities of the species.

The fisheries targeting Atlantic bonito in Morocco are particularly important in terms of catches, but the information about the stock is not available. So, the study of biological parameters of this species is very important as the first step to a rational management of the stock.

This document presents a study of some biological aspects of the Atlantic bonito, being said that the knowledge regarding biology of this species is very limited in the Atlantic Ocean.

Material and Method

Study area. Samples were collected between 2012 and 2015 at the ports of Laayoune and Dakhla. The geographical coordinates are respectively $27^{\circ}05'43.66''$ N, $13^{\circ}25'45.79''$ W and $23^{\circ}39'33''$ N, $15^{\circ}56'47''$ W (Figure 1).

This region of the Kingdom of Morocco is among the most important fishing areas in the world, due to the phenomenon of upwelling, which is almost permanent (Makaoui et al 2000). In the area north of Cap Boujdour, the surface temperature is between 18.4 and 20°C . In south of Cap Boujdour, temperatures between 18.4 and 21.6°C are recorded. The distribution of surface salinity corresponds to the temperature distribution, with 36.2 - 36.4 ppm in Upwelling zone and 36.5 - 36.8 ppm in deeper waters (Figure 2). The Atlantic bonito can adapt to temperatures ranging from 12 to 27°C and at salinities from 14 to 39 ppm (Bianchi et al 1999).

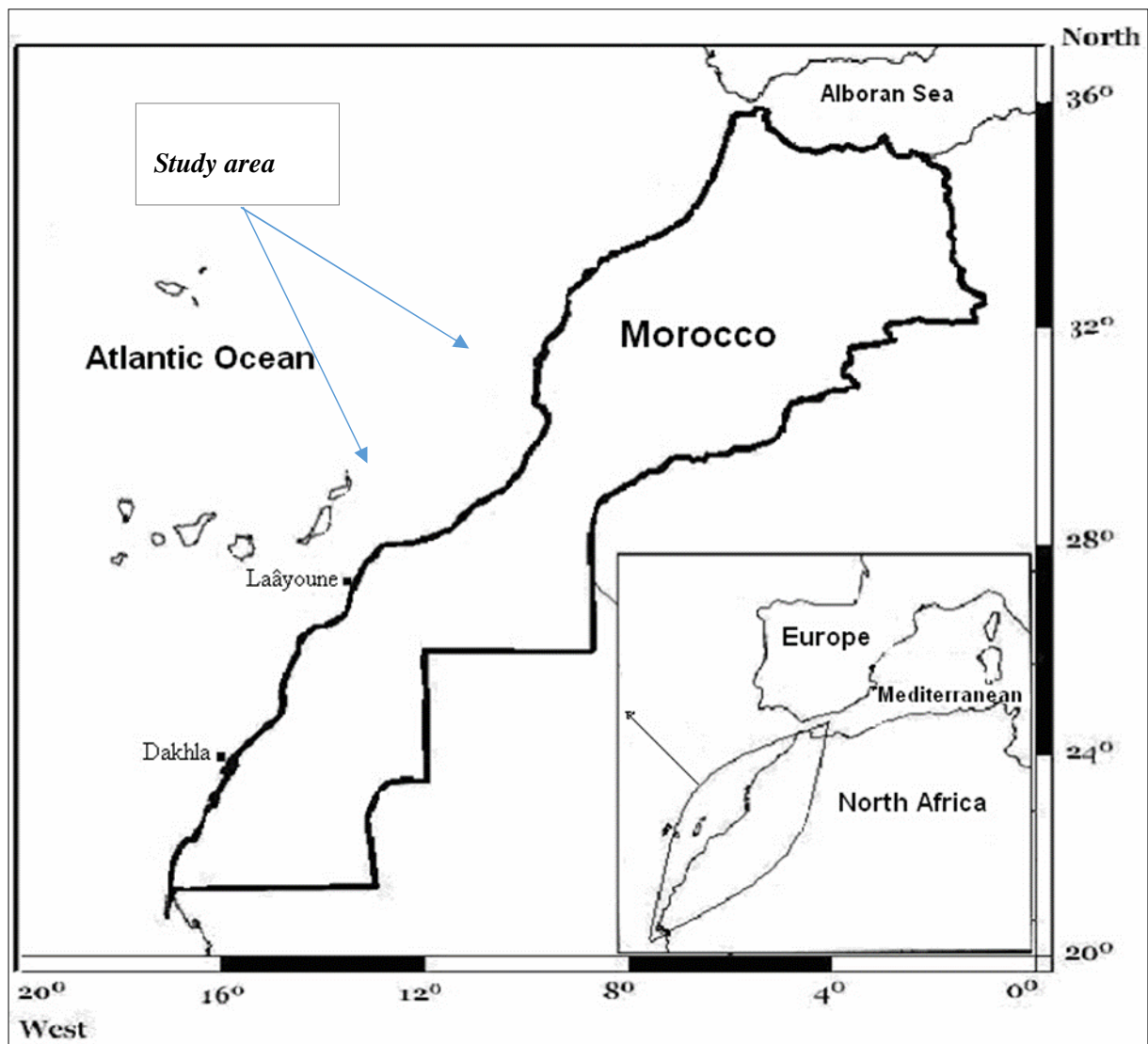


Figure 1. Location of the study area.

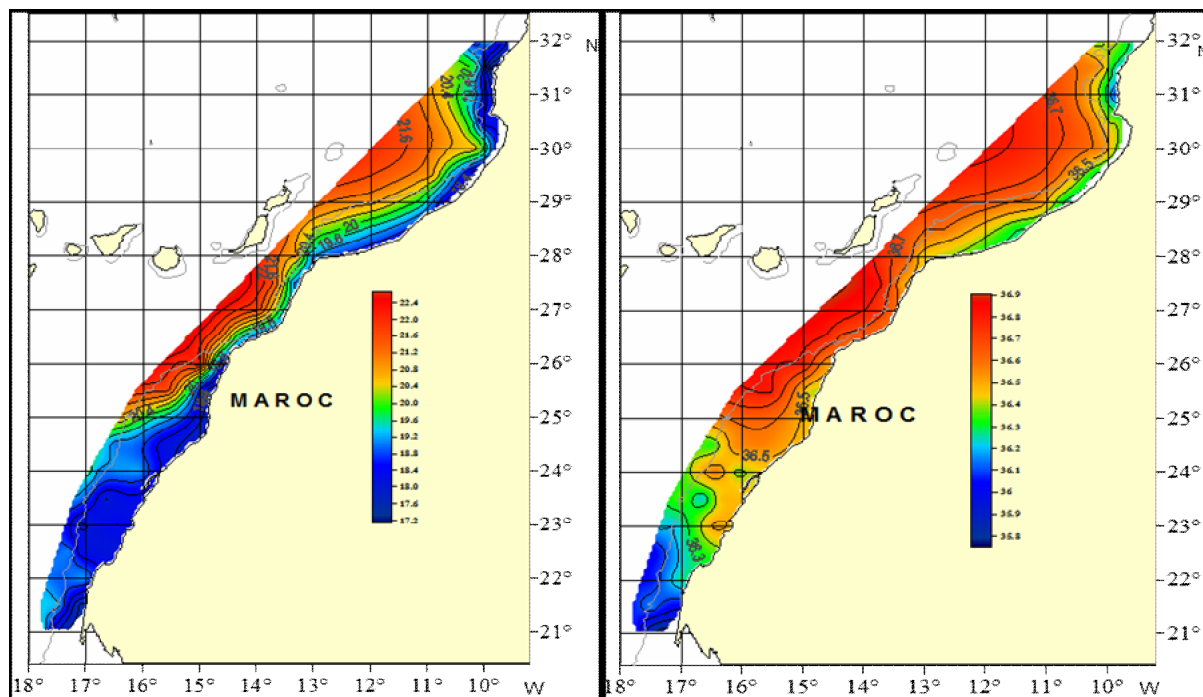


Figure 2. Distribution of the surface temperature in °C (left) and salinity in ppm (right) (Source: Atlantida 2007).

Biological sampling and data sources. All biological sampling data of Atlantic bonito were collected by the laboratories of fishery resources based in Laayoune and Dakhla.

For each biological sampling operation, four boxes (two per category, small and large) are taken randomly from the commercial catches of coastal fishing units to determine their size composition and estimate the biological parameters of Atlantic bonito.

Table 1 shows the number of individuals sampled annually per port. All individuals are measured at the nearest 1 cm (fork length). The biological parameters data were taken from 158 individuals during 2015 and the collected parameters for each fish are: size (mm), weight (g), sex, sexual maturity stage, gonads weight (g) and liver weight (g).

Table 1
Number of Atlantic bonito individuals sampled per year and per port

Year	Number	Port
2012	498	Laayoune
2013	875	Laayoune
2014	530	Dakhla
2015	785	Dakhla

Reproduction. Two approaches were used to determine the spawning period of the Atlantic bonito: a qualitative approach based on monitoring the monthly variation of percentage of different stages of gonad development, and a quantitative approach based on monthly monitoring of changes in gonad somatic index (GSI) (Lahaye 1980) and condition factor K (Do Chi 1978):

$$GSI = (GW/TW) \times 100$$

where: GW is the gonads weight (g) and TW is individual total weight (g).

$$K = (TW \times 100) / L^3$$

where: TW is individual total weight (g) and L is fork length (cm).

The sex ratio is defined as the proportion of each sex in the population, determined by macroscopic observation of gonads. The X^2 test is used in order to

compare sex proportions. It consists of comparing the observed values and theoretical values equality of the workforce.

$$\chi^2_{\text{obs}} = \sum (N_{\text{obs}} - N_{\text{the}})^2 / N_{\text{the}}$$

where: N_{obs} is observed effective of sex in samples; N_{the} is the theoretical effective calculated of sex samples.

Principal hypothesis supposes that we have equal proportions of sexes. The alternative hypothesis proposes that we have a significant difference in proportions between the two sexes:

If $\chi_{\text{obs}} < \chi_{\mu}; 0.05$, principal hypothesis is accepted.

If $\chi_{\text{obs}} > \chi_{\mu}; 0.05$, principal hypothesis is rejected.

Results

Demographic structures. The size frequency analysis of Atlantic bonito catch by coastal long liners shows a dominance of sizes between 31 cm and 74 cm. The large sizes (45-55 cm) are the most dominant in catches. Concerning the port of Laayoune, demographic structures in 2012, shows a predominance of sizes between 44 and 66cm, with two modal classes, 48-49 cm (26%) and 50-51 cm (21%). While in 2013, the demographic structure covers sizes between 41 and 72 cm, with two modal classes, 49-50 cm (17%) and 51-53 cm (27%).

For Dakhla port, the annual size frequency distribution shows a wide range of sizes, with a dominance of sizes between 45 and 55 cm. By comparing the two ports, there is the appearance of sizes less than 40 cm at Dakhla, which is not the case in Laayoune where the minimum sample size is 40 cm FL.

In 2012 and 2013, the monthly distribution of sizes shows generally the dominance of sizes between 48 and 58 cm, with the appearance of large sizes in June, July, August, November and December.

The monthly size structure at the port of Dakhla shows an appearance of large sizes in June, July and August (Figures 3 and 4).

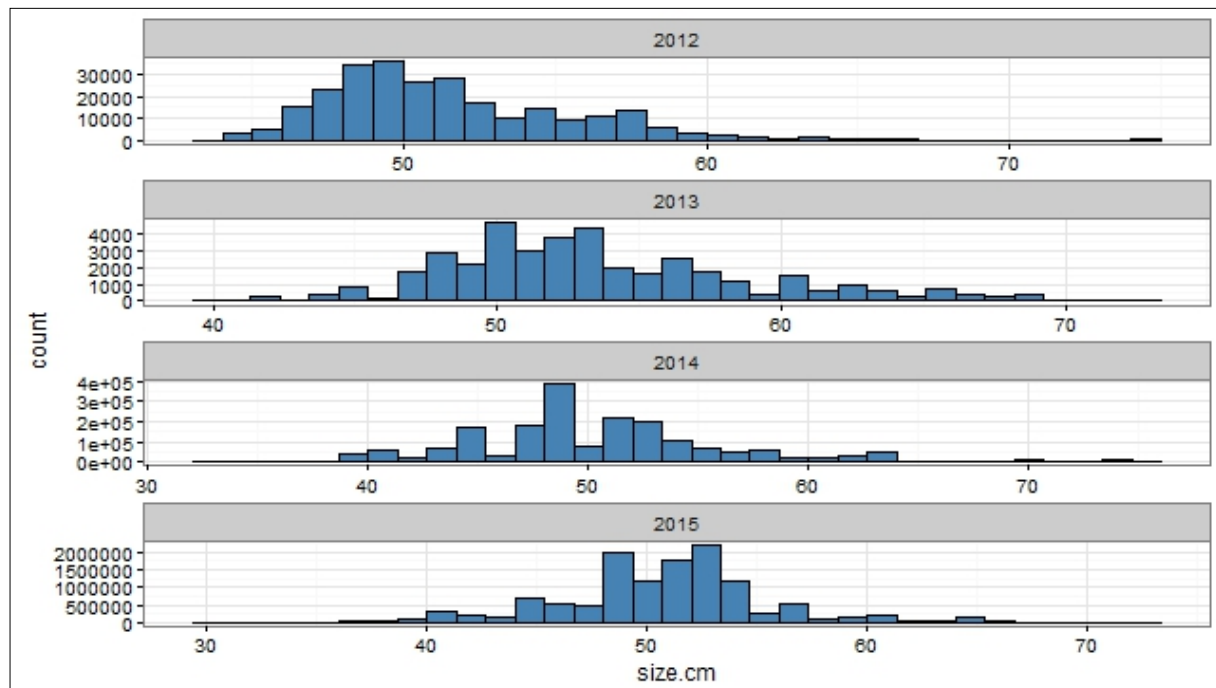


Figure 3. Annual size structure distribution of Atlantic bonito sampled at the port of Laayoune (2012 and 2013) and Dakhla (2014 and 2015).

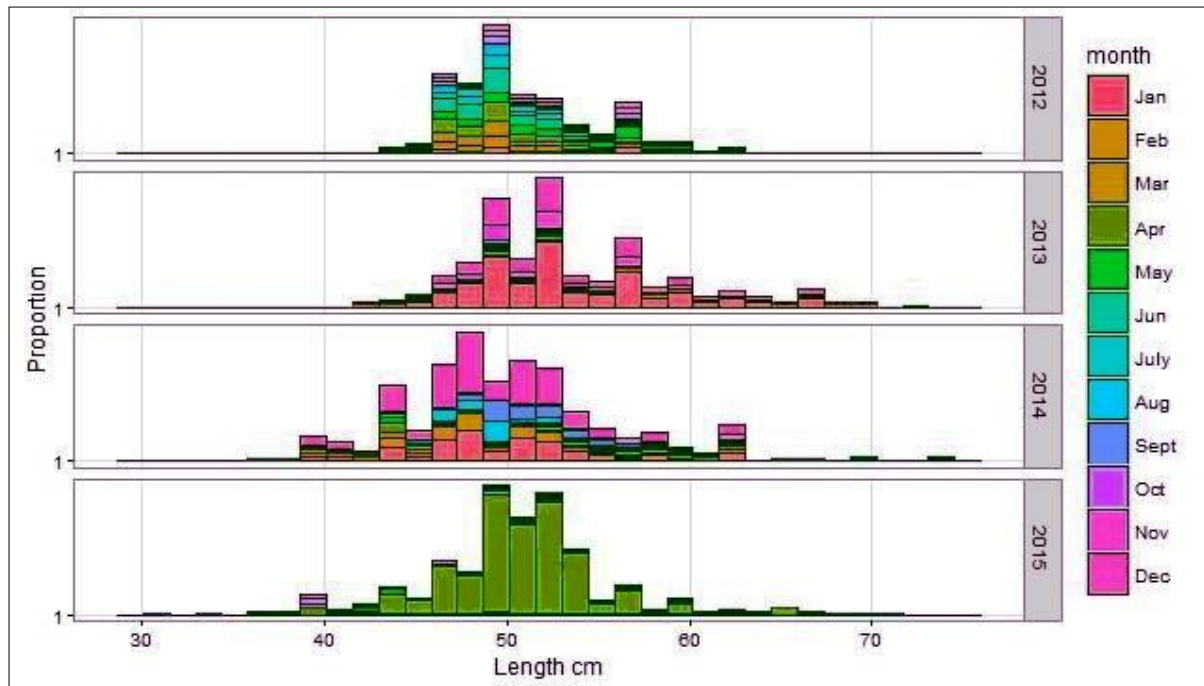


Figure 4. Annual, monthly size distribution of Atlantic bonito sampled in ports of Laayoune (2012 and 2013) and Dakhla (2014 and 2015).

Reproduction. The analysis of GSI shows that the reproduction period of Atlantic bonito is between May and July (Figure 5). The smallest mature female in our samples measures 42 cm (45 cm, Dardignac 1962), while the smallest mature male measures 41 cm (40 cm, Dardignac 1962). These results are confirmed by the monthly monitoring of the percentage of mature individuals. The highest proportion of mature individuals is recorded in May (80%), June (72.7%) and July (77.7%) (Figure 6).

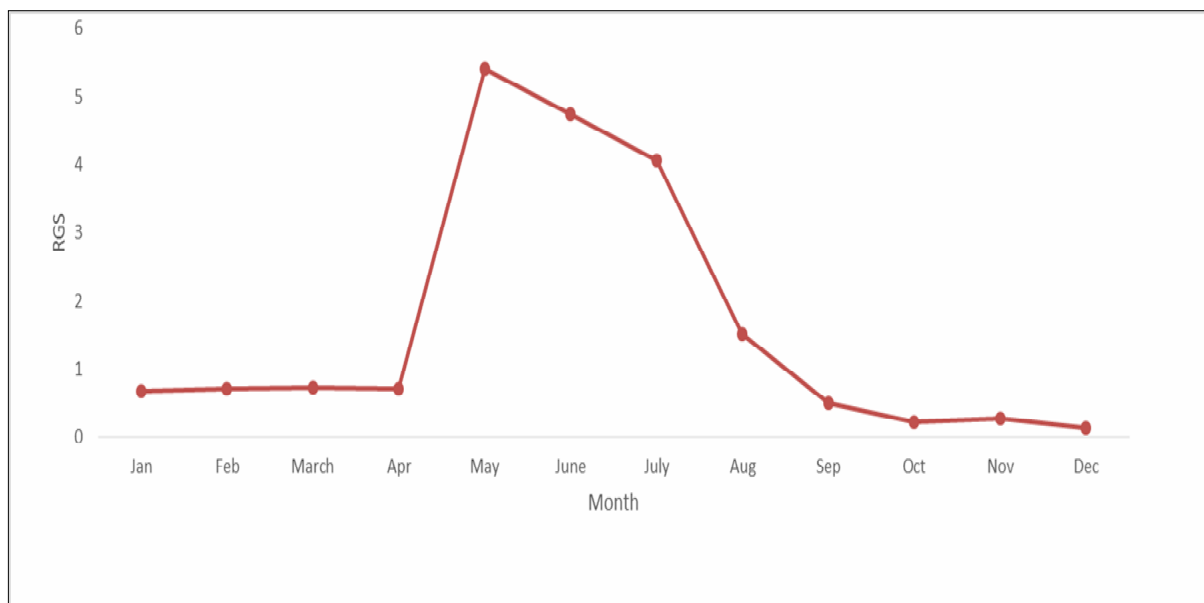


Figure 5. Monthly variations of gonado-somatic index of Atlantic bonito.

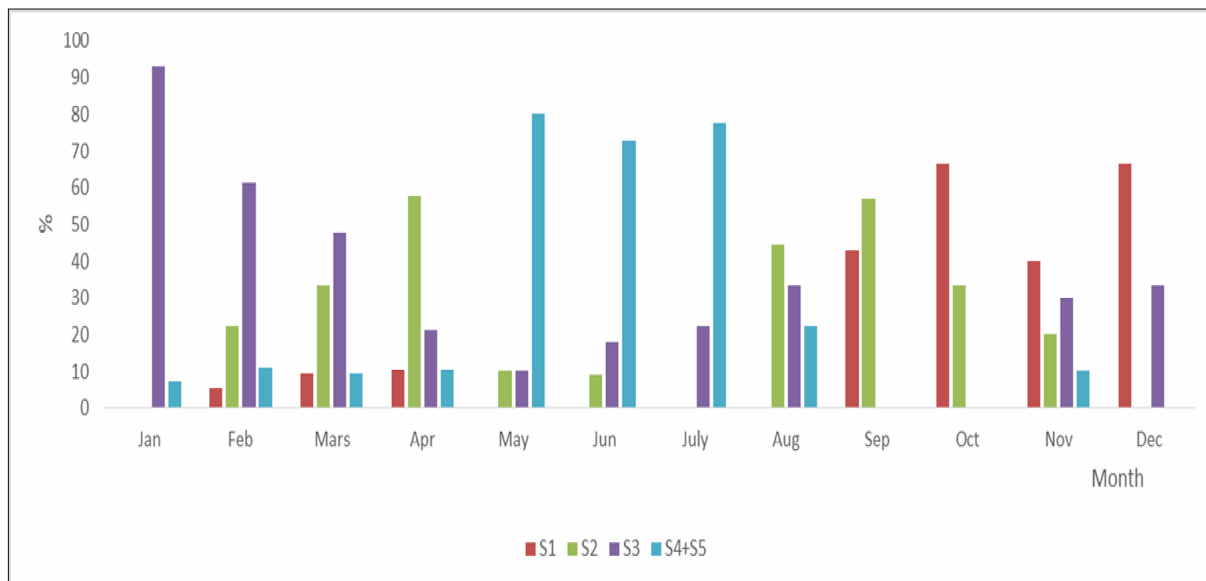


Figure 6. Sexual maturity stages of Atlantic bonito (S1, S2...S5, are the maturity stage).

Condition factor (K). The condition factor (K) varies in the opposite direction of the GSI. Indeed, the maximum value of this index is recorded during the biological recovery of the species (Figure 7).

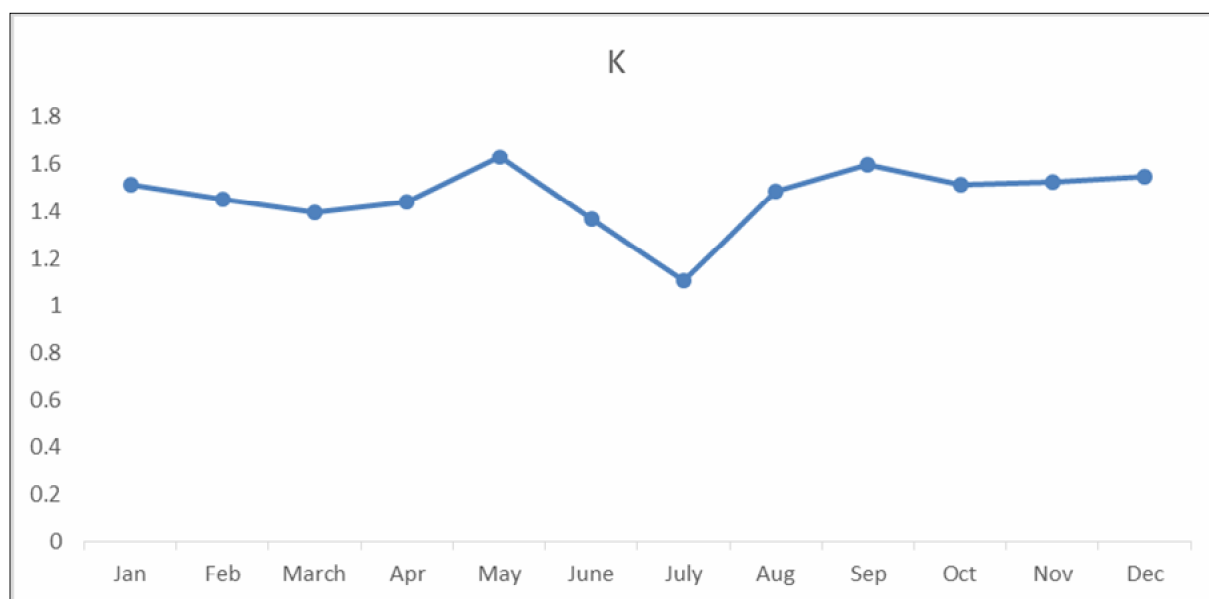


Figure 7. Condition factor of Atlantic bonito.

Sex-ratio. One hundred fifty eight (158) individuals of Atlantic bonito were sampled in 2015 for biological studies. They were divided into 75 females and 83 males. The difference between the two sexes is significant during the seasons of the year (Table 2). The proportions of males and females sampled during 2015 are shown in Figure 8.

Table 2

Variations of proportions of males and females with seasons

	<i>Winter</i>	<i>Spring</i>	<i>Summer</i>	<i>Autumn</i>
Male	32	11	15	25
Female	21	18	13	23
Total	53	29	28	48
%Male	39.62	62.07	46.43	47.92
%Female	60.38	37.93	53.57	52.08
X ² cal	5.36	7.42	0.98	0.71
P	0.25	0.12	0.91	0.95
Rules decisions	SS	SS	SS	SS

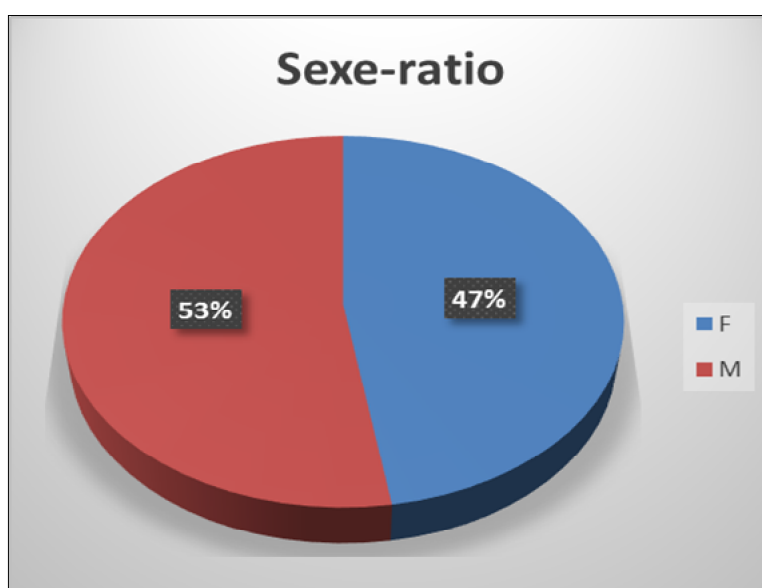


Figure 8. Proportions of males and females in Atlantic bonito.

Discussion. The sizes frequency analysis of Atlantic bonito at ports of Laayoune and Dakhla shows a dominance of mature individuals, whose size is larger than 40 cm. However, we observe sizes smaller than 40 cm only in Dakhla but in small percentage. Knowledge of the early life stages in tunas is very scarce, during the first life stages bonitos are not caught and juvenile life history is unknown (Zengin et al 2005).

Unpublished studies on selectivity conducted in the southern Atlantic coast of Morocco (Baibbat et al 2015), suggest that Atlantic bonito is fully accessible to fishing only from the age of 4 (FL > 40 cm).

As seen in Table 3, the length range of sampled specimens in this study was similar to those found in other studies: Gibraltar Strait: 40.0–55.0 cm (Rodriguez-Roda 1966) and 33.0–70.5 cm FL (Rey et al 1984); the Spanish Mediterranean coasts: 41.0–48.0 cm (Macias et al 2005) and 40.0–61.0 cm (Valeiras et al 2008); Tiran and Sicily coasts of Italy, respectively: 35.0–82.0 cm and 35.0–67.0 cm (Di Natale et al 2006); Adriatic Sea coasts: 33.0–67.0 cm (Franičević et al 2005); the Turkish coasts of the Black Sea, the Sea of Marmara, and the Mediterranean Sea: 29–37 cm (Yankova et al 2013), 14.0–90.0 cm (Kara 1979), 23.0–66.0 cm (Oray et al 2004), 23.5–71.0 cm (Ateş et al 2008), 23.8–72.0 cm (Cengiz 2013).

Table 3

The length range of specimens for Atlantic bonito in different area

<i>Authors</i>	<i>Area</i>	<i>N</i>	$L_{min}-L_{max}$ (<i>cm</i>)
Rodriguez-Roda (1966)	Strait of Gibraltar, Spain	165	40-55
Rey et al (1984)	Strait of Gibraltar, Spain	878	19-72
Macias et al (2005)	Spanish coast of the Mediterranean Sea	183	41-48
Valeiras et al (2008)	Spanish coast of the Mediterranean Sea	136	40-61
Di Natale et al (2006)	Tyrrhenian coast, Italy	240	35-82
Di Natale et al (2006)	Sicilian coast, Italy	109	35-67
Franičević et al (2005)	Coast of the Adriatic Sea	665	33-67
Kara (1979)	Turkish coasts of the Black Sea and the Sea of Marmara	1608	14-90
Oray et al (2004)	Turkish coasts of the Black Sea and the Sea of Marmara	1168	23-66
Ateş et al (2008)	Turkish coasts of the Black Sea and the Sea of Marmara	694	23-71
Cengiz (2013)	Northern Aegean Sea (Gallipoli Peninsula and Dardanelles)	238	23-72
Yankova et al (2013)	Black Sea, Bulgaria	411	29-37
Kahraman et al (2014)	Turkish coasts of the Black Sea and the Sea of Marmara	212	17-63
Present study (2016)	Moroccan Atlantic coast	2688	31-74

All the species of genus are heterosexual and without any dimorphism, however some fishermen are able to recognize male from female by the rigidity of the ventral skin in proximity of the anus (Dardignac 1962; Demir 1963).

Atlantic bonito inhabits neritic and offshore waters, but spawning generally occurs in more coastal area. In the Western Mediterranean there are several spawning grounds: the Algerian coast, Sicily and Balearic Island, the Tyrrhenian, the Ligurian and the Catalan Sea. On the Atlantic coast of Morocco spawning areas have been recognized near Agadir and Casablanca-Fedala (Dardignac 1962; Rodriguez-Roda & Di Centa 1980).

The study of the GSI and the stages of sexual maturity show that Atlantic bonito reproduction period is between May and July. The maximum values of GSI are reported during this period of the year, also the maximum of gonads activity.

These results are in agreement with those by Dardignac (1962), however, other authors reported different period in different area (Table 4). The observed difference in the spawning season could be due to several factors such as variability in environmental conditions (e.g., temperature and salinity), season habitat, fishing area, depth, sampling methodology, selectivity of fishing gear, sex and gonad maturity (Ricker 1969; Bagenal & Tesch 1978; Potts et al 1998; Basilone et al 2006; Froese 2006; Soykan et al 2010).

Table 4

Spawning periods and grounds of Atlantic bonito (from Rey et al (1984) with addition)

<i>Authors</i>	<i>Area</i>	<i>Period</i>
Sanzo (1932)	Sicily	May 20 - June 30
Dieuzeide et al (1954)	Algerian coast	March-May
Rodriguez-Roda (1966)	Gibraltar	May-July
Fournestin (1958)	Atlantic Morocco	June-July
Frade & Postel (1955)	Tropical East Atlantic	February-March
Postel (1955)	Dakar	December-June
Bigelow & Schroeder (1953)	Western Atlantic-USA	June
Sette (1943)	Western Atlantic	July
Sabates & Recasens (2001)	Catalan coast	July
Present study	Southern Atlantic Morocco	May-July

The condition factor (K) evolution shows that both male and female have a similar strategy in using intake energy during the gonads maturity. The maximum values of K correspond to the months that precede the beginning of the reproduction. This implies an accumulation of reserves by the species for the reproduction process, then a transfer of energy for gamete production.

Sex ratio has been studied in Mediterranean since 1966 (Rodriguez-Roda 1966). In this paper a significant difference was observed between the two sexes during the 4 seasons (Table 5). Other studies in the Ionian Sea in the period 1992-1994 (AAVV 1995) obtained a parity of sex ratio.

Table 5

Sex ratio of Atlantic bonito in the Ionian Sea

Year	Sex	Samples	Sex ratio
1992	Males	130	1.24
	Females	105	
1993	Males	33	0.73
	Females	44	
1994	Males	24	0.77
	Females	31	
Total	Males	187	1.04
	Females	180	

Conclusions. In conclusion, the Atlantic bonito stock status remains unknown, although there are some signs of over-exploitation. In addition, continued fishing pressure on this species without any regulation could ultimately reduce the spawning stock below levels sufficient to remain the population. Therefore, it is expected that this results will contribute to further studies to be carried out in the future in terms of fishery management.

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References

- AAVV, 1995 Characterization of large pelagic stocks (*Thunnus thynnus* L., *Thunnus alalunga* Bonn, *Sarda sarda* Bloch, *Xiphias gladius* L.) in the Mediterranean. Final report, EC Contract No XIV, MED/91/012.
- Abid N., Benchoucha S., El Araaf S., El Fanichi C., Baibbat S., Idrissi M. H., Hamdi H., Oumarous M., 2015 Ressources et pecheries de grands pelagiques a l'echeance 2014. In: Institut National de Recherche Halieutique (INRH), Rapport Scientifique, pp. 84-139.
- 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. Journal of Applied Ichthyology 24:546–550.
- Atlantida, 2007 Campagne de suivi des écosystème pélagique par le navire Atlantida dans les eaux marocaine de la zone comprise entre Cap Cantin et Cap Blan.
- Bagenel T. B., Tesch F. W., 1978 Age and growth. In: Methods for assessment of fish production in fresh waters. Bagenel T. B. (ed), Blackwell Scientific Publication, Oxford, UK, pp. 101–136.
- Baibbat S., Abid N., Palma C., Kell L., 2015 A length based assessment for atlantic bonito (*Sarda sarda*). Collect Vol Sci Pap ICCAT 72(8):2208-2220.

- Basilone G., Guisande C., Patti B., Mazzola S., Cuttitta A., Bonanno A., Vergara A. R., Maneiro I., 2006 Effect of habitat conditions on reproduction of the European anchovy (*Engraulis encrasicolus*) in the Strait of Sicily. *Fisheries Oceanography* 15:271–280.
- Bianchi G., Carpenter K. E., Roux J. P., Molloy F. J., Boyer D., Boyer H. J., 1999 FAO species identification field guide for fishery purposes. The living marine resources of Namibia. Rome, FAO, 265 pp.
- Bigelow H. B., Schroeder W. C., 1953 Fishes of the Gulf of Maine. *Fishery Bulletin of the Fish and Wildlife Service*, volume 53, 577 pp.
- Campo D., Mostarda E., Castriota L., Scarabello M. P., Andaloro F., 2006 Feeding habits of the Atlantic bonito, *Sarda sarda* (Bloch, 1793) in the southern Tyrrhenian Sea. *Fisheries Research* 81:169–175.
- Cengiz Ö., 2013 Some biological characteristics of Atlantic bonito (*Sarda sarda* Bloch, 1793) from Gallipoli Peninsula and Dardanelles (northeastern Mediterranean, Turkey). *Turkish Journal of Zoology* 37:73–83.
- Collette B. B., 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 Fisheries Synopsis 125(2), 137 pp.
- Dardignac J., 1962 La bonite du Maroc Atlantique (*Sarda sarda* Bloch). *Rev Trav Inst Pêches Marit* 26(4):399-406.
- Demir M., 1963 Synopsis of biological data on bonito *Sarda sarda* (Bloch) 1793. FAO Fish Rep 6(2):101-129.
- 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. *Col Vol Sci Pap ICCAT* 59:564–570.
- Dieuzeide R., Novella M., Roland J., 1954 Catalogue des poissons des côtes Algériennes. *Bulletin des Travaux de la Station d'Aquiculture et de Peche de Castiglione* 4-6, 384 pp.
- Do Chi T., 1978 Modèles cinétiques et structuraux en dynamique des populations exploitées. Application aux squilles, *Squilla mantis* L. (Crustacé Stomatopode) du golfe de Lion. Thèse de Doctorat d'Etat de l'Université de Montpellier, 272 pp.
- Fournestin J., Dardignac J., Maurin C., Vincent A., Coupè R., Boutiere H., 1958 Données nouvelles sur les poissons du Maroc Atlantique. *Rev Trav Inst Pêches Marit* 22:379–493.
- Frade F., 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 Adriatica* 46:213–222.
- Froese R., 2006 Cube law, condition factor and weight–length relationships: history, meta-analysis, and recommendations. *Journal of Applied Ichthyology* 22:241–253.
- ICCAT, 2010 ICCAT Manual. International Commission for the Conservation of Atlantic Tuna. In: ICCAT Publications [on-line]. Updated 2013.
- IGFA, 2001 Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA.
- Kahraman A. E., Göktürk D., Yildiz T., Uzer U., 2014 Age, growth, and reproductive biology of Atlantic bonito (*Sarda sarda* Bloch, 1793) from the Turkish coasts of the Black Sea and the Sea of Marmara. *Turkish Journal of Zoology* 38:614-621.
- Kara F., 1979 Observations on growth and relationship between length and weight of *Sarda sarda* (Bloch). *Inv Pesq* 43:95-105.
- Lahaye J., 1980 Les cycles sexuels chez les poissons marins. *Oceanis* 6(7):637-654.
- Macias D., Gomez-Vives M. J., Garcia 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* 58:470–483.
- Makaoui A., Orbi A., Larissi J., Zizah S., Hilmi K., 2000 Principales caractéristiques océanographiques de la côte Atlantique marocaine de 1994 à 1998. INRH, Casablanca, Maroc, Rapport Trav Doc No 109, 52 pp.
- 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* 56:784–788.

- Postel E., 1955 Contributions à l'étude de la biologie de quelques Scombridae de l'Atlantique tropico-oriental. Annales Station Oceanographique de Salammbò 10, 167 pp.
- Potts J. C., Manooch III C. S., Vaughan D. S., 1998 Age and growth of vermilion snapper from the southeastern United States. Transactions of the American Fisheries Society 127:787-795.
- Rey J. C., Alot E., Ramos A., 1984 [Synopsis of biology of *Sarda sarda* (Bloch) in the Mediterranean and Eastern Atlantic]. Col Vol Sci Pap ICCAT 20(2):469-502. [in Spanish]
- Ricker W. E., 1969 Effects of size-selective mortality and sampling bias on estimates of growth, mortality, production and yield. Journal of the Fisheries Research Board of Canada 26:479-541.
- Rodriguez-Roda J., 1966 [Study of tuna, *Euthynnus alleteratus* (Raf.), bonito, *Sarda sarda* (Bloch) and frigate tuna, *Auxis thazard* (Lac.) captured by the Spanish almadrabas]. Inv Pesq 30:247-292. [in Spanish]
- Rodriguez-Roda J., Di Centa A., 1980 [Area of sunset tuna, frigate tuna and bonito in the coasts of Spain and Morocco]. Col Doc Cient ICCAT 15 (2), Madrid. [in Spanish]
- Sabatés A., 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.
- Sanzo L., 1932 [Eggs and early larval stages of *Pelamys sarda* Cuvier and Valenciennes]. Mem Com Talass Ital 188: 3-9. [in Italian]
- Sette O. E., 1943 Biology of the Atlantic mackerel (*Scomber scombrus*) of North America. Part 1: early life history, including the growth, drift, and mortality of the egg and larval populations. US Fish Wildl Serv Fish Bull 50:149-237.
- Soykan O., İlkyaz A. T., Metin G., Kinacigil H. T., 2010 Growth and reproduction of blotched picarel (*Spicara maena* Linnaeus, 1758) in the central Aegean Sea, Turkey. Turkish Journal of Zoology 34:453–459.
- Valeiras X., Macias D., Gomez M. J., Lema L., Alot E., Ortiz de Urbina J. M., de la Serna J. M., 2008 Age and growth of Atlantic bonito (*Sarda sarda*) in western Mediterranean Sea. Col Vol Sci Pap ICCAT 62:1649-1658.
- Yankova M., Pavlov D., Mihneva V., 2013 Length–weight relationships of eight fish species from the Bulgarian Black Sea waters. In: Animal diversity, natural history and conservation. Gupta V. K., Verma A. K. (eds)., Vol 3, New Delhi, India, Daya Publishing House, pp. 189-195.
- 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.

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