BULLET TUNA (*AUXIS ROCHEI*)

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Taxonomy

Bullet tuna (*Auxis rochei*) is a species in the Kingdom Animalia. Bullet tuna was named *Auxis rochei* in 1810 by Antonio Risso and is one of four species part of the genus *Auxis* which itself is one of five genera which form the tribe Thunnini (collectively known as the tunas).

Table 1. Taxonomic hierarchy and nomenclature (source: ITIS)

Kingdom	Animalia
Subkingdom	Bilateria
Infrakingdom	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Superclass	Actinopterygii- ray-finned fishes
Class	Teleostei
Subclass	Acanthopterygii
Superorder	Perciformes - perch-like fishes
Order	Scombroidei - tunas, mackerels, bonitos, albacores, ribbonfishes
Family	Scombridae
Genus	Auxis - frigate mackerels, frigate tunas
Species	Auxis rochei

Common names: Bullet tuna [English]; bonitou [French]; melvera [Spanish]; tongol lisong [Indonesian]

Synonyms: (source: WoRMS, FAO)

- *Auxis bisus* (Bonaparte 1845)
- *Auxis maru* (Kishinouye 1915)
- *Auxis ramsayi* (Castelnau 1879)
- *Auxis thynnoides* (Bleeker 1855)
- *Auxis vulgaris* (Cuvier & Valenciennes 1831)
- *Thynnus rocheanus* (Risso 1827)
- *Scomber bisus* (Rafinesque 1810)
- *Scomber rochei* (Risso 1810)
- *Thunnus rocheanus* (Risso 1926)

Distribution & habitat

Geographic range

Bullet tuna is an oceanic species found in the temperate and tropical areas of the major oceans (**Fig. 1**) (Uchida 1981, Collette 1987, Jasmine et al. 2013). It is a highly migratory epi-/meso-pelagic neritic and oceanic species which is widely distributed in tropical and subtropical waters and is heavily influenced by seasonal variations in coastal temperatures (Uchida 1981, Collette et al. 2001).

Bullet tuna exhibit a strong schooling behaviour (Uchida 1981, Collette 1987, Widodo et al. 2012). Adults are principally caught in coastal waters and around islands that have oceanic salinities. The preferred temperature range of bullet tunas is 13.6 - 29°C (Kaschner et al. 2016, Collette & Graves 2019).

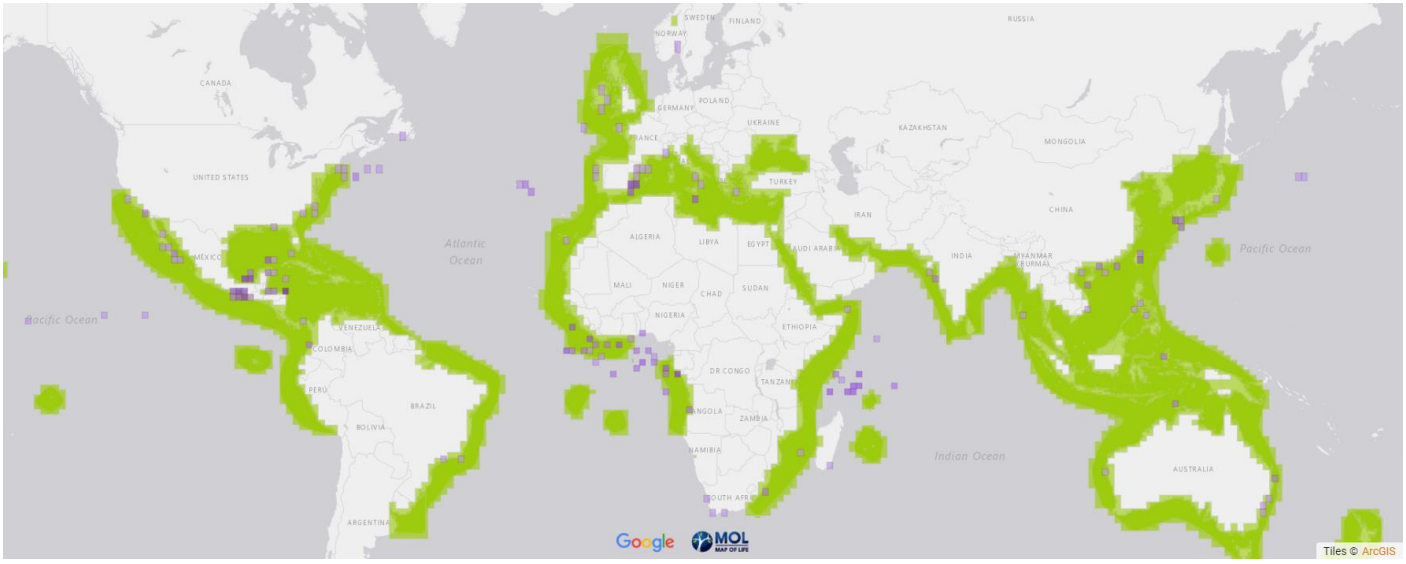

Fig. 1. Global distribution of bullet tuna according to IUCN expert range maps (green envelope) and observations (purple points) recorded in the Global Biodiversity Information Facility (purple squares). Source: www.mol.org

Movements & migrations

Bullet tuna is a species that forms schools both in single species schools or with other small tunas (Recio et al. 2022). Their maximum depth is thought to be around 200m, but fish spend most of their time in the top 10m of the water column (Collette & Aadland 1996, Collette & Graves 2019).

Population structure

Little information is known about the population structure of bullet tuna within the Indian Ocean, but this stock is considered to be separate from the stocks in the Atlantic and Pacific Oceans.

The results of recent genetic analyses conducted on 120 samples collected from four landing sites around the island of Bali, Indonesia led to the conclusion that there is a single population of bullet tuna with high genetic diversity around Bali and its adjacent waters (Agustina et al. 2022)**.**

In 2012, the IOTC WPNT hypothesised that there may be sub-populations of bullet tuna including one which is in the regions of West India and East India and the Bay of Bengal, and the other is around Australia, Malaysia, Indonesia and Thailand (IOTC 2012). However, participants of this meeting also noted that there is an absence of reliable evidence relating to the stock structure of bullet tunas and other neritic species so currently each species is assumed to exist as a single stock throughout the Indian Ocean.

Biology

Growth & morphometrics

Little is known about the biology of bullet tuna in the Indian Ocean. It is the smallest of the tuna species found in Indian Ocean waters, with an average size of 35 cm fork length (FL) (Jasmine et al. 2013). The maximum recorded size of bullet tuna is 50 cm fork length and 1.84 kg (Collette & Graves 2019) and common fork lengths in the Indian Ocean range between 15-25 cm (Silas & Pillai 1982).

It is generally considered to be a fast-growing species (Jasmine et al 2013). From bullet tuna samples collected along the coastal waters of Sri Lanka from 2015-2017, Herath et al. (2019) concluded that the species has an allometric growth based on length-weight and length-length relationships found (meaning that fish gain weight faster than they gain length). This finding is in line with studies conducted in Indian waters by (Jasmine et al. 2013) and the Mediterranean (Bök & Oray 2001, Macias et al. 2005). However, during a study conducted in the Banda Sea, Amri et al. (2019) concluded that the species displays an isometric growth which is in line with the conclusion drawn by (Febrianty et al. 2014) who studied fish in the western Java region. A summary of the length-weight and growth relationships estimated by various studies can be found in **Table 2** and **Table 3.**

Bullet tuna are thought to be short lived with a maximum life span of around 5 years (Jasmine et al. 2013).

Table 2. Morphometric relationships for bullet tuna. Dressed weight (aka carcass weight) corresponds to headed and caudal peduncle-off weight (PD), i.e., the body without head, gills, guts, tail, and fins

Source measure	Target measure	Equation type	a	b	N	Source and location
Weight	Length L	$W = a \times L^b$	7.6 x 10^{-3}	3.249		Jasmine et al. 2013 India
Weight	Length L	$W = a \times L^b$	1.487x 10^{-5}	2.9265		Silas et al. 1985 Cochin, India
Weight	Fork Length FL	$W = a \times FL^b$	5.187x 10^{-6}	3.1711		Muthiah 1985 Mangalore, India
Weight	Length L	$W = a \times L^b$	8.2x10^{-7}	3.8758	126	Silas & Pillai 1985 Lakshadweep Islands, India

Weight	Fork Length FL	$W = a \times FL^b$	7.6x10^{-3}	3.249		Rohit et al. 2014 Kerala & Karnataka, India
Weight	Fork Length FL	$W = a \times FL^b$	3.1x10^{-3}	3.47		Gopakumar & Ajithkumar 2003 South Kerala, India
Weight	Fork Length FL	$W = a \times FL^b$	6.3x10^{-6}	3.2567		Tampubolon et al. 2016 West Sumatra
Total Weight	Fork Length FL	$TW = a \times FL^b$	1.5 x 10^{-3}	3.7092		Tampubolon et al. 2021 West Sumatra
Weight	Fork Length FL	$W = a \times FL^b$	9 x10^{-3}	3.089		Noegroho et al. 2013 West Sumatra (February)
Weight	Fork Length FL	$W = a \times FL^b$	1.4 x10^{-2}	2.984		Noegroho et al. 2013 West Sumatra (March)
Weight	Fork Length FL	$W = a \times FL^b$	3.0 x10^{-2}	2.727		Noegroho et al. 2013 West Sumatra (April)
Weight	Fork Length FL	$W = a \times FL^b$	1.43 x10^{-2}	3.0167	287	Amri et al. 2019 Banda Sea, Indonesia

Table 3: von Bertalanffy growth model parameters in various studies conducted globally

Source	**N**	**L_{inf} (cm)**	***k***	**t_o**	**Location**
Amri et al. 2019	7,716	33.63	0.73	-0.213	Banda Sea, Indonesia
Noegroho & Chodrijah 2015		43.50	0.54	0.070	West Sumatra
Asrial 2020		31.50	0.57	-0.025	Southern Sumbawa, Indonesia
Mudumala et al. 2018		47.38	1.35	-0.23	North-West India
Jasmine et al. 2013		42.3	0.61	-0.0337	India
Gopakumar & Ajithkumar 2003		34.0	1.10		South Kerala, India
Rohit et al. 2014		34.00	1.1		India

Pillai & Ganga 1985		34.00	1.1		India
Pillai & Ganga 1985		42.00	1.0	-0.0133	Mangalore, India
Pillai & Ganga 1985		40.0	1.0	-0.0135	Vizhinjam, India
Rohit et al. 2014		42.3	0.61	-0.0337	Kerala & Karnataka, India

Reproduction

Bullet tuna is a multiple spawner with asynchronous oocyte development and fecundity estimates ranging between 31,000 and 163,000 eggs per spawning (depending on the size of the fish) (Silas 1969, Muthiah 1985a, Niiya 2001, Macias et al. 2005, Kahraman et al. 2010, Rohit et al. 2014). Estimates of batch fecundity range from 52 to 242 oocytes per g of body mass (Niiya 2001, Macias et al. 2005, Jasmine et al. 2013)

Spawning occurs closer to shore than for other tuna species and mostly where sea surface temperatures at 24°C or above (Collette & Graves 2019). Larval studies indicate that bullet tuna spawn throughout its range and throughout the year with peaks at various times of the year depending on location.

Studies conducted in India have shown peaks in spawning during the months of January and July (Rohit et al. 2014). Muthiah (1985) found that bullet tuna off the coast of Mangalore spawn between September and December while (Amri et al. 2019) found that the species spawned from June-November in the Banda Sea.

The size at which 50% of the bullet tuna population reaches maturity (L_{50}) is thought to be around vary from between 18-36 cm FL depending on the location and this is reached at around 2 years of age (Rodriguez-Roda 1983, Muthiah 1985b, Silas et al. 1985, Macias et al. 2005, Juan-Jordá et al. 2013, Amri et al. 2019, Collette & Graves 2019).

Trophic ecology

Bullet tuna is thought to be a nonselective generalist feeder and epipelagic offshore predator (Mostarda et al. 2007). They forage mainly on small fishes, particularly anchovies, crustaceans (commonly crab, *Acetus* species and stomatopod larvae) and squids (Jasmine et al. 2013, Noegroho et al. 2013, Rohit et al. 2014). Cannibalism is common and because of their high abundance, bullet tunas are considered to be an important prey for a range of species, especially the commercial tunas (Collette & Graves 2019).

In the Tyrrhenian Sea around Sicily, Italy, Mostarda et al. (2007) observed a change in diet composition of bullet tuna in relation to their size with the medium sizes fish (25.1-40.0 cm FL) having the most heterogeneous diet (including hyperiids, fish larvae and other invertebrates) while the largest fish (40.1-46.5 cm FL) fed primarily on fish larvae and hyperiids.

The trophic level of bullet tunas has been estimated by Fishbase to be around 4.4 ±0.61 based on its known prey species

Markets

Bullet tuna are marketed in many forms including fresh, frozen, dried, salted, smoked and canned (Collette 1995, Frimodt 1995). The species is thought to have a relatively high economic value in both the domestic and international markets (Kantun et al. 2019).

Stock status

Stock status.

A new assessment was carried out for bullet tuna in 2021 using the data-limited techniques (CMSY and LB-SPR), however the catch data for bullet tuna are very uncertain given the high percentage of the catches that had to be estimated due to a range of reporting issues. Due to a lack of fishery data for several gears, only preliminary stock status indicators can be used. The lack of data on which to base an assessment of the stock is a cause for concern. Stock status in relation to the Commission's B_{MSY} and F_{MSY} reference points remains unknown

Table 4. Bullet tuna (*Auxis rochei*) key management quantities.

Management Quantity	**Indian Ocean**
Most recent catch estimate (2020)	32,251 t
Mean catch over last 5 years[1] (2016-20)	22,690 t
MSY (plausible range)	unknown
Data period used in assessment	-
F_{MSY} (plausible range)	-
B_{MSY} (plausible range)	-
$F_{current}/F_{MSY}$ (plausible range)	-
$B_{current}/B_{MSY}$ (plausible range)	-

Outlook

Annual catches of bullet tuna have steadily increased from around 2,000 t in the early 1990s to around 13,000 t in 2015-2017. In 2018, catches sharply increased to 33,000 t – mostly due to an increase in catches reported by Indonesian industrial purse seine fisheries (Fig. 1). In 2019, the catches of bullet tuna decreased to less than 24,000 t despite a major increase in the number of Indonesian industrial purse seiners in operation. There is considerable uncertainty around bullet tuna catches and insufficient information to evaluate the effect that these catch levels may have on the resource. Research emphasis should be focused on improving the data collection and reporting systems in place and collating catch per unit effort (CPUE) time series for the main fleets, size compositions and life trait history parameters (e.g., estimates of growth, natural mortality, maturity, etc.).

Management advice

For assessed species of neritic tunas and seerfish in the Indian Ocean (longtail tuna, kawakawa and narrow-barred Spanish mackerel), the MSY was estimated to have been reached between 2009 and 2011 and both F_{MSY} and B_{MSY} were breached thereafter. Therefore, in the absence of a stock assessment of bullet tuna a limit to the catches should be considered by the Commission, by ensuring that future catches do not exceed the average catches estimated between 2009 and 2011 (8,547 t). This catch advice should be maintained until an assessment of bullet tuna is available. Considering that MSY-based reference points for assessed species can change over time, the stock should be closely monitored. Mechanisms need to be developed by the Commission to improve current statistics by encouraging CPCs to comply with their recording and reporting requirements, so as to better inform scientific advice.

The following should be also noted:

- The Maximum Sustainable Yield estimate for the Indian Ocean stock is unknown (Management advice is based on a proxy from the 3 assessed species).
- **Limit reference points:** The Commission has not adopted limit reference points for any of the neritic tunas under its mandate.
- Further work is needed to improve the reliability of the catch series. Reported catches should be verified or estimated, based on expert knowledge of the history of the various fisheries or through statistical extrapolation methods.
- Research emphasis should be focused on collating catch per unit effort (CPUE) time series for the main fleets, size compositions and life trait history parameters (e.g., estimates of growth, natural mortality, maturity, etc.).
- Species identification, data collection and reporting urgently need to be improved.
- There is limited information submitted by CPCs on total catches, catch and effort and size data for neritic tunas, despite their mandatory reporting status. In the case of 2020 catches (reference year 2019), 40% of the total catches was either fully or partially estimated by the IOTC Secretariat, which increases the uncertainty of the stock assessments using these data. Therefore, the management advice to the Commission includes the need for CPCs to comply with IOTC data requirements per Resolution 15/01 and 15/02.
- **Main fisheries (mean annual catch 2016-2020)**: bullet tuna are caught using purse seine (58.1%), followed by line (20.5%) and gillnet (14.5%) (**Fig. 1**). The remaining catches taken with other gears contributed to 6.9% of the total catches in recent years.
- **Main fleets (mean annual catch 2016-2020)**: most bullet tuna catches are attributed to vessels flagged to India (36.2%) followed by Indonesia (33.7%), and Thailand (22.1%). The 15 other fleets catching bullet tuna contributed to 8% of the total catch in recent years.

Management Measures

Conservation and Management Measures

Bullet tuna in the Indian Ocean are currently subject to a number of Conservation and Management Measures adopted by the Commission:

- Resolution 19/05 *On a ban on discards of bigeye tuna, skipjack tuna, yellowfin tuna and non-targeted species caught by purse seine vessels in the IOTC are of competence* states that all purse seiners must retain and land all dead non-targeted species including other tunas except when the fish are 'unfit for human consumption'
- Resolution 15/01 *On the recording of catch and effort data by fishing vessels in the IOTC area of competence* sets out the minimum logbook requirements for purse seine, longline, gillnet, pole and line, handline and trolling fishing vessels over 24 metres length overall and those under 24 metres if they fish outside the EEZs of their flag States within the IOTC area of competence.
- Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs)* indicated that the provision are applicable to tuna and tuna-like species
- Resolution 14/05 *Concerning a record of licensed foreign vessels fishing for IOTC species in the IOTC area of competence and access agreement information* which sets out the requirements for licensing foreign vessels in the IOTC area of competence
- Resolution 10/08 *Concerning a record of active vessels fishing for tunas and swordfish in the IOTC area* which sets out the requirement for CPCs to submit a list of active vessels to the Secretariat yearly

- Resolution 11/04 *On a Regional Observer Scheme* which details the observer programme which should be implemented by CPCs to improve the collection of verified catch data and other scientific data related to fisheries for tuna and tuna-like species in the IOTC Area of Competence

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Identification guides

Identification of tuna and tuna-like species in the Indian Ocean:
https://iotc.org/sites/default/files/documents/2014/04/IOTC_IDTuna_vfinal4%28E%29.pdf

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SPC Offshore fish identification cards for small-scale fishermen:
http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Anon_13_TunaIDCards.pdf

Tuna caught in Indonesian waters:
https://static1.squarespace.com/static/52c1c633e4b035d7c738b56a/t/5aaa8b93f9619ada929e0366/1521126295989/Tuna-Types-Caught-in-Indonesian-Waters.pdf

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