CHAPTER 2.1.10.7: BLACKFIN TUNA	**AUTHORS: F. H. V. HAZIN, N. P. A. BEZERRA, D. L. VIANA (UFRPE)**	**LAST UPDATE: June 2021 Original: English**

2.1.10.7 Description of blackfin tuna (BLF)

1. Names

1.a. Classification and taxonomy

Species name: *Thunnus atlanticus* (Lesson, 1830)
ICCAT species code: BLF
ICCAT names: Blackfin tuna (English), Thon à nageoires noires (French), Atún aleta negra (Spanish)

Synonyms:
Scomber coretta (Cuvier, 1829)
Thunnus coretta (Cuvier 1829)
Thunnus balteatus (Cuvier, 1832)
Orcynus balteatus (Cuvier, 1832)
Parathunnus atlanticus (Lesson, 1831)
Parathunnus rosengarteni (Fowler, 1934)
Parathunnus ambiguus (Mowbray, 1935)
Thynnus atlanticus (Lesson, 1831)
Thynnus balteatus (Cuvier, 1832)
Thynnus coretta (Cuvier, 1829)

According to Collette and Nauen (1983), blackfin tuna is classified as follows:

- Phylum: Chordata
- Subphylum: Vertebrata
- Superclass: Gnathostomata
- Class: Osteichthyes
- Subclass: Actinopterygii
- Order: Perciformes
- Suborder: Scombroidei
- Family: Scombridae
- Tribe: *Thunnini*
- Genus: *Thunnus*
- Species: *Thunnus atlanticus*

1.b. Common names

The list of vernacular names used according to ICCAT (Anon, 1990), Fishbase (Froese and Pauly, 2021) and FAO (Carpenter, 2003) is presented below. The list is not exhaustive and some local names might not be included.

Brazil: Albacora, Albacora-cachorro, Albacora-preta, Albacorinha, Atum, Atum-negro, Atum-preto, Binta
China: 黑鰭金槍魚, 黑鳍金枪鱼
Colombia: Atún
Cuba: Albacora, Blackfin Tuna, Falsa albacora
Denmark: Sortfinnet tun
Dominican Republic: Albacora
Estonia: Atlandi tuun

France: Thon à nageoires noires, Giromon, Bonite noir, Bonite, Thon noir, Petit thon, Thon nuit
Guadeloupe: Giromon, Thon noir
Haiti: Bonite
Japan: Mini maguro, Monte maguro, Taiseiyo maguro
Martinique: Bonite noire, Petit thon, Thon à nageoires noires, Ton noir
Mexico: Atún aleta negra
Nicaragua: Atun aleta negra
Portugal: Albacorinha, Atum-barbatana-negra
Puerto Rico: Albacora, Atlantic blackfin tuna, Atuncito, Blackfin tuna, Bonito
Russia: тунец черноперый, Atlanticheskyj tunets, Chernij tunets
Seychelles: Ton noir
Spain: Atún aleta negra, Atún des aletas negras
St. Lucia: Thon nuit
Sweden: Karibisk tonfisk, Svart tonfisk
Trinidad and Tobago: Albacore, Blackfin tuna
United States of America: Blackfin tuna, Deep-bodied tunny
Venezuela: Atun aleta negra, Atún aleta negra, Atún Atlántico

2. Identification: characteristics of *Thunnus atlanticus* (Figures 1 and 2)

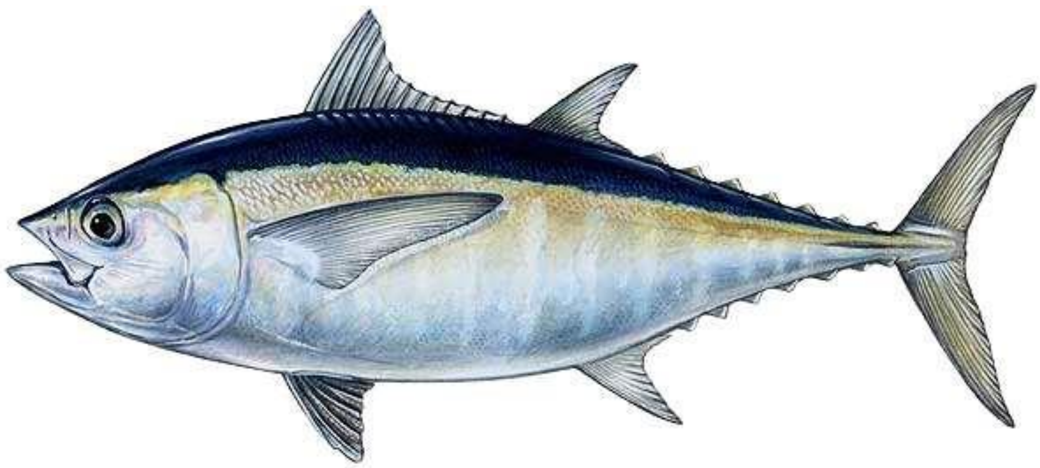

Figure 1. Drawing of an adult blackfin tuna by Duane Raver, Jr.
(http://en.wikipedia.org/wiki/File:Blackfin_tuna, Duane_Raver_Jr.jpg)

Blackfin tuna is one of the smallest tuna species. The largest recorded size for this species was 108 cm fork length (FL) for a weight of 20.6 kg (IGFA, 2001). The maximum total weight ever observed was 22.39 kg with a length of 104 cm FL (IGFA, 2021). Average catch size is 72 cm FL for a weight between 6 and 7 kg (Collette and Nauen, 1983).

Its longevity can exceed 5 years (Collette and Nauen, 1983).

***External characteristics**:*

- Body fusiform, slightly compressed laterally.
- Pectoral fins of moderate length (between 22% and 31% of fork length), with 31 to 35 soft rays.
- Two dorsal fins separated by a small space and followed by 7 to 9 finlets.
- Anal fin followed by 6 to 8 finlets.
- Half-moon shaped caudal fin that supports a strong lateral keel between 2 smaller keels on each side of the peduncle.
- Small and bifid inter-pelvic process.
- Corselet covered with small scales. Larger and thicker, yet unremarkable, scales on the corselet.

Colour:

- Black-metallic blue in dorsum, silver-grey in lower sides and a whiteish abdomen.
- Dark first and second dorsal fin and anal fin with a silver shimmer.
- Finlets mainly dark coloured with the exception of some small yellow or white zones in young individuals (Nakamura and Séret, 2002).
- The abdomen of some individuals has white-silver marks.

Internal:

Between 19 and 25 gill rakers on the first branchial arch. The liver is divided into 3 lobes, with the right lobe being the longest. The ventral surface of the liver has no striations. Small swim bladder.

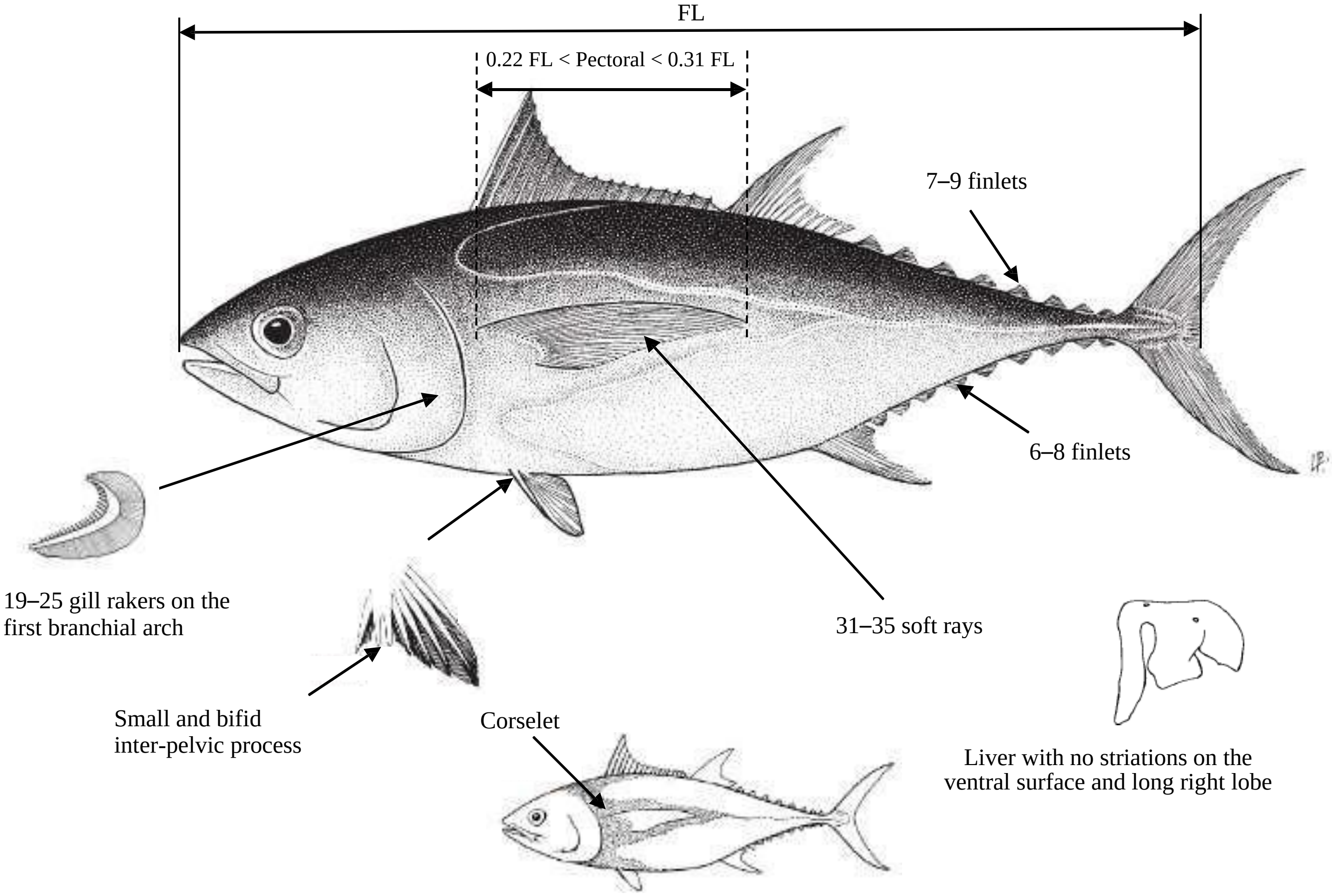

Figure 2. Diagram of the most important characteristics of *Thunnus atlanticus* (based on Collette and Nauen, 1983).

3. Distribution and population ecology

3.a Geographic distribution

The blackfin tuna is found exclusively in the Western Atlantic, from the island of Martha's Vineyard, Massachusetts, USA, in the north, to Trinidad Island and Rio de Janeiro, Brazil, in the south. The distribution area extends from about 40°N to 22°S, including the wider Caribbean Sea and Gulf of Mexico (Collette and Nauen, 1983). According to Zavala-Camin et al. (1991), the occurrence of the species in Brazil has been observed in the far south. Bezerra et al. (2011, 2013) reported its presence in Saint Peter and Saint Paul Archipelago (0°55'N; 029°20'W) (**Figure 3**). The species occurs sometimes in shallow waters where it can be caught by beach seines, such as in Saint Lucia or in the Virgin Islands (Taquet *et al.*,2000).

3.b. Habitat preferences

The largest concentrations of blackfin tuna have been observed at depths between 20 m and 700 m, with the majority reported between 40 m and 50 m (Maghan and Rivas, 1971). Fenton et al. (2015), using pop-up satellite archival tags (PSATs) on blackfin tunas in the northern Gulf of Mexico, showed that the species has a strong preference for shallow waters between 0 and 57 m depth, spending 90% of their time within this range, while performing deep dives, occasionally, down to 217 m.

The main limiting factor affecting the distribution of the species appears to be the sea water temperature, with a minimal isotherm for their distribution at around 20°C (Froese and Pauly, 2012). According to Fenton et al. (2015), the minimum temperature recorded for the species was 13.9°C, in the northern Gulf of Mexico, where the species spent 89% of its time in temperatures ranging from 21.9 to 26.6°C (Fenton *et al.*,2015).

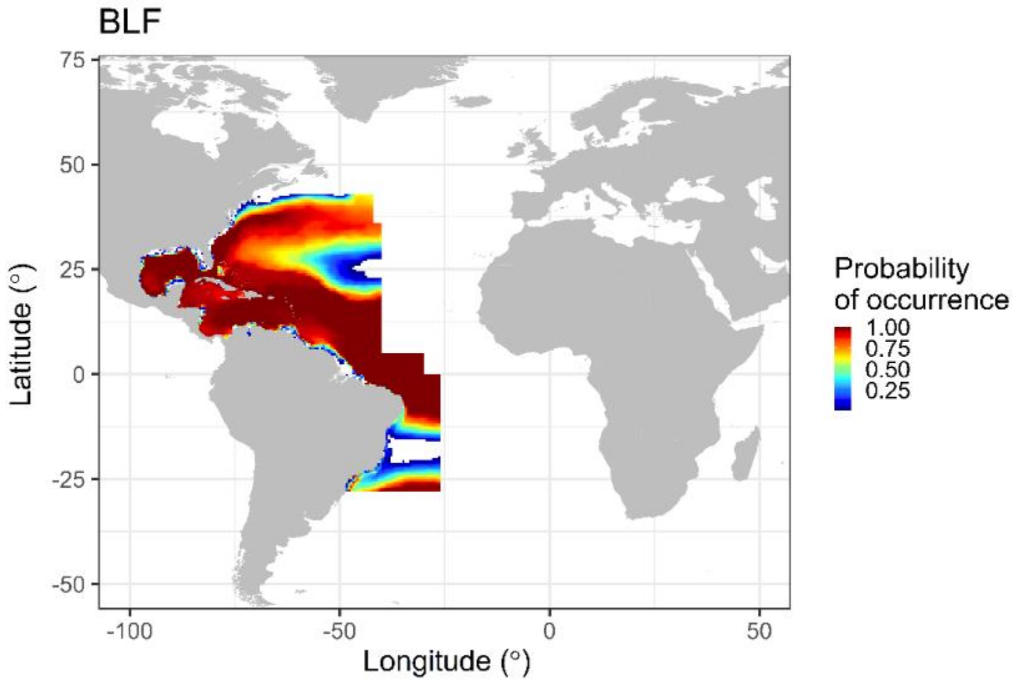

Figure 3. Distribution of blackfin tuna based on data available on FishBase and aquamaps.org website. The range colours indicate degree of probabilities of occurrence.

3.c. Migrations

Large pelagic fish, and particularly tunas, tend to congregate in upwelling areas (Ramos and Sangra, 1992), near shallows and oceanic continental slopes, sites with favourable feeding conditions (Fiedler and Bernard, 1987). The blackfin tuna is known for swimming in the epipelagic zone, being commonly found traveling in large schools, close to shore (Collette and Nauen, 1983). Studies using tagging and recovery data or telemetry on blackfin tuna are limited, with most information about the species habitat preferences being provided by fishing data. Tagging campaigns, however, have greatly contributed to increase the knowledge on the movements of pelagic fish, including the blackfin tuna. The species have been recaptured in the same area where they were tagged in Saint Vincent and the Grenadines (Singh-Renton and Renton, 2007) and Bermuda (Luckhurst *et al.*,2001), showing at least some degree of site fidelity with high recapture rates, sometimes after a long period of time (almost 4 years). Luckhurst et al. (2001) suggested that recaptures near release sites are likely due to favourable conditions for feeding and reproduction. In addition, recoveries happened both inshore, in more sheltered areas with a greater concentration of schools, as well as offshore, although in smaller numbers (Singh-Renton and Renton, 2007). It is possible that some populations are migratory, while others are resident.

Ten blackfin tuna were tagged with Pop-up Satellite Archival Tags (PSAT) in the north-central Gulf of Mexico by Fenton et al. (2015) to evaluate their horizontal and vertical migrations. The pop-up locations showed that only three fish moved away from the tagging site more than 38 km (38.0–97.5 km). The PSAT of six fish popped-up close to the tagging location (<20 km), suggesting some site fidelity. According to Fenton et al. (2015), the fish may either have left the tagging zone and returned by the time of detachment or may have remained around the tagging area, near oil platforms in the Gulf of Mexico, continuously. On the order hand, four blackfin tunas tagged with acoustic tags off Northeast Brazil spent short time intervals (maximum of 48 min) around the FADs, suggesting a low site fidelity in that case, with a maximum Total Resident Time of only two days (Queiroz-Veras *et al.*,2020). These differences in behavior may be due to the distinct oceanographic conditions in those areas, prey availability or local depth of the structure, among many others.

4. Biology and life history parameters

For the purpose of describing the life history parameters, two stock units were considered: Southwest Atlantic (SW) and Northwest Atlantic (NW).

4.a. Growth

The age and growth of blackfin tuna were determined by ring marks in the first dorsal fin spine in Cuba, from January 1983 to March 1984 (Coll and Mendez, 1986). The parameters found for the von Bertalanffy growth equation were: $L\infty$= 598.2 mm (FL), k = 0.33 years^{-1} and $t_0 = -4.42$ days. No significant difference was found between the growth of males and females.

Doray et al. (2004) used the microstructures present in the otoliths of blackfin tuna to estimate the age and growth of specimens caught around FADs in Martinique. The formation of growth striations followed a daily rhythm. The parameters found for the von Bertalanffy growth equation in this study, combined for both sexes, were: $L\infty$= 71.4 cm (FL), k = 0.002 days^{-1} and $t_0 = -80$ days. The results suggest that the daily growth of blackfin tuna is more significant in its younger stages. The sample of this study contained a large number of juveniles and could therefore better characterise the growth of this group.

Freire et al. (2005) found the following parameters for the von Bertalanffy growth curve using a study based on length frequency distribution: $L\infty$ = 92 cm (FL), k = 0.65 years^{-1} and t_0 = 0 years. In the Florida Straits (USA), otoliths were extracted from 207 individuals (29.5 cm to 92 cm FL) for applying von Bertalanffy's logarithmic growth model. The estimated parameters were as follows: $L\infty$ = 95.34 cm, k = 0.28 years^{-1}, and t_0= –1.53 years for both sexes. For von Bertalanffy parameters calculated by sex, the male curve was: $L\infty$ = 118.57 cm, k = 0.15 years^{-1}, and t_0 = –2.25 years; and the female curve was: $L\infty$ = 88.62 cm, k = 0.30 years^{-1}, and t_0 = –1.58 years (Adams and Kerstetter, 2014) (**Table 1**).

Table 1. Summary of the von Bertalanffy growth curve parameters for the blackfin tuna. Southwest Atlantic (SW) and Northwest Atlantic (NW).

Area	$L\infty$ (FL*, cm)	*K*	t_0	References
AT-NW (Cuba)	59.82	0.33 years^{-1}	−4.42 days	Coll and Mendez,
AT-NW (Martinique)	71.4	0.002 days^{-1}	−80 days	Doray *et al.*,2004
AT-SW (Brazil)	92	0.65 years^{-1}	0 years	Freire *et al.*,2005
AT-NW (USA)	95.34	0.28 years^{-1}	–1.53 years	Adams and Kerstetter, 2014

**FL= fork length*

4.b. Length-Weight relationship

Overall, the results of several authors (**Table 2**) suggest that the growth of blackfin tuna is relatively isometric.

Table 2. Different *Thunnus atlanticus* length-weight relationships. W= weight; GWT= gutted weight; RWT= round weight; L= length; TL= total length; FL= fork length; N= number of samples. Southwest Atlantic (SW) and Northwest Atlantic (NW).

Area	Equations (size-weight)	N	Size range (cm)	References
Cuba (NW)	$W=3.935x10^{-4}L^{2.97}$	1,760	34 – 52	Carles, 1971
Cuba (NW)	$W=8.26x10^{-5}L^{2.6302}$	418	34 – 73	Valle-Gômez, 1992
Brazil (SW)	$RWT=0.0255TL^{2.8438}$	303 ♀	46 - 74	Vieira *et al.*,2005a
	$RWT=0.0108TL^{3.0588}$	643 ♂	47 – 86	
	$RWT=0.0128TL^{3.0165}$	946	46 – 86	
Brazil (SW)	$GWT=0.00003FL^{2.8569}$	617♂ and ♀	23 – 87	Freire *et al.*,2005
Martinique (NW)	$RWT=0.00001FL^{3.0819}$	2,428 ♂ and ♀	18.5 – 81	Rivoalen *et al.*,2007
Martinique (NW)	$GWT=0.00002FL^{3.0279}$	1,946 ♂ and ♀	20 –78	Rivoalen *et al.*,2007
Colombian Caribbe (NW)	$W = 0.019L^{2.93}$	1412	27 – 72	Duarte *et al.*,2015
Gulf of Mexico (NW)	$W= exp(-16.6)L^{2.83}$	255	49.9 – 89	Pulver and Whatley, 2016

4.c. Reproduction

• *Spawning*

Several authors have reported that surface temperature is an important parameter for larvae distribution and abundance (Katsanevakis and Verriopoulos, 2006; Sánchez-Velasco *et al.*,2004). It appears that blackfin tuna reproduce when the water temperature reaches 27°C (Juarez and Frias, 1986). Hare et al. (2001) showed that, close to Puerto Rico, on average, *T. atlanticus* larvae are deeper at night than during the day (between 10 and 35 m), while the salinity and temperature are homogenous to a depth of 80 m. This mobility is reduced by the presence of a halocline or thermocline. Notwithstanding, Pereiro Abreu and Frías Fonseca (2010) found no correlation between surface temperature and the presence of larvae.

The presence of mature and spawning individuals, eggs and/or larvae, indicates that the blackfin tuna spawns in a large part of their distribution, whenever the conditions are favourable. Furthermore, recent results suggest that the blackfin tuna is capable of spawning in oligotrophic waters away from the continental shelf, in waters with high salinity (Pruzinsky *et al.*,2020).

Pruzinsky et al. (2020) collected tuna and tuna-like species early life stages in the Gulf of Mexico. The larvae of the blackfin tuna were found offshore in oligotrophic habitats characterized by high salinity, lower chlorophyll-*a* concentrations and away from the shelf break. Larval and juvenile blackfin tunas were also more abundant at night (1.27 ind. 10^{-5} m^{-3}) than during daytime (0.32 ind. 10^{-5} m^{-3}). They suggested then that adults of blackfin tuna probably spawn in open-ocean areas where larvae and eggs may have their chances of survival increased due to reduced predation, compared to the continental shelf. The same authors also noted a higher abundance of larvae and juveniles, in the Gulf of Mexico, during the summer months, starting in June, shortly after the increase in SST, and continuing through September, with a peak in August. In Cuba, strong concentrations of larvae (up to 435 larvae/100 m^2) were recorded in April (Pereiro Abreu and Frías Fonseca, 2010) and in May-July (Olvera Limas *et al.*,1988). In Puerto Rico and the Virgin Islands, the presence of larvae was noted during scientific campaigns in May and November/December, although the seasonal variation of larvae abundance suggests a spawning peak in spring and summer (Hare *et al.*,2001).

Blackfin tuna spawning activity in the Gulf of Mexico seems to start in late spring and to continue through summer, between April and November, with a peak from June to July (Richardson *et al.*,2010; Cornic *et al.*,2018). The reproduction period in the southeast of the United States occurs between April and November (Idyll and De Sylva, 1963; Juarez, 1978), peaking from May to July, when larval abundance is higher (Richardson *et al.*,2010; Ahrabi-Nejad, 2014).

Mature, reproducing individuals were observed in Cuba (Carles, 1971). During July and August, completely mature individuals were the most abundant, representing 83.6% of females and 77.4% of males. In Martinique, females in the active reproductive phase were found mainly between March and August and mature males, from June to August, with a reproductive peak in June (Pau *et al.*,2017). Freire et al. (2005) and Vieira et al. (2005b) suggest that reproduction of the blackfin tuna off northeast Brazil occurs mainly from September to December. Initial maturation takes place during the months of September and October, followed by a more intense spawning activity during the following two months. Notwithstanding, the latest work on blackfin tuna reproduction in Brazil, developed in the Saint Peter and Saint Paul Archipelago, suggested that the species is actively spawning in all months of the year (Bezerra *et al.*,2013), despite a clear peak of reproductive activity from January to March (**Table 3**). Microscopic analysis of blackfin tuna caught in Southeast Florida showed specimens spawning capable and actively spawning in May and June, for females, and from February to October, for males, peaking in May and June for both sexes (Ahrabi-Nejad, 2014) (**Table 3**).

Table 3. Spawning period of the blackfin tuna off the Atlantic Ocean. Dark grey = actively spawning Black = peak of reproductive activity. Southwest Atlantic (SW) and Northwest Atlantic (NW).

Areas	J	F	M	A	M	J	J	A	S	O	N	D	References
NW (Puerto Rico and Virgin Islands)													Hare *et al.*,2001
SW (Brazil, northeast)													Freire *et al.*,2005
SW (Brazil, northeast)													Vieira *et al.*,2005b
SW (Brazil, SPSPA)													Bezerra *et al.*,2013
NW (Southeast Florida, USA)													Richardson *et al.*,2010; Ahrabi-Nejad, 2014
NW (Gulf of Mexico)													Cornic *et al.*,2018; Pruzinsky *et al.*,2020
NW (Cuba)													Olvera Limas *et al.*,1988; Pereiro Abreu and Frías Fonseca, 2010
NW (Martinique)													Pau *et al.*,2017

- *Maturity*

Blackfin tuna reach sexual maturity between 39 and 55 cm (fork length) (**Table 4**). Two studies carried out in Brazil show that males reach maturity at a larger size than females (Freire *et al.*,2005; Bezerra *et al.*,2013). The published data (**Table 4**) suggest that size at first maturity increases southward in the blackfin tuna distribution area. In Cuba, this size is estimated at 39 cm (Valle-Gômez, 1992), while in San Andrés it is 40 cm (Castro *et al.*,2007). Notwithstanding, in Brazil, gonad maturity is reached between 52 and 55 cm, for males, and between 48 and 51 cm, for females. In most cases, females mature at a smaller size than males (Freire *et al.*,2005; Bezerra *et al.*,2013).

Table 4. Different sizes at first maturity of *Thunnus atlanticus*, where FL_{50} and TL_{50} = fork length (FL) and total length (TL) at which 50% of individuals have reached maturity; FL_{100} and TL_{100} = fork length and total length at which 100% of individuals have reached maturity. Southwest Atlantic (SW) and Northwest Atlantic (NW).

Area	*Size at first maturity (cm)*	*References*
USA, Southeast Florida (NW)	TL_{50} = 43.52 ♂ and 39.23♀/ TL100= 58.2 ♂ and 100.24 ♀	Ahrabi-Nejad, 2014
Cuba (NW)	FL50 = 39	Valle-Gômez, 1992
Martinique (NW)	FL_{50}= 45 ♂ and 46 ♀	Pau *et al.*,2017
Colombia (San Andrés) (NW)	FL50 = 40	Castro *et al.*,2007
Brazil (Rio Grande do Norte) (SW)	FL_{50} = 52.1 ♂ and 49.8 ♀	
Brazil (Rio Grande do Norte) (SW)	TL_{50} = 51 ♀/ TL100 = 57.5 ♀	Vieira *et al.*,2005b
Brazil (Saint Peter and Saint Paul Archipelago) (SW)	FL_{50} = 55 ♂ and 48 ♀	Bezerra *et al.*,2013

- *Sex ratio*

All studies conducted with blackfin tuna showed a higher proportion of males to females. Two Brazilian studies obtained the following sex-ratio values: 1.9♂: 1♀ (Freire *et al.*,2005) (although not significantly different from 1:1), and 2.1♂:0.5♀ (Vieira *et al.*,2005b). Bezerra et al. (2013) found a larger proportion of males throughout the year (except for March and September), in SPSPA, with a sex-ratio of 2.2♂: 1♀. Males also predominated in the South Florida with a sex ratio of 1♂: 0.51♀ (Ahrabi-Nejad, 2014). In Martinique, the sex ratio calculated over all samples also favored males (1,7♂: 1 ♀) (Pau *et al.*,2017).

During experimental fishing carried out around FADs close to Martinique, Taquet et al. (2000) observed that 80% of the blackfin tuna with a fork length between 30 and 82 cm were male. Males were more frequent at larger lengths (>55 cm) in Cuba (Valle-Gômez, 1992). The fork length of all sampled specimens off northeast Brazil varied from 39.5 to 74.0 cm, for females, and between 43.0 and 86.0 cm, for males (Freire *et al.*,2005; Vieira *et al.*,2005a). According to Bezerra et al. (2013), males were more frequent on large size classes (> 60 cm) too, while females predominating in smaller lengths. The conclusions are similar in all studies of blackfin tuna: males are predominantly larger than females with disproportionately more males in the population.

- *Fecundity*

The batch fecundity varied between 272,025 and 1,140,584 eggs for 56.0 and 68.0 cm FL females, respectively, in Saint Peter and Saint Paul Archipelago (Bezerra *et al.*,2013). In coastal waters off northeast Brazil (Vieira *et al.*,2005b), the minimum and maximum absolute fecundity were 224,708 and 4,874,389 eggs, in females from 52.0 and 72.2 cm TL.

4.d. First life stages

Eggs and Larvae

Blackfin tuna eggs are pelagic, with little information about their size/diameter. Notwithstanding, Bezerra et al. (2013) noted hydrated oocytes greater than 400 µm. Most blackfin tuna larvae have pigments on the ventral region of the tail (Hare *et al.*,2001), which are always absent in yellowfin tuna. In a group of 215 blackfin tuna larvae of about 9.0 mm SL, this characteristic was present in 93% of them and absent in only 7% (Richards *et al.*,1990). Larvae also present pigmentation on the upper and lower jaw, in the cerebral region, on the upper extremity of the preopercle and on the distal region of the spiny dorsal fin (Juarez, 1972).

Salinity was an important predictor of both distribution and abundance of blackfin tuna larvae, indicating that variation in salinity might affect their occurrence and survival. Although blackfin tuna larvae were detected in a wide range of salinities, higher probability of occurrence and abundance were associated with intermediate salinities (30–34), suggesting that marine areas with some degree of influence of freshwater inflow are potentially a suitable habitat for blackfin tuna larvae (Cornic *et al.*,2018). According to Margulies (1993) and Wexler et al. (2011), *apud* Cornic et al. (2018), tuna larvae are also sensitive to temperature, which can affect their growth and their ability to forage and avoid predators. Several studies have shown that warmer temperatures within anti-cyclonic eddies are favorable for the development of blackfin tuna larvae (Richardson *et al.*,2010; Lindo-Atichati *et al.*,2012; Rooker *et al.*,2013).

4.e. Diet

Blackfin tuna is an epipelagic species that mainly lives in the upper 57 m of the water column (Maghan and Rivas, 1971; Fenton *et al.*,2015). It feeds on epipelagic and deep-water preys during daytime (Headley *et al.*,2009), with occasional deep dives into the mesopelagic zone. However, nocturnal feeding activity has also been suggested for the species (Albuquerque *et al.*,2019).

The blackfin tuna has a high trophic specialisation and a high trophic level. It has a varied diet mainly composed of fish, cephalopods, and crustaceans (Carles, 1971; Manooch and Mason, 1983; Guevara, 1984; Headley *et al.*,2009). In quantitative terms, fish represent the largest part of its diet. Seahorse (*Hippocampus reidi*) was found in the stomach contents of a blackfin tuna for the first time in northeast Brazil (Silveira and Silva, 2020). Shrimps of Sergestidae family, larval stages of decapod crustaceans, fish from Myctophidae family and unidentified teleosts were the most significant prey items in the Saint Peter and Saint Paul Archipelago (Albuquerque *et al.*,2019).

Several studies have shown that the diet of tunas varies depending on size. In the study performed by Guevara (1984), in Cuba, a large variation in diet composition was observed, according to their size. The stomachs of blackfin tunas of over 62 cm FL had a significant volume (55% of the total volume) of molluscs, mainly cephalopods. Individuals of smaller size classes, however, had mostly fish remains, with molluscs representing under 15% of the total volume. Therefore, large individuals seem to decrease their consumption of fish in favour of cephalopods. The presence of floating waste and algae in the stomachs of young tunas implies that they also feed on the surface (Manooch and Mason, 1983). Larvae collected from blackfin tuna up to 15 mm consumed mainly Nauplii, Calanoid copepods and *Farranula* spp. Copepods, in the Straits of Florida (Gleiber *et al.*,2020).

Prey size seems to vary in accordance with the size of the blackfin tuna. Manooch and Mason (1983) showed that small individuals prefer smaller prey (crustacean larvae and juvenile fish), while larger individuals choose larger prey (adult fish).

4.f. Physiology

Like other tunas, blackfin tuna is a very active species. The ability to conserve metabolic heat in red muscle and other regions such as the brain, eyes and guts (regional endothermy), in addition to an elevated metabolic rate and frequency-modulated cardiac output, distinguish tunas from other fish (Graham and Dickson, 2004; Dickson and Graham, 2004). These specialisations allow tunas to swim continuously and quickly, increasing the efficiency of their muscles to perform long-distance migrations and move vertically in the water column, through different temperatures (Watanabe *et al.*,2015). Tunas have evolved highly developed central and lateral vascular counter-current heat exchangers (*retia mirabilia*), which reduce heat loss through muscles and makes oxygen exchange more efficient (Graham and Dickson, 2004). The vascularisation of the skin is more developed in the *Thunnus* family than in other tunas. The blackfin tuna has a combination of the small central *rete* and lateral heat exchangers (Orrell *et al.*,2006). Their size and stage of development also affect their ability to conserve heat. Adults have a higher mass and are able to conserve more heat by thermal inertia than juveniles (Brill *et al.*,1999; Maury, 2005). The swimming mode of tunas is characterised by a propulsion system that involves minimal lateral undulation and the concentration of thrust production in the rapidly oscillating caudal fin. Tunas are the only teleost to use this swimming mode (Graham and Dickson, 2004).

4.g. Behaviour

The behaviour of blackfin tuna around floating objects, such as FADs has been studied by several authors. Catch data and underwater observations around FADs confirm the aggregation of blackfin tuna in Martinique region. Aggregations of several mature males and females around FADs were observed in May and June during the spawning season (Taquet *et al.*,2000). Many other studies were carried out in Martinique by Doray et al. (2005, 2006, 2007, 2009) and Doray (2006), mainly by means of echosounders and videos. The results show significant aggregations of blackfin tunas around FADs. The observed fish schools are multi-species (e.g. yellowfin tuna and skipjack), but are consistent in terms of the size of individuals. The studies carried out in Martinique made it possible to distinguish two types of daytime tuna aggregations and one type of night-time aggregation. During daytime, concentrations of juvenile tunas (average FL: 30 cm) were observed very close to the surface, in 25% of the daytime period, in addition to large aggregations of tunas in the sub-surface (depth of between 35 and 100 m) in all daytime period. These aggregations are essentially composed of blackfin tunas with 58 cm FL. Finally, a smaller sub-surface aggregation of tunas and "extranatant" species (fish that remain at a distance between 10 and 50 m from the FAD) is observed in 75% of night-time periods. The low vulnerability of sub-surface tunas to the line-fishing techniques used during daytime indicates that they do not actively feed during the day. These fish may preferentially feed on mesopelagic organisms during transition and night-time periods around moored FADs (Doray *et al.*,2007). In the first assessment of an anchored FAD used off Recife (northeast Brazil), in the continental shelf break, blackfin tuna did not aggregate (Queiroz-Veras et al. 2020).

Springer (1957), studying their feeding activity off the coast of Mississippi, observed schools of individuals weighing 2 to 3 kg writhing on the surface, from 4 p.m. on, visibly targeting small fish measuring under 7.6 cm. This continued until nightfall. According to Marcille (1985), it is easy to observe schools of blackfin tuna, usually medium-sized and very mobile, due to their surface activity and the presence of birds.

4.h. Natural mortality

Natural mortality was calculated by Freire et al. (2005) by means of the Pauly (1980) equation, with an average surface water temperature of 27.2°C, between 1996 and 1997 fishing cruises. The natural mortality rate was estimated as 0.94 per year.

5. Fisheries biology

5.a. Populations/ Stock structure

Tunas are subdivided into the temperate subgenus *Thunnus* South 1845 (bluefin group) and the tropical subgenus *Neothunnus* Kishinouye, 1923 (yellowfin group) (Collette, 1978). The *Neothunnus* group includes blackfin tuna *Thunnus atlanticus* Lesson, 1831, long-tail tuna *Thunnus tonggol* Bleeker, 1851, and yellowfin tuna *Thunnus albacares* Bonaterre, 1798 (Bayona-Vasquez *et al.*,2018).

Bayona-Vasquez et al. (2018) analyzed the mtDNA from two individuals of blackfin tuna from the Gulf of Mexico and concluded that the Bayesian tree showed blackfin tuna and southern bluefin tuna (*Thunnus maccoyii* Castelnau, 1872) as more closely related to *Neothunnus* than to the pacific bluefin tuna (*T. thynnus orientalis* Linnaeus, 1758) and albacore (*Thunnus alalunga* Bonaterre, 1778), which results in another paraphyly of the bluefin tuna group. Similarly, despite nuclear markers have indicated blackfin tuna and pacific bluefin tuna as sister groups, paraphyly is maintained because southern bluefin tuna is more closely related to the yellowfin group than to the bluefin.

Márquez et al. (2014) carried out the sequencing of complete mitochondrial genome of 16,528 bases of a specimen of *T. atlanticus* collected in the Colombian Caribbean (San Andres Archipelago), with total genomic DNA extracted from muscular tissue. The complete mitochondrial genome presented a GC content of 46.2% and contained 13 protein-coding sequences (CDS) related to the respiratory chain, 2 ribosomal RNA genes (rRNA) and 21 transfer RNAs (mtRNA). Thus, the authors concluded that *Thunnus atlanticus* mitochondrial genome presents perfect synteny with its congeners.

Saxton (2009) studied the genetic structure of a population of blackfin tuna coming from two regions: the Gulf of Mexico and the Northwest Atlantic. Three hundred and twenty-three mitochondrial DNA base pairs and six loci microsatellites were analysed. The results showed an important differentiation among these areas, suggesting that blackfin tuna might have more than one stock in the Western Atlantic.

5.b. Description of fisheries:

The blackfin tuna is a relatively small species that frequently schools with skipjack tuna, *Katsuwonus pelamis* Kishinouye, 1915, yellowfin tuna, *Thunnus albacares* Bonnaterre, 1788, and little tunny, *Euthynnus alleteratus* Rafinesque, 1810 (Taquet *et al.*,2000), resulting in fisheries interactions throughout their entire western Atlantic range (Fenton *et al.*,2015). They are fished for recreation and for consumption throughout their range, though different fishing methods are practiced in different areas (Ahrabi-Nejad, 2014). In Miami, Florida, it is caught by recreational anglers throughout the year, with catches made of mostly one through five-year old fish (Idyll and De Sylva, 1963). It is an important component of the offshore tuna fishery in the Gulf of Mexico (Cornic *et al.*,2018), as well, being seasonally important to artisanal (small-scale commercial) and sport fisheries throughout the Lesser Antilles (Doray *et al.*,2004), and in other locations in the wider Caribbean Sea (Arocha *et al.*,2012), including Cuba (Carles Martin, 1991), the Dominican Republic (ICCAT, 2006), the Bahamas and Florida (Collette, 2002), Venezuela (Narváez *et al.*,2017; Arocha *et al.*,2012; ICCAT, 2006), Bermuda (Luckhurst *et al.*,2001), and Brazil (Freire *et al.*,2005). In the USA, the species has only a minor importance to the commercial pelagic longline fisheries with catches being generally discarded due to their low market value. Notwithstanding, the blackfin tuna is a common target species for the recreational rod-and-reel fishery (Fenton *et al.*,2015).

ICCAT Task 2 data statistics for the blackfin tuna are probably incomplete. Actually, it is likely that most juveniles, which are very difficult to distinguish from other tuna species, are not included in these catch data. According to Arocha et al. (2012), in Venezuela, catches of blackfin tuna by the artisanal fisheries are reported as '*albacora*' by the fishers and has been confused with *T. alalunga* in the national catch statistics. According to Arocha et al. (2009), in the Community of Playa Verde, where an important artisanal drift-gillnet fishery occurs, it was confirmed that '*albacora*' is actually blackfin tuna (*T. atlanticus*). As in Venezuela, in Brazil, Freire et al. (2005) reported that almost 100% of the artisanal catch of 'albacora' is *Thunnus atlanticus*. Thus, data from artisanal fisheries targeting blackfin tunas in the region cannot be properly analyzed because national and local databases also record this species as albacore 'albacora', together with 3 other species (*T. albacares*, *T. alalunga*, and *T. obesus*).

Since 1950, the total reported landings of blackfin tunas have increased considerably from around 300 t, in the 1950s, to around 2,000 t, in the early 1970s and 1980s. During the 1990s, the total landings surpassed 4,000 t in various years, dropping, however, sharply in the early 2000s, with values close to 1,000 t, in 2005. From that year on, until the end of the series, blackfin tuna landings have been fluctuating around 2,000 t. ICCAT yearly mean reported catches, from 1950 to 2019, was 1,757 t, with a peak of 4,756 t, reported in 2002. In general, most of the catches come from the Northwest Atlantic, which has accounted for ~90%, in average, of the total landed catch, with landings from the Southwest Atlantic being considerably lower (around 8%) (**Figure 4**).

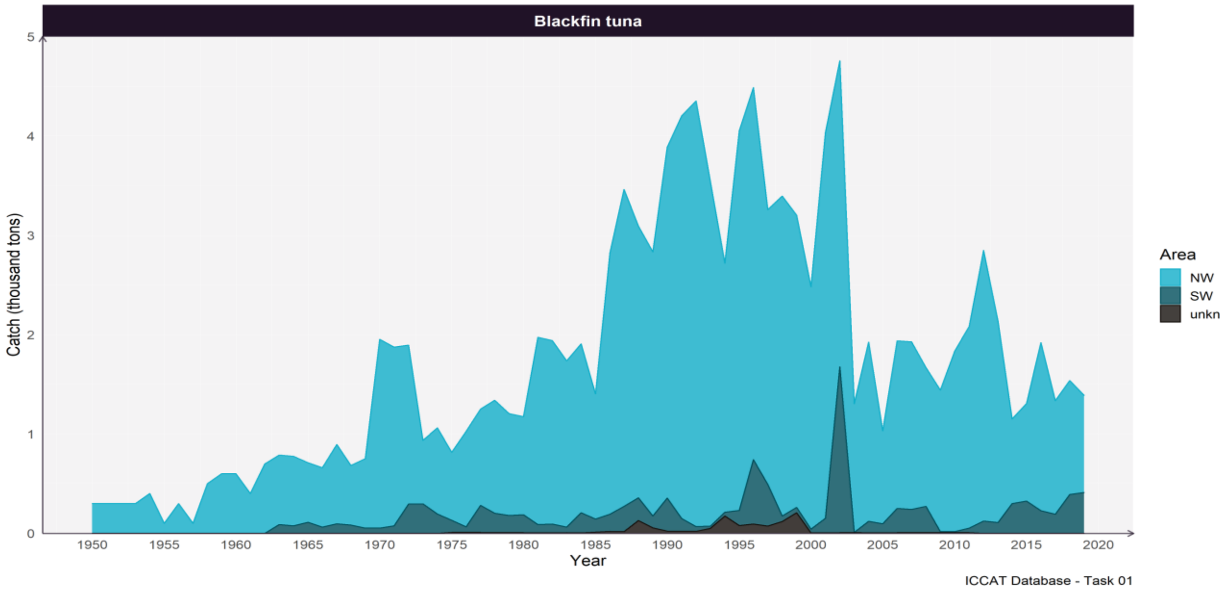

Figure 4. Blackfin tuna landings reported to ICCAT database, by region, from 1950 to 2019. Southwest Atlantic (SW) and Northwest Atlantic (NW).

According to FAO statistics (FAO, 2021), reported landings of blackfin tuna has increased considerably from around 600 t, in the 1950s, to 2,000 t, by the late 1970s, to 4,000 t, by the early 2000s, with a peak of 5,265 t in 2002. A drop in worldwide production can be observed from 2010, to 2,500 t through 2019, when it dropped again to around 2,000 t (FAO, 2021).

France has had the largest catches of BLF for the time series reviewed (1950-2019), followed by Guadeloupe, Martinique, Venezuela and Cuba. Together, these countries responded for about 75% of worldwide production. France reported a total close to 35,000 t of landings, for all the years grouped, with an annual average of around 500 t, even without reporting data between 1997 and 2009. Spain, on the other hand, appears to have stopped reporting data since 1995. Since the beginning of the historical series, 20 countries have reported data, of which 5 have not reported data in the more recent period (FAO, 2021).

In the later decade (2011-2019), several changes were observed. Cuba reported an increase in catches (6,911 t) with an average of 371 t until 2010, increasing to 767 t, from 2011 on; followed by the Dominican Republic (2,543 t) and Brazil (2,126 t), which together accounted for about 70% of total landings in this more recent period (16,148 t). Venezuela occupies the fourth position (1,300 t), and since the first year reported, until 2010, it informed average catches around 800 t. After 2000, however, catches from Venezuela showed a clear decreasing trend, while catches of blackfin tuna for the rest of the countries in the region increased steadily (Narváez *et al.*,2017). In the last decade (2011-2019), yearly mean catches from Venezuela dropped to only 144 t (with no data reported in the last 2 years (2018 and 2019) (FAO, 2021).

5.c Size distribution of catches

Blackfin tuna is exploited mainly by surface gears and artisanal fisheries, such as bait boats, handlines, small-scale longlines, rod and reel, traps, gillnets and purse seines. Considering each region for the historical trend of the time series reviewed (1950-2019), the blackfin tuna is mainly caught by purse seine (15.9%) and by rod and reel (15.8%) in the Northwest Atlantic and by bait boat (23.0%) and by longline (10.5%) in the Southwest Atlantic. However, most of catches are from unknown gear (NW= 46.2%, SW= 60.9%). For the unknown areas, landings of blackfin tuna come especially from rod and reel fisheries. Unknown gears were more representative before the 2000s. In the Northwest Atlantic, rod and reel fisheries were the most important in terms of landings in the last decades representing ~50% of total landings, since 2006 (**Figure 5**).

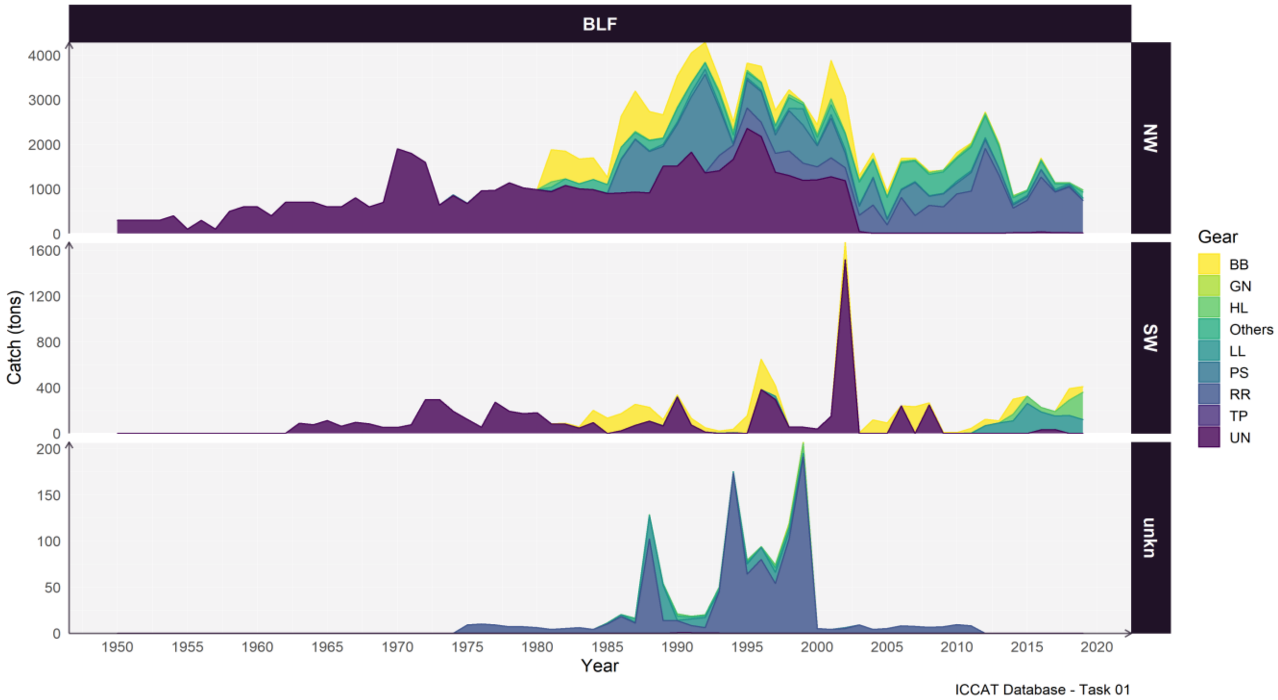

Figure 5. Catch distribution by gear and region of blackfin tuna in the Atlantic Ocean for 1950 to 2019(MT). BB: baitboats, GN: gillnets, HL: handline, LL: longline, PS: purse seine, RR: rod and reel, TP: traps. Others includes: trawl (TW), trolling (TR), haul seine (HS), trammel net (TN), sport (SP), tended line (TL), and harpoon (HP). UN: Unknown

In the Caribbean region, the individuals caught have a minimum size of 20 cm and a maximum size between 60 and 70 cm (Valle-Gômez, 1992; Rivoalen *et al.*,2007; Gobert, 1988; Castro *et al.*,2007). The maximum size seems to be higher in South America (89.0 cm), from northeast Brazil (Freire and Lessa, 2009), 95.5 cm, from Venezuela (Arocha *et al.*,2012), and 98.0 cm, from the Saint Peter and Saint Paul Archipelago, Brazil (Bezerra *et al.*,2013). However, in other studies undertaken in the North Atlantic, Headley et al. (2009) noted a maximum size of 91cm, corroborating, in general, with ICCAT Task 2 data base (1979-2019), where the largest specimens of blackfin tuna came from the Northwest Atlantic and the smallest (below 40 cm) from the Gulf of Mexico (**Figure 6**). Since 1977, the mean size reported for blackfin tuna in the Northwest Atlantic has increased from 52.8 cm, through 1999, to 60.1 cm, in 2019, peaking at 64.2 cm, in 2016 (**Figure 8**). Little size data is available for the South Atlantic, and mean size is around 60 cm (**Figure 7**). Several studies carried out in Martinique have shown that the length frequency of catches differs depending on the fishing gear used. In the case of offshore trolling, for instance, there are two peaks: the largest one around 25 cm and a second one between 50 and 55 cm. In the case of deep-water trolling in shallows and shores, the majority of catches are around 50-55 cm.

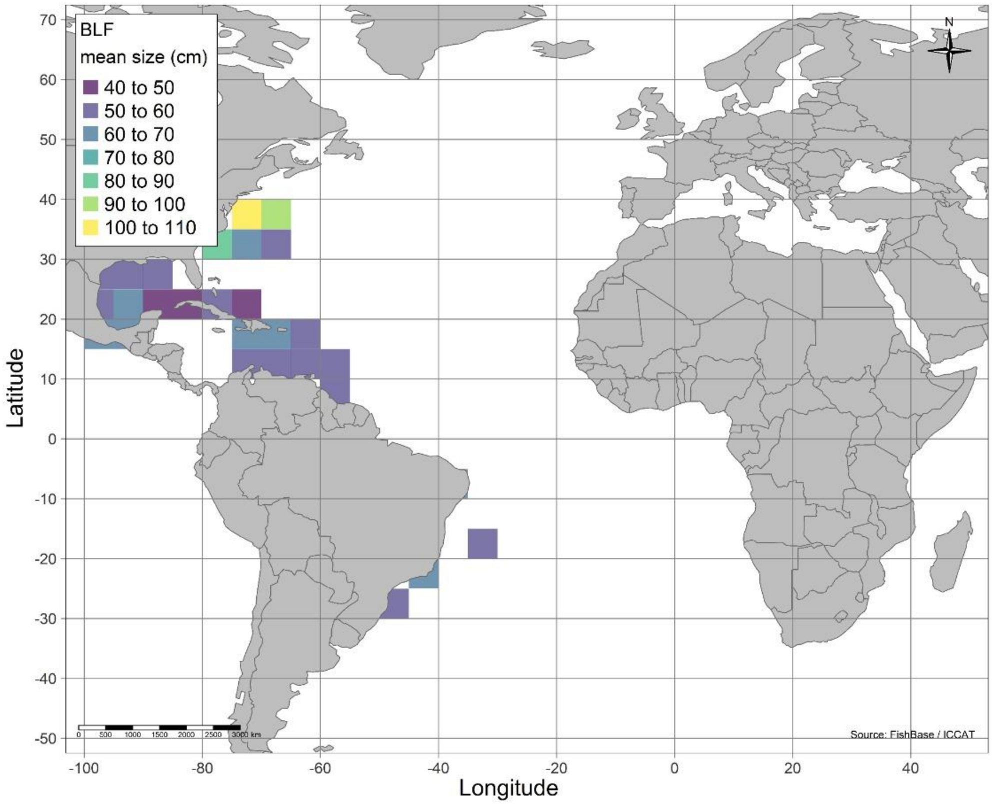

Figure 6. Mean size (FL) of blackfin tuna in each quadrant of 5x5°, between 1979 and 2019, from ICCAT database.

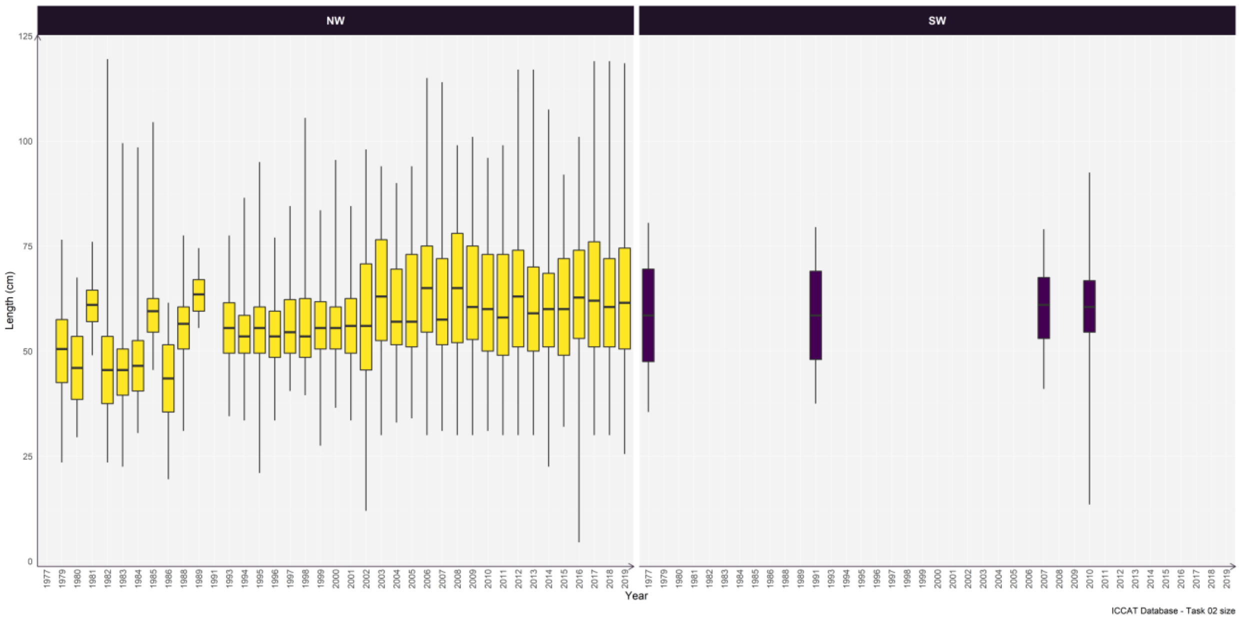

Figure 7. Mean length data (FL) for blackfin tuna in the Atlantic Ocean between 1977 and 2019. Southwest Atlantic (SW) and Northwest Atlantic (NW).

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