

Reproduction of Blackfin tuna *Thunnus atlanticus* (Perciformes: Scombridae) in Saint Peter and Saint Paul Archipelago, Equatorial Atlantic, Brazil

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Abstract: Reproducción del atún de aleta negra *Thunnus atlanticus* (Perciformes: Scombridae) en el Archipiélago San Pedro y San Pablo, Atlántico Ecuatorial, Brasil. The reproduction of Blackfin tuna *Thunnus atlanticus* has been described for coastal regions, and for a long time, this species was considered to be a strictly continental spawner. Recently, this species was observed around a seamount habitat 500 nautical miles Northeast of Brazil, located between South America and Africa. In this study we describe the reproductive biology of Blackfin tuna at Saint Peter and Saint Paul Archipelago (SPSPA). Male and female gonads were sampled from December 2008 to July 2010, and analyzed macro and microscopically. A total of 361 fish were sampled (247 males and 114 females). Males were more common than females, with a sex ratio of 2.2 ♂:1♀. The fork length (FL) of all sampled specimens ranged from 38 to 98cm, and larger length classes were more frequent in males. It was possible to distinguish six maturity phases for females: immature, developing, spawning capable, actively spawning, regressing and recovering. Five phases were identified for males: immature, developing, spawning capable, actively spawning and recovering. The gonad index (GI) mean monthly values ranged from 6.6 (SD=4.1) to 58.4 (SD=34.7) for females, and from 2.6 (SD=1.3) to 66.2 (SD=30.4) for males. For both sexes, the largest GI values were observed at the beginning of the first semester of the year. Size at first maturity was estimated at 48cm FL and 55cm FL for females and males respectively. Approximately 80% of the specimens were adults and considered to be in reproductive conditions. Histological analysis of the ovaries and testes showed that most of the specimens were sexually mature and were reproductively active during all months of the year. However, females with mature ovaries, with large amounts of hydrated oocytes and post-ovulatory follicles, were mainly found from December to March, thus these months may constitute the main spawning season in SPSPA. Batch fecundity varied between 272 025 and 1 140 584 oocytes for 56 and 68cm FL females respectively. Oocyte development and spawning patterns suggest a multiple spawning behavior. The results revealed that Blackfin tuna is using the SPSPA as a spawning ground, similar to other species commonly observed in the same area during the same reproductive season. Rev. Biol. Trop. 61 (3): 1327-1339. Epub 2013 September 01.

Key words: *T. atlanticus*, reproduction, seamounts, spawning season, gonad index (GI), reproductive cycle.

Blackfin tuna, *Thunnus atlanticus* (Lesson, 1831), are present in the Western tropical Atlantic Ocean, between 40°N and 31°S latitude (Zavala-Camin *et al.* 1991), and are most common in coastal regions (Collette & Nauen 1983, Maguire *et al.* 2006). In Brazil,

the species is caught by artisanal fishermen throughout the Northeast coast, primarily in Baía Formosa, Rio Grande do Norte State where the majority of catches are recorded, with annual landings of around 30t (Vieira *et al.* 2005a, Nóbrega & Lessa 2007).



Notwithstanding the species preference for coastal waters, significant catches of Blackfin tuna have been recorded in the oceanic realm in recent years off Saint Peter and Saint Paul Archipelago (SPSPA) (Bezerra *et al.* 2011). This species is caught along with other species traditionally fished in that area, such as Yellowfin tuna (*T. albacares* Bonnaterre, 1788), Wahoo (*Acanthocybium solandri* Cuvier, 1832), Rainbow runner (*Elagatis bipinnulata* Quoy e Gaimard, 1825), and Marginated fly-fish (*Cheilopogon cyanopterus* Valenciennes, 1846) (Lubbock & Edwards 1981, Oliveira *et al.* 1997, Vaske Jr. *et al.* 2005, 2006). Excluding Yellowfin tuna, which is the most abundant species caught in that region, all other species mentioned above spawn in SPSPA surroundings (Lessa *et al.* 1999, Viana 2007, in prep., Duarte-Neto *et al.* 2009, Pinheiro *et al.* 2011). These species spawn through the year and exhibit high fecundity, which is driven by high water temperatures in this equatorial oceanic zone, and may contribute to the success

of multiple spawning (Hunter & Goldberg 1980, Hunter & Macewicz 1985, Travassos *et al.* 1999).

Despite significant catches of Blackfin tuna in Northeastern Brazil and within the vicinity of SPSPA, there is a paucity of information regarding its reproductive biology, especially in island habitats. In this context, the aim of this work was to describe the reproductive biology of the Blackfin tuna in the Saint Peter and Saint Paul Archipelago. Findings could subside the development and adoption of conservation measures needed to ensure the sustainability of exploited stocks.

MATERIAL AND METHODS

Study site: This study was conducted from December 2008 to July 2010 in the Saint Peter and Saint Paul Archipelago located at 0°55'02" N - 29°20'42" W (Fig. 1). It is a small group of rocky islands situated about 500 nautical miles

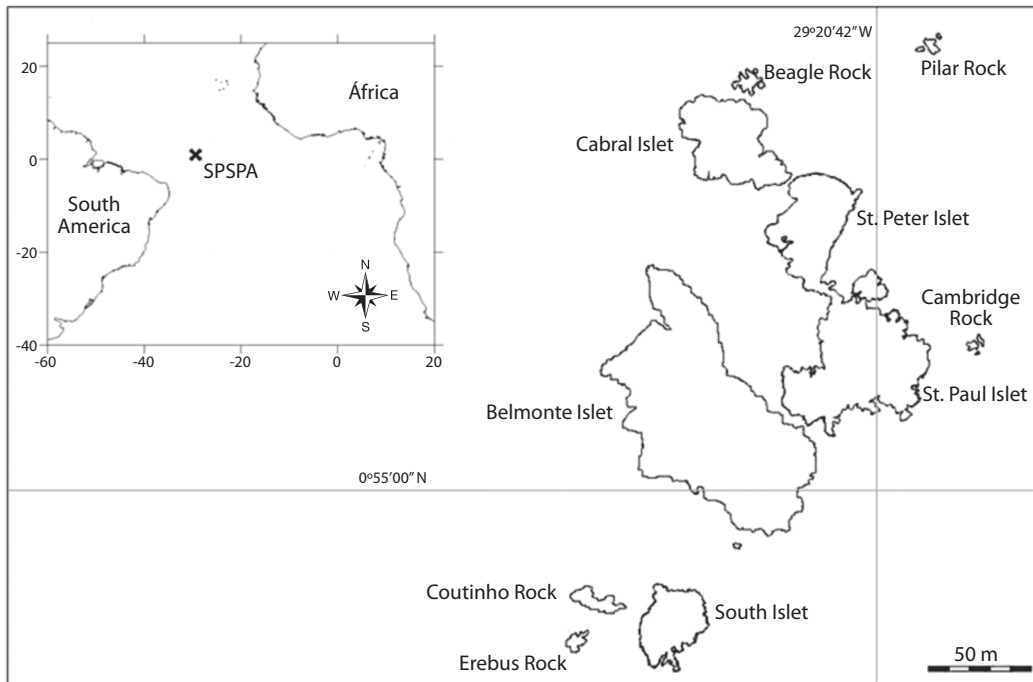


Fig. 1. Saint Peter and Saint Paul Archipelago (SPSPA), Brazil.

from the Brazilian coast (Campos *et al.* 2005). Fisheries around SPSPA are dominated by fishing boats operating trolling, handline and longline gear far from the island, mainly during the night (Vaske *et al.* 2006).

Sample procedures and data analyses:

All gonads were obtained during scientific expeditions to SPSPA, from specimens caught by commercial fishing boats operating in the area. Fork lengths (FL) of all specimens were measured to the nearest centimeter. Differences in the length-frequency distribution of males and females were tested using a Kolmogorov-Smirnov test ($p < 0.05$) (Zar 2010).

Gonads were fixed *in situ* in 10% formaldehyde and analyzed later in a laboratory.

Length, width and weight of gonads from all specimens were measured, and the sex identified. Sex ratios for all months were tested using a Chi-square test (χ^2 , $p < 0.05$) to identify statistically significant differences in sex proportion (Zar 2010).

All gonads were first evaluated macroscopically for maturity stages. Then, in order to allow for histological analysis, a small section was obtained from the middle portion of each gonad, dehydrated (alcohol), cleared (xylene), embedded in paraffin, sectioned in the microtome (6 μ m) and finally stained (hematoxylin-eosin) following the method by Hunter & Macevicz (1985). Six maturity phases were established for females as follow: I-immature, II-developing, III-spawning capable, IV-actively spawning, V-regressing, VI-recovering. Five phases were identified for males: I-immature, II-developing, III-spawning capable, IV-actively spawning, V-recovering, adapted from Vieira *et al.* (2005b), Chen *et al.* (2010) and Brown-Peterson *et al.* (2011).

The Gonad Index (GI) of adults was calculated using the following equation from Schaefer & Orange (1956): $GI = (G_w \cdot 10^5) / FL^3$, where G_w = gonad weight (grams) and FL = Fork length (millimeters). In order to identify the spawning season in SPSPA, the monthly mean GI was calculated for each sex separately.

Size at first maturity was estimated from a logistic curve based on relative frequency of adults in each length class, according to the formula $M_f = \exp [a + b \cdot F_L] / (1 + \exp [a + b \cdot F_L])$, where M_f is the fraction of adult specimens. This method was fitted using maximum likelihood with Statistica 7 software (Zar 2010).

To estimate batch fecundity, we applied the equation: $F_B = nWg/w$, where F_B = total number of hydrated oocytes in ovaries, n = number of hydrated oocytes in the aliquot, Wg = weight of both ovaries and w = weight of ovary aliquot; this was adapted from Hunter *et al.* (1985). For this purpose, aliquots of 0.5g were obtained from the middle portions of 10 female gonads caught from December 2008 to March 2009, which were defined as actively spawning based on the abundance of hydrated oocytes as indicated by sampled data. However, it was not possible to exclude female gonads in the actively spawning phase that showed few post-ovulatory follicles (POF) and an elevated number of hydrated oocytes.

RESULTS

Sex ratio: A total of 361 specimens were measured and sexed (247 males and 114 females). The sexual proportion of all individuals sampled was 1♀:2.2♂, with males being predominant in the total sample ($\chi^2 = 13.6$, $p < 0.05$, $df = 11$). The Chi-square test monthly variation was also applied for grouped years. Females were more frequent than males only in March and September. Males prevailed in all remaining months, with statistically significant differences in February, April, May, June, July, October and November (Table 1).

The fork length (FL) of all sampled specimens varied from 38 to 98cm. Females FL ranged from 46 to 98cm, with two modes classes: one at 58-62cm and another at 62-66cm. FL for males ranged from 38 to 78cm, with the mode at 66-70cm. There were significant differences between FL of males and females (Kolmogorov-Smirnov, $p < 0.05$, $p = 0.001$). Males were more frequently in larger

TABLE 1
Monthly sex ratio of *Thunnus atlanticus* from Saint Peter and Saint Paul Archipelago
in the period between December 2008 and July 2010 (n=361)

Months	Female (n)	Male (n)	Female (%)	Male (%)	χ^2
January	4	5	44.4	55.6	1.2
February	2	4	33.3	66.7	11.1*
March	7	6	53.8	46.2	0.6
April	10	20	33.3	66.7	11.1*
May	18	74	19.6	80.4	37.1*
June	7	35	16.7	83.3	44.4*
July	3	8	27.3	72.7	20.7*
August	9	12	42.9	57.1	2.0
September	23	20	53.5	46.5	0.5
October	6	27	18.2	81.8	40.5*
November	5	10	33.3	66.7	11.1*
December	20	26	43.5	56.5	1.7
Total	114	247	31.6	68.4	13.6*

*Significant difference at a level of 5% ($p < 0.5$).

classes (>66 cm), while females predominated the smaller sizes (Fig. 2).

Spawning season: The gonad index (GI) average monthly values varied from 6.6 (SD=4.1) to 58.4 (SD=34.7) and from 2.6 (SD=1.3) to 66.2 (SD=30.4) for females and males, respectively. The lowest average for females was observed during August, while the highest occurred in March. High values were

also found in January (mean 55.0, SD=17) and February (mean 56.2, SD=35) (Fig. 3). For males, the lowest average GI value was observed in July, while the highest values occurred in January and February. According to these results, the reproductive activity of Blackfin tuna around the SPSPA begins at the end of the second semester (November) and extends to March, with high GI values mainly in the three first months of the year.

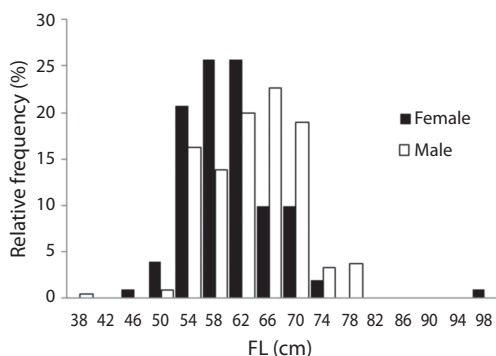


Fig. 2. Relative frequency of the fork length (FL) of female and male of *Thunnus atlanticus* caught around the Saint Peter Saint Paul Archipelago between December 2008 and July 2010 (n=361).

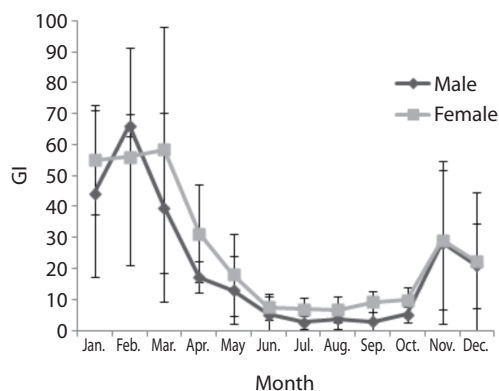


Fig. 3. Monthly values of the gonad index (GI) for female and male of *T. atlanticus* caught around the Saint Peter and Saint Paul Archipelago between December 2008 and July 2010 (Lines means standard deviation, n=330).

Reproductive cycle: According to macro and microscopic analysis of the ovaries, all six maturity phases were found in females (n=114): immature (n=4; 3%), developing (n=6; 5%), spawning capable (n=11; 10%), actively spawning (n=60; 53%), regressing (n=27; 24%) and recovering (n=6; 5%). Males (n=247) were found in all five maturity phases: immature (n=27; 11%), developing (n=51;

21%), spawning capable (n=60; 24%), actively spawning (n=89; 36%) and recovering (n=20; 8%). The gonad maturation phases for both females and males are described in tables 2 and 3, respectively. According to these results, most of the ovaries and testes analyzed were from adult individuals, as 96.5% of the females and 89.0% of males showed characteristics of reproductively active specimens.

TABLE 2
Macroscopic and microscopic characterization of the maturity phases of the ovaries of *T. atlanticus* in the Saint Peter and Saint Paul Archipelago, adapted from Vieira *et al.* (2005b), Chen *et al.* (2010) and Brown-Peterson *et al.* (2011)

Maturity phases	Macroscopic characteristics	Microscopic characteristics
I. Immature (n=4)	Rigid structure, small and light, colored bright red. Ovaries with average width of 0.9cm (SD=0.3) and mean weight of 10.2g (SD=8.7).	Well-defined cellular organization with the presence of several unyolked oocytes in perinuclear regions. Only oogonia and primary growth (PG) oocytes.
II. Developing (n=6)	Composition firm and a little more intense staining due to the onset of vascularization. Ovaries with an average width of 1.7cm (SD=0.4), mean weight of 22.9g (SD=15.8) and 10.7 (SD=7.3) average GI.	Oogones, cortical alveolar (CA), primary and secondary vitellogenic oocytes (Vtg1 and Vtg2). No evidence of tertiary vitellogenic oocytes (Vtg3).
III. Spawning capable (n=11)	Large structure, firm and heavy weight, highly vascularized, with intense red color. Ovaries with an average width of 3.1cm (SD=1.4), mean weight of 73.9g (SD=60.9) and 28.7 (SD=14.4) average GI.	All oocyte stages present and abundance of tertiary vitellogenic oocytes (Vtg3).
IV. Actively spawning (n=60)	Imminent spawning Composition with early sagging, heavy weight, highly vascularized, with red coloration and spontaneous release of hydrated oocytes. Ovaries with an average width of 2.6cm (SD=0.9), mean weight of 77.2g (SD=23.3) and 36.4 (SD=26.9) average GI. Recent spawning	Hydrated oocytes (translucent) in large quantities and with few POFs.
	Structure flabby, wrinkled, light colored dark red and a few spontaneous release of hydrated oocytes. Ovaries with an average width of 1.0cm (SD=0.4), mean weight of 29.1g (SD=15.1) and 14.6 (SD=10) average GI.	High number of POFs and hydrated oocytes rare.
V. Regressing (n=27)	Composition very flabby and wrinkled, light and dark colored. Ovaries width an average of 1.0cm (SD=0.4), mean weight of 17.7g (SD=11.2) and 8.7 (SD=4.3) average GI.	Few POFs, atresia (any stage), some residual CA and Vtg1-Vtg2 oocytes.
VI. Recovering (n=6)	Difficult to macroscopic differentiation. Ovaries with an average width of 1.2cm (SD=0.3), mean weight of 18g (SD=3.5) and 8.6 (SD=2.2) average GI.	Reorganization of unyolked oocytes to the beginning of a new reproductive cycle, and atresia. Only oogonia and primary growth oocytes present.

GI: Gonad Index; POF: post-ovulatory follicle.

TABLE 3
Macroscopic and microscopic characterization of maturity phases of *T. atlanticus* testes from the Saint Peter and Saint Paul Archipelago, adapted from Vieira *et al.* (2005b), Chen *et al.* (2010) and Brown-Peterson *et al.* (2011)

Maturity phases	Macroscopic characteristics	Microscopic characteristics
I. Immature (n=27)	Small testes with lighter coloration. Testes with an average width of 0.7cm (SD=0.3) and mean weight of 4.2g (SD=3.1).	Vas deferents with small size, espermatogonia present, rare spermatids, and no spermatozoans.
II. Developing (n=51)	Mid-large size testes with lighter coloration and volume increased. Testes with an average width of 1.9cm (SD=0.8), mean weight of 18.6g (SD=12.5) and 5.5 (SD=3.3) average GI.	Many spermatocytes and spermatids. Few spermatozoans.
III. Spawning capable (n=60)	Firm structure and light colored. Testes with an average width of 3cm (SD=0.7), mean weight of 73.8g (SD=30.5) and 26.7 (SD=12.3) average GI.	Widely extended and vas deferens filled with spermatozoans and few spermatids. All stages of spermatogenesis present.
IV. Actively spawning (n=89)	Imminent spawning Structure with little sagging and spontaneous release of seminiferous fluid. Testes with an average width of 2.5cm (SD=0.5), mean weight of 42.3g (SD=20.1) and 18.5 (SD=11.5) average GI.	Abundant spermatozoans and the appearance of voids in the vas deferens.
	Recent spawning. Composition quite flaccid. Testes with an average width of 2cm (SD=0.4), mean weight of 27.9g (SD=12.5) and 11.2 (SD=6.8) average GI.	Partially emptied and the vas deferens with smaller diameter.
V. Recovering (n=20)	Flaccid structure and volume decreased. Testes with an average width of 1.6cm (SD=0.6), mean weight of 17.7g (SD=13.4) and 7.6 (SD=2.8) average IG.	Vas deferens total empty and some residual spermatozoans.

GI: Gonad Index.

Monthly distribution of proportional female maturity phases showed few individuals with immature ovaries demonstrating spawning during all of the months, and higher reproductive activity observed in the first quarter of the year (Fig. 4).

Regarding males, spawning capable specimens with their vas deferens full of sperm or actively spawning (with part of these vessels empty) were present almost all months of the year (Figs. 5 E,F). Although male individuals were more abundant throughout the period studied, testes in this maturity phase were also observed mainly during the first quarter of the year, which represented a higher reproductive activity period for Blackfin tuna in SPSPA (Fig. 4).

Higher frequency of actively spawning females, with greater amounts of hydrated oocytes and post-ovulatory follicles (Fig. 5 A,B,C), occurred between December and March, evidence of a higher reproductive activity around SPSPA during this period. Ovaries regressing and recovering, with disordered cellular organization, follicular atresia and some oogone nest, recovered rapidly for new reproductive seasons (Fig. 5D). Blackfin tuna spawn in batches around SPSPA as observed by the continuous and joint presence of hydrated oocytes and post-ovulatory follicles in the histological sections of actively spawning females, which characterizes imminent spawning (in the next 24h) and recent spawning (in the last 24h).

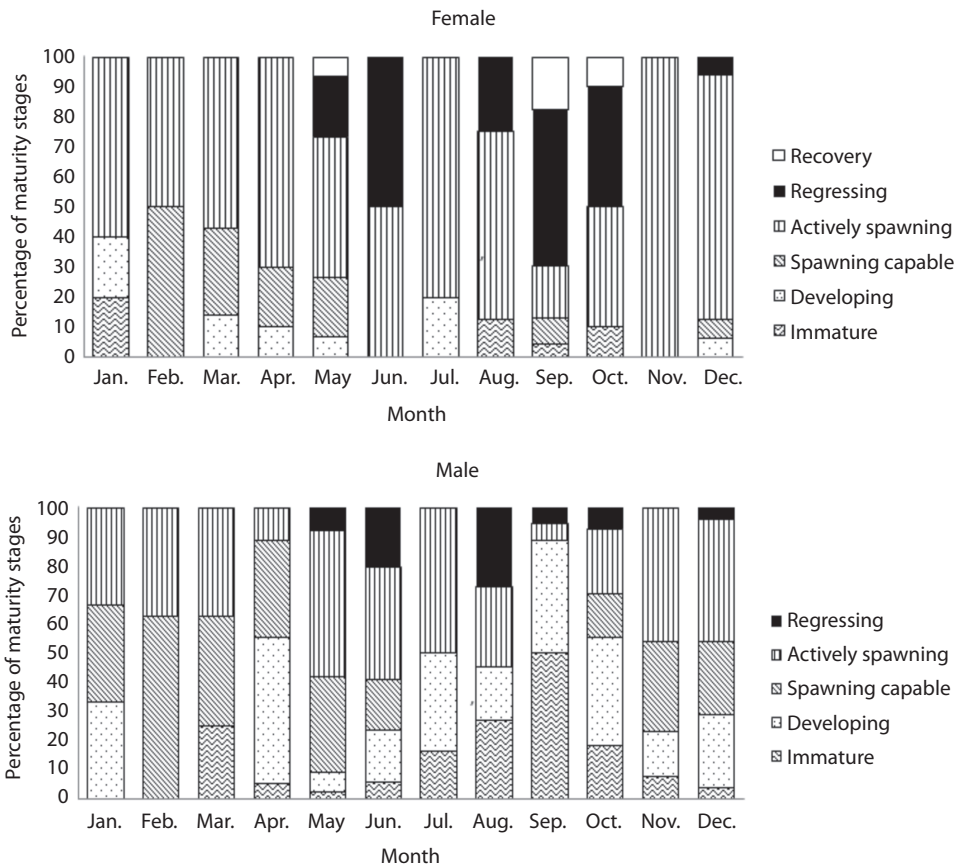


Fig. 4. Monthly distribution of the maturational phases for female and males of *T. atlanticus* caught around the Saint Peter and Saint Paul Archipelago between December 2008 and July 2010 (n=361).

Length at first maturity (L_{50}): The estimated length at first maturity for females and males was 48cm (CI=15) FL and 55cm (CI=15) FL, respectively (Fig. 6). Only four out of the 114 females sampled were smaller than L_{50} (3.5%); a total of 46 out of 247 males were smaller than L_{50} (18.6%).

Batch fecundity: In regards to fecundity per batch, the lowest number of hydrated oocytes was 272 025, in a 56cm FL female with gonads weighing 120.90g. The highest fecundity was 1 140 584 hydrated oocytes in a 68cm FL female, with a gonads weighing 387.69g. The average fecundity per batch was 554 512 oocytes. In general, the number of hydrated

oocytes was higher in samples with more gonad weight (Fig. 7). Nevertheless, the relationship between the number of hydrated oocytes and FL was not linear, due to the presence of larger individuals presenting few hydrated oocytes (98cm and 392 796 hydrated oocytes) and smaller specimens with advanced hydration (62cm and 509 030 hydrated oocytes).

DISCUSSION

Sex ratio: The sex proportion observed was different from the male-female proportion expected for most tunas. The high natural mortality rate of females, male hostility during courtship, female predation during spawning

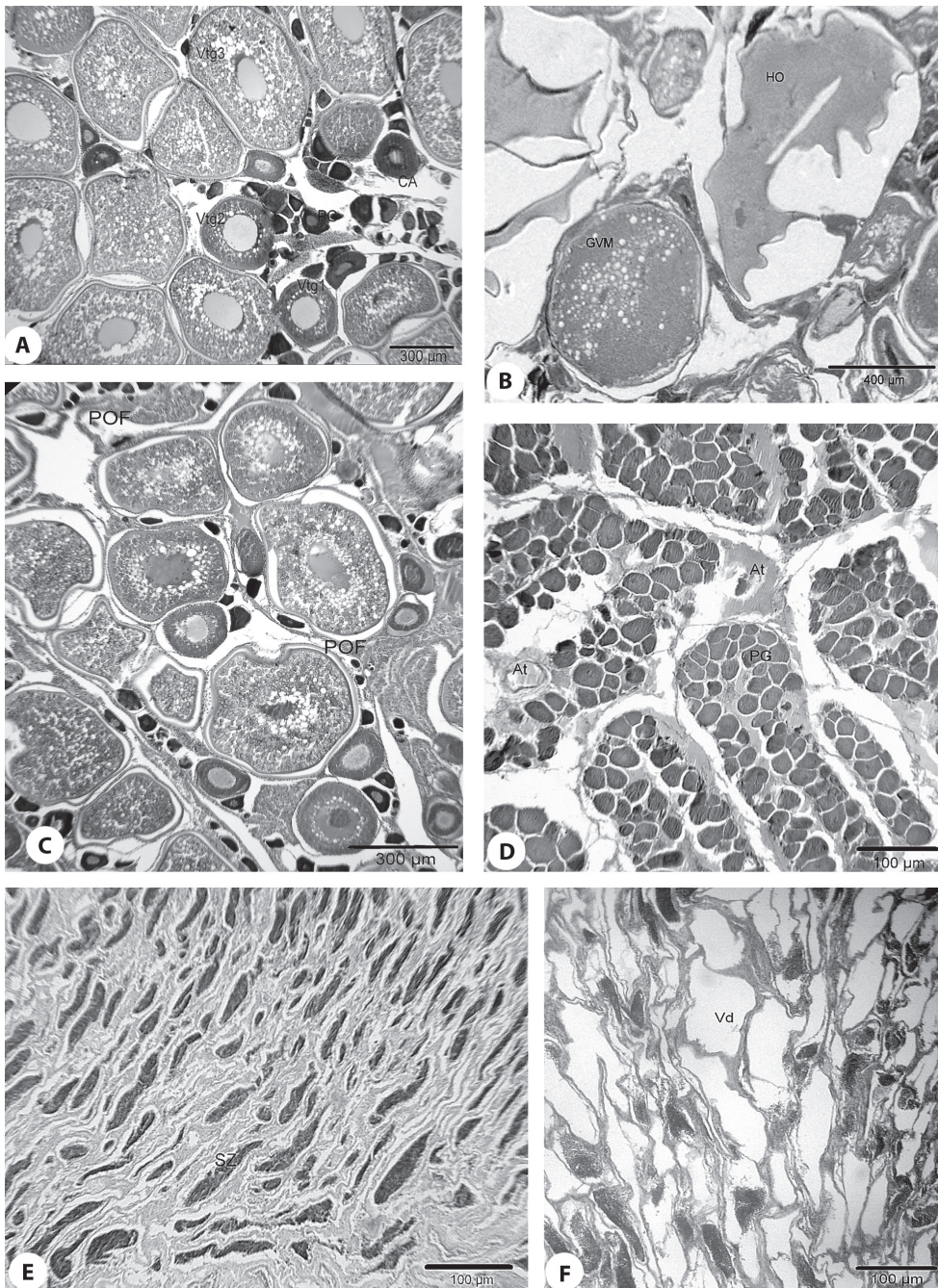


Fig. 5. Histological section of ovaries (females) and testis (males) of *T. atlanticus*. (A) Oocyte from a spawning capable female with: primary growth oocyte (PG), cortical alveolar (CA), primary vitellogenic oocyte (Vtg1), secondary vitellogenic oocyte (Vtg2) and tertiary vitellogenic oocyte (Vtg3). (B) Oocyte from an actively spawning (imminent spawning) with: Hydrated oocyte (Ho), germinal vesicle migration (GVM). (C) Oocyte from an actively spawning (recent spawned) female with: post-ovulatory follicle (POF). (D) Oocytes from a recovering female with: primary growth oocyte (PG) and atresia (At) (E) actively spawning (imminent spawning) male with vas deferens fully of spermatozoa (SZ). (F) actively spawning (recent spawning) male with total empty from vas deferens (Vd) and some residual spermatozoans (Sz). Optical zoom from 0.10 X.

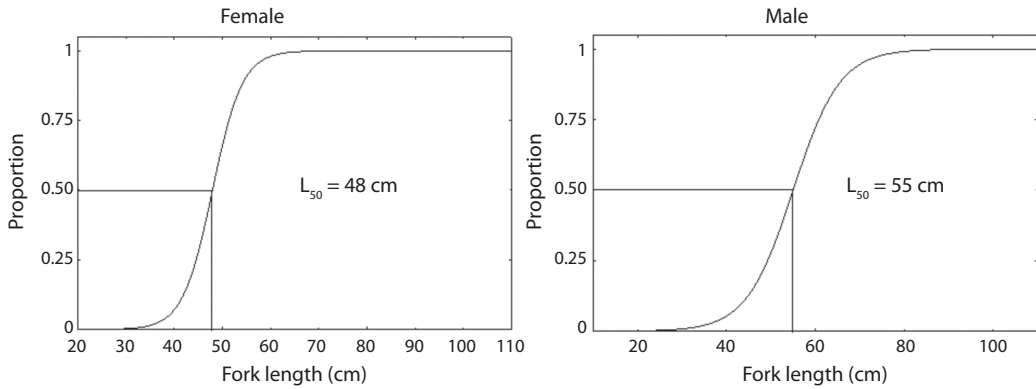


Fig. 6. Size at first maturity for female and male of *T. atlanticus* caught around the Saint Peter and Saint Paul Archipelago between December 2008 and July 2010 (n=361).

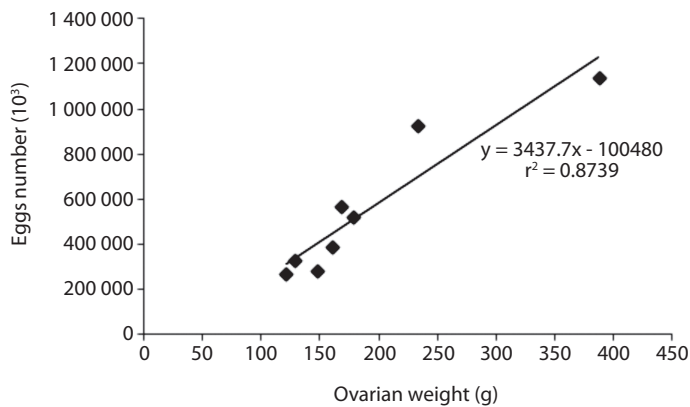


Fig. 7. Relationship between fecundity and ovary weight for females of *T. atlanticus* caught around the Saint Peter and Saint Paul Archipelago between December 2008 and July 2010 (n=10).

behavior, and susceptibility to fishing gear are all factors that may have influenced male predominance in this study (Garcia Coll *et al.* 1984, Schaefer 1998). Vieira *et al.* (2005a) also observed a larger proportion of males of *T. atlanticus* (2.1:0.5) during a study carried out in the state of Rio Grande do Norte State. Male biased sex ratio for Blackfin tuna (1.9:1) was also reported in Northeastern Brazil (Freire *et al.* 2005), and similar male abundance was observed in the same region (Cruz & Paiva 1964, Cruz 1965). In Cuba, the sexual proportion of Blackfin tuna was similar to studies carried out in Brazil (Baéz-Hidalgo & Bécquer

1994). Large numbers of males were also observed in the Northern Atlantic (1.7:0.7) (Coll 1987).

In contrast, larger size tunas such as Bigeye tuna *Thunnus obesus* (Lowe, 1839) caught in Northeastern Brazil exhibit a greater proportion of females (1.4:1.0), which is not far from the more common relationship 1:1 (Figueiredo 2007, in prep.). Studies with Bigeye tuna and Yellowfin tuna in the Pacific Ocean reported significant differences between the sexes, and males once again predominated. This suggests that the distinction between the number of males and females may also be related to the

selectivity of the several fishing gear types used to catch these individuals in different regions of the ocean (Schaeffer 2001, Zhu *et al.* 2010). Polygamy behavior during spawning is another hypothesis to explain the male biased sex ratio. Competition between male increases the fertility and possibility to mate with females (Pandian 2010). Higher values for GI observed for males in this study and reported by Freire *et al.* (2005) in Northeastern Brazil are the possible result of male competition for best reproductive performance. Sperm production increasing testes volume also indicates male domination observed by the sex ratio.

Size relationship: The size range of Blackfin tuna caught in coastal waters of Northeastern Brazil, from 36 to 89cm (Freire 2009), is very close to that found around the SPSPA, and in other studies undertaken in the North Atlantic (32 to 91cm) (Headley *et al.* 2009). The Rio Grande do Norte State, as in this study, showed that females were more abundant in small size classes, while males were mostly represented in the larger size classes (Vieira *et al.* 2005b). Females are generally larger than males among fish species, although for some tunas the inverse relationship is true (Schaefer 2001). Thus, the high energy cost of somatic and gonad growth for females and greater longevity in males may contribute to differential growth rates between sexes and possibly relates to the lower frequency of females in the upper length classes (Brill 1996, Zavala-Camin 1996).

Spawning patterns: Tunas generally migrate to waters with high temperatures (above 24°C) to spawn. Water temperature is one of the most important environmental features for egg and larva survival, a fact observed for *T. albacares*, *T. thynnus* (Linnaeus, 1758), *T. obesus* and *Katsuwonus pelamis* (Linnaeus, 1758) (Stéquert *et al.* 2001, Medina *et al.* 2002, Mariani *et al.* 2010). In this study, the highest GI of Blackfin tuna was found in the first semester around the SPSPA, which coincides with the reproductive season of other pelagic fishes that also use the SPSPA as a spawning

ground (Lessa *et al.* 1999, Viana 2007, in prep., Pinheiro *et al.* 2011). The variation of the gonad maturation phases distributed throughout the year also suggests successive spawning around SPSPA, possibly driven by high average annual temperatures of 27.5°C (Travassos *et al.* 1999). These conditions are quite favorable to this reproductive strategy, as opposed to what occurs in temperate regions, where most fish are total spawners in the summer (Yoneda *et al.* 2002, Abascal *et al.* 2004, Ewing & Lyle 2009). Histological analyses of the ovaries of female Blackfin tuna with large amounts of hydrated oocytes and post-ovulatory follicles legitimizes the concept of multiple spawning and asynchronous gonad development, a characteristic common to most tropical marine fish (Wootton 1991, Hazin 1993, in prep., Goldstein *et al.* 2007, Chen *et al.* 2010). However, co-occurrence of females that are in regressing, recovering and developing phases supports the idea of rapid recovery for new spawning periods.

During the year it was also possible to note a high number of male testes with the vas deferens full of sperm and actively spawning. This supplies the high reproductive demand of active females and promotes the species' reproductive success at the SPSPA. Testes full of sperm have also been observed in *K. pelamis* males in Pacific waters, due to its equally rapid reproductive cycle (Hunter *et al.* 1986, Ashida *et al.* 2010).

Length at first maturity: Eighty percent of specimens analyzed were spawning capable or actively spawning, considering the size at first maturity (L_{50}) for females (48cm) and males (55cm). Freire *et al.* (2005) reported first size of capture around 58.1cm FL in Northeastern Brazil which is above the size at first maturity for the species. In studies carried out with Blackfin tuna in Baía Formosa (RN), the estimated L_{50} for females was 51cm total length, but showed no estimation for males (Vieira *et al.* 2005). Freire (2009) estimated the average size at first maturation for the same species at 49.2 and 51.3cm FL for females

and males respectively; these values that are relatively close to those generated by this study. Therefore, Blackfin tuna females are able to reproduce at a smaller size than males in the Southern Atlantic. Determining the size at first maturity is crucial to managing the Blackfin tuna population in this area since it may be used to establish minimum catch sizes for management purposes.

Fecundity: In this study, the average fecundity per batch was 554 512 hydrated oocytes, a much lower value than the one found for the same species off the coast of Rio Grande do Norte (an average of 1451 841 hydrated oocytes) (Vieira *et al.* 2005a). However, in this study the estimate for fecundity per batch may be biased due to inclusion of ovaries containing hydrated oocytes or with few postovulatory follicles, a result of sampling procedures that were limited by fishing time periods in the spawning grounds during spawning behavior. This difficulty was also reported by Hunter *et al.* (1986) and Schaefer (1996) for tunas, resulting in lower estimates of fecundity for larger individuals. The great amount of energy used by Blackfin tuna to grow and, especially, to migrate (because of its predominantly coastal geographic distribution, see Bezerra *et al.* 2011) might be related to the lower fecundity at the Saint Peter and Saint Paul Archipelago.

Nevertheless, further studies are necessary to elucidate the Blackfin tuna migratory movements within the tropical Atlantic Ocean, especially regarding the specimens that use the SPSPA as spawning grounds and possibly as a feeding area.

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RESUMEN

A pesar de la importancia de las capturas del atún de aleta negra *Thunnus atlanticus* en el noreste de Brasil y en las cercanías del Archipiélago San Pedro y San Pablo (ASPSP), hay una escasez de información sobre su reproducción, especialmente en las islas. La reproducción del atún de aleta negra en este archipiélago se estudió de diciembre 2008 a julio 2010. Con este fin, se recolectaron 361 gónadas de hembras y machos, los machos fueron predominantemente más frecuentes en la muestra total, con una proporción sexual de 1♀:2.2 ♂. La longitud furcal todos los ejemplares muestreados varió entre 38 y 98 cm, y los machos fueron más abundantes en las clases de mayor longitud. Los valores medios mensuales del índice gonadal (IG) variaron de 6.6 (SD=4.1) a 58.4 (SD=34.7) y de 2.6 (SD=1.3) a 66.2 (SD=30.4) para hembras y machos, respectivamente. Los mayores valores de IG para ambos sexos fueron observados el inicio del primer semestre. Los análisis histológicos mostraron que la mayoría de los ovarios y testículos correspondieron a especímenes aptos para reproducirse. Sin embargo, hembras con ovarios maduros, con gran cantidad de oócitos hidratados y folículos post ovulatorios, se encontraron principalmente de diciembre a marzo, que se considera es la época de reproducción del atún de aleta negra alrededor del ASPSP.

Palabras clave: *T. atlanticus*, reproducción, islas oceánicas, temporada de desove, índice gonadal (IG), ciclo reproductivo.

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