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PESCA E ECOLOGIA DO TUBARÃO GALHA-BRANCA OCEÂNICO (*Carcharhinus longimanus*, Poey 1861) NO ATLÂNTICO OESTE TROPICAL

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Keep walking…

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Resumo

O objetivo geral do presente trabalho consistiu em agregar informações ao conhecimento sobre o tubarão galha-branca oceânico (*Carcharhinus longimanus*), principalmente no que se refere à sua distribuição, abundância relativa e preferências de habitat no Atlântico oeste tropical. Apesar de ser uma espécie muito capturada na pesca oceânica de atuns, informações sobre estes aspectos da biologia da espécie são escassas e até mesmo ausentes na literatura. No primeiro artigo, foram analisados dados de captura e esforço de 14.560 lançamentos de espinhel pelágico realizados por embarcações arrendadas da frota atuneira brasileira, nos anos de 2004 a 2009. A CPUE, expressa pelo número de tubarões capturados a cada mil anzóis, exibiu uma tendência de aumento gradual ao longo dos anos, variando de 0,04 em 2004 para 0,14 em 2007. Em 2008, entretanto, a CPUE sofreu um aumento considerável, chegando a 0,45 e em seguida caindo para 0,10 em 2009. A distribuição espacial da CPUE por ano e por trimestre mostrou que a área delimitada por 10°S e 20°S de latitude e por 030°W e 040°W de longitude concentrou os maiores valores. Embora o comprimento total tenha variado entre 50 e 320 cm, quase 80% dos indivíduos capturados eram menores que 180 cm, tamanho de primeira maturação publicado na literatura. A distribuição espacial dos comprimentos mostrou uma concentração de indivíduos maiores entre 020°W e 030°W e entre 05°S e 20°S. Outra área de concentração de indivíduos maiores parece estar presente ao norte de 5°N, entre estas mesmas longitudes. No segundo artigo, foram analisados dados referentes ao deslocamento horizontal e vertical, com ênfase nas preferências de temperaturas e profundidades de dois tubarões galha-branca marcados com marcas do tipo "*pop-up satellite archival tag*". As marcações ocorreram no final de janeiro e início de fevereiro de 2010, sendo o primeiro galha-branca marcado uma fêmea de 135 cm de comprimento total e o segundo um macho de 152 cm. Os resultados mostraram que ambos os tubarões apresentaram uma nítida preferência pelas águas quentes e superficiais da camada de mistura, permanecendo pelo menos 95% do tempo em águas com temperaturas acima de 26,0°C e 86% nos primeiros 50 m. Não foram registrados mergulhos profundos, com a profundidade máxima de 128 m e a temperatura mínima foi 15,6°C. Apesar da distribuição vertical restrita, os dados indicaram que os dois tubarões realizaram migrações circadianas na coluna d'água, estando mais próximos da superfície durante o dia. Os locais de marcação e desprendimento das marcas não foram distantes um do outro, com a máxima distância percorrida sendo de 1.884 milhas náuticas. O deslocamento diário variou de 12,86 a 20,94 milhas náuticas e a velocidade média de natação ($\pm$ SE) variou de 0,41 $\pm$ 0,16 a 1,00 $\pm$ 0,09 nós. Os movimentos verticais indicam migração no sentido leste-oeste.

Palavras chave: Abundância relativa, distribuição, CPUE, telemetria por satélite, movimentos horizontais, preferências térmicas e batimétricas.

Abstract

The aim of this study was to add valuable information to the knowledge of the oceanic whitetip shark, especially with regard to its distribution, relative abundance and habitat preferences in the western tropical Atlantic Ocean. Despite of being a widely distributed and abundant species this kind of information is scarce or even absent in the literature. In the first article, catch and effort data from 14,560 longline sets carried out by the Brazilian chartered tuna longline fleet, from 2004 to 2009, were analyzed. The CPUE, expressed as the number of sharks caught per thousand hooks, exhibited a tendency to increase gradually over the years, ranging from 0.04 in 2004 to 0.14 in 2007. In 2008, however, the CPUE increased sharply, reaching 0.45 and then dropping back to 0.10 in 2009. The CPUE spatial distribution by year and quarters of the year showed that the area bounded by 10°S and 20°S of latitude and 030°W and 040°W of longitude concentrated the highest values. The majority of the oceanic withetip sharks caught by this fleet were under the size of first maturity. Although the total length ranged from 50 to 320 cm, almost 80% were under 180 cm (published size at first maturity). The spatial distribution showed a concentration of larger specimens from about 020°W to 030°W and from5°S to 20°S. Another area of concentration of larger specimens seems to be present to the north of 5°N, between the same longitudes. In the second article, data on horizontal movements and temperatures and depths experienced by two oceanic whitetip sharks tagged with pop-up satellite archival tags were analyzed. Tagging occurred in late January and early February of 2010, the first whitetip tagged was a female measuring 135 cm in total length and the second was male measuring 152 cm. Both sharks had a remarkable preference for warm and shallow waters of the mixed layer, spending at least 95% of the deployment period in waters with temperatures above 26.0°C and 86% in the first 50 m. Deep diving behavior was not registered. The maximum recorded depth was 128 m and the minimum temperature was 15.6°C. Despite their narrow depth distribution, both sharks performed diel vertical migrations. Tagging and pop-off sites were not far from each other and the maximum distance traveled was 1,884 nautical miles. Daily displacement ranged from 12.86 to 20.94 nautical miles and mean swimming speed (± SE) ranged from 0.41 ± 0.16 to 1.00 ± 0.09 knots. The horizontal movements indicated a westward migration.

Keywords: relative abundance, distribution, CPUE, satellite telemetry, horizontal movements, temperature and depth preferences.

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Sumário

1. Introdução

Os Chondrichties formam um grupo relativamente pequeno, que inclui espécies de tubarões, raias e quimeras. Atualmente, esse grupo contém aproximadamente 1.115 espécies descritas, das quais, 481 espécies pertencem a 101 gêneros e 30 famílias de tubarões (Compagno, 1990). Tubarões e raias pelágicos representam cerca de 6% do total das espécies de elasmobrânquios existentes no mundo e dessas, apenas 64 habitam regiões oceânicas (Camhi et al., 2009). Os elasmobrânquios possuem um ciclo de vida do tipo K-estrategista, caracterizado pelo crescimento lento, alta longevidade, maturidade sexual tardia e baixa fecundidade (Hoenig e Gruber, 1990). Em razão dessas características, os elasmobrânquios, apresentam uma baixa taxa de crescimento populacional (Cortés, 2000) que os tornam muito mais vulneráveis à sobrepesca, quando comparados aos peixes teleósteos (Musick et at., 2002; Compagno et al., 2005).

De acordo com o Shark Specialist Group - SSG (1996), as populações de elasmobrânquios estão sendo negativamente impactadas por um conjunto de atividades humanas, encontrando-se, algumas delas, seriamente ameaçadas devido a: 1) estratégias de vida, referidas acima, que as tornam particularmente vulneráveis à exploração, dificultando a sua recuperação quando em depleção; 2) rápido crescimento de pescarias não regulamentadas nas quais as mesmas incidem tanto como espécie-alvo quanto como fauna acompanhante; 3) altos índices de captura e mortalidade; 4) estímulo à captura “incidental” e ao descarte, devido ao alto preço de subprodutos, especialmente das barbatanas; 5) perda de zonas de berçário e outras áreas costeiras críticas para o seu desenvolvimento; 6) degradação ambiental e poluição. Segundo a mesma fonte, até as pescarias sujeitas a regimes de manejo são ainda pouco compreendidas ou controladas. Em geral, há baixo esforço de pesquisa, as espécies não são adequadamente identificadas e não há, em muitos casos, qualquer registro de captura das espécies que compõem a fauna acompanhante.

Desde 1980, o número de elasmobrânquios desembarcados vem aumentando significativamente, alcançando, na última década, uma taxa estimada de 5% ao ano (Clarke, 2004), com uma produção atual em torno de 800.000 t (FAO, 2009). Dulvy et al. (2008), avaliando a condição de populações de 21 espécies de tubarões e raias oceânicos capturados regularmente por diferentes pescarias, concluiu que mais da metade se encontrava ameaçada (52%), principalmente em razão das elevadas mortalidades por pesca, associadas à uma completa ausência de medidas de manejo e à freqüente baixa qualidade dos dados de captura.

Entre os métodos de pesca com maior incidência de elasmobrânquios inclui-se a pesca de atuns e afins com espinhel. No Oceano Atlântico, essa pescaria se iniciou em 1956, a partir de embarcações japonesas arrendadas, baseadas em Recife (Hazin et al., 1990; Mazzoleni e Schwingel, 2002), de onde se desenvolveu para todo o Atlântico, sendo atualmente praticada por diversos países, dentre os quais o Brasil. Embora, esta pescaria seja direcionada à captura de atuns (*Thunnus* spp.) e do espadarte (*Xiphias gladius*), um considerável montante de elasmobrânquios é capturado como fauna acompanhante (Bonfil, 1994). Entre as principais espécies de fauna acompanhante incluem-se os tubarões das famílias Carcharhinidae, Lamnidae, Alopidae e Sphyrnidae. A família Carcharhinidae se destaca pelos altos índices de captura dos tubarões galha branca oceânico (*Carcharhinus longimanus*), azul (*Prionace glauca*) e lombo preto (*Carcharhinus falciformis*), que são consideradas as espécies de tubarões oceânicos mais abundantes do globo (Compagno, 1984; Taniuchi, 1990; Bonfil, 1994).

A organização responsável pela avaliação e manejo dos estoques de tubarões e raias oceânicos capturados em conjunção com a pesca de atuns e afins no Oceano Atlântico, é a Comissão Internacional para a Conservação do Atum Atlântico (ICCAT- *International Commission for the Conservation of Atlantic Tunas*). Criada em 1966, no Rio de Janeiro, e constituída atualmente por quase 50 países, a ICCAT é hoje a maior organização regional de ordenamento pesqueiro do mundo. Acompanhando a tendência observada em outros fóruns internacionais, a ICCAT tem aumentado substancialmente a atenção dispensada às questões relativas ao manejo e à conservação dos tubarões. A primeira medida de ordenamento adotada pela Comissão relativa a esse importante grupo zoológico foi a Resolução 95-2 (1995), a qual incentivou os países membros a aportarem dados sobre os elasmobrânquios capturados como fauna acompanhante. Desde então, além de monitorar a condição dos estoques das principais espécies de tubarão capturadas, a ICCAT tem aprovado, também, uma série de medidas de ordenamento pesqueiro voltadas à conservação, incluindo, entre várias outras, a proibição, em 2004, da prática do descarte de tubarões após a retirada das suas barbatanas (*finning*) (ICCAT Rec. 04-10). Tais iniciativas têm sido amplamente apoiadas pelo Brasil, uma vez que o país foi um dos primeiros em todo mundo a ter uma legislação no sentido de banir a prática do *finning* já em 1998 (Portaria do IBAMA, Nº 121, de 24 de agosto de 1998). Recentemente, na reunião da ICCAT ocorrida em Paris em novembro de 2010, uma recomendação específica para o tubarão galha-branca foi aprovada (ICCAT Rec. 10-07), proibindo a retenção a bordo, o transbordo, armazenamento e venda deste tubarão (inteiro ou partes do corpo).

Dentre as espécies de tubarões citadas acima, o tubarão galha-branca oceânico tem sido um grande alvo da prática do *finning*, principalmente devido ao alto valor das suas longas e distintas nadadeiras (Camhi et al., 2009), constituindo-se tal prática um motivo de grande preocupação mundial. Em decorrência da intensa pressão pesqueira sofrida pela espécie, somada a escassez de informações acerca de seus aspectos populacionais, o tubarão galha-branca oceânico teve sua classificação recentemente modificada de baixo risco para vulnerável na Lista Vermelha da IUCN (Baum et al., 2006). Poucas informações estão disponíveis para a espécie, principalmente no

Oceano Atlântico Sul, entre estas cita-se Lessa et al. (1999a e 1999b), Domingo et al.(2007) e Coelho et al. (2009). A maior parte dessas informações está relacionada a aspectos biológicos, tais como, morfometria, reprodução, idade e crescimento. No que se refere à distribuição espacial, abundância relativa e preferências de habitat, as informações são praticamente inexistentes.

Diante deste contexto, foram elaborados dois artigos científicos visando contribuir para o enriquecimento do conhecimento sobre alguns aspectos ecológicos e pesqueiros de tubarão galha branca oceânico no Atlântico Oeste Tropical. O primeiro artigo teve como objetivo avaliar a distribuição, abundância relativa e a composição de tamanhos das capturas da espécie, a partir da análise de dados provenientes da frota atuneira brasileira. O segundo artigo teve como objetivo avaliar as preferências de habitat do tubarão galha-branca oceânico, principalmente no que se refere às faixas de profundidade e temperatura e aos seus movimentos verticais, através do uso de marcas do tipo PSAT (*pop-up satellite archival tags*). Além de servirem para a elaboração de futuros planos de manejo e conservação da espécie, espera-se que os resultados gerados também contribuam para o fortalecimento da participação brasileira no âmbito da ICCAT, a partir da proposição de medidas de conservação. Neste sentido, a presente pesquisa, além de ecologicamente relevante, assume também uma significativa importância política e sócio-econômica.

2. Espécie estudada

O tubarão galha-branca oceânico, *Carcharhinus longimanus* (Figura 1), é uma espécie amplamente distribuída nas águas epipelágicas de regiões tropicais e subtropicais (Compagno, 1984). É facilmente distinguida das outras espécies da família Carcharhinidae por apresentar nadadeiras peitorais muito longas, largas e arredondadas. Outra característica marcante é a presença de manchas esbranquiçadas nas extremidades das suas nadadeiras. O tubarão galha-branca é considerado como uma das espécies de tubarões pelágicos mais abundantes, juntamente com os tubarões azul e lombo-preto (*Prionace glauca* e *Carcharhinus falciformis*) (Compagno, 1984; Taniuchi, 1990; Bonfil, 1994). A espécie é freqüentemente capturada nas pescarias de atuns (*Thunnus* spp.) e espadarte (*Xiphias gladius*) com espinhel pelágico.

Os primeiros trabalhos a descreverem a distribuição, abundância, estrutura de tamanhos, dieta, comportamento e reprodução da espécie foram realizados há mais de 50 anos, na porção oeste de Atlântico Norte (Backus et al., 1956) e no Pacífico Leste (Strasburg, 1958). Muitos anos se passaram até que mais informações acerca da história natural do tubarão galha-branca oceânico se tornassem disponíveis (Saika e Yoshimura, 1985), e apenas ao final da década de 90 é que dados do Atlântico Sul começaram a ser publicados (Lessa et al., 1999a & 1999b). Recentemente, Domingo et al. (2007) e Coelho et al. (2009) acrescentaram mais informações acerca da distribuição, abundância relativa e biologia reprodutiva da espécie no Atlântico Sul.

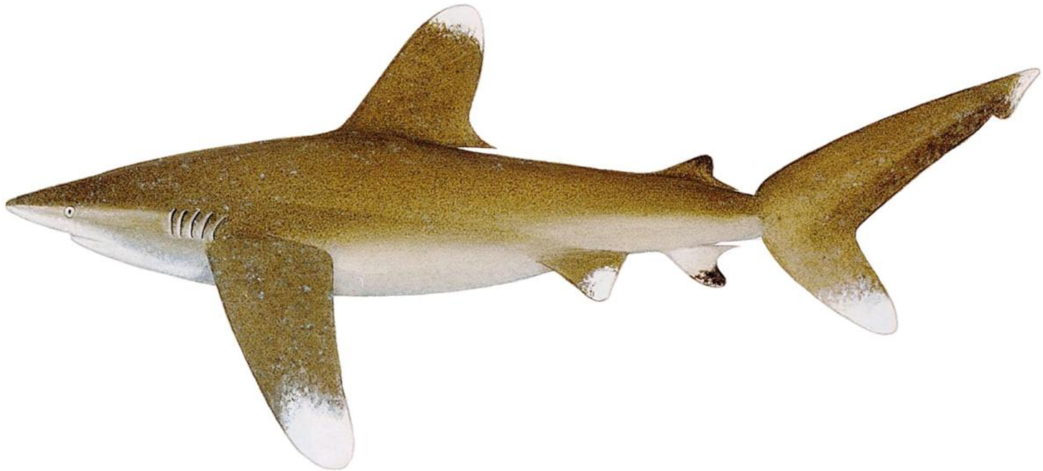

Figura 1. Desenho esquemático do tubarão galha-branca oceânico, *Carcharhinus longimanus* (Fonte: Last & Stevens, 1994.).

O tubarão galha-branca oceânico é um predador de topo de cadeia, que se alimenta principalmente de teleósteos e cefalópodes oceânicos. Na sua dieta são comuns diversas espécies da família Scombridae e Carangidae, assim como peixe-espada, barracuda e dourado (Backus et al., 1956; Compagno, 1984). Assim como os outros representantes da família Carcharhinidae, o galha-branca oceânico é vivíparo placentário, com tamanhos de primeira maturação estimados variando entre 168 e 196 cm de comprimento total (Saika e Yoshimura, 1985; Seki et al., 1998; Lessa et al. 1999; Coelho et al., 2009). A espécie apresenta um crescimento moderado e atinge o tamanho de primeira maturação com cerca de 6 a 7 anos de idade (Seki et al., 1998; Lessa et al. 1999a). Os tamanhos máximos reportados indicam que o tubarão galha-branca oceânico pode chegar a 300 cm ou mais (Compagno, 1984).

3. Artigos científicos

3.1. Artigo científico I

SIZE, DISTRIBUTION AND CATCH RATES OF THE OCEANIC WHITETIP SHARK CAUGHT BY THE BRAZILIAN TUNA LONGLINE FLEET

SUMMARY

Catch and effort data from 14,560 longline sets carried out by the Brazilian chartered tuna longline fleet, from 2004 to 2009, were analyzed aiming at assessing the size, distribution and the relative abundance of the oceanic whitetip shark (Carcharhinus longimanus) in the southwestern and equatorial Atlantic Ocean. For the spatial analyzes, all data were grouped into 5° x 5° squares. The CPUE for the oceanic whitetip shark exhibited a gradual increase, from 0.04, in 2004, the first year of the time series, up to 0.14, in 2007. In 2008, however, the CPUE increased sharply, reaching 0.45, dropping, then, back to 0.10, in 2009. The spatial distribution of the CPUE by quarters of the year and by year (quarters combined) showed that the square bounded by 10°S and 20°S and by 030°W and 040°W concentrated the highest values for the species. The majority of the oceanic withetip sharks caught by this fleet were under the size of first maturity. Although the total length ranged from 50 to 320 cm, almost 80% were under 180 cm (published size at first maturity). The spatial distribution showed a concentration of larger specimens from about 020°W to 030°W and from 5°S to 20°S. Another area of concentration of larger specimens seems to be present to the north of 5°N, between the same longitudes.

KEYWORDS

CPUE, Carcharhinus longimanus, distribution, size

Introduction

The oceanic whitetip shark, *Carcharhinus longimanus*, is widely distributed in tropical and subtropical epipelagic waters of all oceans (Compagno, 1990). It is easily distinguishable from the other species of the Carcharhinidae family by the round shape of its long pectoral and dorsal fins, as well as by the white stains in their margins. The species is considered to be one of the three most abundant pelagic sharks, together with the blue and silky sharks *(Prionace glauca* and *Carcharhinus falciformis*) (Compagno, 1984; Taniuchi, 1990; Bonfil, 1994).

The oceanic whitetip shark is frequently caught by pelagic longline fisheries targeting tuna and swordfish, all over the world. Due to the great increase of the fishing pressure on its stocks in the past decades, the species has been classified, since 2006, as vulnerable by the IUCN Red List of Threatened Species (Baum et al., 2006).

Despite the great ecological importance of the oceanic whitetip shark and its high vulnerability, only little information is available on the species, especially in the South Atlantic Ocean (Lessa et al., 1999a & 1999b; Domingo et al., 2007; Coelho et al., 2009). Besides, most of the information available is related to biological aspects (morphometry, reproduction, age and growth), with very little being yet known in relation to its spatial distribution and relative abundance.

Therefore, in the present study, data from the Brazilian tuna longline fleet were analyzed, aiming at assessing the distribution, catch rates and size composition of the oceanic whitetip shark in the southwestern and equatorial Atlantic Ocean.

Material and methods

Catch and effort data from 14,560 longline sets carried out by the Brazilian chartered tuna longline fleet, from 2004 to 2009, were analyzed. The longline sets were distributed in a wide area of the equatorial and southwestern Atlantic Ocean, ranging from 10°N to 35°S of latitude and from 007°E to 045°W of longitude. Data were obtained from the logbooks filled out by on-board observers of the National Observer Program. The logbook contained information on the number of hooks, the number of fish caught, by species, and the geographic position at the beginning of each set.

The National Observer Program aims to collect precise information on fishery strategy, catch composition and biological data of chartered foreign vessels, mainly the ones that are based on ports of northeast Brazil. The program covers approximately 30% of the whole Brazilian longline fleet and almost 60% of the fleet based on the northeast. This data series was chosen due to its known accuracy, especially when compared with the logbooks filled out by the fishermen (Travassos, unpublished data).

Catch per unit of effort (CPUE) was calculated as the number of sharks/1,000 hooks by year and by quarters (years combined). For the spatial distribution of the CPUE the catch and effort data were grouped into 5°x5° squares of latitude and longitude. In this case, the CPUE was calculated by the sum of all catch and all effort in each square.

From 2005 on, additional data on sex, total length (TL), fork length (FL) and inter-dorsal (ID) length begun also to be collected. All lengths were obtained by laying the fish on the deck and measuring it in a straight line. Whenever the TL was not available, the FL and the ID were converted to TL by the following equations, calculated with the available data: CT= 1.1348 FL + 12.537 and CT= 3.4221 ID + 27.396. A total of 1,612 individuals were measured, representing 68% of the oceanic whitetip sharks caught (2,353). Of these, 1,218 were sexed. For the spatial analysis, the mean length was calculated for each 5°x5° square. Squares in which the number of fish measured was smaller than five were excluded from the spatial analysis.

Results and discussion

The fishing effort peaked in 2005, when about 8 million hooks were deployed, almost the double from the previous year. From 2005 on, the number of hooks exhibited a declining trend, until 2009, last year included in the series, when about only 1 million hooks were used (Figure 1). The spatial distribution of the fishing effort also varied throughout the period, with 2005 showing the greatest spatial coverage, naturally due to the higher number of hooks deployed that year (Figure 2).

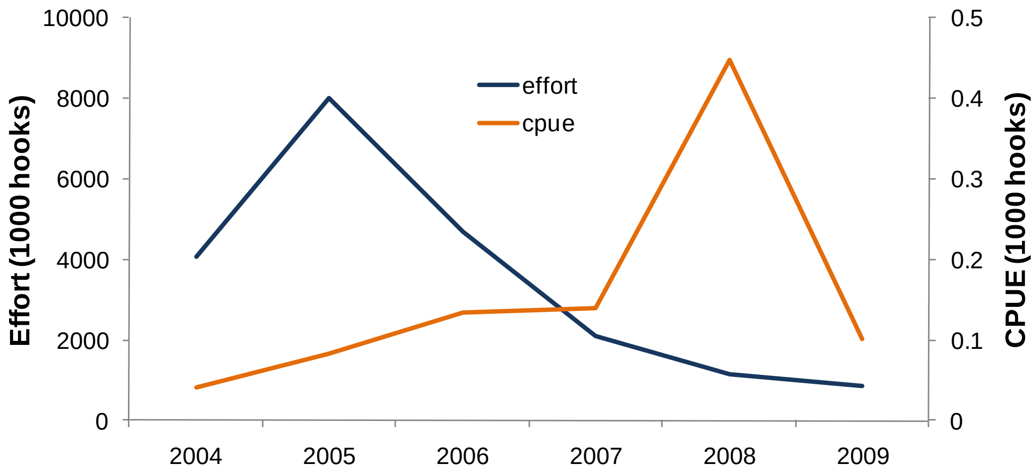

Figure 1. Yearly total effort and mean CPUE of the oceanic whitetip shark, *Carcharhinus longimanus*, caught by the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean.

The area with the greatest concentration of effort was located between the latitudes of 5°N and 5°S (Figures 2 and 3). Oceanic islands, such as the Archipelago of Saint Peter and Saint Paul, Fernando de Noronha Island and Rocas Atoll, as well as several seamounts, pertaining to the North Brazil Chain and to the Fernando de Noronha Chain, present in that area, are considered to be important fishing grounds for tuna and tuna-like species off northeast Brazil (Hazin, 1993). Moreover, that important fishing ground is located at a rather short distance from the ports where the longliners are based (Natal - Rio Grande do Norte, Recife - Pernambuco and Cabedelo - Paraiba). Another important fishing area is located further south, near the seamounts and islands of the Vitoria-Trindade Chain (Figures 2 and 3).

The catch per unit of effort (CPUE) for the oceanic whitetip shark exhibited a gradual increase, from 0.04 sharks/1000 hooks, in 2004, the first year of the time series, up to 0.14, in 2007 (Figure 1). In 2008, however, the CPUE increased sharply, reaching 0.45, dropping, then, back to 0.10, in 2009.

The spatial distribution of the CPUE by year (Figure 4) shows that, in 2004, the number of zero catches was very high, with positive catches being only recorded between the latitudes of 10°N and 5°S, and values ranging from 0.01 to 0.08 sharks/1000 hooks. From 2005 on, positive catches were recorded more southward (up to 30°S) and eastward (up to 0°), than in 2004. High CPUE values (> 0.58), from 2005 to 2007, were recorded in the square from 10°S to 20°S and from 30°W to 40°W, with the only exception of a high value also recorded in 2006, close to the African coast (0-5°N; 10°- 15°W). In 2008, the year with the highest mean CPUE (0.45), the area with the highest catch rates was expanded northwestward, extending from 5°S to 20°S and from 25°W to 40°W. During that year, catches of the oceanic whitetip shark were recorded in almost all 5° squares where there was effort. In 2009, the 5° square mean CPUE values became generally low again, with none being above 0.28, and several squares exhibiting no catch. Domingo et al. (2007), analyzing data from the Uruguayan longline fleet, found the highest CPUE (0.49 sharks/ 1,000 hooks) for the species in an area close to the one which showed the highest CPUE in the present study (around 20°S/ 35°W). Except from an apparent trend for the oceanic whitetip shark to move away from the Brazilian southeast coast in the fourth quarter of the year, the CPUE distribution by quarters (Figure 5) showed no clear pattern of seasonal change.

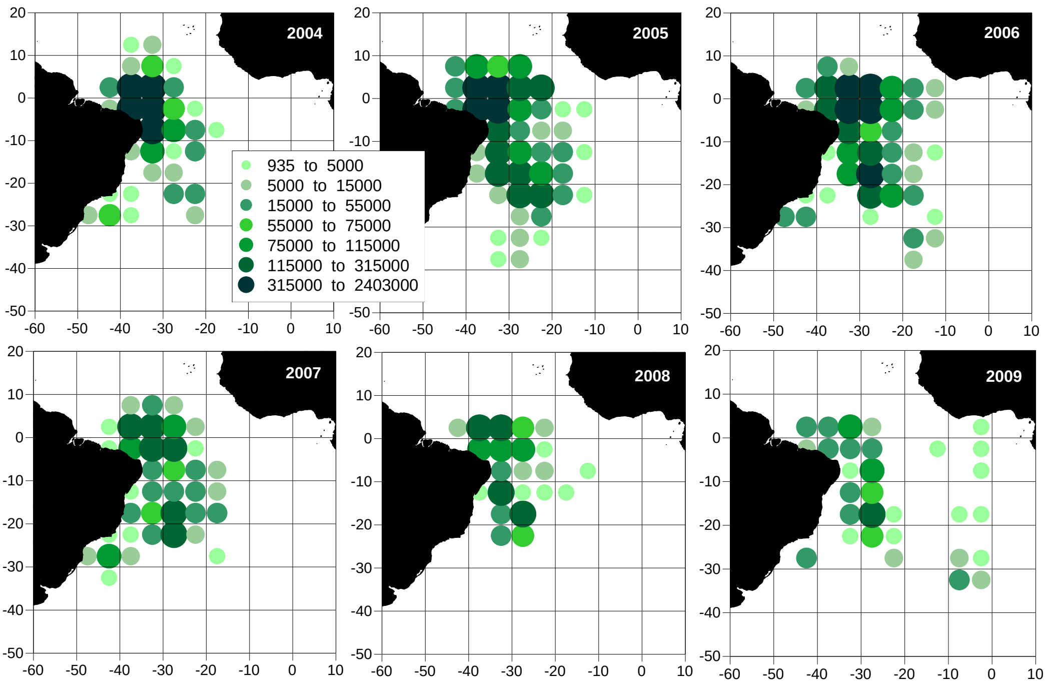

Figure 2. Yearly distribution of the fishing effort (in number of hooks), of the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean.

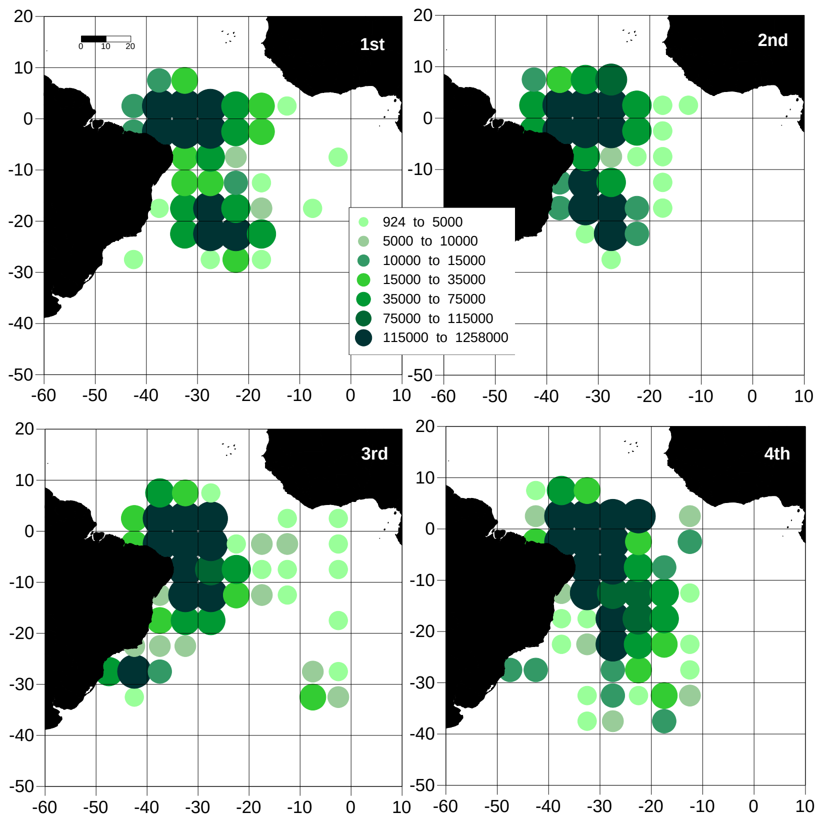

Figure 3. Quarterly distribution of the fishing effort (in number of hooks), of the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean.

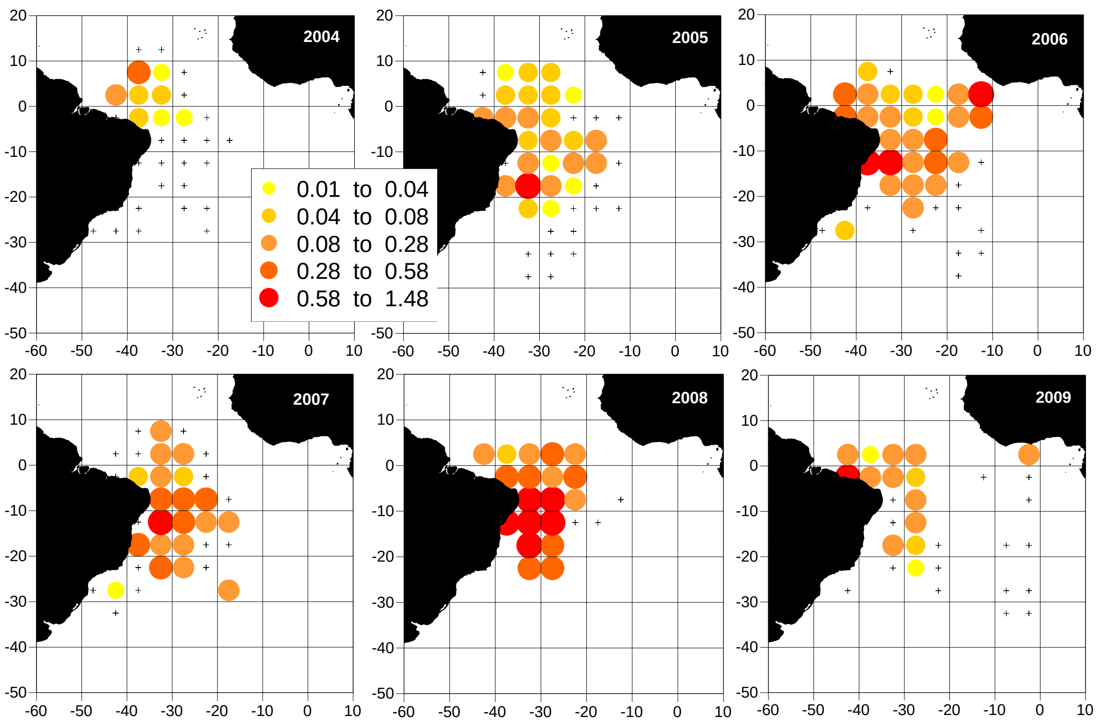

Figure 4. Yearly distribution of the CPUE of the oceanic whitetip shark, *Carcharhinus longimanus*, caught by the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean. The crosses represent zero catch.

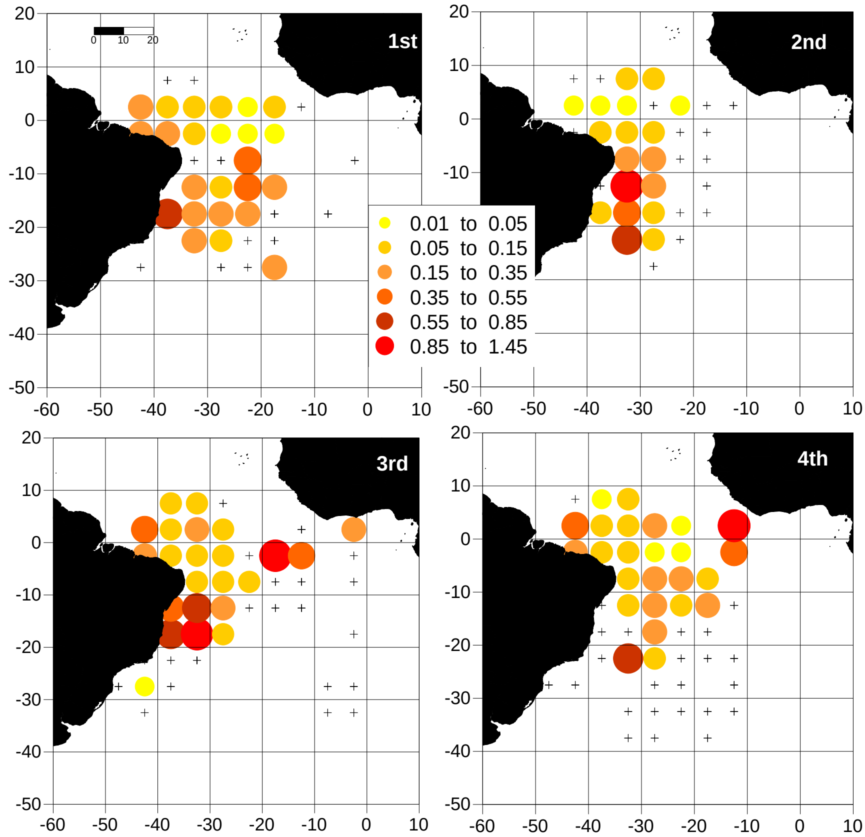

Figure 5. Quarterly distribution of the CPUE of the oceanic whitetip shark, *Carcharhinus longimanus*, caught by the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean. The crosses represent zero catch.

The proportion of the oceanic whitetip shark in relation to the total catch and in relation to the catches of elasmobranches were very low (Figure 6), equaling 0.3% and 2.8%, respectively. The oceanic whitetip shark yearly proportion of the total catch did not exceed 0.4%, except for 2008, when it reached 1.4%. Its proportion in relation to the elasmobranch catches also showed a peak of 8.2% in 2008. In the remaining years this proportion ranged from 0.8% to 3.4%. These values are much lower than those observed by Lessa et al. (1999a), in an experimental survey of pelagic fishes conducted between 1992 and 1997 in the southwestern equatorial Atlantic, where the whitetip catches represented almost 30% of all elasmobranchs, being the second most abundant shark, outnumbered only by the blue shark (*Prionace glauca*).

The results, however, are not comparable, due to the significant differences in the fishing gear and methods used by the experimental and the commercial operations, the first ones having operated in much shallower layers, where the species is known to be much frequently caught (Nakano et al., 1997). More recent results, obtained with the use of PSAT tags (Pop-up satellite archival tags), have confirmed that this species is closely associated to the surface (Tolotti et al., unpublished data).

Besides the depth of fishing, there are several other factors that may directly influence the catchability of a fish species in the longline fishery, thus altering the relationship between its catch rate (CPUE) and its actual abundance. Hazin et al. (1998), for instance, described marked fluctuations in the CPUE of several species, including the oceanic whitetip shark, over a period of many years, due to modifications in fishing strategy, such as changes on target species, discovery of new fishing grounds and introduction of new fishing technologies. Burgess et al. (2005), in turn, reported that the material of the branch line (nylon or steel), as well as the size, type and depth of the hook, can greatly influence the catchability of shark species. They also indicated that market changes may modify the target species of the fishery, directly interfering, therefore, in the catchability of the species caught.

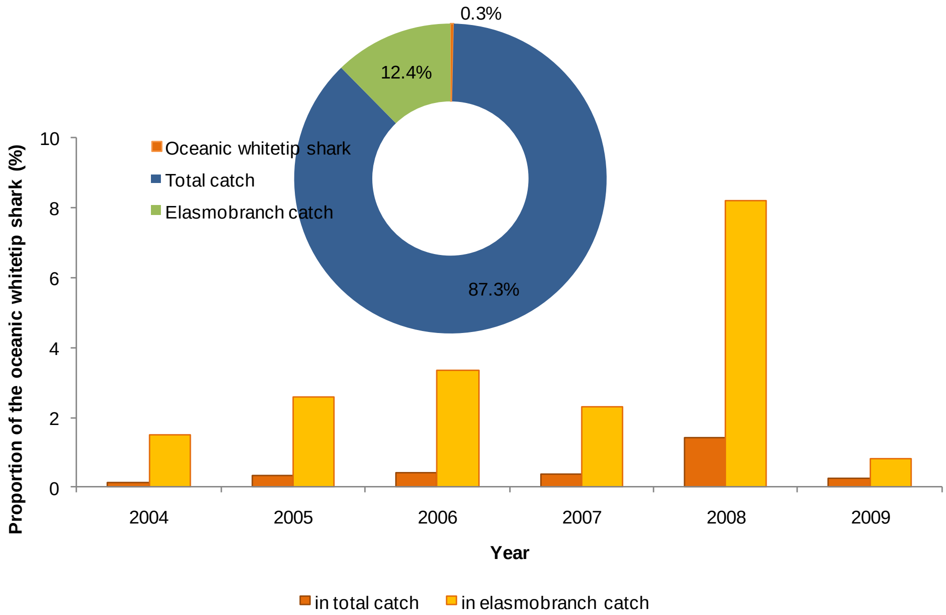

Figure 6. Proportion of the oceanic whitetip shark, *Carcharhinus longimanus*, in total and elasmobranch catches, of the Brazilian chartered tuna longline fleet, from 2004 to 2009, in the equatorial and southwestern Atlantic Ocean.

In the present case, as well, the changes of CPUE over the years can probably be explained, at least in part, by changes in fishing strategies, especially related to longline configuration of different flags that were active during the study period. The most representative flags from 2004 to 2009 were Panama, Spain and Morocco, the late also fishing with Spanish technology. Over the studied years there was a great variation in the number of vessels by flag, with a predominance of Panamanian boats in the first three years (2004 to 2006), and of vessels with Spanish technology in the last three (2007 to 2009) (Figure 7). The annual mean CPUE of the oceanic whitetip shark by flag (Figure 8), on the other hand, clearly shows much lower values for the UK (ENG), Portugal (POR) and Panama (PAN) flagged vessels, than for those flying Spanish

(SPA), Honduran (HON) and Moroccan (MOR) flags, and therefore the changes in the yearly mean CPUE throughout the period might very well merely reflect the changes in fleet composition. Even if that is the case, however, the change in the proportion of fishing effort from different fleets would not be sufficient to explain the sharp increase observed in 2008, which resulted mainly from the sign coming from the Spanish fleet (Figure 8). The reasons for such anomaly, however, could not be identified in the present work, and might be related to operational, biological or ecological factors.

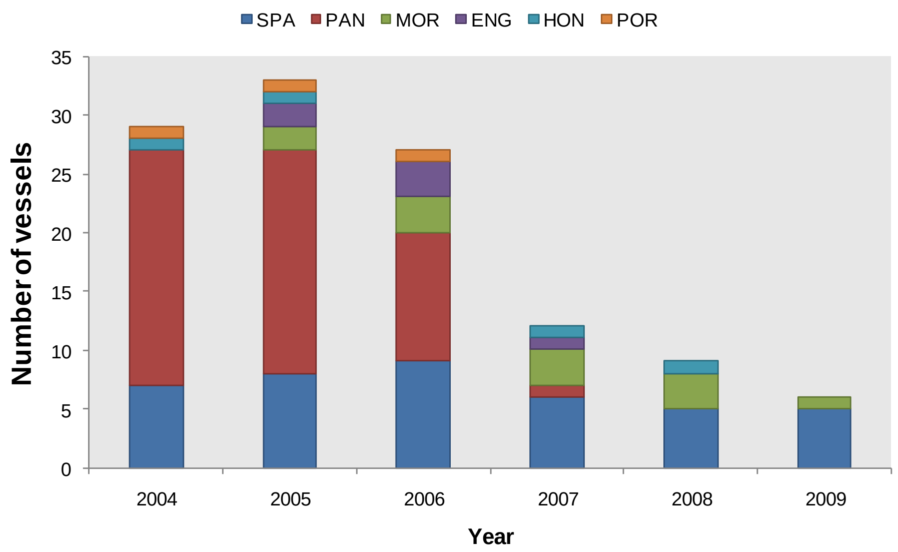

Figure 7. Yearly number of chartered longline vessels, by flag, operating in the equatorial and southwestern Atlantic Ocean, from 2004 to 2009.

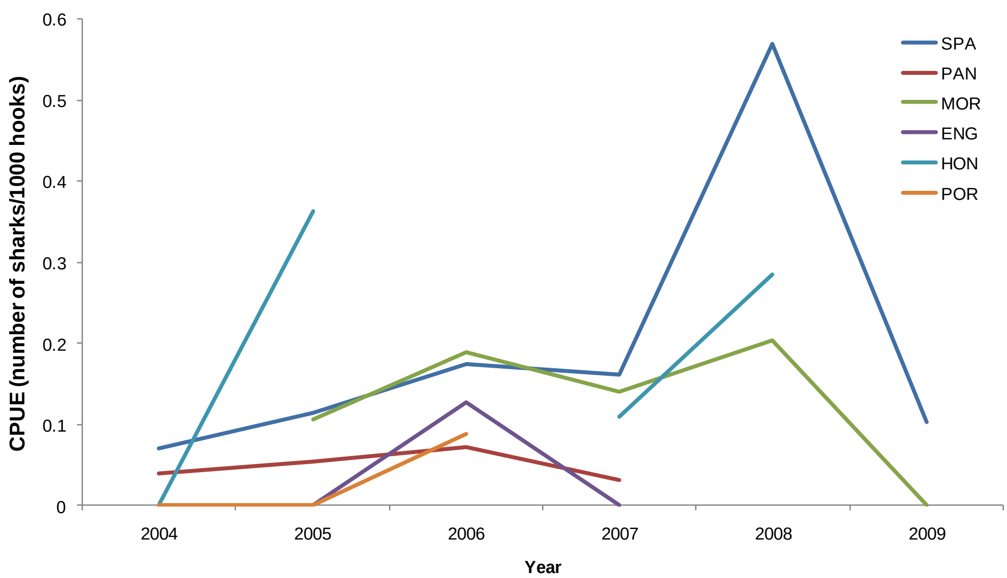

Figure 8. Catch per Unit of Effort (CPUE), of the oceanic whitetip shark, *Carcharhinus longimanus*, by flag, of the Brazilian chartered longline vessels, operating in the equatorial and southwestern Atlantic Ocean, from 2004 to 2009 (SPA= Spain, PAN= Panama, MOR= Morocco, ENG= United Kingdom (UK), HON= Honduras, and POR= Portugal).

The total length of the 1,612 individuals measured ranged from 50 to 320 cm, in males, and from 50 to 311 cm, in females. The majority of males and females lied between 100 and 180 cm TL (Figure 9), with 78% having less than 180 cm and being, thus, probably juvenile according to Lessa et al. (1999b). Of the 1,218 specimens sexed, 653 were female and 565 were male, resulting in a sex ratio very close to 1:1 (1:0.86, female: male). These values were very close to those found by other studies carried out in the same area (Lessa et al., 1999a & 1999b; Asano et al., 2004; García-Cortéz & Mejuto, 2002; Coelho et al., 2009).

Lessa et al. (1999b) suggested, based on a small individual caught with fresh umbilical scars, that the size at birth is around 70 cm TL. Coelho et al. (2009) found near-term embryos measuring 52 cm, and therefore hypothesized that the size at birth should be around 55 and 65 cm, as proposed by Compagno (1984). The three individuals measuring 50 cm TL found in the present work, however, indicate that the size at birth might be smaller than previously reported.

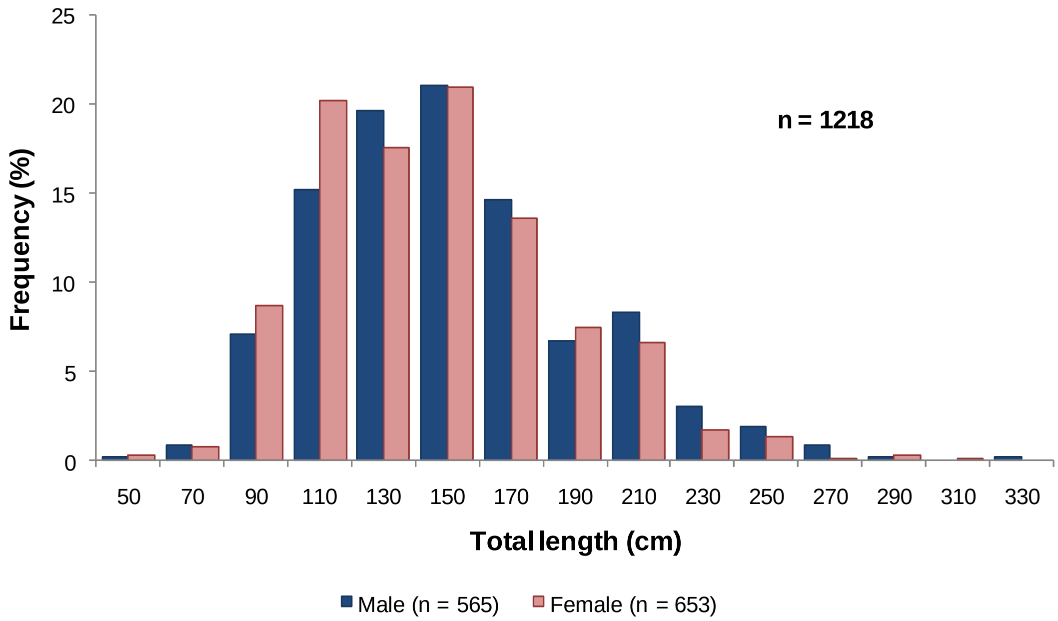

Figure 9. Length-frequency distribution of the oceanic whitetip shark, *Carcharhinus longimanus*, caught in the southwestern equatorial Atlantic Ocean, between 2005 and 2009.

Former studies indicated that a geographical segregation by sex may occur for the oceanic whitetip shark (Backus et al., 1956; Strasburg, 1958). In the present study, however, no evidence has been found of a spatial segregation by sex (Figure 10). Coelho et al. (2009) suggested that the high percentage of small individuals in the southwestern equatorial Atlantic, also found in the present work, may indicate a segregation by size in the Atlantic Ocean. Alternatively, Lessa et al. (1999) hypothesized that the large proportion of juveniles might be a result of the continuous fishing pressure on the entire population. In order to clarify this matter, however, data from a much longer time series and a much broader geographical coverage of the Atlantic Ocean are necessary.

The spatial distribution of the 5° square mean lengths (Figure 11) shows a concentration of larger specimens from about 020°W to 030°W and from 5°S to 20°S. Another area of concentration of larger specimens seems to be present to the north of 5°N, between the same longitudes.

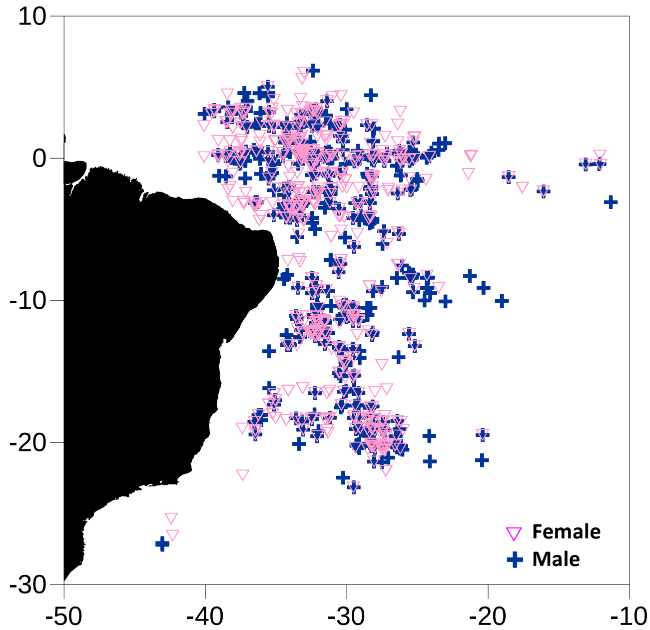

Figure 10. Spatial distribution of males and females of the oceanic whitetip shark, *Carcharhinus longimanus*, caught in the southwestern equatorial Atlantic Ocean, between 2005 and 2009.

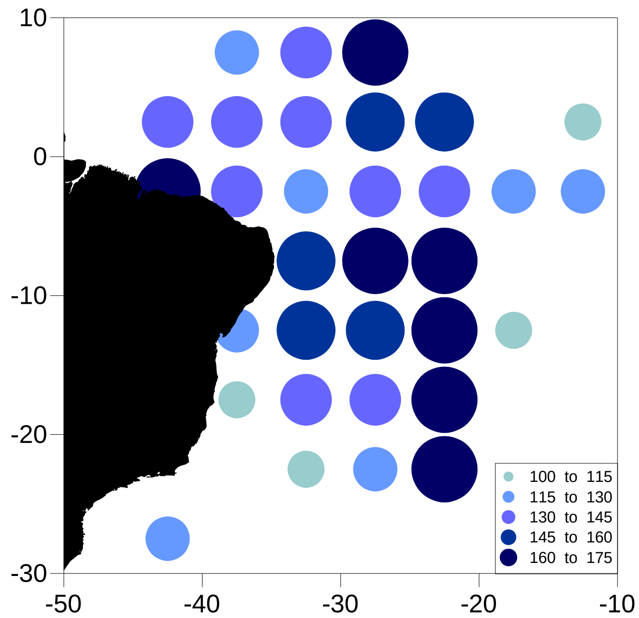

Figure 11. Mean lengths, by 5^{o} squares, of the oceanic whitetip shark, *Carcharhinus longimanus*, caught in the southwestern equatorial Atlantic Ocean, between 2005 and 2009.

This study has shown that the catch rates of the oceanic whitetip shark are very sensitive to changes in fishing strategy and gear, especially to those related with hook depth. It is also clear that the largest part of the specimens of this species caught in the southwestern equatorial Atlantic is composed of juveniles. These results indicate that conservation measures, such as adoption of a minimum size of capture to protect juveniles or even prohibition of onboard retention, should be applied to ensure the sustainability of the oceanic whitetip shark exploited in the Atlantic Ocean.

Acknowledgments

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3.2. Artigo científico II

TEMPERATURE AND DEPTH PREFERENCES AND SMALL-SCALE HORIZONTAL MOVEMENTS OF THE OCEANIC WHITETIP SHARK IN THE WESTERN EQUATORIAL ATLANTIC OCEAN

SUMMARY

The objective of this study was to generate information on depth and temperature preferences and horizontal movements of the oceanic whitetip shark (Carcharhinus longimanus) in the western equatorial Atlantic Ocean. To that aim two sharks were tagged with pop-up satellite archival tags during a fishing trip of a commercial fishing boat from the Brazilian tuna longline fleet in the beginning of 2010. The first shark tagged was a female measuring 135 cm TL and the second one was a male measuring 152 cm TL. Both sharks had a remarkable preference for warm and shallow waters of the mixed layer, spending at least 95% of the deployment period in waters with temperatures above 26.0°C and 86% in the first 50 m. Deep diving behavior was not registered. The maximum recorded depth was 128 m and the minimum temperature was 15.6°C. Despite their narrow depth distribution, both sharks performed diel vertical migrations. Tagging and pop-off sites were not far from each other and the maximum distance traveled was 1,884 nautical miles. Daily displacement ranged from 12.86 to 20.94 nautical miles and mean swimming speed (± SE) ranged from 0.41 ± 0.16 to 1.00 ± 0.09 knots. The *horizontal movements indicated a westward migration.*

KEYWORDS

Pop-up satellite archival tag, diel vertical movements, migration

Introduction

The oceanic whitetip shark (*Carcharhinus longimanus*) is a circumtropical species known as one of the most abundant pelagic sharks worldwide (Compagno, 1984; Bonfil et al., 2008), being frequently caught by pelagic longline fisheries targeting tuna and swordfish. Bonfil (1994) estimated that 7,253 oceanic whitetip sharks (about 145 t) were taken annually as incidental catch in the North Pacific and another 539,946 individuals (about 10,800 t) were taken in the central and South Pacific. For the Atlantic and Indian Oceans it was not possible to estimate annual caches due to insufficient amount of data and high expected variation in catch rates.

Despite its worldwide distribution and frequent catches in most of the high-seas fisheries little has been published on the species biology and ecology. Some general studies, including data on distribution, abundance, size structure, diet, reproduction and behavior of the oceanic whitetip shark were conducted in the western North Atlantic and in the eastern Pacific Ocean, more than fifty years ago (Strasburg, 1958; Backus et al., 1956). Since then, however, very little was added to the knowledge on the species until the past decade when new data from the South Atlantic was published by Lessa et al. (1999a & 1999b), Domingo, et al. (2007) and Coelho et al. (2009). Except for assumptions made on the basis of fisheries data and conventional tagging programs (Backus et al., 1956; Strasburg, 1958; Kohler et al., 1998), information regarding oceanic whitetip migration, vertical movements and temperature preferences are still almost inexistent.

The use of electronic tags has recently added valuable information on the species depth and temperature preferences in the Pacific Ocean, although these results were not yet published and have only been cited in other scientific publications (Burgess et al., 2005; Bernal et al., 2009). Electronic tags allow the remote monitoring of fishes and other marine species, making it possible to study the species behavior, habitat preferences and movement patterns (Nelson, 1990).

During the past decades, this kind of tags underwent major technological improvements, among which the development of pop-up satellite archival tags (PSAT) stands out (Block et al., 2001). PSATs were developed in the mid 90’s, especially for tracking large marine species (Arnold & Dewar, 2001; Gunn & Block, 2001), and have been successfully used in a great variety of pelagic species, including tunas (Block et al., 1998, 2001; Lutcavage et al., 1999; Sibert et al., 2003; Teo et al., 2007), billfishes (Graves et al., 2002; Kerstetter et al., 2003; Goodyear et al., 2006), and sharks (Sims et al., 2003; Bonfil et al., 2005; Weng et al., 2005; Stokesbury et al., 2005).

In this context, the present work intends to generate information on the oceanic whitetip shark habitat preferences, regarding depth distribution, temperature ranges and horizontal movements, in the western equatorial Atlantic Ocean, through the use of pop-up satellite archival tags.

Material and methods

Two oceanic whitetip sharks, caught on sets done by a commercial fishing boat of the Brazilian tuna longline fleet operating off the Northeast cost of Brazil, were tagged with pop-up satellite archival tags (PAT tag version MK 10, Wildlife Computers). The Mk10 PATs collect data on water temperature, pressure (depth) and ambient light level (for estimation of geolocations). Temperature and depth resolutions are 0.05°C and 0.5 m, respectively. Tags were set to collect data at 10 seconds intervals throughout the deployment period, summarized into one hour histograms of 14 bins. Circle hooks were used to increase the chances of post release survival. Sharks were brought on board for body length measurement and tagging, for no longer than five minutes prior to release. Tags were attached through a fin loop of polyamide monofilament (2.0 mm) coated with a silicon tube to minimize friction damage. Tagging locations were recorded by using the vessel's global positioning system.

The first oceanic whitetip shark tagged (A) was a female, measuring 135 cm total length (TL), while the second (B) was a male, measuring 152 cm TL. The female specimen was tagged on January 29, 2010, and the tag started transmitting after 60 days of deployment, as scheduled. The second tagging occurred about one week after the first one, on February 5, with the tag beginning to transmit after 90 days of deployment, also as scheduled. The tag from shark A was 69% successfully decoded by the Argos satellites and 108 one-hour histograms of time-at-depth and temperature were received. A total of 12 light readings were also received, making it possible to estimate 6 light-based geolocations. The second tag was 86% successfully decoded, with 678 histograms and 114 light readings received, allowing the estimation of 51 geolocations. The tags detached from the oceanic whitetip sharks at a depth of 63 and 89 meters for shark A and B, respectively.

The horizontal movements of tagged sharks were estimated by processing the data received from the Argos satellites with the manufacturer light-based geolocation software (WC-GPE: Global Position Estimator Program suite, available on: www.wildlifecomputers.com). Longitude is estimated from the time of local noon and latitude from the length of the day through the dawn and dusk symmetry method. In order to minimize the errors usually associated to this geolocation estimation (Metcalfe, 2001; Musyl et al., 2001; Nielsen et al., 2006; Lam et al., 2008), the state-space Kalman filter statistical model was applied (Sibert et al., 2003). This model is widely used and is freely available as the KFtrack package, which is plug-in for the open source statistical software R (Nielsen & Sibert, 2004).

The total traveled distance was calculated by summing the distances between each consecutive geolocation point, while the daily displacement was estimated by dividing the total traveled distance by the number of days from the deployment period. To obtain better accuracy, the swimming speed was calculated by dividing the distance between all consecutive days that were available per 24 hours. After this, a mean swimming speed $\pm$ standard error was estimated. Depth and temperature data were analyzed in relation to the different periods of the day to search for diel movement patterns. Day and night data were separated according to the local times of sunrise and sunset. To compare daytime and nighttime distributions, for both depth and temperature, Pearson's chi-squared tests were performed. All statistical tests were performed at the 95% confidence level.

Results

Horizontal movements

Both tagging took place near the equator in the western side of the Atlantic Ocean and for the two sharks tagging and pop-up sites were not much far from each other (Figure 1). If the sharks had moved in a straight line, shark A would have moved 231 nautical miles (nm) and shark B 510 nm (Table 1).

During the 60 days of deployment, shark A moved approximately 771 nm, with an estimated daily displacement of 12.86 nm. The mean swimming speed was (± SE) 0.41 ± 0.16 knots. The movement of Shark A was predominantly westward, towards the American continent, and slightly northward (Figure 2).

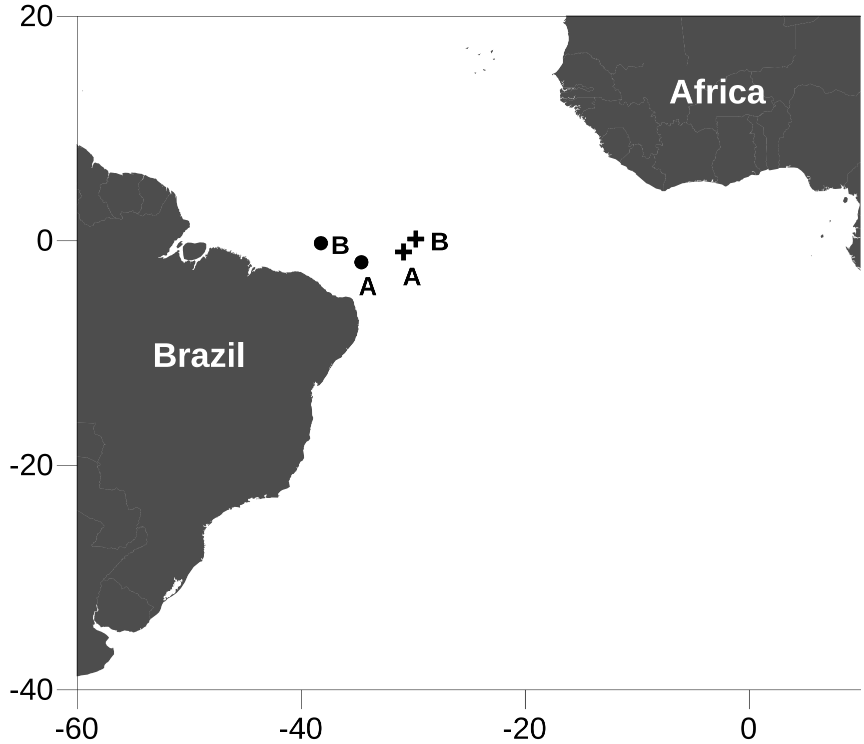

Figure 1. Tagging and pop-off positions of the two oceanic whitetip sharks tagged with pop-up satellite archival tags in the western equatorial Atlantic Ocean. Crosses represent tagging location, and circles, the pop-off location.

Table 1. Summary data of the two oceanic whitetip sharks tagged with pop-up satellite archival tags in the western equatorial Atlantic Ocean.

Shark	Sex	Total length	Tagging date	Tagging Latitude	Tagging Longitude	Pop-up date	Days at liberty	Pop-up Latitude	Pop-up Longitude	Distance between tagging and pop-up
A	F	135 cm	01/29/2010	0.995° S	30.88° W	03/30/2010	60	1.914° S	34.62° W	231 nm
B	M	152 cm	05/02/2010	0.158° N	29.77° W	05/06/2010	90	0.218° S	38.25° W	510 nm

Shark B moved approximately 1,884 nm over the 90 days deployment, with an estimated daily displacement of 20.94 nm. Its mean swimming speed was 1.00 ± 0.09 knots. The horizontal movements of shark B can be divided into three phases, with the following predominant directions: a) northward and westward; b) eastward and south; and c) west and slightly southward (Figure 3). Overall, however, shark B movements were mainly westward, as were the movements of shark A. Both sharks remained approximately within the same area, near the equator, from 30°W to 40°W and from 0° to 5°N.

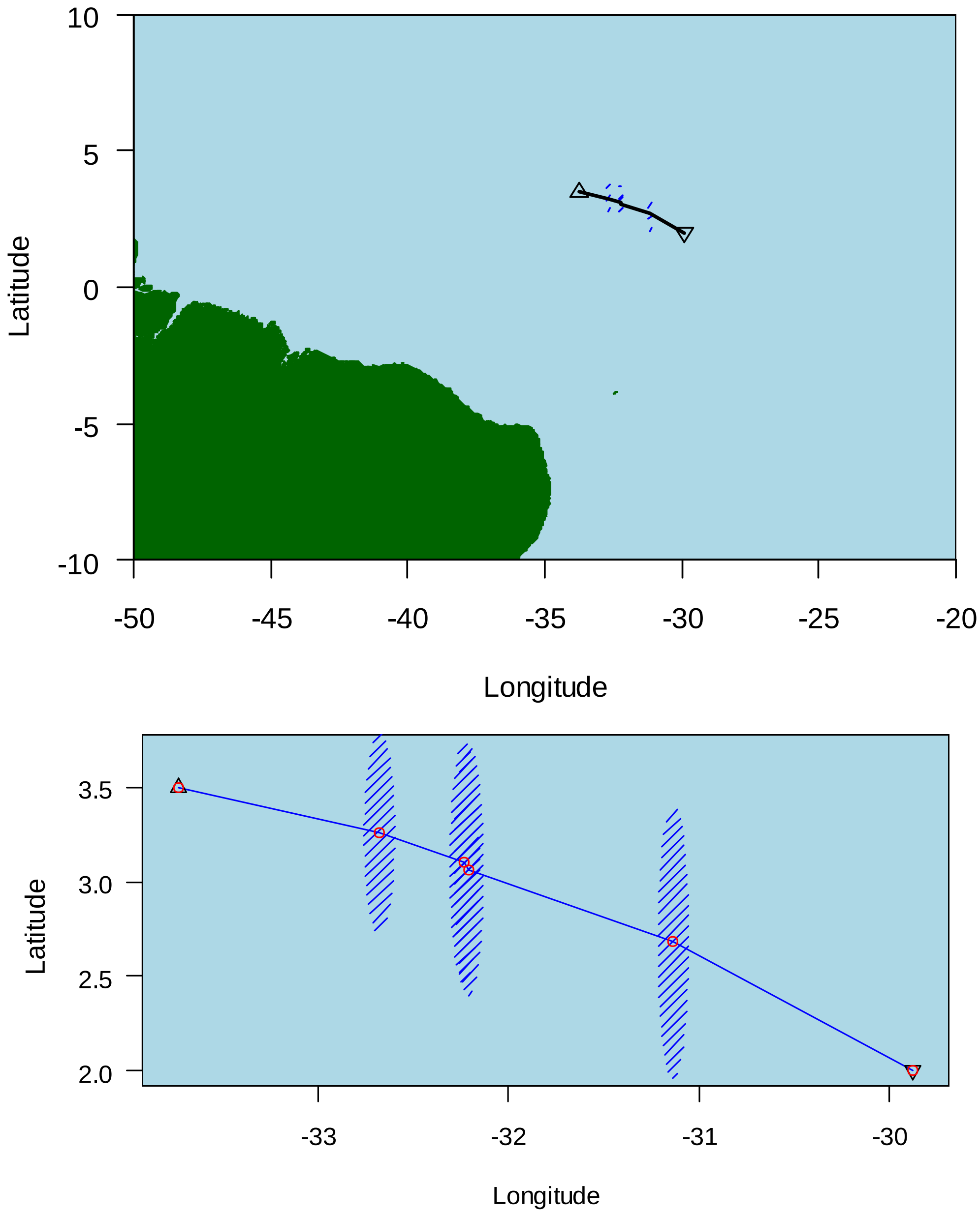

Figure 2. Most probable track for an oceanic whitetip shark (shark A) tagged in the western equatorial Atlantic Ocean determined by Kalman Filter. Blue shaded area represents the confidence intervals. The inverse triangle (∇) indicates the begging of the track and open triangle (Δ) indicates the end.

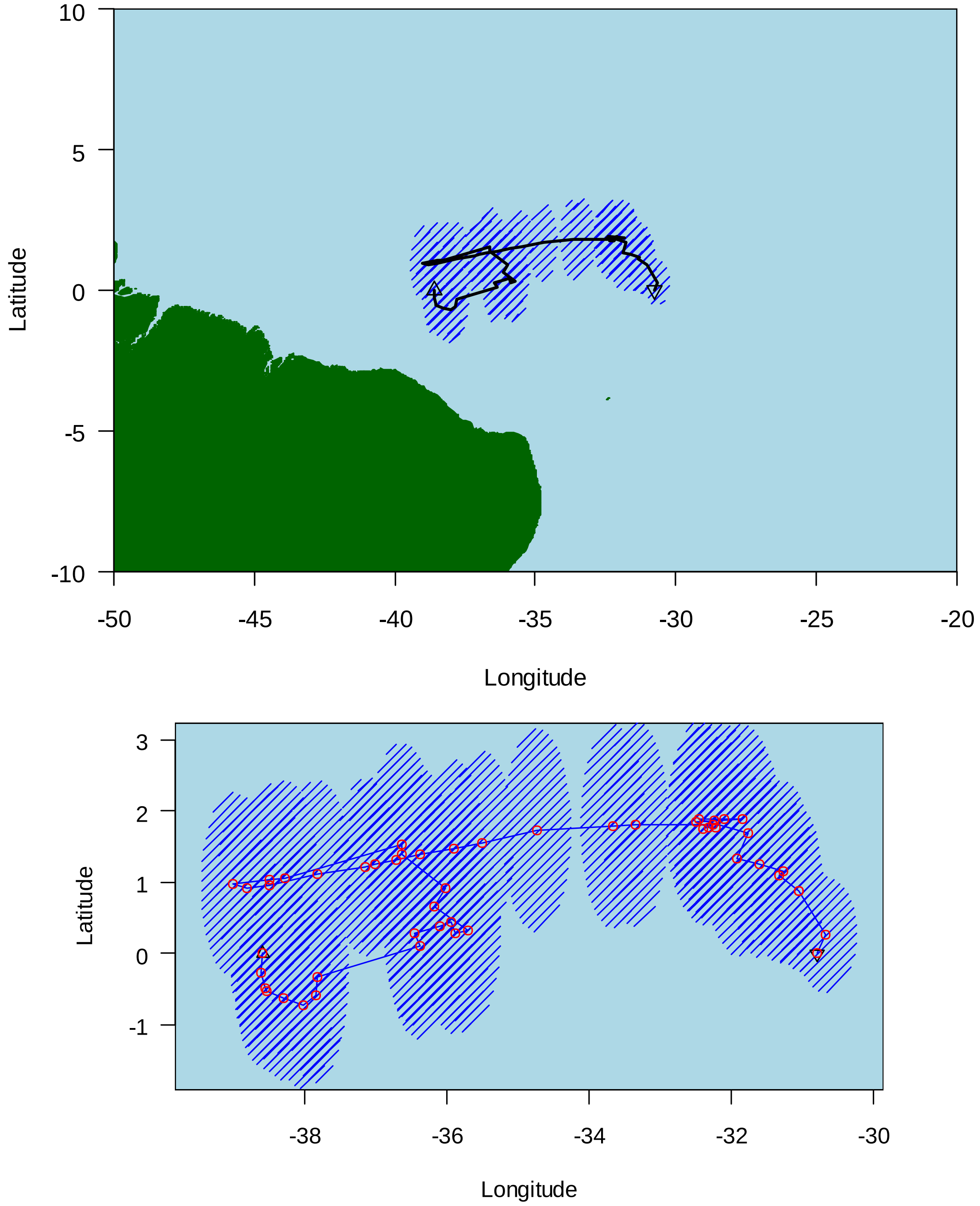

Figure 3. Most probable track for an oceanic whitetip shark (shark B) tagged in the western equatorial Atlantic Ocean determined by Kalman Filter. Blue shaded area represents the confidence intervals. The inverse triangle (∇) indicates the begging of the track and open triangle (Δ) indicates the end.

Depth and temperature preferences

Both sharks exhibited a remarkable preference for warm and shallow waters of the mixed layer. Shark A spent 97% of the time in waters with temperatures above 26.0°C and 86% in the first 50 m. Average depth of the mixed layer according to the vertical temperature profiles from both tagged sharks and other research results in this area is 50 m (Travassos et al., 1999). Similarly, shark B spent 95% of the time at warm waters above 26.0°C and 88% in the mixed layer. The minimum temperature experienced by shark A was 15.6°C, at a corresponding depth of 112 m, while shark B dove down to 128 m and experienced a minimum temperature of 17.6°C. For both sharks, incursions to depths below 100 m, under the thermocline, were not very common and expositions to waters under 20°C were even rarer. Shark A made only two dives beyond this depth, one to 104 m, in the beginning of the deployment period, on January 31st; and another to 112 m, on March 21st, near the end of the deployment period. Shark B made considerably more dives to depths below 100 m. Those dives occurred in three distinct periods: a) between February 21 and 25; b) between March 12 and 13; and c) on May 05 (Figure 4).

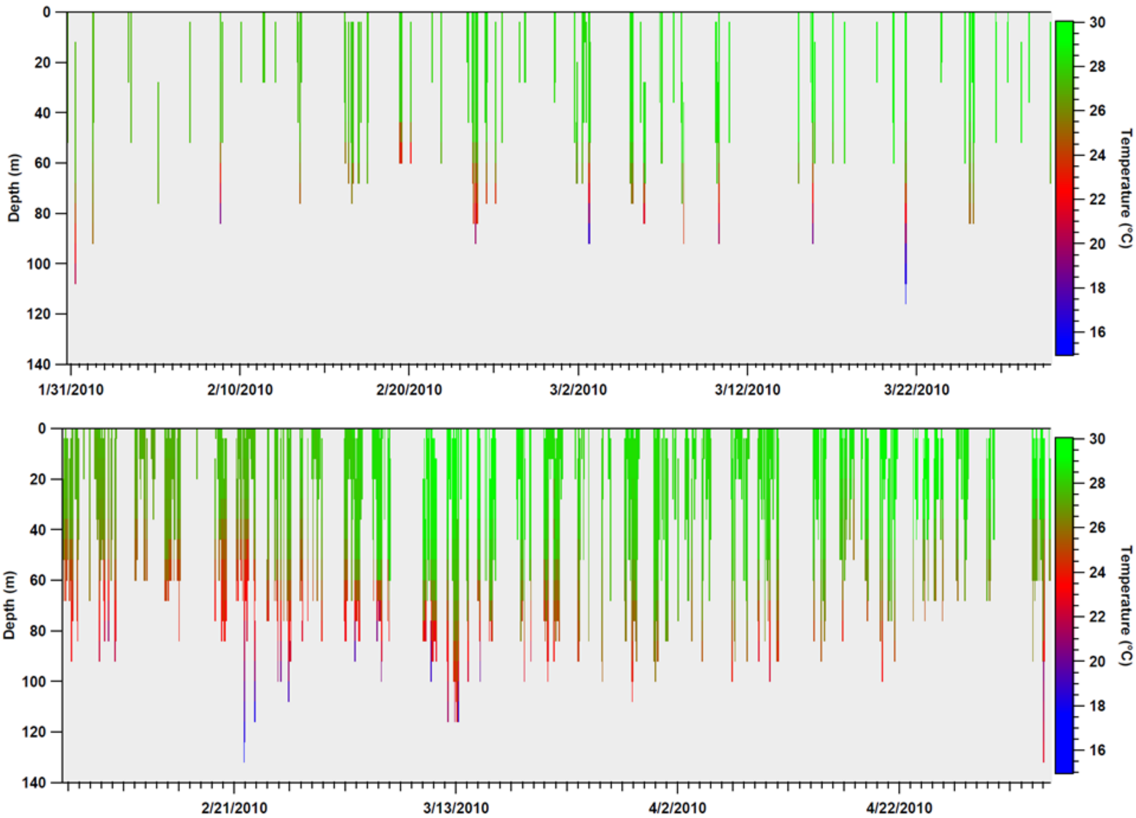

Figure 4. Minimum-maximum depths and water temperatures experienced by two oceanic whitetip sharks in the western equatorial Atlantic Ocean (shark A: top, shark B: bottom).

There was no evident difference in temperature preference between day and night, for both sharks, with the most frequent temperatures ranging from 26° to 30°C, in both periods of the day (Figure 5). The Pearson's chi-squared test did not indicate significant differences between daytime and nighttime temperature-frequency distributions ($p = 0.97$ and 0.76, for sharks A and B, respectively). For shark A, day and night frequencies were: (mean ± standard error) 57.3 ± 6.23 and 51.7 ± 6.12, for the

28-30°C, interval, and 39.7 ± 6.30 and 45.1 ± 6.16, for the 26-28°C interval. For shark B, day and night frequencies were 68.0 ± 2.35 and 59.0 ± 2.15, for the 28-30°C interval, and 29.2 ± 2.24 and 34.4 ± 1.95, for the 26-28°C interval.

Day and night depth preferences, however, seemed to differ, with both sharks staying at shallower depths during the day. This apparent difference was confirmed by the chi-squared test (p = 2.32E-04 and 6.23E-03; respectively). For shark A the most frequent depth intervals were 0-10 m during daytime (36.9% ± 3.56), followed by 30-50 m during night time (27.7% ± 2.51). The most frequent intervals for shark B were 0-10 m during both day and night time, but the frequency dropped from 46.4% ± 1.68, during the day, to 27.3% ± 1.46, during the night. Both sharks spent some time at the surface, especially in the daytime period (Figure 5). Shark A stayed at the surface up to 4.07% ± 1.13 of the time, while shark B stayed 15.67% ± 1.35.

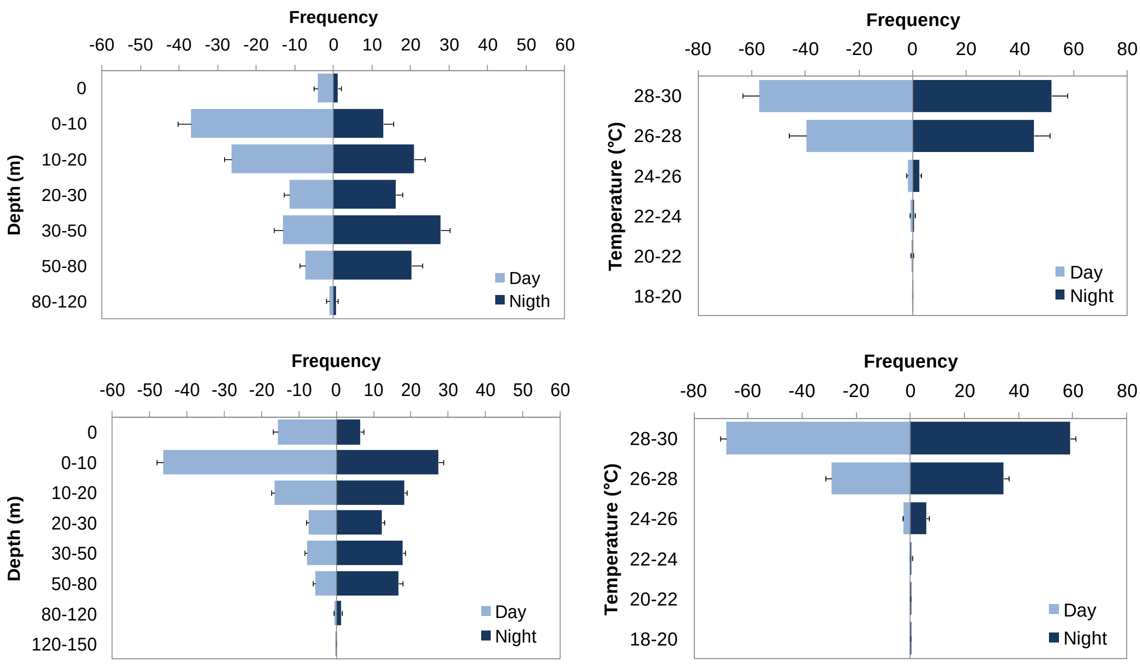

Figure 5. Depth and temperature distributions of two oceanic whitetip sharks tagged in the western equatorial Atlantic Ocean. Mean frequencies (± SE) were determined using all one hour histograms received from satellites (shark A: top, shark B: bottom).

The differences between day and night depth preferences might indicate diel movement pattern and the maximum depth data set also suggest the same diel movements (Figure 6). During daytime depth ranges were much shallower than during nighttime, especially for shark B, which had a wider depth distribution. Regarding the hours of the day, depth ranges were much shallower during light hours then within dark hours. The hours when sharks were closer to the surface were 09:00 and 10:00 am, followed by 11:00 am and noon. In general, day maximum depths ranged from the surface to 50 m and night maximum depths were from 50 m down.

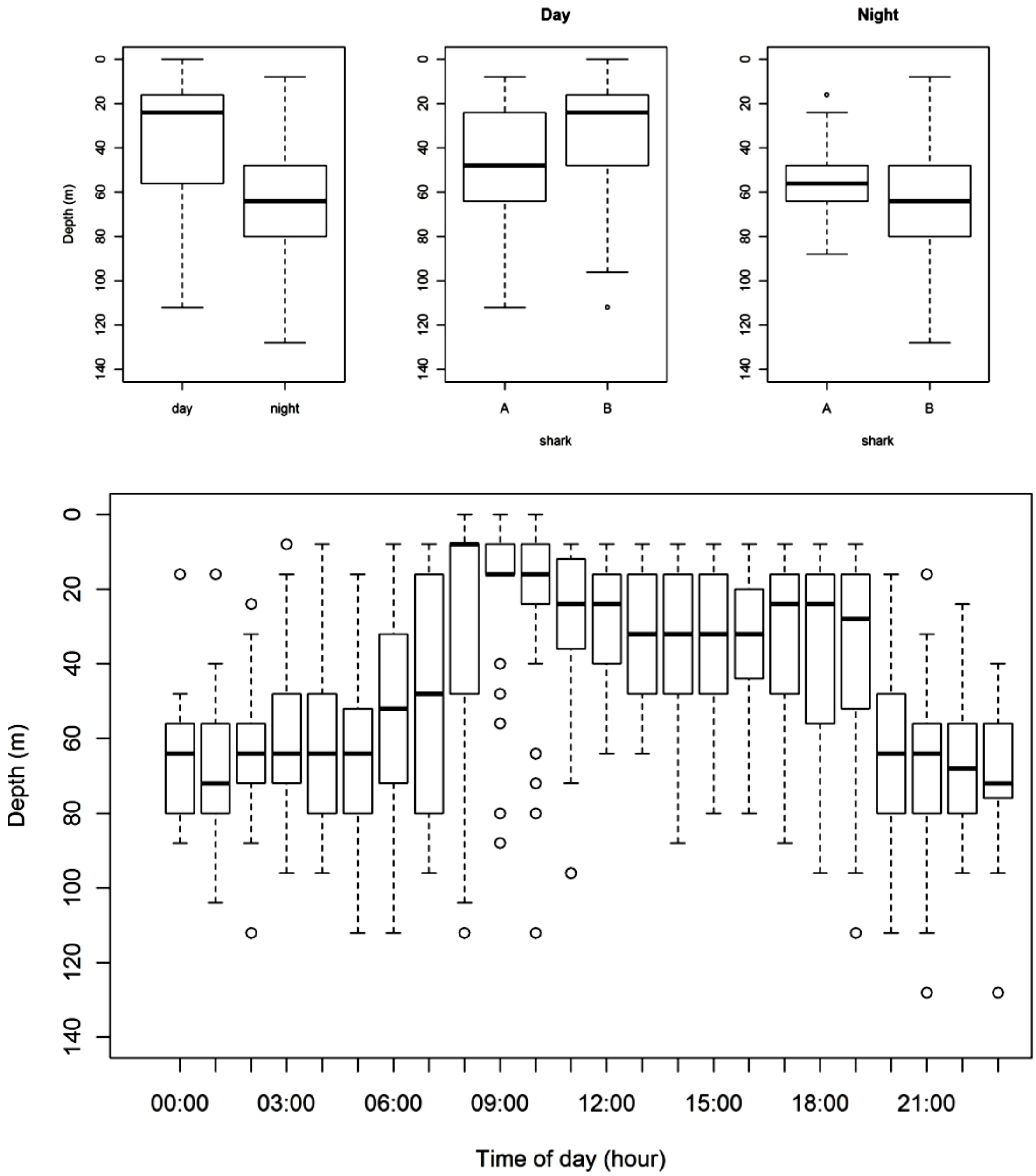

Figure 6. Box plots showing the distribution of maximum depths in relation to day and nighttime (top) and to each hour of the day (bottom) for two oceanic whitetip sharks tagged in the western equatorial Atlantic Ocean. Whiskers indicate the 95% confidence intervals, boxes represent the 25th and 75th quartiles, horizontal black lines indicate the median and open circles are the outliers.

According to the vertical temperature profiles, shark A experienced more stratified waters than shark B (Figure 7). The temperature profile of shark A exhibited a very steep thermocline with a gradient of 1.9°C.10m^{-1}, while in the profile from shark B the thermocline gradient was 0.9°C.10m^{-1}, indicating a less steep thermocline. The mixed layer temperature varied from (mean $\pm$ standard deviation) 28.4°C $\pm$ 0.56 to 27.9°C $\pm$ 0.70, in shark A profile, and from 28.4°C $\pm$ 0.56 to 27.8°C $\pm$ 0.83, in shark B.

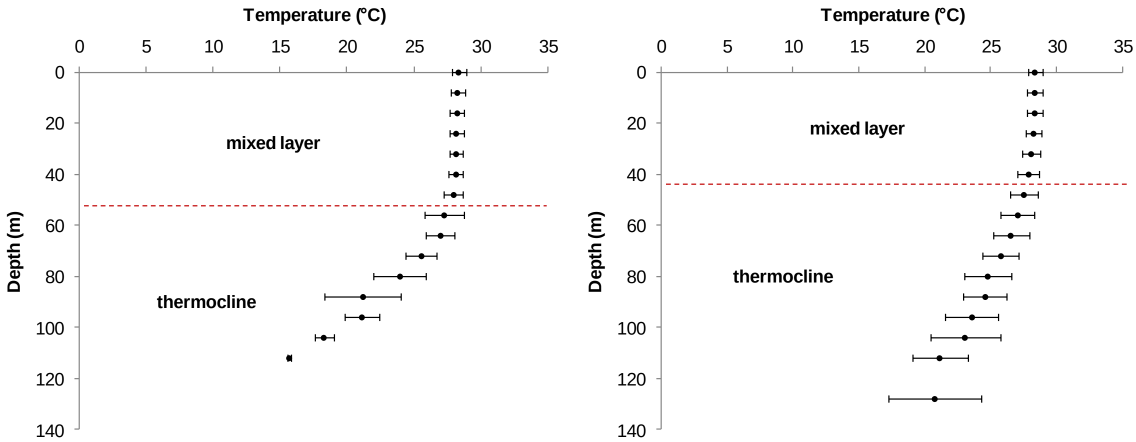

Figure 7. Vertical temperature profiles experienced by two oceanic whitetip sharks in the western equatorial Atlantic Ocean (shark A: left, shark B: right).

Discussion

The oceanic whitetip shark has been known as an epipelagic predator of warm tropical waters (Compagno, 1984), an assumption that is in accordance with the results found by the present study. Bernal et al. (2009) considered the oceanic whitetip as being part of a diverse group of pelagic fishes that spend the majority of their time in the upper uniform-temperature surface layer and rarely descend to water temperatures below 20°C. This description is consistent with the findings of the present study, as well. Both tagged sharks showed a remarkable preference for waters of the mixed layer, which went down to approximately 50 m and varied from 28.4° to 27.8°C. Both sharks did dive to waters below 20°C, however these instances accounted for less than 1% of the deployment period. The preferred temperatures were clearly above 26°C, since sharks spent at least 95% of their time in such temperatures.

Musyl et al. (2004), working with tagging experiments off Hawaii, found the oceanic whitetip sharks to spend 95% of their time between the surface and 102 m depth and in waters with temperature between 25.3° and 30.0°C, which is close to the pattern seen in the present case. Differently from the oceanic whitetip sharks tagged off Hawaii, however, those tagged in the western Atlantic Ocean spent more time inside the thermocline (up to 14% of the time). Yet, this could be due to the differences in the vertical temperature profiles of both areas, since the thermocline off Hawaii is much deeper, located as deep as 200 m, than in the western Atlantic (Rebert et al. 1985).

Oceanic whitetip shark remarkable preference for shallow waters is also reflected on the depths of the longline hooks where the species is most commonly caught. Nakano et al. (1997), for instance, concluded that the catch rates of the oceanic whitetip shark increased significantly with the decrease of hook depth. Data from the Brazilian longline fleet also showed that the CPUE of the oceanic whitetip shark tended to be lower for the vessels aiming at bigeye tuna (*Thunnus obesus*), which operate with deeper longline, than for the vessels aiming at swordfish (*Xiphias gladius*), which operate with a shallower gear (Tolotti et al., unpublished data).

Even though the depth range was not much wide, there were significant differences between day and night depths for both tagged sharks, which might indicate diel movements, although in a reverse way since in a normal diel movement pattern the species tend to stay near the surface at shallower waters during nighttime and at deeper waters during daytime (Sims et al., 2005). Different patterns in circadian depth distributions are very common within pelagic fishes, even when depth ranges are not wide (Brill et al., 1999; Huse & Korneliussen, 2000; Musyl et al., 2003; Sims et al., 2005; Pade et al., 2009). Musyl et al. (2004) also found differences in the circadian depth preferences of the oceanic whitetip shark, but, differently from what was seen in the present study, the species tended to spend more time at deeper waters during the day and at shallower waters during the night. These circadian differences are most likely related with the vertical migration of prey species within the deep scattering layer (Sims et al., 2005; Bernal et al., 2009; Pade et al., 2009), an aspect, however, that could not be investigated in the present study.

The fact that both whitetip sharks tagged showed an overall westward movement might be an indication that they were following the South Equatorial Current, which moves in this same direction (Stramma & Schott, 1999). Data from a cooperative tagging program conducted by the US Nactional Marine Fisheries Service between 1962 and 1993 also found indications of westward movements for the species along the equatorial Atlantic (Kholer et al., 1998). This same tagging program estimated a daily displacement of 17.50 nm and a maximum swimming speed of 0.73 knots, which are very close to the ones found in the present study. These swimming speeds, therefore, confirm that the oceanic whitetip shark is a slow-moving species when compared to other pelagic sharks, such as the silky shark (*Carcharhinus falciformis*) (Backus et al., 1956; Strasburg, 1958; Compagno, 1984).

The present results showed that the oceanic whitetip shark has a remarkable preference for warm and shallow waters and that, despite of its relatively narrow deph distribution, it does perform diel vertical migrations. Additionaly, horizontal movements indicate a westward migration, probably following the water flow of the South Equatorial Current in the western equatorial Atlantic. In order to better understand, however, the species general migratory pattern in this ocean, additional studies on its vertical and horizontal movements are still required.

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4. Considerações finais

Os resultados apresentados mostram que o tubarão galha-branca oceânico é freqüente nas capturas da frota atuneira nacional e suas taxas de captura estão fortemente associadas à configuração do espinhel, principalmente no que se refere à profundidade dos anzóis. Essa condição está relacionada à natureza altamente epipelágica da espécie, que permanece grande parte do tempo (>85%) nos primeiros 50 m de profundidade. Os resultados também mostraram que a pesca no Atlântico oeste Tropical incide fortemente sobre a parcela juvenil da população, com a grande maioria dos espécimes capturados estando abaixo do tamanho de primeira maturação sexual. De maneira conjunta, todas essas informações podem contribuir para a criação de ações de manejo que auxiliem na manutenção e conservação da espécie.

Na prática, algumas das informações geradas no presente trabalho já foram efetivamente utilizadas para sugerir um tamanho mínimo de captura como medida de manejo para a espécie junto a ICCAT, que culminou na Resolução 10-07 citada anteriormente. Em conjunto com informações geradas através de outros estudos, a exemplo da biologia reprodutiva, essa medida foi sugerida com base na alta proporção de jovens capturados e no fato do *C. longimanus* apresentar alta probabilidade de sobrevivência pós-captura, conforme demonstrado através do sucesso dos experimentos de marcação. Esse exemplo ressalta a importância dos resultados gerados, bem como evidencia a atenção que vem sendo dada a espécie em comissões internacionais em decorrência da sua vulnerabilidade à crescente pressão pesqueira.

A natureza das informações geradas em ambos os artigos apresentados também podem embasar outras medidas de manejo. Um exemplo seria a retirada dos anzóis mais superficiais do espinhel quando a espécie-alvo apresentar uma distribuição vertical mais profunda, como é o caso da albacora bandolim (*Thunnus obesus*). Beverly et al. (2009) sugerem que essa medida pode ser eficiente já que diminui as taxas de capturas de várias espécies de fauna acompanhante e aumenta o número de anzóis disponíveis para a espécie-alvo de distribuição mais ampla. Além disso, os autores também sugerem que a utilização de anzóis mais profundos no espinhel reduziria as interações entre a pesca esportiva, recreativa e comercial.

De qualquer forma, é necessário salientar, que mesmo gerando informações importantes e que podem ser efetivamente utilizadas na criação de medidas de manejo, o presente trabalho representa apenas uma pequena parcela no conhecimento da espécie. Principalmente para o Atlântico Sul, poucas informações estão disponíveis, sendo de suma importância que o tubarão galha-branca oceânico continue sendo objeto de pesquisas envolvendo aspectos biológicos, ecológicos e pesqueiros. Sendo assim, pretende-se dar continuidade ao monitoramento pesqueiro da espécie e realizar mais experimentos de marcação eletrônica, focando em períodos de marcação mais longos.

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