FIRST OBSERVATIONS OF MIGRATORY MOVEMENTS AND HABITAT PREFERENCE OF ATLANTIC SAILFISH, *ISTIOPHORUS PLATYPTERUS*, IN THE SOUTHWESTERN ATLANTIC OCEAN

Bruno L. Mourato[1,2], Felipe C. Carvalho[3], Fábio H.V. Hazin[2], José C. Pacheco[2,] Humberto G. Hazin[2,] Paulo Travassos[2], and Alberto F. Amorim[4]

SUMMARY

Pop-up Satellite Archival Tags (PSAT) were deployed in two sailfish released off the Brazilian southeast coast, in front of Rio de Janeiro. Both fish were hooked in the mouth and were in good condition when released. They spent the vast majority of their time within the upper ten meters of the water column. The fish with tag 75715 spent more than 71%, during day time, and more than 65%, during night time, between 0 and 5m. The vertical distribution of the tagged sailfish 78007 was a little deeper, with more than 70% and 69% of the time being distributed at depths between 5 and 10m, during day and night periods, respectively. Both fish spent most of the time within a temperature range between 26º and 28ºC. The tagged fish 75715 dived to a maximum depth of 88m, while the tagged fish 78007 dived much deeper, reaching 376m. The geo-location estimates show that both tagged fish did not move significantly away from the tagging site. The first sailfish (tag 75715) moved approximately 1,437.5 km away from the Brazilian coast, towards the southeastern, while the second (tag 78007) traveled over 3,564.2 km, towards the southwestern, but also farther from shore.

RÉSUMÉ

Des marques-archives pop-up reliées par satellite (PSAT) ont été apposées sur deux voiliers remis à l'eau au large de la côte du Sud-Est du Brésil, face à Rio de Janeiro. Les deux poissons ont été hameçonnés dans la bouche et se trouvaient en bonne condition lorsqu'ils ont été remis à l'eau. Ils ont passé la plus grande partie de leur temps dans les 10 mètres supérieurs de la colonne d'eau. Le poisson porteur de la marque 75715 a passé plus de 71% de la journée, et plus de 65% de la nuit, entre 0 et 5 mètres. La distribution verticale du voilier porteur de la marque 78007 était un peu plus profonde, plus de 70% et de 69% du temps se répartissant à des profondeurs d'entre 5 et 10 m, pendant les périodes diurnes et nocturnes, respectivement. Les deux poissons ont passé la plupart du temps dans une gamme de températures entre 26º et 28ºC. Le poisson porteur de la marque 75715 a plongé à une profondeur maximum de 88 m, tandis que le poisson porteur de la marque 78007 a plongé à une profondeur bien plus grande, atteignant 376 m. Les estimations de l'emplacement géographique indiquent que les deux poissons marqués ne se sont pas considérablement éloignés du lieu de marquage. Le premier voilier (marque 75715) s'est éloigné d'environ 1.437,5 km de la côte brésilienne, vers le Sud-Est, tandis que le deuxième (marque 78007) a parcouru plus de 3.564,2 km, vers le Sud-Ouest, mais s'éloignant également davantage du rivage.

RESUMEN

Se colocaron marcas archivo pop-up por satélite (PSAT) en dos peces vela liberados en aguas de la costa sudoriental brasileña, frente a Río de Janeiro. Ambos peces fueron anzuelados por la boca y estaban en buen estado cuando fueron liberados. Pasaron la gran mayoría del tiempo en los diez metros superiores de la columna de agua. El pez con la marca 75715 pasó más del 71% durante el día y más del 65% durante la noche, entre 0 y 5 m. La distribución vertical del pez con la marca 78007 fue un poco más profunda, con más del 70% y el 69% del tiempo distribuido en profundidades entre 5 y 10 m, durante el día y la noche respectivamente. Ambos peces pasaron la mayoría del tiempo dentro de un rango de temperaturas entre 26º y 28º C. El pez con la marca 75715 se sumergió hasta una profundidad máxima de 88 m, mientras que el

[1] PhD. Student – Universidade Federal de Pernambuco/Departamento de Oceanografia, Recife-PE, Brasil (bruno.pesca@gmail.com).
[2] Universidade Federal Rural de Pernambuco/Departamento de Pesca e Aqüicultura, Recife- PE, Brasil
[3] University of Florida, Program of Fisheries and Aquatic Sciences
[4] Instituto de Pesca/APTA/SAA, Santos-SP, Brasil.

pez con la marca 78007 se sumergió más profundamente, alcanzando los 376 m. Las estimaciones de geo-localización mostraron que ambos peces marcados no se alejaron significativamente del lugar de marcado. El primer pez vela (marca 75715) se alejó aproximadamente 1.437,5 km de la costa brasileña, hacia el sudeste, mientras que el segundo (marca 78007) viajó aproximadamente 3.564,2 km hacia el sudoeste, pero también más lejos de la costa.

KEYWORDS

Tagging, migrations, ethology, Atlantic sailfich

1. Introduction

In the Atlantic Ocean, sailfish is widely distributed in subtropical and tropical waters, being also occasionally present in temperate latitudes (Beardsley *et al.* 1974; Nakamura, 1985). The pelagic longline fisheries targeting tunas and swordfish catch a variety of by-catch species, including sailfish, which is also targeted by recreational fisheries throughout the tropical and subtropical waters of this ocean. By far, however, the greatest source of sailfish fishing mortality comes from the pelagic longline fishery. The current status of Atlantic sailfish stocks is not well known, mainly due to an acute lack of data, which is an issue of considerable international concern (Anon, 2009).

In spite of the great importance of the sailfish, for both recreational and commercial fisheries, there is no information about sailfish habitat preferences in the southwestern Atlantic Ocean. This kind of information (*e.g.* amount of time a fish spends at a given depth) is, nevertheless, very important in order to properly assess the catchability of a given species by the pelagic longline fishing gear. For this reason, the influence of depth preferences by different species on the selectivity and catch composition of the longline sets has been receiving increasing attention, in fisheries research. For the southwestern Atlantic, most of the work done on sailfish, including analysis of its distribution and relative abundance, are only based in commercial and recreational catch and fishing effort data. This paper presents the first observations of vertical and horizontal habitat utilization of sailfish in this region of the Atlantic Ocean, based on data collected by popup satellite archival tags (PSATs).

2. Material and methods

Pop up Satellite Archival Tags (MK10 PSAT model), manufactured by Wildlife Computers (Washington, USA), were deployed in two sailfish released off the Brazilian southeast coast, in front of Rio de Janeiro State. The pop up tags were programmed to release within 60 days after attachment, record data at each second and transmit data condensed in histograms (*i.e.* percentage of time at each depth and temperature at each pre-established bins) at each interval of three hours. The PSAT tags were attached with a tether made of nylon monofilament with ≈ 16-20 cm of length. To alleviate torque forces, a swivel was placed halfway along the tether. The tagheads used were also constituted of nylon.

Conventional rod and reel techniques, using trolled dead baits, were employed for catching the specimens. Circle hooks were also used in order to increase the survival of tagged fish. Once fish were hooked and brought to leader and reeled close to the boat, the pop-up satellite tag was deployed. The tagging target area was a little below the base of the dorsal fin, between the interneural and neural spines (Musyl and Naughton, 2007). In addition, a conventional plastic tag was also affixed to the fish **(Figure 1).** The PSAT tags were anchored by a harpoon equipped with a stainless steel tag applicator modified to be driven 5-7 cm into the dorsal musculature. Prior to release, individual weights were visually estimated.

Pop-up satellite tags are routinely used to estimate the location of fishes using light level data collected from an external light sensor on the tags. However, previous studies have assessed the accuracy of light level geo-location estimates and have shown that light level longitude estimates are much more accurate and robust than light level latitude estimates (Musyl *et al*. 2001). Due to the challenges of estimating latitudes from light level data, several studies have used sea surface temperature (SST) in conjunction with light levels to improve latitude estimates (Teo *et al*. 2004). In the present study we used the SST latitude estimation algorithm proposed by Teo *et al*. (2004) to assess the accuracy of the geo-location estimates of the sailfish tagged off Rio de Janeiro-RJ.

3. Results and discussion

Two sailfish were caught using conventional rod and reel techniques and tagged with PSATs (**Table 1)**. The fish with tag 75715 was estimated to weight ≈ 20 kg and ≈ 135 cm (eye-Fork length - EFL). The sailfish with tag 78007 was estimated to weight ≈ 25-30 kg and 150-165 cm EFL (**Figure 1**). Both fish were hooked in the mouth and were in good condition when released.

Both tagged sailfish lost their PSAT prematurely and began transmitting data before the expected dates (60 days after deployment). The tags 75715 and 78007 remained attached to the fish 16 and 51 days respectively (**Table 1**). One of the possible reasons for the premature release is the kind of tagheads used. The regular nylon tagheads, used in the present work, present a low retention rate (Musyl and Naughton, 2007). The same authors also mentioned that to maximize retention times of tags on the fish, the surface area of the tagheads should be increased and placed between adjacent interneural and neural spines, near to the base of the dorsal fin. The two sailfish were tagged probably a little lower of the proper target area which may also have contributed to a premature release of the PSATs (**see Figure 1**).

Both fish spent the vast majority of their time within the upper ten meters of the water column. The fish with tag 75715 spent more than 71%, during day time, and more than 65%, during night time, between 0 and 5m (**Figure 2**). The vertical distribution of the tagged sailfish 78007 was a little deeper, with more than 70% and 69% of the time being distributed at depths between 5 and 10m, during day and night periods, respectively (**Figure 3**). Both fish spent most of the time within a temperature range between 26º and 28ºC. The fish 75715 remained between 27ºand 28ºC for 45% of day time and 49% of night time (**Figure 2**). The tagged sailfish 78007 remained between 26º and 28ºC, for 55% and 56% of day arrnd night times, respectively (**Figure 3**).The vertical habitat use observed in the present analysis is consistent with reports of previous acoustic tracking of sailfish in the Arabian Gulf (Hoolihan, 2004), as well as of several PSAT tags (Prince and Goodyear, 2006; Hoolihan and Luo, 2007).

The depth distribution for both fish indicates a period of adaptation after tagging, corresponding to three days after tagging, for 75715, and two days, for 78007. These days were, therefore, excluded from the analysis, since the observed patterns do not represent the normal behavior of the species. Although the majority of the time spent by both sailfish was concentrated near the surface, they did make occasional deep dives. The tagged fish 75715 dived to a maximum depth of 88m (**Figure 4**), while the tagged fish 78007 dived much deeper, reaching 376m (**Figure 5**). These dives may be related to the opportunistic feeding behavior of sailfish. Although the PSAT technology does not allow the study of feeding events, two particularities of the sailfish biology seem to support this hypothesis. The first one, of physiological and anatomical nature, is related to the fact that sailfish, like other Istiophorids, have a specialized eye/ brain heater organ, allowing these deeper dives (Block, 1986). The second is related to stomach content analyses done in the same region, which show the presence of some mesopelagic species in their diet (Rosas-Alayola *et al*., 2002; Vaske-Júnior, 2005). The sailfish, therefore, appears to be well adapted for feeding in cooler waters, well below the surface, which would then support the hypothesis that the short-term vertical incursions done by the sailfish in the present study may have had a feeding purpose. The time at minimum and maximum depth by hour (at each 3h interval, **Figures 4** and **5**) suggests that the movement between the surface and deeper layers was relatively rapid **(Figures 4** and **5)**.

The geo-location estimates suggest that both tagged fish did not move significantly away from the tagging site. The first sailfish (tag 75715) moved approximately 1137.5 km away from the Brazilian coast, towards southeast (**Figure 6**), while the second (tag 78007) traveled over 3564.2 km, towards the southwest (**Figure7**), but also farther from shore. The sailfish seems to start its reproductive migration from Brazilian northeast coast to southeast, around mid September, arriving in November/ January, off southeast, to spawn, mainly during January/ February, remaining in the spawning ground until early march (Arfelli and Amorim, 1981; Mourato *et al*., 2009). After spawning off southeast Brazil, the sailfish probably moves eastward, following the south Atlantic Gyre, which could drive them as far as the eastern side of the South Atlantic, close to the African coast. Despite of the fact that the two tagged sailfish did not show this migration pattern, the rather short monitored time (16 and 51 days, for 75715 and 78007, respectively) may have prevented that. Additional information on vertical and horizontal habitat utilization by sailfish, obtained by PSATs and/ or acoustic tags are needed in order to better understand the migratory movements of the species in the South Atlantic Ocean, particularly after spawning, off the southeastern coast of Brazil.

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Table 1. Summary of two pop-up satellite tags deployed on sailfish in the southwestern Atlantic.

PSAT ID	*Estimated weight (kg)*	*Tagging date*	*Position tagging*	*Pop-up date*	*Pop-up position*
75715	25-30	1-Feb-09	23º28'S/42º26'W	16-Feb-09	25º31'S/41º39'W
78007	20	26-Jan-09	23º19'S/42º18'W	16-Mar-09	24º23'S/42º08'W

Figure 1. Sailfish with a PSAT attached (78007) in front of Rio de Janeiro, southeast Brazilian coast.

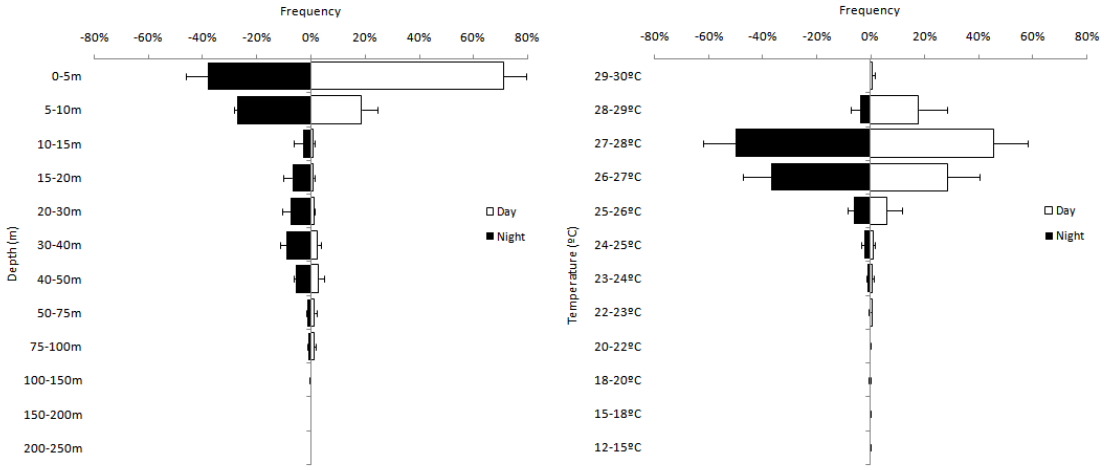

Figure 2. Proportion of time at depth (left) and proportion of time at temperature (right) during day and night periods from tag number 75715. Horizontal error bars for proportion of time at depth and temperature represents the confidence interval of estimates (95% of confidence).

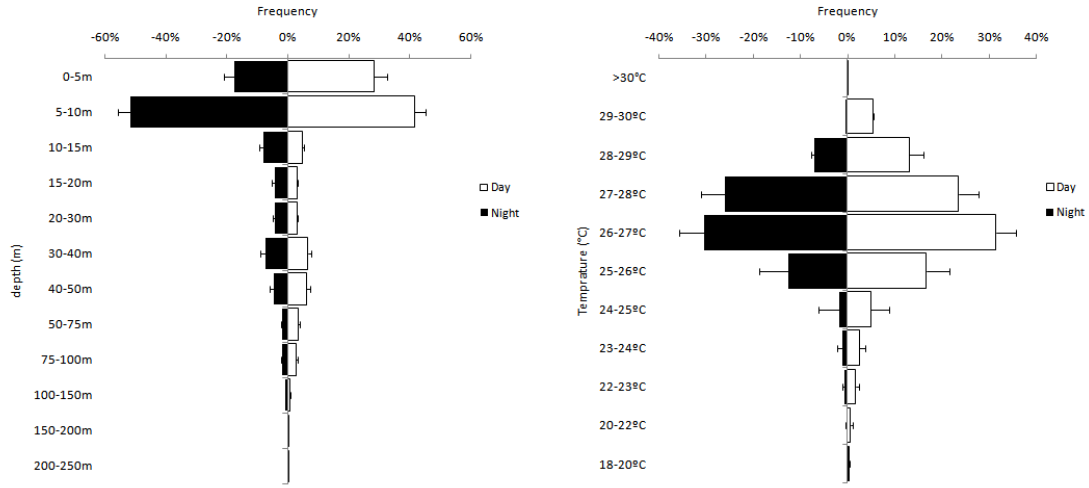

Figure 3. Proportion of time at depth (left) and proportion of time at temperature (right) during day and night periods from tag number 78007. Horizontal error bars for proportion of time at depth and temperature represents the confidence interval of estimates (95% of confidence).

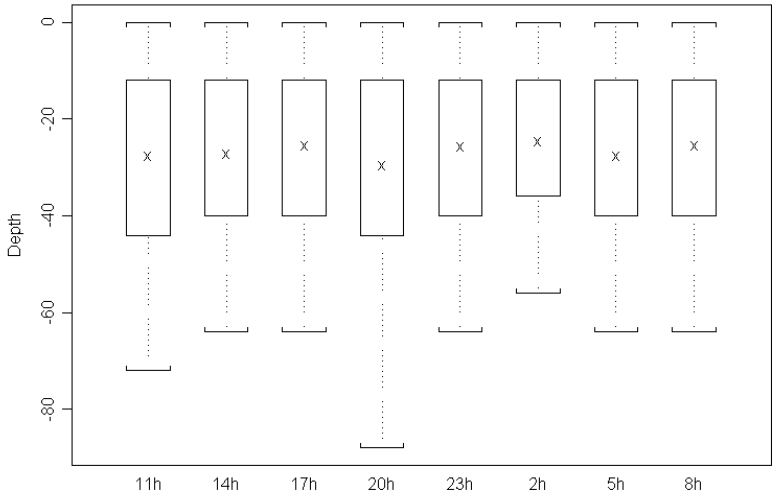

Figure 4. Box-plot of depth (m) by hour interval (3h) showing the mean, maximum and minimum depths of sailfish in southwestern Atlantic (tag number 75715)

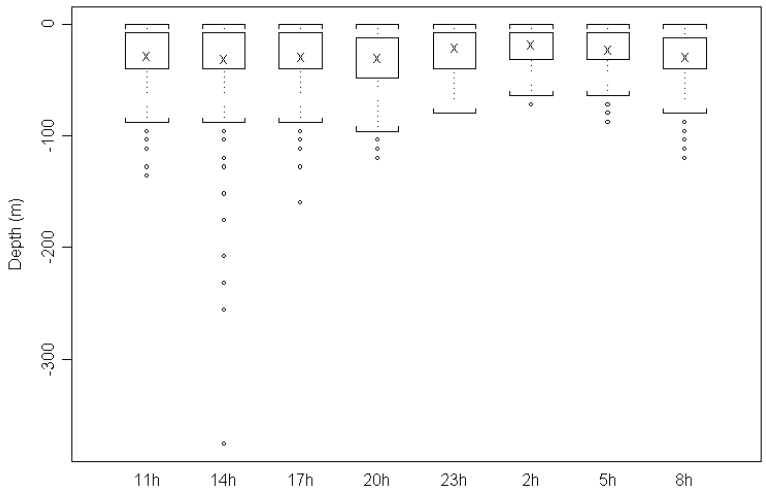

Figure 5. Box-plot of depth (m) by hour interval (3h) showing the mean, maximum and minimum depths of sailfish in southwestern Atlantic (tag number 78007).

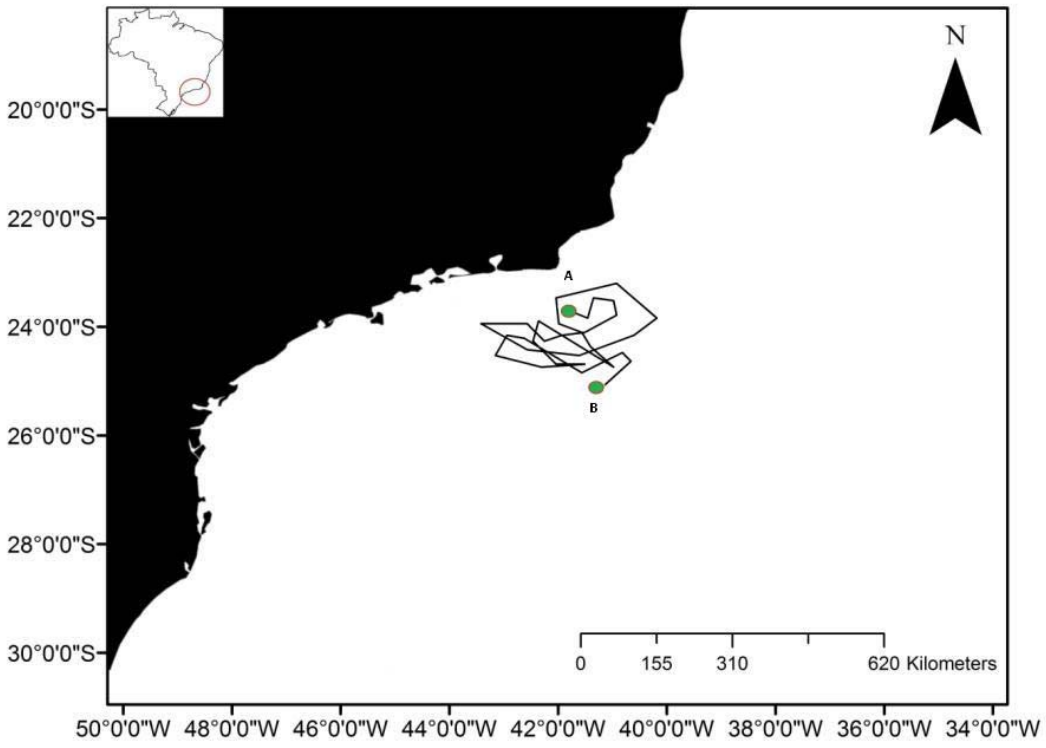

Figure 6. Geo-location track for sailfish in southwestern Atlantic (tag number 75715).

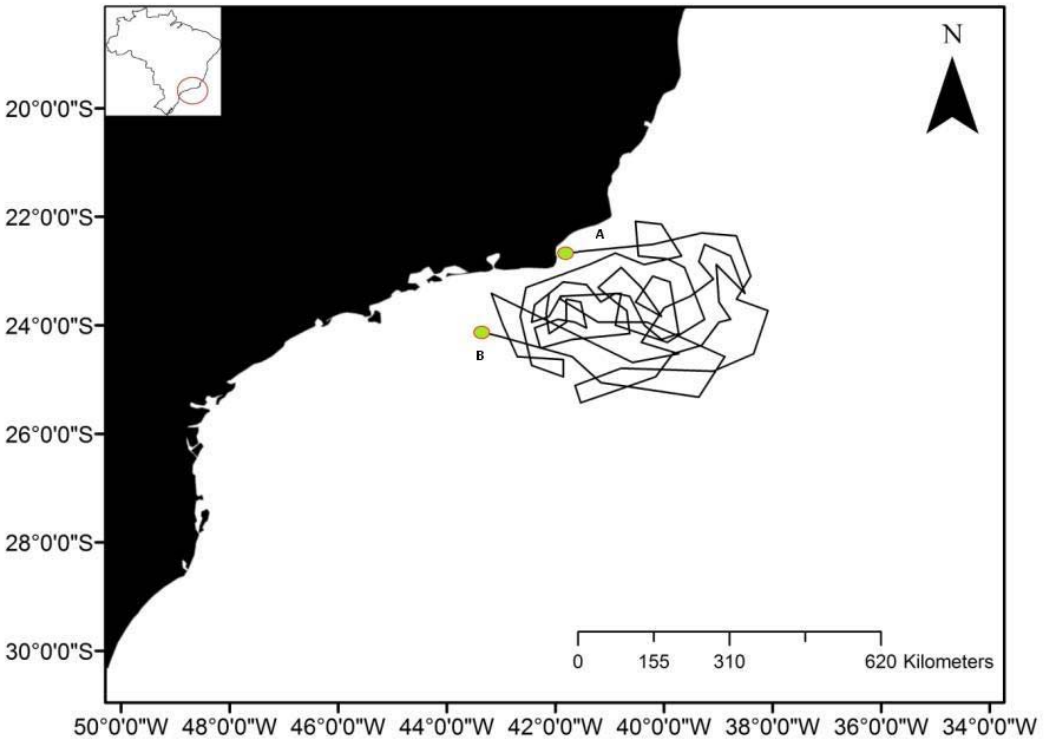

Figure 7. Geo-location track for sailfish in southwestern Atlantic (tag number 78007).