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# FEEDING STRATEGY OF THE NIGHT SHARK (*CARCHARHINUS SIGNATUS*) AND SCALLOPED HAMMERHEAD SHARK (*SPHYRNA LEWINI*) NEAR SEAMOUNTS OFF NORTHEASTERN BRAZIL

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## ABSTRACT

A total of 425 stomachs of night shark (*Carcharhinus signatus*), and 98 stomachs of scalloped hammerhead shark (*Sphyrna lewini*), from longline and surface gillneters near seamounts off northeastern Brazil, were analysed between 1992 and 1999. Both predators prey upon reef and benthopelagic fishes, migrant cephalopods and deep water crustaceans, showing similar feeding niches (Schoener Index T=0.75). The great prey richness of the diets may reflect the fact that the marine food web for these species is very extensive in this region. Due to the concentration for feeding of both predators in the seamounts, intense fisheries should be monitored to avoid localised depletions.

## RESUMO

Um total de 425 estômagos de tubarão-toninha (*Carcharhinus signatus*) e 98 estômagos de tubarão-martelo-entalhado (*Sphyrna lewini*), oriundos da pesca de espinhel e pesca com rede de emalhe nas adjacências dos bancos oceânicos do nordeste do Brasil, foi analisado entre 1992 e 1999. Ambas as espécies predam sobre peixes bento-pelágicos e recifais, cefalópodes migradores, e crustáceos de águas profundas, apresentando nichos alimentares similares (Índice de Schoener T=0.75). A alta riqueza de presas nas dietas deve ser um reflexo de que as teias alimentares para estas espécies são consideravelmente longas nessa região. Devido à concentração alimentar de ambos predadores nos bancos oceânicos, a pescaria intensa deve ser monitorada para evitar depleções locais.

Descriptors: Feeding aggregations, Seamounts, *Carcharhinus signatus*, *Sphyrna lewini*.
Descritores: Agregações alimentares, Montes submarinos, *Carcharhinus signatus*, *Sphyrna lewini*.

## INTRODUCTION

The night shark *Carcharhinus signatus* and the scalloped hammerhead shark *Sphyrna lewini* are the main elasmobranch species captured in the adjacencies of the seamounts off northeastern Brazil.

*C. signatus* is a common semi-oceanic carcharhinid found along the outer continental and insular shelves of the tropical and warm temperate Atlantic (COMPAGNO, 1984), being the commonest *Carcharhinus* in the Brazilian shelf breaks (GADIG; MOREIRA JUNIOR, 1992; SOTO, 2001). According to HAZIN et al. (1990), the main captures of *C. signatus* are made westward of 35ºW in the area, while the blue shark (*Prionace glauca*) is the most abundant species east of it. The occurrences of *C. signatus* are closely related to shallow seamounts, where a high CPUE (Catch per Unit of Effort) is obtained (HAZIN et al., 1990; MENNI et al., 1995), being the most important elasmobranch species in the seamount area being found in up to 90% of catches (SANTANA et al., 2006). In Brazilian waters, the preferencial distribution of *C. signatus* ranges between 20 and 500 m depths (SOTO, 2001). In the last decade, *C. signatus* changed from being a by-catch of semi-oceanic longliners to being a direct target species, due to increases in the value of their meat and fins, in areas of relatively large abundance around seamounts (HAZIN et al., 2000). Only recent studies have been carried out on *C. signatus* in northeastern Brazil, the first report on this species in the region having been undertaken by Menni et al. (1995), followed by studies on its reproductive biology (HAZIN et al., 2000), age determination and growth (SANTANA; LESSA, 2004), and on total mercury contamination (FERREIRA et al., 2004). The species´ feeding habits are still unknown.

Similarly, *S. lewini* is a semi-oceanic species distributed throughout tropical and temperate oceans (COMPAGNO, 1984). As from 1996 several vessels of the northeastern oceanic fleet have employed surface monofilament gillnets and, as a result, the proportion of *S. lewini* in the total oceanic captures has increased from 0.05 % to 13 % of the total catch (HAZIN et al., 2001). In Brazilian waters, *S. lewini* is found along the coast, including the Fernando de Noronha Archipelago, with distribution ranging between 10 and 40 m depth, extending out to the shelf break (SOTO, 2001). Aspects of reproductive biology have been studied in this region by HAZIN et al. (2001). The species is also found in the Saint Peter and Saint Paul Archipelago, where there is a local longline fishery targeting *S. lewini*, *C. falciformis* and tunas (OLIVEIRA et al., 1997; VASKE JUNIOR et al., 2005). The feeding habits of *S. lewini* are normally reported for young specimens (CLARKE, 1971; BUSH; HOLLAND, 2002; BUSH, 2003; BRUYN et al., 2005; TORRES-ROJAS et al., 2006) due to the ease of obtaining large samples in the beach and coastal fisheries, where individuals between 50 and 130 cm are captured. However, there is little information concerning the larger individuals that are captured around seamounts.

The aim of the present study is to provide supplementary information on the feeding habits and similarities of the diets of *C. signatus* and *S. lewini* in the adjacencies of seamounts off northeastern Brazil, and as a complementary study to ascertain their population dynamics, thus initiated for both these species in this region of the Atlantic.

## MATERIAL AND METHODS

The study area is located between 35°W and 40°W, and 0° and 05°S (Fig. 1). Sampling was carried out between 1992 and 1999, where sharks were collected from fishing vessels that operate longline and drifting gillnets. The longline used consisted of a multifilament mainline with secondary lines attached in cluster of six or seven hooked lines. Fishing operations began about 02:00 hours and ended at dawn. The baits used were Brazilian sardine (*Sardinella brasiliensis*) and occasionally flying fish (*Cypselurus cyanopterus*). Drifting gillnets have a stretched mesh of 17 to 30 cm, are 12 m in depth, and 1 to 7 km in length. The fishing activity was conducted in the vicinity of the shallow seamounts (between 45 and 230 m depths) off the States of Ceará and Rio Grande do Norte, more precisely on the banks of Aracati, Guará and Sírius**.**

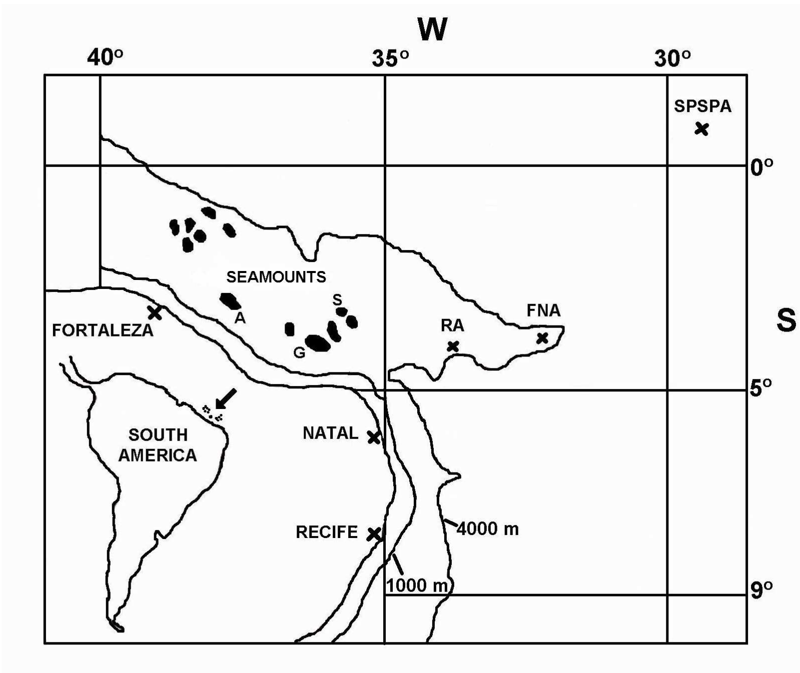



Fig. 1. Main seamounts off northeastern Brazil. A – Aracati; G – Guará; S – Sirius; RA – Rocas Atoll; FNA – Fernando de Noronha Archipelago; SPSPA – Saint Peter and Saint Paul Archipelago. Isobaths of 1000 and 4000 m are shown.

The sharks were landed in Natal, measured in cm TL, dissected, and their stomachs removed and stored, frozen, for later identification of the prey items in the laboratory. Prey organisms in the stomach contents were identified to the lowest possible taxon. A prey taxon was called a "food item", and a unit of prey organism a "prey". The number of prey of each food item, the mantle length for cephalopods (cm ML), total length for other organisms (cm TL), and wet weight (W,g) of each prey in each stomach were recorded. A richness prey curve was computed to infer whether the stomachs sampled were sufficient to obtain the food spectrum of both predators.

The importance of each food item in the diet was obtained by the Index of Relative Importance (IRI) (PINKAS et al., 1971; CORTÉS, 1997), modified to weight in the pooled samples of the species, as follows: $IRI_i = \%FO_i \times (\%N_i \times \%W_i)$, where $\%FO_i$ is the relative frequency of occurrence of each food item; $\%N_i$ is the proportion in prey number of each item in the total food; and $\%W_i$ is the proportion by weight of each item in the total food.

The niche overlap between predators was determined by the Schoener Index (T), (SCHOENER , 1970): $T = 1 - 0.5 \sum |Px_i - Py_i|$, where, $Px_i$ is the proportion in frequence of occurrence of the food item “i” in the diet of the predator “x”, and $Py_i$ is the proportion in frequence of occurrence of the food item “i” in the diet of the predator “y”. Significant biological similarity was considered to exist when $T \geq 0.6$ (SCRIMGEOUR; WINTERBOURN, 1987).

## Results

The total length of 425 specimens of *C. signatus* and 98 specimens of *S. lewini*, of both sexes, is shown in Figure 2. If the size at sexual maturity for females of *C. signatus* is estimated at between 200 and 205 cm TL, while that for males is between 185 and 190 cm TL (HAZIN et al., 2000), then the majority of specimens were considered sexually immature. Sexual maturity of *S. lewini* ranges between 180 and 200 cm TL for males, and between 180 and 240 cm TL for females (HAZIN et al., 2000), hence, as with *C. signatus*, the majority of specimens of *S. lewini* had not reached sexual maturity.

The richness of food items for *C. signatus* did not attain stability even though 215 stomachs were analyzed (Fig. 3). There was no tendency to stabilization for *S. lewini* either, but in this case this may have been due to the small number of stomachs analyzed.

Teleosts and cephalopods were the main prey items for both predators observed in the IRI ranking, nevertheless, when more specific groups are taken into account, some differences and similarities are to be observed. A total of 215 stomachs of *C. signatus* contained some food, 29 taxa of which were identified, including 10 species of fish, 14 cephalopods, 3 crustaceans, 1 tunicate, and 1 sea bird. Among the fish noteworthy predation occurred upon small pelagic species such as *Diaphus* sp., *Acanthurus* sp., *Howella* sp., and *Brama caribbea* (Table 1). Also important were large pelagic fish such as *Katsuwonus pelamis*, *Thunnus albacares* and *Xiphias gladius*. The cephalopods *Histioteuthis* sp., *Ommastrephes bartramii*, *Octopoteuthis* sp., *Vampyroteuthis infernalis* and Cranchiidae were the main representatives in the diet by IRI ranking. The deep water shrimp *Heterocarpus ensifer* was the main crustacean item. The presence of salps and the seabird *Puffinus gravis* was observed on two ocasions.

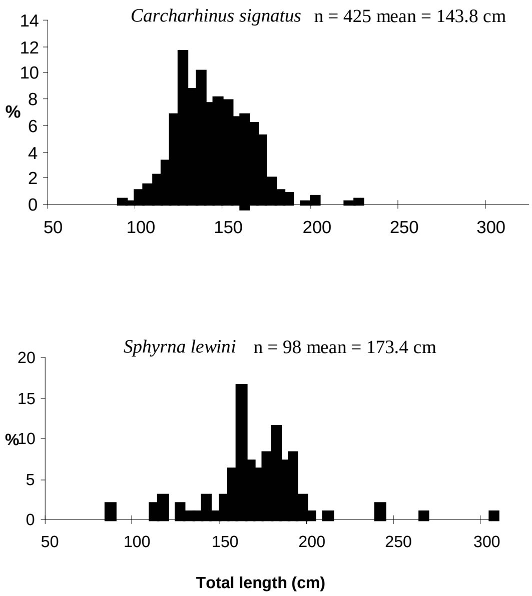
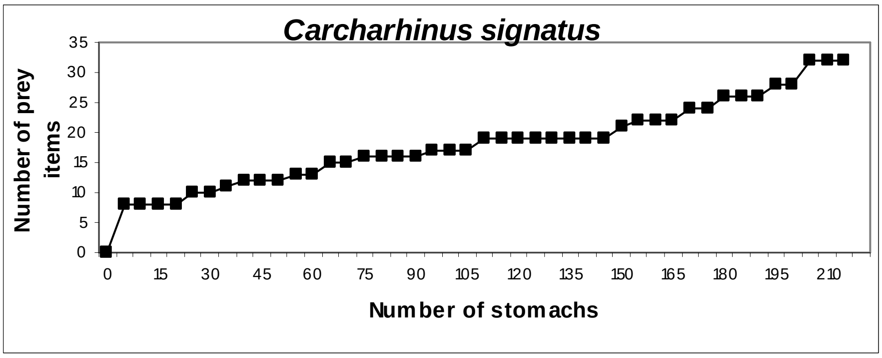



Fig. 2. Length distributions for *Carcharhinus signatus* and *Sphyrna lewini* from seamounts off northeastern Brazil.

In the stomachs of 50 of the 98 *S. lewini*, there was some food. 27 taxa were observed: 10 species of fish, 15 cephalopods and 2 crustaceans (Table 1). The main fish prey items were reef dwelling species, such as *Lutjanus buccanella*, *Sparisoma viride*, Monacanthidae, Muraenidae, but also pelagic predators such as *Sphyraena barracuda*, *Caranx* sp., *Ruvettus pretiosus*, and *Thunnus obesus*. The squid *Histioteuthis* sp. was the main prey item, followed by O*mmastrephes bartramii* and Cranchiidae. The similarity of the diets of *C. signatus* and *S. lewini*, measured by the Schoener Index (T), showed that both species share the same prey spectrum, with a significant degree of similarity (T = 0.75).



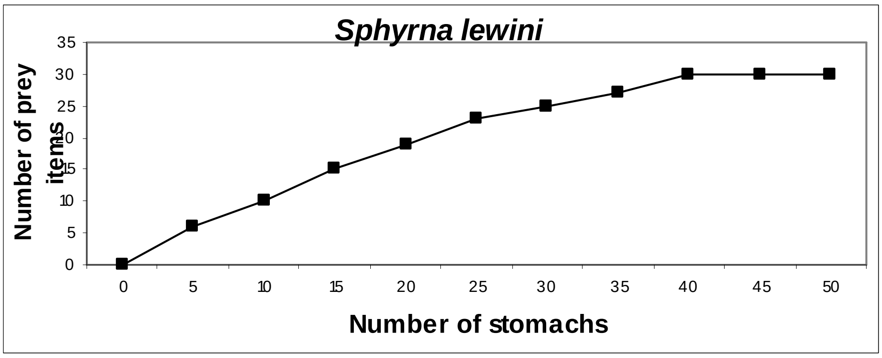




Fig. 3. Richness prey curve for *Carcharhinus signatus* and *Sphyrna lewini* from seamounts off northeastern Brazil.

Table 1. Number, weight and frequence of occurrence of food items, and IRI ranking (first to tenth) for *Sphyrna lewini* and *Carcharhinus signatus* of oceanic banks off northeastern Brazil.

| | *Sphyrna lewini* | | | | | | | *Carcharhinus signatus* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Stomachs containing food: 50** | | | | | | | **Stomachs containing food: 215** | | | | | | |
| | **Empty stomachs: 48** | | | | | | | **Empty stomachs: 210** | | | | | | |
| **Prey items** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** |
| *Acanthurus* sp. | | | | | | | | 3 | 0.89 | 2 | 0.02 | 1 | 0.47 | |
| *Brama caribbea* | | | | | | | | 9 | 2.68 | 498 | 4.13 | 7 | 3.26 | **10** |
| *Diaphus* sp. | | | | | | | | 1 | 0.30 | 9 | 0.07 | 1 | 0.47 | |
| *Caranx* sp. | 2 | 0.28 | 800 | 3.26 | 2 | 4 | | | | | | | | |
| *Howella* sp. | | | | | | | | 4 | 1.19 | 27 | 0.22 | 1 | 0.47 | |
| *Katsuwonus pelamis* | | | | | | | | 4 | 1.19 | 1726 | 14.31 | 3 | 1.40 | |
| *Lutjanus bucanella* | 1 | 0.14 | 6620 | 26.97 | 1 | 2 | **6** | | | | | | | |
| Monacanthidae | 1 | 0.14 | 390 | 1.59 | 1 | 2 | | | | | | | | |
| Muraenidae | 1 | 0.14 | 4664 | 19.00 | 1 | 2 | **7** | | | | | | | |
| *Ruvettus pretiosus* | 2 | 0.28 | 3481 | 14.18 | 2 | 4 | **5** | | | | | | | |

Table 1. Cont.

| | *Sphyrna lewini* | | | | | | | *Carcharhinus signatus* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Stomachs containing food: 50** | | | | | | | **Stomachs containing food: 215** | | | | | | |
| | **Empty stomachs: 48** | | | | | | | **Empty stomachs: 210** | | | | | | |
| **Prey items** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** |
| Serranidae | | | | | | | | 1 | 0.30 | 300 | 2.49 | 1 | 0.47 | |
| *Sparissoma viride* | 4 | 0.56 | 321 | 1.31 | 1 | 2 | | | | | | | | |
| *Sphyraena barracuda* | 1 | 0.14 | 1200 | 4.89 | 1 | 2 | | | | | | | | |
| Teleostei | 54 | 7.56 | 1697 | 6.91 | 25 | 50 | **2** | 11 | 3.27 | 2659 | 22.04 | 64 | 29.77 | **1** |
| *Thunnus albacares* | | | | | | | | 5 | 1.49 | 3279 | 27.18 | 2 | 0.93 | **9** |
| *Thunnus obesus* | 1 | 0.14 | 2810 | 11.45 | 1 | 2 | **10** | | | | | | | |
| *Xiphias gladius* | | | | | | | | 2 | 0.60 | 1270 | 10.53 | 2 | 0.93 | |
| **FISHES** | **69** | **9.66** | **22999** | **93.69** | | | | **43** | **12.8** | **9941** | **82.42** | | | |
| Cephalopoda | 9 | 1.26 | 159 | 0.65 | 7 | 14 | **9** | 24 | 7.14 | 600 | 4.97 | 15 | 6.98 | **2** |
| *Chiroteuthis* sp. | 10 | 0.28 | 12 | 0.05 | 1 | 2 | | 7 | 0.89 | 14 | 0.12 | 3 | 1.40 | |
| Cranchiidae | 28 | 2.94 | 246 | 1 | 11 | 22 | **4** | 17 | 3.57 | 80 | 0.66 | 10 | 4.65 | |
| *Halyphron atlanticus* | 1 | 0.14 | 4 | 0.02 | 1 | 2 | | | | | | | | |
| *Histioteuthis* spp. | 139 | 18.35 | 680 | 2.77 | 21 | 42 | **1** | 35 | 9.23 | 203 | 1.68 | 16 | 7.44 | **3** |
| *Hyaloteuthis pelagica* | 33 | 4.62 | 11 | 0.04 | 1 | 2 | | 7 | 2.08 | 26 | 0.22 | 3 | 1.40 | |
| *Japetella diaphana* | 1 | 0.14 | | | 1 | 2 | | | | | | | | |
| Octopodidae | 8 | 0.84 | 2 | 0.01 | 2 | 4 | | 2 | 0.30 | 2 | 0.02 | 1 | 0.47 | |
| *Octopoteuthis* sp. | 4 | 0.14 | 2 | 0.01 | 1 | 2 | | 33 | 6.25 | 193 | 1.60 | 12 | 5.58 | **7** |
| *Acanthurus sp.* | | | | | | | | 3 | 0.89 | 2 | 0.02 | 1 | 0.47 | |
| *Brama caribbea* | | | | | | | | 9 | 2.68 | 498 | 4.13 | 7 | 3.26 | **10** |
| *Diaphus sp.* | | | | | | | | 1 | 0.30 | 9 | 0.07 | 1 | 0.47 | |
| *Caranx sp.* | 2 | 0.28 | 800 | 3.26 | 2 | 4 | | | | | | | | |
| *Howella sp.* | | | | | | | | 4 | 1.19 | 27 | 0.22 | 1 | 0.47 | |
| *Katsuwonus pelamis* | | | | | | | | 4 | 1.19 | 1726 | 14.31 | 3 | 1.40 | |
| *Lutjanus bucanella* | 1 | 0.14 | 6620 | 26.97 | 1 | 2 | **6** | | | | | | | |
| *Monacanthidae* | 1 | 0.14 | 390 | 1.59 | 1 | 2 | | | | | | | | |
| *Muraenidae* | 1 | 0.14 | 4664 | 19.00 | 1 | 2 | **7** | | | | | | | |
| *Ruvettus pretiosus* | 2 | 0.28 | 3481 | 14.18 | 2 | 4 | **5** | | | | | | | |
| *Scombridae* | 2 | 0.28 | 1016 | 4.14 | 2 | 4 | | 3 | 0.89 | 171 | 1.42 | 3 | 1.40 | |
| *Serranidae* | | | | | | | | 1 | 0.30 | 300 | 2.49 | 1 | 0.47 | |
| *Sparissoma viride* | 4 | 0.56 | 321 | 1.31 | 1 | 2 | | | | | | | | |
| *Sphyraena barracuda* | 1 | 0.14 | 1200 | 4.89 | 1 | 2 | | | | | | | | |
| *Teleostei* | 54 | 7.56 | 1697 | 6.91 | 25 | 50 | **2** | 11 | 3.27 | 2659 | 22.04 | 64 | 29.77 | **1** |

Table 1. Cont.

| | ***Sphyrna lewini*** | | | | | | | ***Carcharhinus signatus*** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Stomachs containing food: 50** | | | | | | | **Stomachs containing food: 215** | | | | | | |
| | **Empty stomachs: 48** | | | | | | | **Empty stomachs: 210** | | | | | | |
| **Prey items** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** | **N** | **%N** | **W** | **%W** | **FO** | **%FO** | **IRI** |
| *Thunnus albacares* | | | | | | | | 5 | 1.49 | 3279 | 27.18 | 2 | 0.93 | **9** |
| *Thunnus obesus* | 1 | 0.14 | 2810 | 11.45 | 1 | 2 | **10** | | | | | | | |
| *Xiphias gladius* | | | | | | | | 2 | 0.60 | 1270 | 10.53 | 2 | 0.93 | |
| *FISHES* | 69 | 9.66 | 22999 | 93.69 | | | | 43 | 12.8 | 9941 | 82.42 | | | |
| *Cephalopoda* | 9 | 1.26 | 159 | 0.65 | 7 | 14 | **9** | 24 | 7.14 | 600 | 4.97 | 15 | 6.98 | **2** |
| *Chiroteuthis sp.* | 10 | 0.28 | 12 | 0.05 | 1 | 2 | | 7 | 0.89 | 14 | 0.12 | 3 | 1.40 | |
| *Cranchiidae* | 28 | 2.94 | 246 | 1 | 11 | 22 | **4** | 17 | 3.57 | 80 | 0.66 | 10 | 4.65 | |
| *Halyphron atlanticus* | 1 | 0.14 | 4 | 0.02 | 1 | 2 | | | | | | | | |
| *Histioteuthis spp.* | 139 | 18.35 | 680 | 2.77 | 21 | 42 | **1** | 35 | 9.23 | 203 | 1.68 | 16 | 7.44 | **3** |
| *Hyaloteuthis pelagica* | 33 | 4.62 | 11 | 0.04 | 1 | 2 | | 7 | 2.08 | 26 | 0.22 | 3 | 1.40 | |
| *Japetella diaphana* | 1 | 0.14 | | | 1 | 2 | | | | | | | | |
| *Octopodidae* | 8 | 0.84 | 2 | 0.01 | 2 | 4 | | 2 | 0.30 | 2 | 0.02 | 1 | 0.47 | |
| *Octopoteuthis sp.* | 4 | 0.14 | 2 | 0.01 | 1 | 2 | | 33 | 6.25 | 193 | 1.60 | 12 | 5.58 | **7** |

## Discussion

The concentration of predators around seamounts is evident by reason of the large numbers of reef and pelagic fishes that occur there, as also of epi and mesopelagic cephalopods, which are diverse and abundant food resources for other predators too (MORATO et al., 2008). As a consequence, the predators become the target of a localized and specific fishery fleet, as in the case of the fishing for *S. lewini* and *C. signatus* around the northeastern Brazilian seamounts.

The presence of specimens of reef and pelagic fish in the diet of *S. lewini* shows that this species searches for its prey close to the reefs as much as in the adjacent pelagic environment, suggesting that there is a constant displacement between shallow and deep waters. Nevertheless, all the cephalopods preyed upon are oceanic species, particularly *Histioteuthis* sp., which is a common species in shelf break and oceanic waters (ROPER; YOUNG, 1975). Cephalopods like *Chiroteuthis* sp. and *Vampyroteuthis infernalis*, and the shrimp *Heterocarpus ensifer* inhabit deep waters, beyond 300 m, which means that *S. lewini* make incursions into deep waters, descending to the bed to feed upon deep-dwelling prey. Smale and Cliff (1998) observed that adults of *S. lewini* from South Africa consumed more oceanic than neritic cephalopods. Analysis of the diet of small and coastal specimens of *S. lewini* from Hawaii showed that the most common prey items were alpheid shrimps and two species of goby, the most abundant benthic local megafauna (BUSH, 2003). In the Gulf of California (Mexico), dark squid (*Loliolopsis diomedeae*) and the bony fish Carangidae and Gerreidae were the main prey items among the 87 identified (TORRES-ROJAS et al., 2006). In South Africa, 60 teleost species were found in the stomachs, Trichiuridae, Pomadasydae and Sparidae being the most representative fish, but coastal cephalopods and sharks of the family Scyliorhinidae were also found (BRUYN et al., 2005).

In the case of *C. signatus*, there is a preference for migrant squids such as *Histioteuthis* sp., *Ommastrephes bartramii*, *Ornithoteuthis antillarum*, and also *Vampyroteuthis infernalis*. The deep water shrimp *Heterocarpus ensifer* is the main prey among crustaceans, as was also observed for *S. lewini*. On the other hand, fish preyed upon by *C. signatus* belong more to the pelagic than to the reef habitat, which means that the predator searches for prey in the pelagic waters around the oceanic banks, and occasionally comes near to the shelf break of the banks. Patokina and Litvinov (2005) found shelf break species such as *Trichiurus* sp. and *Octopoteuthis sicula* in Sierra Leone waters in the stomachs of 11 individuals of *C. signatus*.

The feeding strategy of both predators in the region seems to bring them close to seamounts to prey upon the reef and bentho-pelagic fishes and migrant cephalopods commonly found in shelf breaks, and also upon deep-water crustaceans such as the penaeid *Heterocarpus ensifer*. According to Cortés (1999), both predators have very similar trophic levels, 4.2 for *C. signatus*, and 4.1 for *S. lewini*, that is evident at these seamounts, because both predators have a preference for shelf breaks when they are juveniles and adults involved. The high prey richness of the diets suggests that these species belong to very extensive food webs at the seamounts off Brazil and reinforce the idea that these sharks occupy upper trophic levels, as proposed by Cortés (1999).

*Carcharhinus signatus* is considered to be globally vulnerable on the basis of significant population declines throughout its Western Atlantic range, and *S. lewini* is classified as Lower Risk – near threatened (LR/nt) on the IUCN Red List 2004. As observed by Worm et al. (2003), the seamounts in the present study may be an example of concentration of biodiversity, or hotspots in open waters, with features that enhance local production and consequently maintain an important concentration of commercial sharks. Seamounts shallower than 400 m depth show significant aggregation effects (MORATO et al., 2008) and a special effort should be made to ensure a sustainable fishery in the vicinities of these habitats. In this way, due to the concentration for feeding of both predators in the seamounts, intense fisheries should be monitored to avoid localised depletions.

## ACKNOWLEDGEMENTS

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## REFERENCES

BUSH, A. Diet and diel feeding periodicity of juvenile scalloped hammerhead sharks, *Sphyrna lewini*, in Kaneohe Bay, Oahu, Hawaii. **Env. Biol. Fishes**, v. 67, p. 1 - 11, 2003.

BUSH, A; HOLLAND, K. Food limitation in a nursery area: estimates of daily ration in juvenile scalloped hammerheads, *Sphyrna lewini* (Griffith & Smith, 1834) in Kaneohe Bay, Oahu, Hawaii. **J. exp. mar. Biol. Ecol.,** v. 278, p. 157 - 178, 2002.

BRUYN, P.; DUDLEY, S. F. J.; CLIFF, G.; SMALE, M. J. Sharks caught in the protective gill nets off Kwazulu-Natal, South Africa. 11. The scalloped hammerhead shark *Sphyrna lewini* (Griffith and Smith). **Afr. J. mar. Sci.,** v. 27, n.3, p. 517 - 528, 2005.

CLARKE, T. A. The ecology of the scalloped hammerhead shark, *Sphyrna lewini*, in Hawaii. **Pacific Sci**., v. 25, p. 133 - 145, 1971.

COMPAGNO, L. J. V. FAO Species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. **FAO Fish. Synop.,** v. 125, n. 4, p. 251 - 655, 1984.

CORTÉS, E. A. critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. **Can. J. Fish. aquat. Sci.,** v. 54, p. 726 - 738, 1997.

CORTÉS, E. Standardized diet compositions and trophic levels of sharks. **ICES J. mar. Sci**., v. 56, p. 707 - 717, 1999.

FERREIRA, A. G.; FARIA, V. V.; CARVALHO, C. E. V.; LESSA, R. P. T.; SANTANA, F. M. Total mercury in the night shark, *Carcharhinus signatus* in the western equatorial Atlantic. **Braz. Arch. Biol. Tech.,** v. 47, n. 4: 629 - 634, 2004.

GADIG, O. B. F.; MOREIRA JÚNIOR, W. Tubarões da Costa Brasileira. **Leopoldianum**, v. 18, n. 52, p. 111-119, 1992.

HAZIN, F. H. V.; COUTO, A. A.; KIHARA, K.; OTSUKA, K.; ISHINO, M. Distribution and abundance of pelagic sharks in the southwestern equatorial **Atl. J. Tokio Univ. Fish**., v. 77, n. 1, p. 51 - 64, 1990.

HAZIN, F. H. V.; LUCENA, F. M.; SOUZA, T. S. A. L.; BOECKMANN, C. E.; BROADHURST, M. K.; MENNI, R. C. Maturation of the night shark, *Carcharhinus signatus*, in the Southwestern Equatorial Atlantic ocean. **Bull. mar. Sci.,** v. 66, n. 1, p. 173 - 185, 2000.

HAZIN, F. H. V.; FISCHER, A.; BROADHURST, M. Aspects of reproductive biology of the scalloped hammerhead shark, *Sphyrna lewini*, off northeastern Brazil. **Env. Biol. Fishes,** v. 61, p. 151 - 159, 2001.

MENNI, R. C.; HAZIN, F. H. V.; LESSA, R. P. Occurrence of the night shark *Carcharhinus signatus* and the pelagic stingray *Dasyatis violacea* off northeastern Brazil. **Neotrópica** v. 41, n. 105-106, p. 105 - 110, 1995.

MORATO, T.; VARKEY, D. A.; DAMASO, C.; MACHETE, M.; SANTOS, M.; PRIETO, R.; SANTOS, R. S.; PITCHER, T. Evidence of a seamount effect on aggregating visitors. **Mar. Ecol. Prog. Ser**., v. 357, p. 23-32, 2008.

OLIVEIRA, G. M.; EVANGELISTA, J. E. V.; FERREIRA, B. P. Considerações sobre a biologia e a pesca no Arquipélago dos Penedos São Pedro e São Paulo. **Bolm Técnico-Cient. CEPENE,** v. 5, n. 1, p. 31 - 52, 1997.

PATOKINA, F. A.; LITVINOV, F. F. Food composition and distribution of elasmobranches on the shelf and upper slope of the Eastern Central Atlantic. **ICES CM 2005/N: 26,** 2005.

PINKAS, L.; OLIPHANT, M. S.; IVERSON, I. L. K. Food habits of albacore, bluefin tuna, and bonito in Californian waters. **Fish Bull., Dept Fish and Game, California,** , v. 152, 105 p, 1971.

ROPER, C. F. E.; YOUNG, R. E. Vertical distribution of pelagic cephalopods. **Smithson. Contrib. Zool.,** v. 209, p. 1 - 51, 1975.

SANTANA, F. M.; LESSA, R. Age determination and growth of the night shark (*Carcharhinus signatus*) off the northeastern Brazilian coast. **Fish. Bull.**, v. 102, p. 156 - 167, 2004.

SANTANA, F. M.; LESSA, R.; CARLSON, J. *Carcharhinus signatus*. In: **2006 IUCN Red List of Threatened Species**. IUCN, 2006. < www.iucnredlist.org>.

SCHOENER, T. W. Nonsynchronous spatial overlap of lizards in patchy habitats. **Ecology,** v. 51, p. 408 - 418, 1970.

SCRIMGEOUR, G. L.; WINTERBOURN, M. J. Diet, food resource partitioning and feeding periodicity of two riffle-dwelling fish species in a New Zealand river. **J. Fish Biol**., v. 31, p. 309 - 324, 1987.

SMALE, M. J.; CLIFF, G. Cephalopods in the diets of four shark species (*Galeocerdo cuvier, Sphyrna lewini, Sphyrna zygaena,* and *S. mokarran*) from Kwazulu-Natal, South Africa. **S. Afr. J. mar. Sci.,** v. 20, p. 241 - 253, 1998.

SOTO, J. M. Annotated systematic checklist and bibliography of the coastal and oceanic fauna of Brazil. I – Sharks. **Mare Magnum,** v. 1, n. 1, p. 51 - 120, 2001.

TORRES-ROJAS, Y.; HERNANDEZ-HERRERA, A.; GALVAN-MAGAÑA, F. Feeding habits of the scalloped hammerhead shark, *Sphyrna lewini,* in Mazatlán waters, southern Gulf of California, Mexico. **Cybium,** v. 30, n.4, p. 85 - 90, 2006.

VASKE JUNIOR, T.; LESSA, R. P.; NÓBREGA, M. F.; MONTEALEGRE-QUIJANO, S.; SANTANA, F. M.; BEZERRA JR. J. L. A checklist of fishes from Saint Peter and Saint Paul Archipelago, Brazil**. J. appl. Ichth.,** v. 21, n.1, p. 75-79, 2005.

WORM, B.; LOTZE, H. K.; MYERS, R. A. Predator diversity hotspots in the blue ocean. **PNAS**, v. 100, n. 17, p. 9884-9888, 2003.

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