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DIET OF THE BLUE MARLIN (*MAKAIRA NIGRICANS*, LACEPÈDE 1802) (PERCIFORMES: ISTIOPHORIDAE) OF THE SOUTHWESTERN EQUATORIAL ATLANTIC OCEAN

VASKE JR., T.[1*]; TRAVASSOS, P. E.[2]; PINHEIRO, P. B. [2]; HAZIN, F. H. V. [2]; TOLOTTI, M. T.[2] & BARBOSA, T. M. [2]

1 - Universidade Estadual Paulista Júlio de Mesquita Filho Campus São Vicente;
2 - Universidade Federal Rural de Pernambuco
***Corresponding author: vaske@ig.com.br**

ABSTRACT

Vaske jr., T.; Travassos, P. E.; Pinheiro, P. B.; Hazin, F. H. V.; Tolotti, M. T. & Barbosa, T. M. 2011 Diet of the Blue Marlin (Makaira nigricans, Lacepède 1802) (Perciformes: Istiophoridae) of the southwestern equatorial Atlantic Ocean. Braz. J. Aquat. Sci. Technol., 15(1): 65 - 70. ISSN 1808-7035. Diet composition of the blue marlin, *Makaira nigricans*, from the southwestern equatorial Atlantic Ocean was analyzed between October 2004 and November 2005. In the 226 stomachs of fish ranging between 100 and 311 cm lower jaw -fork length (LJFL), 44 items were identified, including 31 fishes and 13 cephalopods. Seventy stomachs were empty (23.6 %). *M. nigricans* fed preferentially on heavy and muscular scombrid fishes especially upon the skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758), probably to sustain their high metabolism, and on a variety of other items composed mainly by epipelagic species of fish and cephalopods.

Keywords: blue marlin, feeding habits.

INTRODUCTION

Four specimens of billfishes are commonly caught by pelagic longline off Northeastern Brazil: white marlin (*Tetrapturus albidus*, Poey, 1860), spearfish (*Tetrapturus pfluegeri*, Robins & Sylva, 1963), sailfish (*Istiophorus albicans*, Latreille, 1804), and blue marlin (*Makaira nigricans*, LACEPÈDE 1802), all of them epipelagic (Sylva & Davis, 1963; Ueyanagi et al., 1970; Brock, 1984; Nakamura, 1985; Yang & Gong 1988; Block et al. 1992; Boggs, 1992). The blue marlin, is distributed in the Atlantic ocean between 50oN and 45oS (Nakamura, 1985), being the most tropical of all billfishes. Although the M. nigricans population structure is not yet well defined, there seems to be two stocks separated roughly at 5oN. Total landings for the species in the Atlantic Ocean are around 3,000 tons per year, and both stocks seem to be overfished (Andrade, 2006; Goodyear, 2003; Restrepo et al., 2003).

Main commercial catches occur in the first semester in the central Atlantic, between 5^{o}W and 25^{o}W, and 15^{o}N and 10^{o}S with a CPUE (Catch per Unit of Effort) ranging between 0.02 and 0.16 individuals per 100 hooks, with a mean of 0.025 (Hazin *et al*., 2006). Due to its large size, legendary speed and powerful aerobics on rod and reel, *M. nigricans* is the most popular and prestigious catch for recreational fishermen. In Brazil, sport fisheries are especially developed in the coasts of São Paulo, Rio de Janeiro, Espírito Santo and northeastern region.

Despite of its great ecological and economic significance, the biology of the blue marlin has been little studied so far, in particular in regard to its feeding habits, an aspect which is, however, crucial for the understanding of its ecological role in the pelagic marine ecosystem, as well as of its migratory behavior, including circadian movements.

Previous studies of feeding habits of *M. nigricans* in Brazilian waters are restricted to eight stomachs from specimens caught off south Brazil (22 - 30^{o}S), by Zavala-Camin (1981), and 35 stomachs from the northeastern region (2 – 8^{o}S), by Vaske *et al*. (2004). In other parts of the Atlantic, it was observed a remarkable presence of small tunas in their stomach contents (Krumholtz & Sylva, 1958; Baker, 1966). Therefore, the aim of this study was to investigate the composition of *M. nigricans*' diet, in number, biomass, and frequency of occurrence of prey items, and its feeding strategies in the Southwestern equatorial Atlantic Ocean, especially regarding to the importance of tunas in their diet.

MATERIAL AND METHODS

The study area was located between 15oW and 41oW, and 6oN and 25oS (Fig. 1). Sampling was carried out between October 2004 and November 2005, by observers of the National Observer Program, on board leasing tuna longliners from Taiwan, Spain, and EUA based in the ports of Recife (PE), Cabedelo (PB) and Natal (RN), located in northeast Brazil. The specimens

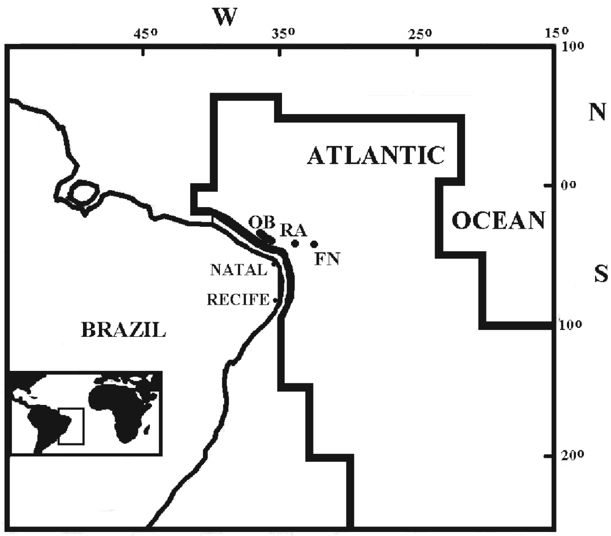

Figure 1 – Sample area of *Makaira nigricans* specimens caught in the Southwestern equatorial Atlantic Ocean, and used for the study of their stomach contents. Natal and Recife are the main landing harbours of tuna fishery in northeasten Brazil. OB – Oceanic Banks; RA – Rocas Atoll; FN – Fernando de Noronha archipelago.

were caught on longline, and identified after death, according to the FAO identification key, and measured its lower jaw-fork length, as recommended by Graham et al. (2006). The stomachs were removed by opening the abdominal cavity and by severing them from the intestine and the esophagus. They were, then, stored in plastic bags and properly labeled and frozen onboard at a temperature of about twenty degrees below zero, for a period ranging from one to three months, depending on the duration of the cruise. Lower jaw-fork length (LJFL) (cm), local position, date of sampling site was individually recorded. Stomach content was considered as the material retained in a sieve of 1 mm mesh. Preys were identified to the lowest possible taxon, using specialized literature or help from specialists. Zavala-Camin (1981), Carvalho-Fo (1999) were useful for fish identification, and Nesis (1982), Roper (1984), and Clarke (1986),) were used for cephalopods. The number of preys of each food item, the mantle length for cephalopods (cm), the total length for other organisms (cm), and the wet biomass of each prey (g) were recorded. An accumulated species curve was used to observe if an optimum sample size was attained when the curve tends to a flat line by visual inspection (Scheiner, 2003; Schilling & Batista, 2008).

The importance of each food item in the diet was obtained by the Index of Relative Importance (IRI) (modified from Pinkas *et al*. 1971), modified to biomass as follows:

$$IRI_i = \%FO_i \times (\%N_i \times \%W_i)$$

Where: $\%FO_i$= relative frequency of occurrence of each food item; $\%N_i$= proportion in prey number of each item in the total food content; and $\%W_i$= proportion in biomass of each item in the total food content. Occurrence of isolated cephalopods beaks was not considered in the IRI calculation, to avoid the overestimation of cephalopod importance in the diet, due to accumulation of beaks in the stomachs (Vaske and Rincón, 1998).

RESULTS

A total of 226 specimens were examined, 85 of them being females, and 141 males. Females ranged in size from 100 cm to 311 cm LJFL, with two modes, the first one between 160 and 175 cm, and the second one between 220 and 235 cm. The 141 males sampled ranged from 104 cm to 267 cm, being more frequent between 190 and 205 cm (Fig. 2).

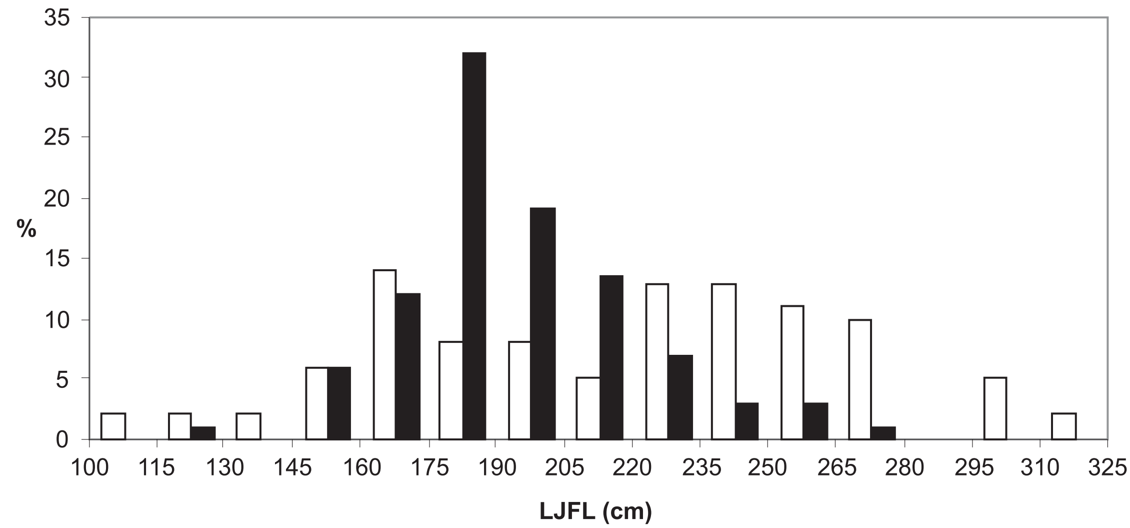

Figure 2 – Lower jaw fork length (LJFL) frequency distribution of blue marlin, *Makaira nigricans* in the Southwestern equatorial Atlantic Ocean, by sex. White bar = females; black bar = males.

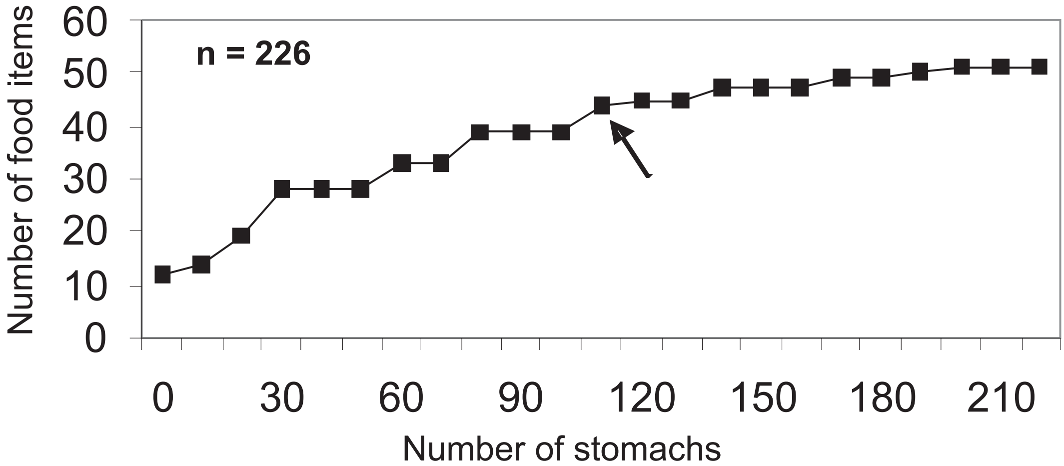

Figure 3 – Accumulation species curve for *Makaira nigricans* in the Southwestern equatorial Atlantic. Arrow indicates the beginning of stabilization.

The stabilization of the food items richness was obtained at 44 food items and 110 stomachs, meaning that the number of examined individuals was sufficient to obtain the feeding spectra of prey species (Fig. 3). A total of 44 items were identified, 31 of which were fish, and 13 were cephalopods (Table 1). Seventy stomachs were empty (23.6 %). Fishes were clearly the preferential prey, accounting for more than 98 % of prey biomass. According to the IRI ranking, with the exception of unidentified Teleostei and Cephalopods, the skipjack tuna, *Katsuwonus pelamis*, was consistently the most important prey item in the diet followed by juveniles of *Dactylopterus volitans*, *Gempylus serpens*, *Coryphaena hippurus*, *Ranzania laevis*, *Brama caribbea*, and *Auxis* sp. Juveniles of *Dactylopterus volitans*, a brephoepipelagic species, were also quite frequent being the third most important prey in the diet. The squids *Sthenoteuthis pteropus* and *Ornithoteuthis antillarum* were the most important items among cephalopods. The present results indicate that *M. nigricans* feeds preferentially upon epipelagic fishes, represented mainly by *K. pelamis*, although occasionally mesopelagic fishes like Chiasmodontidae and Chauliodontidae were also found in their stomachs. With the exception of *K. pelamis*, *Gempylus serpens*, *Alepisaurus ferox*, and *Elagatis bipinnulata*, all other fishes were represented by juveniles or small sized individuals. Prey length ranged between 5 and 72 cm, with the main prey item, *K. pelamis*, however, showing an expressive contribution in the larger size prey groups, between 30 and 60 cm (Fig. 4).

DISCUSSION

Katsuwonus pelamis, the main item in the diet of *M. nigricans*, is a typical epipelagic species of tropical waters, which reinforce the probability of encounter

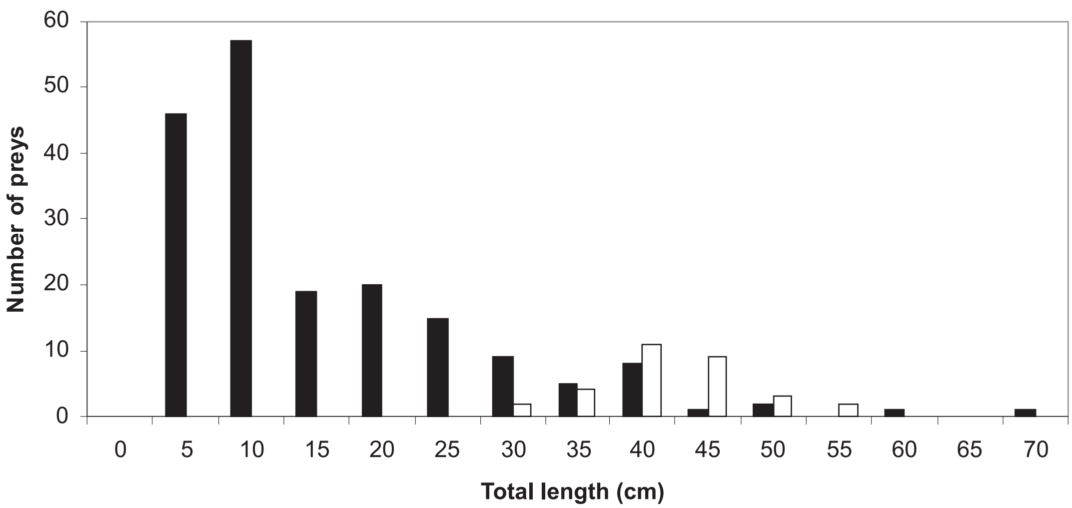

Figure 4 - Lengths of prey items from *Makaira nigricans* stomachs from southwestern equatorial Atlantic Ocean. White bar = *Katsuwonus pelamis*; black bar = other prey.

Table 1 – Percentages in number, biomass, and frequence of occurrence of food items of *Makaira nigricans*. IRI importance according from first (1) most important item, to tenth item (10).

Food items	N	%N	W	%W	FO	%FO	IRI
Katsuwonus pelamis	57	10.38	43787	67.91	52	23.01	**1**
Teleostei	72	13.11	4989	7.74	97	42.92	**2**
Dactylopterus volitans	86	15.66	187	0.29	16	7.08	**3**
Gempylus serpens	50	9.11	535	0.83	21	9.29	**4**
Coryphaena hippurus	16	2.91	2546	3.95	13	5.75	**6**
Ranzania laevis	20	3.64	2848	4.42	7	3.10	**8**
Brama caribbea	23	4.19	403	0.62	7	3.10	**9**
Auxis sp.	14	2.55	624	0.97	7	3.10	**10**
Holocentridae	18	3.28	90.5	0.14	4	1.77	
Diodon hystrix	10	1.82	137	0.21	6	2.65	
Thunnus sp.	6	1.09	1891	2.93	3	1.33	
Lagocephalus laevigatus	5	0.91	2000	3.10	3	1.33	
Mola mola	5	0.91	13	0.02	5	2.21	
Elagatis bipinnulata	1	0.18	2244	3.48	1	0.44	
Brama brama	4	0.73	32	0.05	3	1.33	
Acanthocybium solandri	3	0.55	108	0.17	3	1.33	
Chiasmodontidae	3	0.55	6	0.01	3	1.33	
Istiophoridae	2	0.36	285	0.44	2	0.88	
Synagrops sp.	3	0.55	20	0.03	2	0.88	
Cubiceps sp.	5	0.91	105	0.16	1	0.44	
Xiphias gladius	1	0.18	561	0.87	1	0.44	
Exocoetidae	3	0.54	170	0.26	3	0.88	
Paralepididae	2	0.36	11	0.02	1	0.44	
Sternoptyx diaphana	2	0.36	3		1	0.44	
Alepisaurus ferox	1	0.18	85	0.13	1	0.44	
Decapterus sp.	1	0.18	34	0.05	1	0.44	
Neolatus tripes	1	0.18	22	0.03	1	0.44	
Ruvetus pretiosus	1	0.18	8	0.01	1	0.44	
Ptericombus sp.	1	0.18	6	0.01	1	0.44	
Chauliodontidae	1	0.18	1		1	0.44	
Balistes sp.	1	0.18	1		1	0.44	
FISHES	**418**	**75.45**	**63752.5**	**98.86**			
Sthenoteuthis pteropus	36	6.56	285	0.45	20	1.33	**5**
Ornithoteuthis antillarum	34	6.19	173	0.27	12	5.31	**7**
Cranchiidae	6	1.09	16	0.02	3	1.33	
Enoploteuthidae	13	2.37			1	0.44	
Ocythoe tuberculata	15	2.73	67	0.10	6	2.65	
Hyaloteuthis pelagica	10	1.82	67	0.10	1	0.44	
Ommastrephes bartramii	3	0.55	19	0.03	3	1.33	
Tremoctopus violaceus	4	0.73	81	0.13	4	1.77	
Histioteuthis sp.	4	0.73	18	0.03	4	1.77	
Liocranchia reinhardfi	1	0.18	2		1	0.44	
Japetella diaphana	2	0.36	1		2	0.88	
Taonius pavo	2	0.36			2	0.88	
Onychoteuthis sp.	1	0.18			1	0.44	
CEPHALOPODS	**95**	**24.55**	**444**	**1.14**			
TOTAL	**549**	**100.00**	**64482**	**100.00**			

between both species. Besides, when congregating near the surface, *K. pelamis* is a schooling fish, a behavior that might be advantageous to *M. nigricans*, when it is searching for food. Furthermore, the heavy and muscular body of *K. pelamis* and other scombrids is probably a much more important and efficient energy source for *M. nigricans*, to sustain its high metabolism rate, than small and isolated preys, commonly found in the open ocean. Since most analyzed individuals are adults, it is probable that larger *M. nigricans* needs larger fish to sustain their metabolism, which is profitable along the tropical waters of the Brazilian coast where schools of *K. pelamis* are commonly found. Krumholtz & Sylva (1958) pointed out that the main food items of *M. nigricans* around Bahamas were also Scombridae. Baker (1966) likewise, found the scombrids *K. pelamis*, *Scomber japonicus*, and *Thunnus alalunga* as the main prey items for blue marlin in New Zealand. Block *et al*.

(1992b) observed, by acoustic telemetry, that the swimming speed of *M. nigricans* is 15-25 cm s^{-1} for slower , 80-120 cm s^{-1} for fast swimming, and 225 cm s^{-1} for short bursts of speeds, probably used when an important and agile prey, like *K. pelamis*, is located.

According to Pinto *et al*. (2002) and Andrade & Santos (2003), the spawning area of *K. pelamis* along the Brazilian Coast ranges between 0º – 25ºS, and it is continuous throughout the year. The main catches of *K. pelamis* off southeastern Brazil, however, occur during summer and autumn, probably due to recruitment of young fish and environmental factors, being the main harvest season (Andrade & Santos, 2003). This period is coincident with the highest abundance of *M. nigricans*, which is also present in the area only seasonally, during summer, since the species is not well-adapted to subtropical environments, with preferences for temperatures between 25.5ºC and 29.5ºC (Boyce *et al*., 2008).

Although some authors have reported the use of the bill (rostrum) by blue marlins for striking or spearing *K. pelamis* and other species (Nakamura, 1985; Shimose *et al*., 2007), no damaged prey was observed in the present study.

The presence of seamounts off Ceará and Rio Grande do Norte, and the emerged areas of Rocas Atoll and Fernando de Noronha Archipelago, were the possible causes for the occurrence of brephoepipelagic fish represented by *Dactilopterus volitans*, Holocentridae, *Diodon hystrix*, and *Balistes* sp., also found as important prey items for other pelagic predators in the area (Vaske & Lessa, 2004; Vaske *et al*., 2004). Despite the small size, these fishes are also profitable for *M. nigricans* until an available large prey such as the scombrids can be located.

Cephalopods are well known common items in the diet of pelagic predators, but the low importance of cephalopods in the diet of *M. nigricans* as a whole, is probably explained by the difference in vertical distribution. Cephalopods are vertical migrants, staying below the epipelagic environment during the day, which might reduce the chances of encounters with *M. nigricans*.

In summary, it can be concluded that *M. nigricans* in the southwestern equatorial Atlantic feed on fast swimming epipelagic fishes, especially *K. pelamis*, although their food *spectrum* include small sized species of fish and cephalopods, with occasional occurrences of mesopelagic fishes and squids.

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