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FEEDING HABITS OF THE COMMON DOLPHINFISH *Coryphaena hippurus*, IN NORTHEASTERN BRAZIL'S EXCLUSIVE ECONOMIC ZONE

Hábitos alimentares do dourado, *Coryphaena hippurus*, na Zona Econômica Exclusiva do Nordeste do Brazil

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RESUMO

Os hábitos alimentares do dourado, Coryphaena hippurus *foram analisados através do conteúdo estomacal de 272 peixes. As amostras provenientes da pesca de espinhel de atum da região nordeste na Zona Econômica Exclusiva, foram coletadas entre outubro de 1992 e dezembro de 1999. A dieta compreende 23 taxa de peixes, 13 de cefalópodes, 8 de crustáceos e um de heterópode. De acordo com o Índice de Importância Relativa (IIR), os peixes foram os principais itens alimentares, particularmente os jovens de* Dactylopterus volitans, Brama brama, Cypselurus *sp. e* Balistes *sp. O dourado se alimenta de organismos epipelágicos de uma maneira contínua, ao longo do dia, sobre indivíduos de pequeno tamanho (1 a 7 cm). Não há correlação entre o tamanho das presas e o peso do conteúdo estomacal com o tamanho corporal do dourado.*

Palavras-chaves: *dourado,* Coryphaena hippurus, *dieta alimentar, Zona Econômica Exclusiva, Nordeste do Brazil.*

ABSTRACT

Feeding habits of the common dolphinfish, Coryphaena hippurus *were analyzed from stomach contents of 272 fish. Samples from longline tuna fishing of the Northeastern Brazilian Exclusive Economic Zone, were collected between October ,1992 and December, 1999. The diet comprised 23 taxa of fishes, 13 cephalopods, 8 crustaceans and 1 heteropod. According to the Index of Relative Importance (IRI), fishes were the main food item, particularly young* Dactylopterus volitans, Brama brama, Cypselurus *sp., and* Balistes *sp. Dolphinfish feed on small specimens of epipelagic organisms (1 to 7 cm), continuously throughout the day. There is no correlation between dolphinfish body length and prey length or the weight of the stomach content.*

Key words: *dolphinfish,* Coryphaena hippurus, *feeding habits, Exclusive Economic Zone, Northeast Brazil.*

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INTRODUCTION

The dolphinfish, *Coryphaena hippurus*, is a tropical and subtropical oceanic species of commercial importance in a number of countries (Palko *et al.*, 1982; Oxenford, 1999). Dolphifish are epipelagic and permanent residents of more than 30 percent the ocean surface layers (Norton, 1999). Both species of the family Coryphaenidae, *C. hippurus* and *C. equiselis*, are captured in Brazilian waters, though there are only occasional reports of *C. equiselis*. Due to the economic importance and distribution, several feeding studies have been carried out in the Atlantic. Most of these studies show descriptive lists of food items (Manooch *et al.*, 1984; Oxenford & Hunte, 1999; Rose & Hassler, 1974). Oxenford (1999) sumarized the diets and most important food items using the IRI (Index of Relative Importance), among dolphinfish captured in the North Atlantic between 1959 and 1999. Feeding habits of dolphinfish in Brazil were first reported from specimens captured by longlines in the southwestern and southern regions (23°S to 33°S), emphasizing the importance of brephoepipelagic fishes of coastal species in the diets (Zavala-Camin, 1981 and 1986).

In this study aspects of composition in number, weight and frequency of occurrence of food items preyed on by dolphinfish in the Northeastern Brazilian Exclusive Economic Zone (EEZ) (1°N to 9°S) are analyzed and the vertical distribution and feeding strategy investigated.

MATERIAL AND METHODS

The study area is located between 30°W and 40°W, and 1°N and 8°S, comprising the abyssal plain around the emerged areas of the Rocas Atoll and Fernando de Noronha Archipelago (Figure 1). The main oceanic current in the region is the Southern Equatorial Current that flows from east to west between 20°S and 2-3°N, with a mean speed of 30 cm/s (Tchernia, 1980; Tomczak & Godfrey, 1994), temperatures between 20 - 28°C, and salinities 34 - 35‰ (Longhurst & Pauly, 1987).

The fishes were sampled between October, 1992 and December, 1999 on board longline tuna fishing boats. Stomachs were removed from fishes and preserved in 5% formaline. All material retained in a 1 mm sieve was considered as stomach content. Each taxon was considered a food item and each unit of food item was considered a prey. Stomach fullness was estimated according to the following scale: empty; 25% full; 50% full; 75% full, and full. The digestive stage of prey was determined according the scale: ND – non digested prey; SD – starting digestion (loss of skin, scales, parts of fins and carapaces), AD – advanced digestion (loss of fins and muscle portions), and CD – complete digestion (remains of muscle, bones and carapaces). All prey were counted, weighed (g), and measured for length (mm): fish in fork length; squid in mantle length; and crustaceans and other groups in total length. Stomachs where only bait was found were considered empty. The depths at which dolphinfish were captured were obtained from the position of the hook in the longline in accordance with procedures described by Yoshihara (1954).

The importance of each food item in the diet was determined by the Index of Relative Importance (IRI) (Pinkas *et al.*, 1971) modified to weight:

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

where, $\%FO_i$ - percentage of frequency of occurrence of each food item; $\%N_i$ - percentage of number of occurrence of each food item; $\%W_i$ - percentage of weight of occurrence of each food item.

Cephalopod beaks were not considered for IRI calculation so as to avoid the overestimation of the number of cephalopods due to beak accumulation in the stomachs after digestion (Vaske & Rincón, 1998).

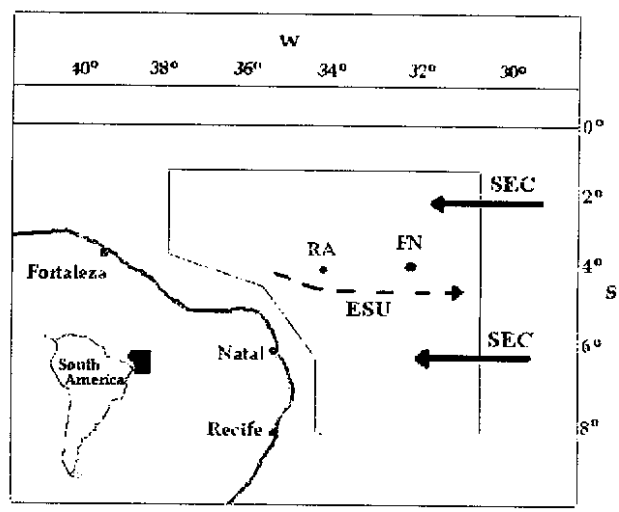

Figure 1 – Sample area in the Southwestern equatorial Atlantic. RA – Rocas Atoll, FN – Fernando de Noronha Archipelago, SEC – Southern Equatorial Current, ESU – Equatorial Southern Undercurrent.

RESULTS AND DISCUSSION

The dolphinfish is recognized as a surface species spending most of its life near the surface, therefore his common prey species should be expected to be all epipelagic. Dolphinfishes of both sexes ranged from 50 cm to 143 cm FL (Figure 2).

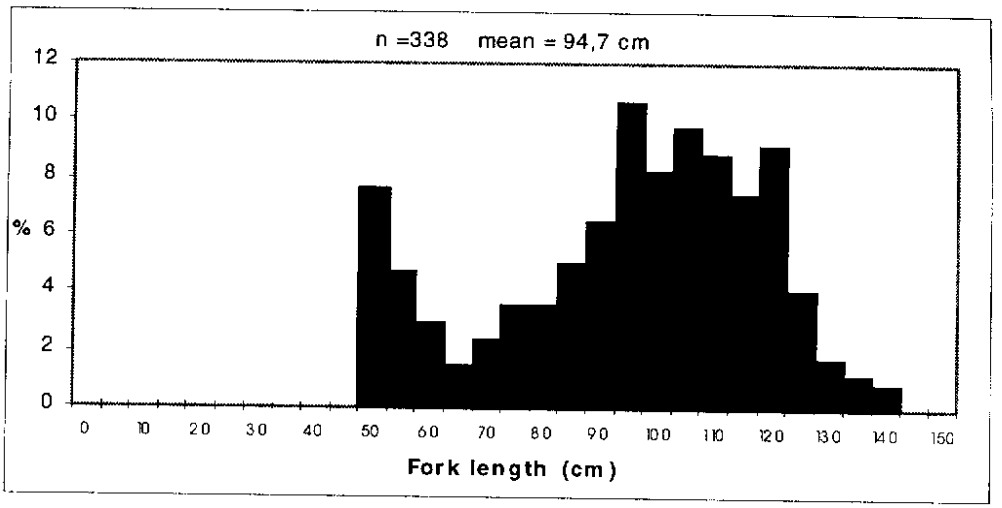

Figure 2 – Size composition of the dolphinfish, *Coryphaena hyppurus*.

No specimens smaller than 50 cm were captured due to longline hook selectivity, though small specimens were frequently sighted at the surface. Capture depths of the longline hooks ranged from approximately 30 to 270 m. Dolphinfishes were captured between 50 and 190 m, with capture occurring more frequently at 50 m (Figure 3). Palko *et al.* (1982) stated that 30 m is the limit of distribution of dolphinfish. Individuals reported on deep hooks of the longline were indeed captured during longline retrieval when fishes were hooked near the boat. All of them were alive when taken onboard.

A total of 272 stomachs were analyzed, 248 contained food and 24 were empty. The diet comprised 23 taxa of fishes: 13 cephalopods, 8 crustaceans and 1 heteropod. The analysis of the IRI, showed that from the ten most important food items, nine were represented by fishes, mainly *Dactylopterus volitans*, the main prey items with an expressive presence in number, weight, and frequency of occurrence (Table I). The food diversity showed stabilization at around 90 stomachs and 30 food items, indicating that the trophic base of dolphinfish in the region as a whole, was sampled satisfactorily (Figure 4).

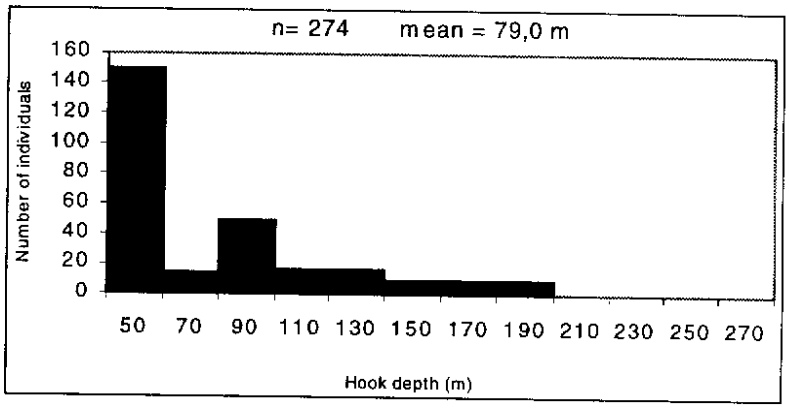

Figure 3 – Depth distribution of hook-caught dolphinfish, *Coryphaena hippurus*.

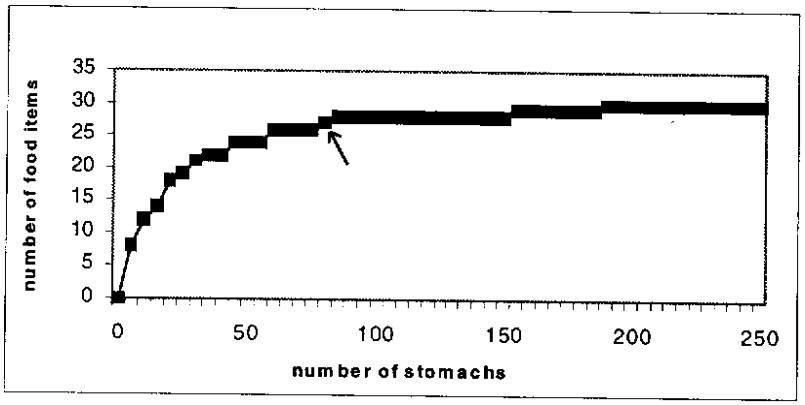

Figure 4 – Cumulative distribution of food items in the stomach of dolphinfish, *Coryphaena hippurus*. Arrow indicates the stabilization point.

Table I - Number (N), weight (W), and frequence of occurrence (FO) of dolphinfish, *Coryphaena hippurus*, food items.
IRI - Ranking of the ten main prey items according Index of Relative Importance.

Food items	N	%N	P	%P	FO	%FO	IRI
FISHES							
Acanthurus spp.	3	0,08	4	0,02	2	0,81	
Alepisaurus ferox	1	0,03	6	0,03	1	0,40	
Antigonia capros	1	0,03	5	0,03	1	0,40	
Balistes sp.	30	0,84	291	1,66	19	7,66	8
Belonidae	1	0,03	2	0,01	1	0,40	
Brama brama	89	2,49	623	3,55	49	19,76	4
Caranx spp.	1	0,03	10	0,06	1	0,40	
Coryphaena hippurus	13	0,36	2343	13,36	12	4,84	5
Dactylopterus volitans	2331	65,17	3642	20,76	85	34,27	1
Decapterus punctatus	2	0,06	29	0,17	2	0,81	
Diaphus sp.	2	0,06	6	0,03	1	0,40	
Diodon hystrix	61	1,71	511	2,91	14	5,65	7
Cypselurus spp.	157	4,39	3617	20,62	43	17,34	3
Fistularia sp.	18	0,50	23	0,13	3	1,21	
Gempylus serpens	20	0,56	229	1,31	13	5,24	9
Holocentridae	1	0,03	3	0,02	1	0,40	
Lagocephalus sp.	3	0,08	614	3,50	3	1,21	10
Monacanthidae	7	0,20	162	0,92	6	2,42	
Oxyporhamphus micropterus	4	0,11	76	0,43	4	1,61	
Ptericombus petersii	1	0,03	5	0,03	1	0,40	
Ranzania laevis	2	0,06	250	1,43	2	0,81	
Scombridae	2	0,06	79	0,45	2	0,81	
Teleostei	187	5,23	4262	24,30	100	40,32	2
TOTAL	2937	82,11	16792	95,72	212	85,48	
MOLLUSCS							
Cephalopoda	12	0,34	84	0,48	6	2,42	
Chiroteuthis sp.(beak)	2	0,06			2	0,81	
Cranchiidae (beak)	3	0,08			3	1,21	
Histioteuthis spp.	4	0,11	70	0,40	3	1,21	
Histioteuthis spp. (beak)	11	0,31			10	4,03	
Hyaloteuthis pelagica (beak)	2	0,06			2	0,81	
Japetella diaphana (beak)	9	0,25			7	2,82	
Ocythoe tuberculata (beak)	5	0,14			2	0,81	
Ommastrephes bartramii	49	1,37	322	1,84	3	1,21	
Onychoteuthidae(beak)	1	0,03			1	0,40	
Ornithoteuthis antillarum	10	0,28	25	0,14	1	0,40	

(continuação tabela 1)

Ornithoteuthis antillarum (beak)	33	0,92			7	2,82	
Spirula spirula	13	0,36	4	0,02	3	1,21	
Sthenoteuthis pteropus (beak)	7	0,20			4	1,61	
Tremoctopus violaceus	2	0,06	33	0,19	2	0,81	
Tremoctopus violaceus (beak)	3	0,08			2	0,81	
TOTAL	166	4,64	538	3,07	17	6,85	
CRUSTACEANS							
Brachyscelus crusculum	1	0,03	1	0,01	1	0,40	
Brachyura	2	0,06	1	0,01	2	0,81	
Cirolanidae	4	0,11	3	0,02	4	1,61	
Decapoda	13	0,36	54	0,31	5	2,02	
Euphausiacea	2	0,06			1	0,40	
Hemithyphis tenuimanus	2	0,06	2	0,01	2	0,81	
Phrosina semilunata	1	0,03			1	0,40	
Squiliidae	446	12,47	151	0,86	10	4,03	6
TOTAL	471	13,17	212	1,21	26	10,48	
HETEROPODS							
Oxygyrus keraudrenii	3	0,08			2	0,81	
TOTAL	3577	100	17542	100	-	-	

Mean prey size ranged from 2 to 12 cm throughout the predator length classes, that means that dolphinfish do not select prey in length as the predator increases in size (Figure 5). Prey smaller than 2 cm were not swallowed probably due to gill rakers selectivity (nine gill rakers in average). Rose & Hassler (1974) observed a positive correlation between prey and predator length where juvenile fishes and cephalopods were more frequent in small dolphinfishes (20 to 70 cm), whereas adult specimens of Exocoetidae and juveniles of Scombridae were more frequent in dolphinfish larger than 80 cm. The number of prey per stomach showed a maximum of 24 units, though one to three units were more common. The prey size distribution ranged from 1 to 39 cm, more commonly being between 2 and 7 cm (Figure 6). The largest prey were represented by fishes such as *Alepisaurus ferox, Coryphaena hippurus* and *Decapterus punctatus*.

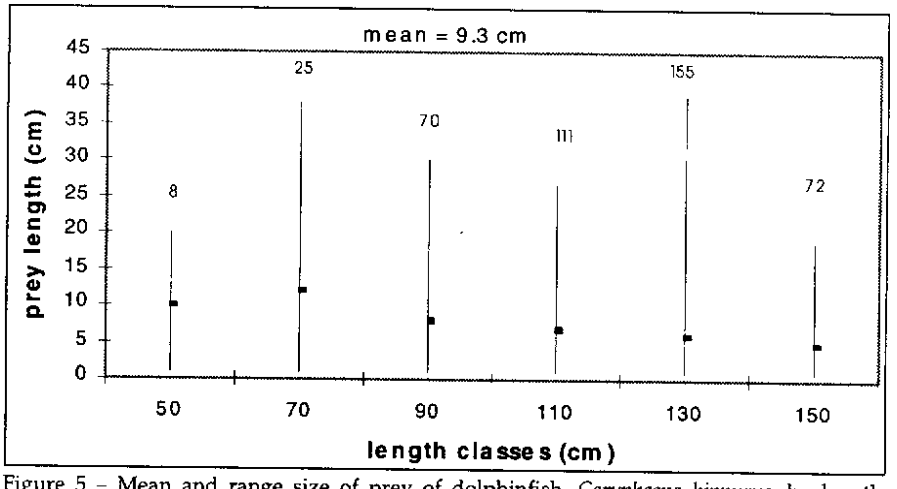

Figure 5 – Mean and range size of prey of dolphinfish, *Coryphaena hippurus*, by length classes. Values on top indicate the number of measured prey.

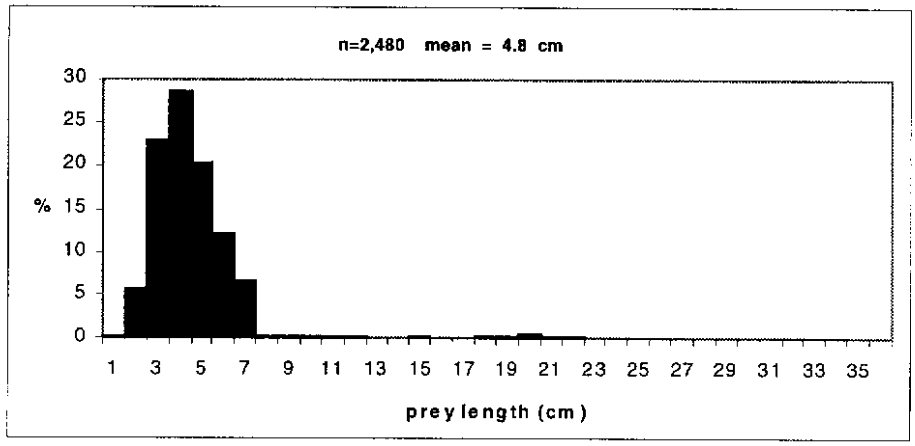

Figure 6 – Prey length of dolphinfish, *Coryphaena hippurus*.

Ten percent of the stomachs were empty, 34% were 25 full, 24% were 50% full, 24 % were 75% full, and 8% were full. Ninety-one percent of stomachs presented some food, which implies a constant feeding activity. The low number of prey per stomach and the constant presence of food in the stomachs may reflect a high digestion rate, mainly in regards to cephalopods (Figure 7). There was no correlation between content weight and predator length, most stomachs contained 1 to 200 g, though the heaviest contents appeared in largest specimens up to 100 cm FL (Figure 8). Benetti *et al.* (1995) pointed out the high metabolic rates found in dolphinfish, similar to that of tuna. This implies high somatic growth rates, rapid digestion and rapid repayment of oxygen debts, which are important abilities for life in the pelagic environment. Therefore, dolphinfish feed continuously so as to maintain their high metabolic rate.

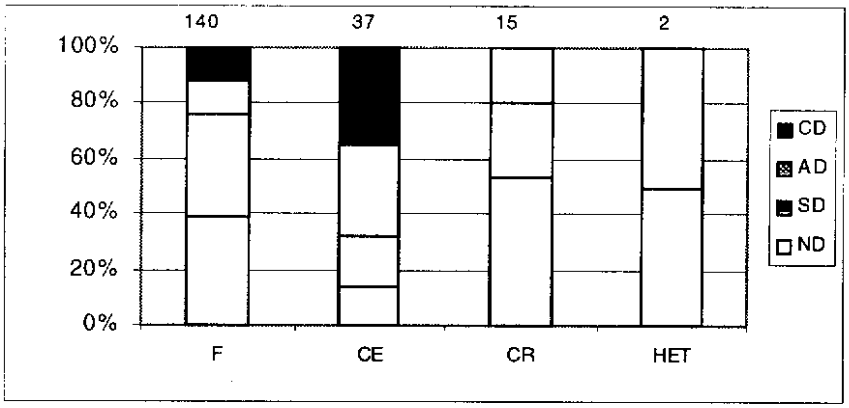

Figure 7 – Prey digestion stages by dolphinfish, *Coryphaena hippurus*. AD – advanced digestion; CD – complete digestion; CE – cephalopods; CR – crustaceans; HET – heteropods. Figures on top indicate number of analyzed prey.

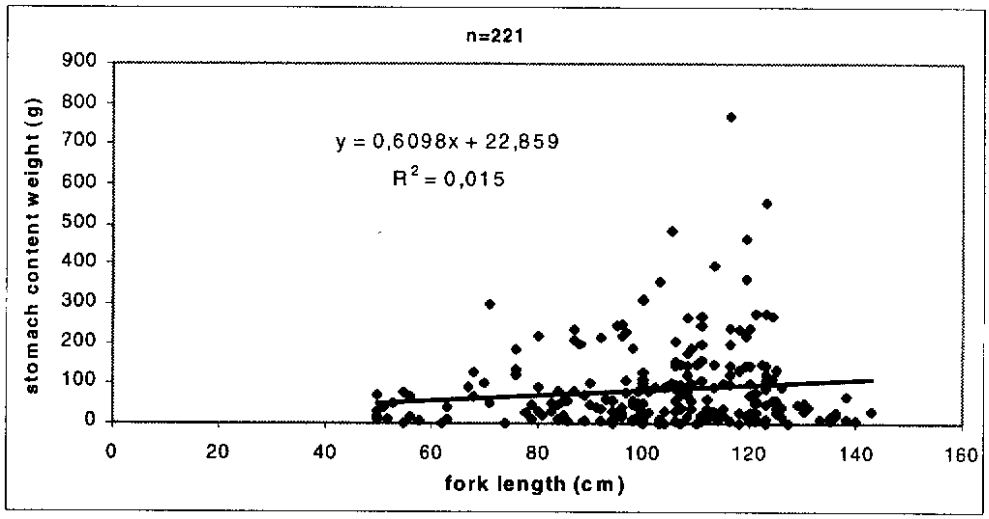

Figure 8 – Relationship between stomach content weight and size of the dolphinfish, *Coryphaena hippurus*.

The influence of oceanic banks, the Rocas Atoll and Fernando de Noronha Archipelago in the sample area was probably the cause of the occurrence of brephoepipelagic fish represented by youngsters of the Dactylopteridae, Carangidae, Diodontidae and Holocentridae families, where adults inhabit coastal waters and islands adjacencies. Oceanic banks allow shelter, food and favorable reproduction conditions for phytoplankton, microzooplankton, micronekton, fishes and cephalopods (Blackburn, 1965; Roden, 1987; Fonteneau, 1991; Rogers, 1994). This concentration of organisms around banks and islands attract predators like the dolphinfish (Uda & Ishino, 1958; Fonteneau, 1991; Holland *et al.*, 1999). Typical families among atolls and islands, such as Balistidae, Acanthuridae, Dactylopteridae, Tetraodontidae, Diodontidae, Holocentridae, Ostraciidae, Carangidae and Monacanthidae were common in the stomachs, with youngsters (2 to 10 cm) prevailing. This is an indication that there is an extensive dispersion of larvae and youngsters from these families in oceanic waters, and dolphinfish take advantage of this abundant resource. The Southern Equatorial Current and Equatorial Southern Undercurrent between the surface and 200 m in depth are the probable factors for the dispersion of youngsters in this region. All studies agree that dolphinfish feed on a wide variety of juveniles from epipelagic species that implies in a forage feeding strategy (Oxenford, 1999).

The twelve main categories of dolphinfish prey in the eastern Caribbean were young Dactyopteridae, Exocoetidae, Mysidacea, Balistidae, Cephalopoda, Tetraodontidae, Trichiuridae, Coryphaenidae, Carangidae, Monacanthidae, Diodontidae and Scombridae (Oxenford & Hunte, 1999). Among the ten main food items found in this study, eight coincide with those found in Caribbean waters. The epipelagic fish *Brama brama* and juveniles of the Squiliidae were the main distinct items found not only in this study, but also among other pelagic predators, such as tuna and billfish, as a common food item and was found to be even the main food item in the Northeastern Brazilian EEZ (Vaske, 2000). *B. brama*, however, is absent among feeding studies in the western central Atlantic from North Carolina, the Gulf of Mexico and the eastern Caribbean. This suggests a limit of *B. brama* distribution in the eastern Caribbean. Zavala-Camin (1981) pointed out that 38 of 59 fish species collected from stomach contents of dolphinfish in southern and southeastern Brazil are juveniles of tropical species that inhabit the Brazilian current. From stomachs of dolphinfish in the southwestern Brazil, Zavala-Camin (1986) observed that only 139 fish specimens were truly epipelagic, in contrast with the 3,542 brephoepipelagic fish specimens encountered. This is an indication of an important energy transference on the part of brephoepipelagic fishes from neritic, bentonic, and mesopelagic zones to the epipelagic zone. Zavala-Camin (1997) points out the importance of juveniles of Balistidae, particularly *Balistes capriscus*, in the south and southwestern Brazilian waters. Exocoetidae are common items in the diet of dolphinfish in the tropical Pacific (Campos *et al.*, 1993), and Caribbean (Oxenford, 1999; Oxenford & Hunte, 1999). Nevertheless, Gibbs & Collette (1959) found no Exocoetidae among collections in the Gulf Stream, and Zavala-Camin (1986) showed that Exocoetidae have low importance in the southwestern Brazil. Exocoetidae are abundant in the present study area (Monteiro *et al.*, 1998), being the second most frequent food item in the diet, which corroborates with the local abundance.

Consumption rate for dolphinfish caught by tuna purse-seine in the eastern Pacific Ocean averaged 5.6% of body weight per day, ranging up to 9.6% for large males and up to 19.8% for small dolphinfish (Olson & Galván-Magaña, 2002). Feeding periodicity among dolphinfish in the eastern Pacific Ocean indicated peak feeding activity in the morning and early afternoon in the eastern region, and throughout the day in the southwestern region (Olson & Galván-Magaña, 2002). Most food items are composed of pelagic specimens that inhabit epipelagic environment during the day. Exceptions include the mesopelagic fish *Diaphus* sp. and the cephalopods *Chiroteuthis* sp., *Histioteuthis* spp., and Cranchiidae, which are luminescent organisms and absent from surface layers during the daylight hours. This food *spectrum* is coherent with feeding throughout the day, although dolphinfish may prey on some migrant luminescent organisms occasionally.

Canibalism was observed in this study and in other ones on dolphinfish (Rose & Hassler 1974; Zavala-Camin, 1981 and 1986; Palko *et al.*, 1982; Oxenford, 1999; Oxenford & Hunte, 1999; Olson & Galván-Magaña, 2002). Non-common or anthropogenic items were also found in the stomachs, such as plastic bags, cardboard, wood, carrots, onions, peanuts, nylon filaments, and longline hooks. Zavala-Camin (1981) found plastic bags, matches, wood, petroleum, and a lighter in dolphinfish from southeastern and southern Brazil. The ingestion of non-common items can occur due to visual confusion, smell (cardboard of bait boxes) and bright colors. These objects are found at the surface and near boats, which is where dolphinfish are more frequently present.

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