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BIOLOGY AND FISHERY OF DOLPHINFISH AND RELATED SPECIES. *E. MASSUTÍ and B. MORALES-NIN (eds.)*

Feeding habits of the dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean*

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SUMMARY: The dolphinfish, *Coryphaena hippurus*, is an oceanic epipelagic fish with economic importance to sport and commercial fisheries throughout its worldwide distribution in tropical and sub-tropical waters. In the eastern Caribbean, dolphinfish are generally piscivorous, eating a wide variety of fish species including small oceanic pelagic species (e.g. flyingfish, halfbeaks, man-o-war fish, sargassum and rough triggerfish), juveniles of large oceanic pelagic species (e.g. tunas, billfish, jacks, dolphinfish), and pelagic larvae of neritic, benthic species (e.g. flying gurnards, triggerfish, pufferfish, grunts). They also eat invertebrates (e.g. cephalopods, mysids, scyphozoans), suggesting that they are essentially non-selective foragers. This appears to be typical of dolphinfish from other locations and of tropical oceanic pelagic species in general. Post-larval flying gurnards and flyingfish rank as the most important prey species overall. However, the diet varies with season, and mysids are a very important component from October to December. Diet also varies slightly with predator size (small dolphinfish eat fewer flyingfish and more squid than larger sized dolphinfish), and with sex (males take proportionally more of the active, fast swimming species such as flyingfish, squid and dolphinfish than do females). From these results and a review of the literature to determine the diet of other tropical oceanic species and the predators of dolphinfish, it can be seen that predator-prey relationships and interspecies competition for food clearly involve other commercially important species. As such, interactions between the surface trolling dolphinfish fisheries, the surface gillnet flyingfish fisheries, and the subsurface longline tuna fisheries in the eastern Caribbean can be expected.

Key words: dolphinfish, *Corypheana hippurus*, diet, dolphinfish, eastern Caribbean

INTRODUCTION

Large maximum size, fast growth rates and extensive migration circuits appear to characterise oceanic pelagic fish in the tropics, (see Pauly, 1978; Fonteneau and Marcille, 1993; ICCAT, 1996; Fishbase, 1996). This is perhaps surprising given the limited food availability typical of tropical (oligotrophic) oceans. In this study we investigate the feeding habits of one such oceanic pelagic species, the dolphinfish (*Coryphaena hippurus*) in an attempt to further understand the feeding ecology of ocean pelagic fish species.

The dolphinfish is economically important to both commercial and sport fisheries throughout its circum-tropical distribution, (e.g. Collette, 1978, 1981, 1984, 1995; Palko *et al.,* 1982; FAO, 1994) and particularly in the eastern Caribbean, where it is one of the most important species landed by the pelagic fishing fleets of commercial and sport fisheries (Hunte, 1987; Mahon, 1993). However, management of oceanic pelagic resources within this

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region is virtually non-existant and biological and ecological information on which to base management decisions is often lacking (Mahon, 1996). One area in which there is little information is the feeding habits of the oceanic pelagic species, although understanding trophic-level interactions through predator-prey relationships is fundamental to predicting interactions among fisheries targetting species from a common food chain, and indeed to developing an ecosystem-based approach to management (an approach which is receiving increasing attention; e.g. Munro (1984), Christensen (1991), Sherman and Laughlin (1992)). In this study we attempt to comment on the possible interaction effects of the commercially important dolphinfish fishery with other fisheries targetting species that may be co-competitors for food resources, predators, or important components of the diet of dolphinfish.

Many authors have commented on the diet of dolphinfish from different locations (e.g. Atlantic Ocean: Schuck, 1951; Gibbs and Collette, 1959; Cabo, 1961; Lewis and Axelsen 1967; Rose and Hassler; 1974; Bannister, 1976; Manooch *et al.,* 1984; Pacific Ocean: Ronquillo, 1953; Tester and Nakamura, 1957; Kojima, 1961; Magnuson and Heitz, 1971; Hida, 1973; Indian Ocean: Ommanney, 1953; Williams, 1956). However, samples sizes were small in many of these studies, and only one study (Lewis and Axelsen, 1967; n=70) has made a preliminary examination of the diet of dolphinfish in the eastern Caribbean.

Analysis of stomach contents is the most direct method of investigating fish diet (see Hynes, 1950; Windell, 1971; Hyslop, 1980; Wootton, 1994 for a review of methods). Here we investigate the feeding habits of dolphinfish from the eastern Caribbean by examining the species composition and relative abundance of prey items, and by considering the effects of season and of predator size and sex/behaviour on diet composition.

METHODS

Freshly caught (< 6 hr old) dolphinfish were sampled from commercial fishers at landing sites around Barbados between January 1981 and June 1982. Viscera from 397 fish of both sexes, ranging in size from 185 to 1240 mm standard length (SL) were removed and stomachs were frozen for later examination of content. Wherever possible, food items were identified to species and then categorised into groups: fish into families; molluscs into the classes Cephalopoda or Gastropoda; crustaceans were all of the order Mysidacea; coelenterates were all of the class Scyphozoa; and algae were all of the genus *Sargassum*. All food items were counted and measured for length: fish in mm fork length (FL); squid in mm mantle length; crustaceans in mm from eyes to telson. When length measurements were not possible, estimates based on mean observed lengths were made for most species. In the case of dactylopterids, which have a bony head shield, the relationship between head shield length and FL was ascertained and was used to fill missing FL data when only the head shield remained. Dietary importance of prey items was assessed in three ways: firstly by numerical abundance (N) of prey items as a percentage of the total number of items in all food categories (e.g. Crisp *et al.*, 1978; Ikusemiju and Olaniyan, 1977); secondly as frequency of occurrence (F) of prey items in dolphinfish stomachs as a percentage of all stomachs examined (e.g. Frost, 1946, 1954; Hunt and Carbine, 1951); and thirdly as size contribution (L) of prey items as a percentage of the combined lengths of all prey items. Finally, an index of relative importance (IRI) of the different food categories was calculated using a modification of the relationship used by Pinkas *et al.* (1971), Prince (1975), and Manooch *et al.* (1984):

$$IRI = (N + L)\,F$$

Differences in the diet (based on numerical abundance of prey items) were evaluated by predator size using three groups (small: 100-499 mm SL, medium: 500-899 mm SL, large: 900-1299 mm SL), by sex and by season using chi-squared contingency tests. Relationships between predator and prey size were evaluated using standard correlation and linear regressions.

RESULTS

All fish

Dolphinfish from the eastern Caribbean are essentially piscivorous, with fish being found in 98% of all stomachs containing food. Only 45 (11%) of the dolphinfish examined had empty stomachs.

TABLE 1. – Relative importance of prey items of dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean.

Group	Prey Item Category	Species	Number (N)	Freq. of occurrence (F)	Combined lengths (mm) (L)
FISH	BALISTIDAE	Unidentified	10	8	494
		Balistes capriscus	16	9	872
		Canthidermis maculatus	17	11	700
		Xanthichthys ringens	132	40	7781
	BELONIDAE	Unidentified	10	8	2133
	CAPROIDAE	*Antigonia* sp.	10	7	320
	CARANGIDAE	Unidentified	42	14	1059
		Caranx sp.	6	5	240
		Decapterus sp.	2	2	130
		Seriola sp.	9	3	329
	CLUPEIDAE	Unidentified	3	3	123
	CORYPHAENIDAE	*Coryphaena hippurus*	5	4	1780
		C. equiselis	28	23	6647
	DACTYLOPTERIDAE	*Dactylopterus volitans*	3661	251	163134
	DIODONTIDAE	*Diodon* sp.	25	16	1813
		Chilomycterus sp.	2	2	140
	EXOCOETIDAE	*Hirundichthys affinis*	272	135	44347
		Cypselurus cyanopterus	2	2	463
	GRAMMICOLEPIDAE	*Xenolepidichthys* sp.	2	2	100
	HEMIRAMPHIDAE	*Hemiramphus* sp.	2	2	384
		Oxyporhamphus sp.	1	1	235
	HOLOCENTRIDAE	*Adioryx* sp.	4	2	163
	ISTIOPHORIDAE	*Istiophorus albicans*	5	5	1928
	MONACANTHIDAE	Unidentified	9	7	1535
		Alutera scripta	5	4	365
		Monacanthus sp.	5	5	250
		Cantherhines sp.	20	8	920
	MULLIDAE	*Mulloidichthys martinicus*	2	2	202
	MYCTOPHIDAE	Unidentified	8	4	1280
	NOMEIDAE	*Psenes* sp.	8	8	376
	POMADASYIDAE	Unidentified	3	2	180
	PRIACANTHIDAE	*Priacanthus cruentatus*	18	5	766
	SCOMBRIDAE	Unidentified	33	14	1608
		Scomberomorus cavalla	3	2	160
		Thunnus sp.			82
	SPHYRAENIDAE	*Sphyraena barracuda*	1	1	280
	STROMATEIDAE	Unidentified	5	5	171
	TETRAODONTIDAE	*Lagocephalus* sp.	84	53	6699
	TRICHIURIDAE	*Aphanopus* sp.	86	44	8794
	UNIDENTIFIED	Adults	13	8	2351
		Juveniles	241	110	12532
MOLLUSCS	CEPHALOPODA	Unidentified	95	59	-
		Spirula spirula	9	8	-
		Onychoteuthis antillarum	3	3	-
	GASTROPODA	*Janthina janthina*	2	1	-
ARTHROPODS	MYSIDACEA	Unidentified	1138	15	29042
COELENTERATES	SCYPHOZOA	Unidentified	1	1	-
ALGAE	SARGASSACEAE	*Sargassum* sp.	-	6	-
EMPTY STOMACHS			-	45	-
TOTALS			6058	397	310810

The stomach contents of 397 dolphinfish by occurrence, number and length of all prey items is given in Table 1. The diet comprises small oceanic pelagic fish (e.g. flyingfish (Exocoetidae), halfbeaks (Hemiramphidae), man-o-war fish (Nomeidae), sargassum and rough triggerfish (Balistidae)); juveniles of large pelagic fish (e.g. jacks (Carangidae), mackerels and tuna (Scombridae), dolphinfish (Coryphaenidae), sailfish (Istiophoridae)); and the pelagic larvae and juvenile phases of species which are generally found in shallow water coral or other benthic communities as adults (e.g. flying gurnards (Dactylopteridae), triggerfish (Balistidae), pufferfish (Tetraodontidae), porcupinefish (Diodontidae), grunts (Pomadasyidae) *inter alia*) (Table 1). Squid (Cephalopoda) occurred in 17%, planktonic mysids (Mysidacae) in 4%, sargassum weed in 2% and jellyfish (Scyphozoa) in < 1% of dolphinfish stomachs containing food.

The size distribution of all dolphinfish prey items (size range: 10-490 mm) is bimodal. The smallest size group (mode 50 mm) comprises mainly pelagic

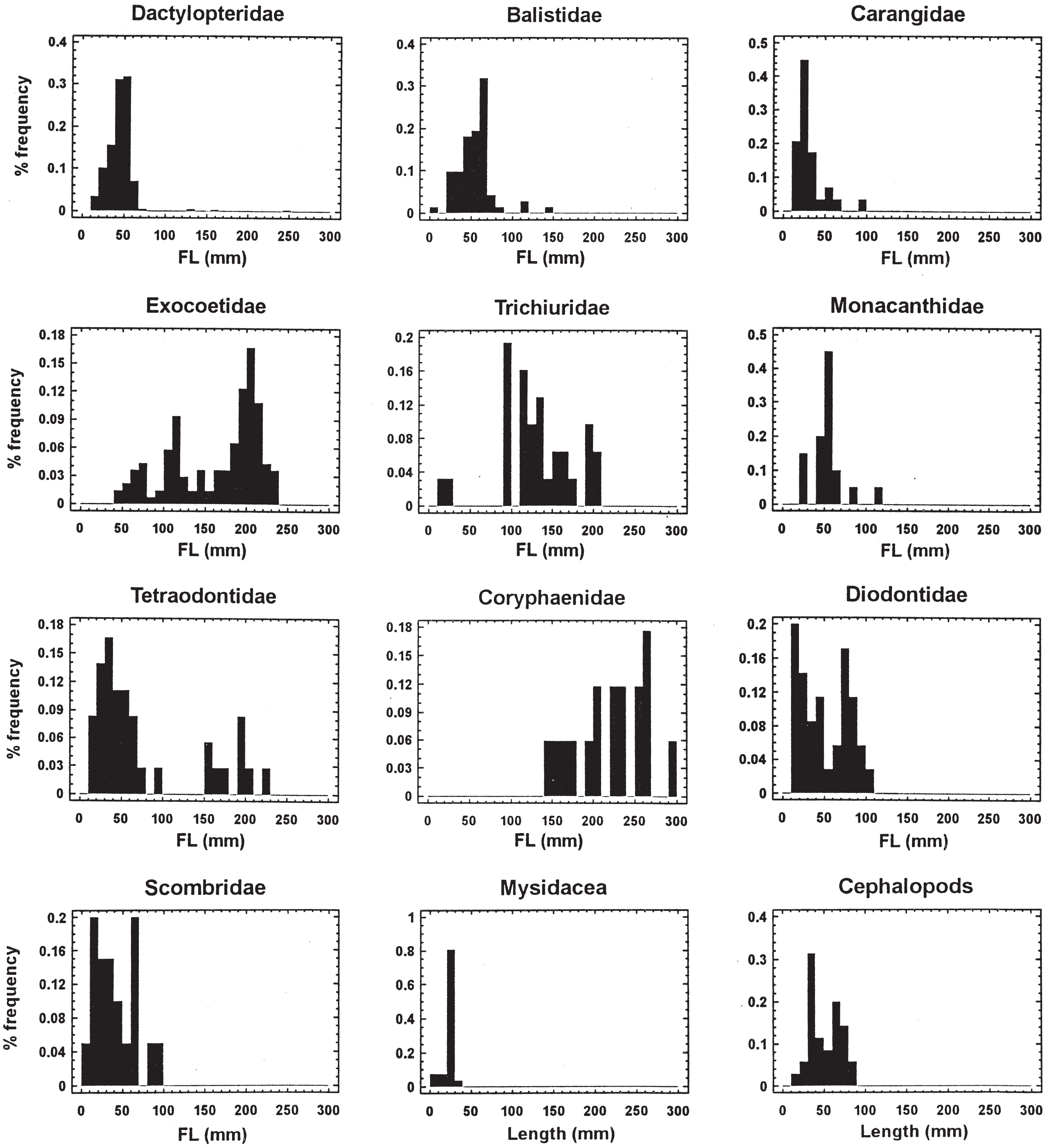

FIG. 1. – Length-frequency distributions for the major prey categories taken by dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean.

larvae, inshore species or sargassum community species, and the largest group (mode 200 mm) comprises mainly juveniles of large oceanic pelagic species or adults of small oceanic pelagic species

The relative importance of the 12 main prey categories is given in Table 2, and their size distribution is given in Figure 1. Juvenile flying gurnards, flyingfish, mysids, juvenile triggerfish, squid and juvenile pufferfish rank as the six most important overall prey categories.

Comparison between sexes

Fish is an equally important component in the diet of both sexes, occurring in 98% of both male and female stomachs containing food. Furthermore,

TABLE 2. – Relative dietary importance of the main prey categories of the dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean. IRI-index of relative importance.

Prey category	Numerical % (N)	% freq of occurrence (F)	% of total combined lengths (L)	IRI (N+L)F	IRI rank
Dactylopteridae	60.4	63.1	52.5	7124.0	1
Exocoetidae	4.5	34.4	14.7	660.5	2
Mysidacea	18.8	3.8	9.3	106.8	3
Balistidae	2.9	16.3	3.2	99.4	4
Cephalopoda	1.8	15.3	1.9	56.6	5
Tetraodontidae	1.4	13.3	2.2	47.9	6
Trichiuridae	1.4	11.1	2.8	46.6	7
Coryphaenidae	0.5	6.8	2.7	21.8	8
Carangidae	1.0	5.3	0.6	8.5	9
Monacanthidae	0.6	5.0	0.7	6.5	10
Diodontidae	0.5	4.5	0.6	5.0	11
Scombridae	0.6	3.5	0.6	4.2	12

there was no difference in the mean number of prey items consumed by males (16 items/stomach) and females (19 items/stomach) (Mann Whitney test: U=0.873, p=0.382). The frequency of empty stomachs did not differ between the sexes (males 11%, females 10%; chi-squared 2x2 contingency test: χ^2=0.08, p=0.784). However, the dietary importance of major prey categories (i.e. those with an abundance (N) >1% in at least one sex) was significantly different between sexes (chi-squared 2x9 contingency test: χ^2=264.36, p<0.001; Fig. 2). Males take proportionally more of the active, fast swimming species such as flyingfish, dolphinfish and squid, whereas females take proportionally more mysids, juvenile jacks and hairtails.

Comparison among size groups

Fish is an equally important component of the diet in all size groups of dolphinfish occurring in 94, 99 and 100% of small, medium and large dolphinfish stomachs respectively (chi-squared 3x2 contingency

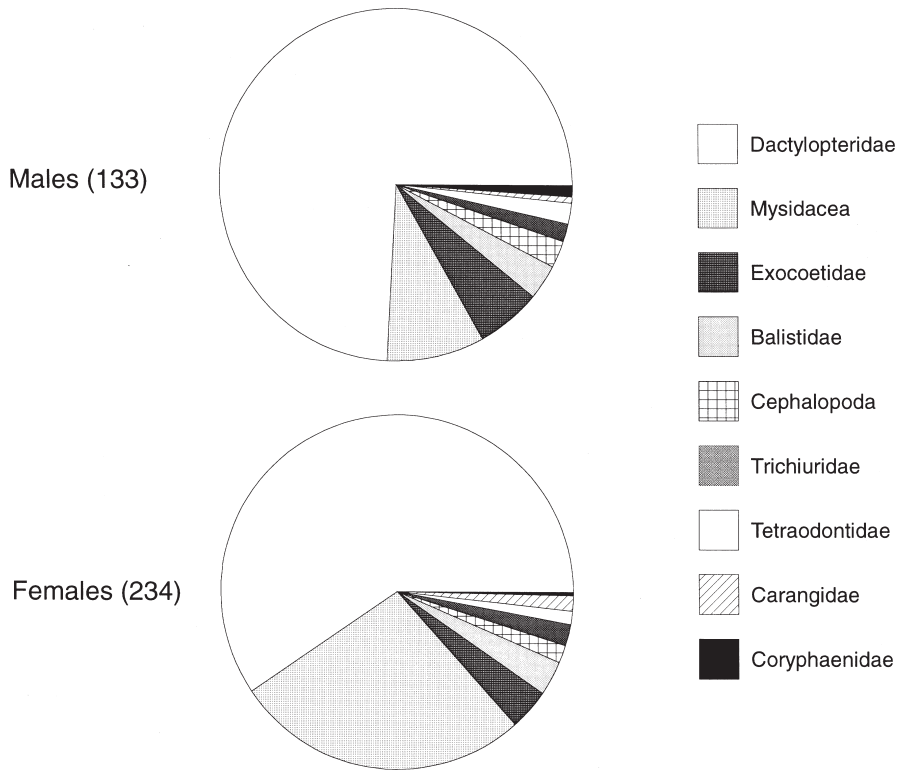

FIG. 2. – Relative dietary importance (by numerical abundance) of major prey categories of dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean, shown separately for males and females.

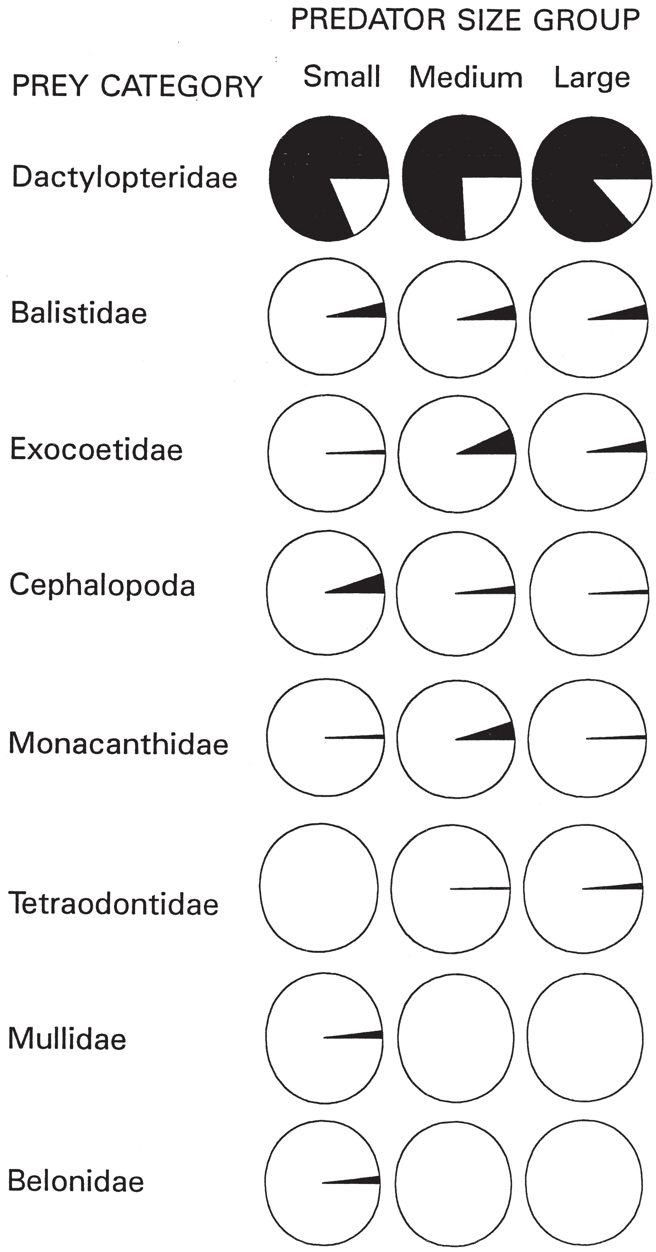

FIG. 3. – Relative dietary importance (by numerical abundance) of major prey categories of dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean, shown separately for small (100-499 mmSL, n=16), medium (500-899 mmSL, n=31) and large (900-1299 mmSL, n=60) sized dolphinfish sampled together in May, June and July.

test: χ^2=6.28, p=0.043). However, the frequency of occurrence of empty stomachs did vary between size groups (small: 6%, medium: 17%, large 4%; chi-squared 3x2 contigency test: χ^2=11.66, p=0.003), with medium-sized fish having a higher percentage.

The dietary importance of major prey categories (i.e. N>1% in at least one size group) compared among predator size groups occurring together in the same months (May-July) showed little difference among them, at least for the two top ranking prey categories (flying gurnards and triggerfish accounting for 87% and 4% of the diet respectively; chi-squared 2x3 contingency test: χ^2=5.99, p=0.201; Fig. 3). However, there was a statistically significant difference among predator size groups when all major prey categories were considered (chi-squared 3x8 contingency test: χ^2=115.64, p<0.001; Fig. 3), driven largely by a very few prey categories (i.e. filefish (Monacanthidae), goatfish (Mullidae) and needlefish (Belonidae)). Small dolphinfish appear to eat fewer flyingfish and more squid than the medium and large sized dolphinfish (Fig. 3).

The changes in diet composition with predator size do not appear to result from a change in prey size preference. For example, the sizes of all prey items do not increase with predator size (Linear correlation: predator vs. prey size; r=0.063, v=972, p=0.056). Moreover, there is no correlation between dolphinfish size and prey size within prey type for flyingfish, pufferfish, squid and dolphinfish (r<0.40, p>0.05 in all cases). However, there is a slight, but significant increase in prey size with predator size for flying gurnards (Linear regression: b=0.024, p<0.001) and for triggerfish (b=0.044, p<0.001).

Comparison among seasons

Fish remains the most important component of the diet throughout the year (Dec-Feb: 97%, Mar-May: 99%, Jun-Aug: 98%, Sept-Nov: 96%) and the frequency of empty stomachs does not vary between seasons (Dec-Feb: 16%, Mar-May: 10%, Jun-Aug: 2%, Sept-Nov: 10%; chi-squared 4x2 contingency test: χ^2=6.829, p=0.078). However, there are significant seasonal changes in major prey categories (i.e. N>1% in at least one season) (chi-squared 4x10 contigency test: χ^2=2094.25, p<0.001; Table 3). Flying gurnards are the most important prey for at least 8 months of the year (Jan-Aug), whilst mysids are the most important prey in October, November and December (Fig. 4). Flyingfish are taken throughout most of the year, whereas filefish are only important in June and July (Fig. 4).

TABLE 3. – Relative seasonal importance (as numercial abundance (N)) of major prey categories (i.e. N > 1% in at least one season) of dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean.

Prey category	Winter (Dec-Feb)	Spring (March-May)	Summer (June-Aug)	Autumn (Sept-Nov)
Dactylopteridae	692	1551	606	294
Mysidacea	657	0	0	481
Exocoetidae	68	152	37	17
Balistidae	19	36	72	48
Cephalopoda	18	55	24	10
Tetraodontidae	19	48	15	5
Trichiuridae	11	64	2	6
Carangidae	31	22	2	4
Monacanthidae	0	2	36	1
Diodontidae	8	2	0	17

DISCUSSION

No technique for examining fish diet is without fault (Wootton, 1994). Dietary importance of prey groups assessed by numerical abundance will tend

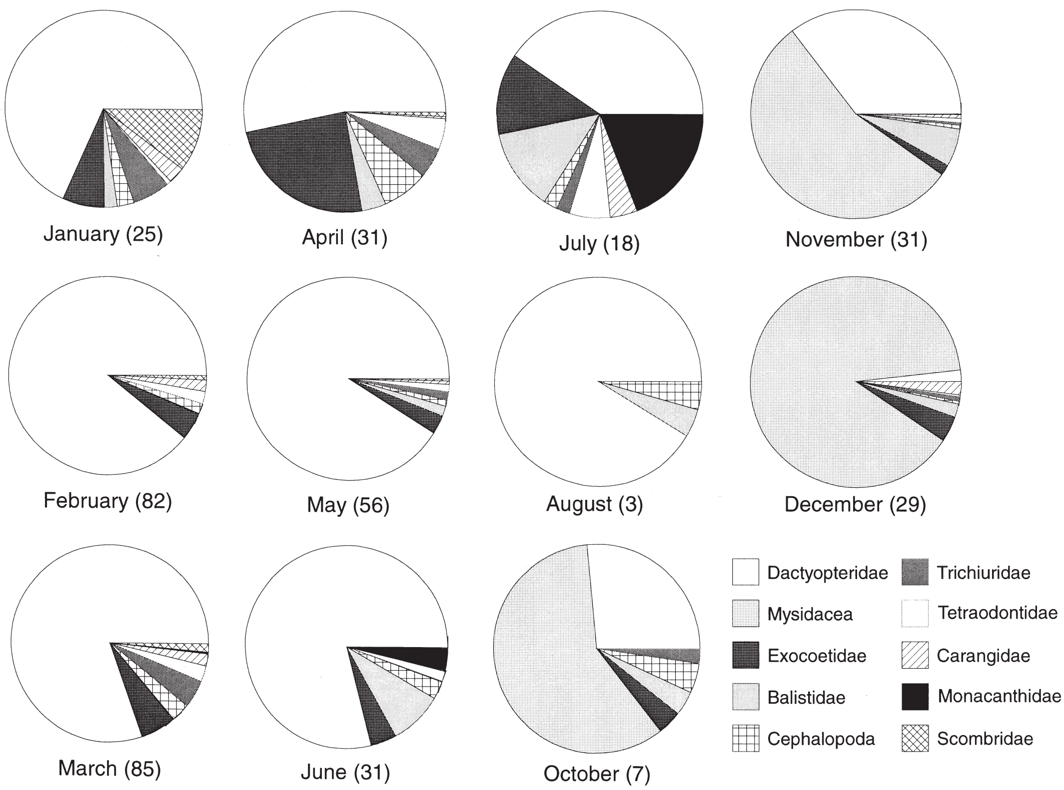

FIG. 4. – Relative dietary importance (by numerical abundance) of major prey categories of dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean, shown separately by month. NB: no fish were available in September.

to over-emphasize the importance of small prey taken in large numbers, (e.g. Hynes, 1950; Mann, 1973; Crisp *et al.,* 1978). This would apply to post-larval flying gurnards and mysid crustaceans, which rank first and second in the diet of dolphinfish by this method alone. Percentage occurrence methods provide a rough qualitative estimate of the food spectrum (Crisp, 1963; Fagade and Olaniyan, 1972), but will tend to under-estimate the importance of prey items taken by a few predators, but in large numbers. In this case an example would be mysids, which rank eleventh by this method alone. Dietary importance of prey categories by prey bulk is typically assessed by weight or volume (e.g. Parker, 1963; Glenn and Ward, 1968; Pedley and Jones, 1978; Manooch *et al.,* 1984). However, in this study prey lengths were used since they could be more accurately measured than weight or volume, given variation in the state of digestion of prey items.

The use of the IRI index was an attempt to minimise bias introduced by any single method. However, differences in resistance to digestion by different prey items may cause inaccuracies in some of the analyses (Berg, 1979). Nevertheless, they are unlikely to affect the general conclusions of this study, since the common fish prey could be recognised by their bones or scales and most invertebrates would be recognised by hard parts such as beaks (squid), shells (ram's horn squids and gastropods) or exoskeletons (mysids).

The percentage of dolphinfish with empty stomachs was lower than that reported for dolphinfish in the south and southeastern United States (16%; Manooch *et al.,* 1984), in North Carolina (17%; Rose and Hassler, 1974), and in the Sea of Japan (21%; Kojima, 1961). This probably reflects differences in the time of day when specimens were caught rather than any real differences in the feeding habits.

These results suggest that flyingfish and post-larval flying gurnards are the two most important diet components of dolphinfish in the eastern Caribbean. Lewis and Axelsen (1967), working with a small sample size and only in the months of February to June, reached a similar conclusion. All the common prey species in the dolphinfish stomachs are known to be epipelagic, indicating that dolphinfish feed in surface waters. The few deep sea specimens such as lanternfish (Myctophidae), larval boarfish (Caproidae) and ram's horn squid (*Spirula spirula*) which were found in the diet might suggest that dolphinfish also feed at great depths. However, lanternfish and many oceanic squid migrate to the surface at night (Leim and Scott, 1966; Fischer, 1978), and boarfish larvae are pelagic (Berry, 1978). Thus, dolphinfish probably remain in surface waters but occasionally feed at night. Night feeding by dolphinfish has been reported by Rothschild (1964) and Shcherbachev (1973).

Many of the prey species are commonly associated with floating objects or sargassum (see Hunter and Mitchell, 1967; Gooding and Magnuson, 1967; Ida *et al.,* 1967; Mitchell and Hunter, 1970; Dooley, 1972), indicating that dolphinfish feed below the floating objects at which they congregate (e.g. Imamura *et al.,* 1965; Kojima 1960a,b; Maniwa and Kojima, 1966; Gooding and Magnuson, 1967; Hunter and Mitchell, 1967; Gomes *et al.,* 1998). This is supported by the presence of sargassum and sugar cane trash (from which Barbadian fishers make FADs) in the stomachs of several dolphinfish, presumably ingested incidently during feeding (Oxenford, 1985). Sargassum fragments in the diet have also been reported by Gibbs and Collette (1959), Rose and Hassler (1974) and Manooch *et al.* (1984). Webb (1981) noted that dolphinfish are capable of considerable manoeverability by extending dorsal and ventral fins for acceleration turns and suggested that this was an adaptation for foraging under floating objects.

Differences in the diet of males and females is supportive of the proposed intersexual differences in schooling behaviour (Oxenford, 1985). Males take a higher proportion of free swimming pelagic species than females, which is consistent with the suggestion that they spend more time away from flotsam. The sexes did not differ in the proportion of fish with empty stomachs nor in the average number of prey consumed. This does not support the suggestion of Rose and Hassler (1974) that males eat more food than females.

A shift in diet as fish grow may inevitably result from the change in fish size, but as a consequence, intraspecific competition between juveniles and adults will be reduced. A slight increase in the average size of some prey species and a slight change in the frequency of different prey categories was observed in eastern Caribbean dolphinfish as they grow, and was also reported for North Carolina dolphinfish (Rose and Hassler, 1974) and dolphinfish from the southeastern and Gulf states of the USA (Manooch *et al*., 1984).

Apparent seasonal differences in the composition of the diet were observed, particularly in the abundance of flying gurnards and mysids. This is likely to be a reflection of the changes in availability of these prey species rather than prey preference changes by different sized dolphinfish, since both medium and large sized dolphinfish were sampled in all months, and small sized fish showed a similar preference for the top ranking prey category (flying gurnards).

The size of prey items of eastern Caribbean dolphinfish ranged from 10 to 490 mmFL and the distribution was bimodal. A similar range (10-390 mm) and bimodal distribution of prey sizes for dolphinfish was noted in Japan by Kojima (1961).

Juveniles of *C. hippurus* were found in 1.01% of the dolphinfish stomachs examined. Cannibalism has previously been reported in wild dolphinfish by Ronquillo (1953) and Kojima (1961) (but they did not report what percentage), by Tester and Nakamura (1957; 3.8%), by Gibbs and Collette (1959; 4.5%), by Shcherbachev (1973; 5.3% - but he did not differentiate between the two *Coryphaena* species), by Bannister (1976; 10%), by Rose and Hassler (1974; 3.8%) and by Mannoch *et al*. (1984; 1.6%). Given that the probability of being surrounded by kin is low, selection against cannibalism is unlikely.

A comparison of the diet of dolphinfish with that from other locations is summarised in Table 4. Flyingfish (Exocoetidae) rank in the first five prey categories in 86% of the locations by occurrence, in 43% by numerical abundance and in 100% by bulk. Other reports state that flyingfish are the primary food fish of dolphinfish in the Atlantic (Gudger, 1932; Farrington, 1949; Schuck, 1951; Migdalski, 1958), in the Pacific (Rothschild, 1964) and in the Indian Ocean (Ommanney, 1953); but Gibbs and Collette (1959) found no flyingfish in their sample of 46 dolphinfish from the Gulf Stream in the Atlantic. Triggerfish (Balistidae) rank in the first five prey categories in 71% of the locations by occurrence, 71% by numerical abundance and 60% by bulk, and jacks (Carangidae) in 43%, 43% and 40% respectively. Cephalopods rank in the first five prey categories in 71% of locations by occurrence but in only one location (Barbados) by numerical abundance and none by bulk. Tuna and mackerel (Scombridae) and dolphinfish (Coryphaenidae) rank among the first five prey categories in 60% of the locations by bulk, but in only one location (Mediterranean) by occurrence. Scombrids and Coryphaenids rank in the first five by numerical abundance in two locations (Gulf Stream and Philippines) and one location (Gulf Stream) respectively. Flying gurnards (Dactylopteridae) rank in the first five prey categories by numerical abundance, by occurrence and by bulk only in Barbados. The migratory nature, circum-tropical distribution and opportunistic feeding behaviour of dolphinfish make more quantitative diet comparisons between locations and between seasons difficult. As Manooch *et al*. (1984) point out, dolphinfish feed on virtually any available species of consumable-size fish or invertebrate, so diet differences are likely to reflect the different faunal assemblages present spatially and temporally. Such non-selective foraging is expected in habitats of low food availability (Krebs and McCleery, 1984), and appears to be typical of large oceanic pelagics (Scott and Tibbo, 1968). The implications of dolphinfish not always acting as a top-level predator are also important when considering an ecosystem management approach.

A comparison of dolphinfish diet with the diets of other large pelagic fish should allow comment on both their predators and their interspecific competition for food. The diet of large pelagics is very similar (tuna: see Dragovich, 1970; Dragovich and Potthoff, 1972; Hida, 1973; Fischer, 1978; Collette and Nauen, 1983; Cayre *et al.,* 1993; billfish: see Scott and Tibbo, 1968; Beardsley *et al.,* 1972; de Sylva, 1974; Fischer, 1978; Fischer *et al.,* 1981; Palko *et al.,* 1981; pelagic sharks: see Fischer, 1978; Fischer *et al.,* 1981; Compagno, 1984), suggesting the potential for interspecific competition. However, given their diverse diet, the importance of interspecific competition is difficult to ascertain and some authors (e.g. Beardsley *et al.,* 1972; Palko *et al.,* 1982) have suggested that it has little inhibitive effect on the competing populations. Nevertheless, competion for food has been reported between dophinfish and similar sized tuna such as *Euthynnus* spp., *Thunnus* spp. and *Katsuwonus* spp. (Parin, 1968; Collette and Nauen, 1983) and between dolphinfish and snake mackerel (*Gempylus serpens*) (Parin, 1968). Defining interspecific food competition as occurring where the presence of a food item exceeds 25% in two or more predators (Johnson, 1977), dolphinfish in Barbados waters would be competing with yellowfin tuna (*Thunnus albacares*) for flying gurnards (*Dactylopterus volitans*) and for filefish (Monacanthidae) (see Lewis and Axelsen, 1967).

A review of the diets of other oceanic pelagic species indicate that dolphinfish, particularly juveniles, serve as prey for many oceanic fish. Their

TABLE 4. – Dietary importance (by rank) of the five main prey categories of dolphinfish (*Coryphaena hippurus*) from each of several locations, assessed by (a) numerical abundance, (b) frequency of occurrence in the stomachs, and (c) total bulk (weights, volumes or lengths).

(a). Numerical abundance

Location		W.C.Atlantic	Gulf Stream		Barbados		Philippines	Japan
Data source		Manooch *et al.* (1984)	Gibbs & Collette (1959)	Rose & Hassler(1974)	Lewis & Axelsen (1967)	This study	Ronquillo (1953)	Kojima (1961)
No. dolphinfish		2219	46	396	70	397	26	1103
Fish	Ammodytidae	.	3	.	.	.	.	.
	Balistidae	1	5	3	4	4	.	.
	Carangidae	5	.	2	.	.	4	.
	Clupeidae	.	.	.	.	.	.	4
	Coryphaenidae	.	.	4	.	.	.	.
	Dactylopteridae	.	.	.	1	1	.	.
	Engraulidae	.	.	.	.	.	.	1
	Exocoetidae	.	.	.	3	3	.	2
	Gempylidae	.	1	.	.	.	.	.
	Holocentridae	.	.	.	.	.	4	.
	Monacanthidae	.	.	.	2	.	.	4
	Mullidae	.	.	.	.	.	2	3
	Nomeidae	.	.	.	5	.	.	.
	Ostraciidae	.	.	5	.	.	.	.
	Scombridae	.	2	.	.	.	3	.
	Syngnathidae	3	.	.	.	.	.	.
	Tetraodontidae	.	4	.	.	.	.	.
	Trichiuridae	.	.	.	.	.	1	.
Invertebrates	Cephalopoda	.	.	.	.	5	.	.
	Decapoda	4	.	1	.	.	.	.
	Mysidacea	.	.	.	.	2	.	.
	Stomatopoda	2	.	.	.	.	3	.

(b). Frequency of occurrence

Location		W.C. Atlantic	Gulf Stream		Barbados		Mediterranean	Worldwide	Hawaii
Data source		Manooch *et al.* (1984)	Gibbs & Collette (1959)	Rose & Hassler (1974)	Lewis & Axelsen (1967)	This study	Bannister (1976)	Shcherbachev (1973)	Tester & Nakamura (1957)
No. dolphinfish		2219	46	396	70	397	20	34	52
Fish	Acanthuridae	.	.	.	.	.	.	4	.
	Balistidae	1	3	2	4	3	.	4	.
	Carangidae	4	5	1	.	.	3	.	.
	Coryphaenidae	.	.	.	.	.	4	.	.
	Dactylopteridae	.	.	.	2	1	.	.	.
	Exocoetidae	5	.	4	1	2	1	1	1
	Monacanthidae	.	4	.	3	.	.	.	.
	Myctophidae	.	.	.	.	.	.	3	.
	Ostraciidae	.	.	.	.	.	.	.	4
	Scombridae	.	.	.	.	.	2	.	.
	Syngnathidae	.	.	.	.	.	.	.	5
	Tetraodontidae	.	.	.	.	5	.	.	.
Invertebrates	Cephalopoda	3	1	5	5	4	.	2	.
	Decapoda	2	2	3	.	.	.	.	3
	Stomatopoda	.	.	.	.	.	.	.	2

(c). Total bulk (weights, volumes or lengths)

Location		W.C. Atlantic	Gulf Stream	Barbados	Japan	Hawaii
Data source		Manooch *et al.* (1984)	Rose & Hassler (1974)	This study	Kojima (1966)	Tester & Nakamura (1957)
No. dolphinfish		2219	396	397	1103	52
Fish	Balistidae	3	4	4	.	.
	Belonidae	.	.	.	.	4
	Carangidae	4	3	.	.	.
	Clupeidae	.	.	.	3	.
	Coryphaenidae	1	5	.	4	.
	Dactylopteridae	.	.	1	.	.
	Diodontidae	5	.	.	.	5
	Engraulidae	.	.	.	1	.
	Exocoetidae	2	1	2	2	1
	Hemiramphidae	.	.	.	.	3
	Scombridae	.	2	.	5	2
	Trichiuridae	.	.	5	.	.
Invertebrates	Mysidacea	.	.	3	.	.

predators include large tuna (Parin, 1968; *Thunnus alalunga*: Murphy, 1914; *T. albacares*: Penrith, 1963; Dragovich and Potthoff, 1972; Takahashi and Mori, 1973; Matthews *et al.,* 1977), sharks (Parin, 1968; *Hexanchus griseus*: Bigelow and Schroeder, 1948), marlin (Sund and Girigorie, 1966; Parin, 1968: *Makaira nigircans*: Farrington, 1949; Takahashi and Mori, 1942; *Tetrapturus albidus*: Wallace and Wallace, 1942; Nakamura, 1971; Nakamura and Rivas, 1972; *T. audax*: Abitia-Cárdenas *et al.,* 1997), sailfish (*Istiophorus platypturus*: Beardsley *et al.,* 1972; Takahshi and Mori, 1973) and swordfish (*Xiphias gladius*: Gorbunova, 1969).

This attempt to identify competitors and predators of dolphinfish has necessarily been done by a literature review of fish diets from widespread locations. More investigations of the feeding habits of oceanic pelagic fish at specific geographical locations is necessary to more accurately define competitors and predators of individual dolphinfish stocks. Within the eastern Caribbean, predator-prey relationships and interspecies competition for food clearly involve other commercially important species. As such, interactions can be expected between the surface trolling dolphinfish fisheries, the surface gillnet fisheries targetting flyingfish (a key prey species) and the subsurface longline fisheries targetting tuna and billfish (co-competitors and predators). However, the interactions will be difficult to model, given the obvious flexibility in the feeding habits of the dolphinfish, which is apparently typical of tropical oceanic species.

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