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FOODS OF GREATER AMBERJACK, *Seriola dumerili*, AND ALMACO JACK, *Seriola rivoliana* (PISCES: CARANGIDAE), FROM THE SOUTH ATLANTIC BIGHT

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Abstract: Stomach contents of 81 greater amberjack, *Seriola dumerili*, 397 to 1,386 millimeters total length (TL) and 49 almaco jack, *S. rivoliana*, 276 to 1,094 mm TL, were examined. The stomachs contained fish, cephalopods, and crustaceans. Index of Relative Importance (IRI) was used to evaluate the contribution of major foods by combining frequency of occurrence, volume, and number. The five highest values for greater amberjack were unidentified fish, Clupeidae, Loliginidae, Bothidae, and Sparidae. For almaco jack, unidentified fish, Loliginidae, Balistidae, Penaeidae, and Portunidae were most important to the diet. Spearman Rank Correlation indicated that the jacks have similar patterns of prey utilization. They are large roving predators that feed on fishes and invertebrates that inhabit open ocean waters or reefs and wrecks.

Key Words: Seriola dumerili; *Seriola rivoliana*; fish foods; South Atlantic Bight.

INTRODUCTION

Most species in the family Carangidae (jacks) are important to ocean recreational fisheries. The Florida pompano, *Trachinotus carolinus*, is perhaps the most popular, certainly the best known for its palatability. Other carangids such as the greater amberjack, *Seriola dumerili*, almaco jack, *S. rivoliana*, banded rudderfish, *S. zonata*, lesser amberjack, *S. fasciata*, blue runner, *Caranx crysos*, crevale jack, *C. hippos*, bar jack, *C. ruber*, permit, *Trachinotus falcatus*, and African pompano, *Alectis ciliaris*, are excellent gamefish also. The members of the genus *Seriola* are the largest jacks, some attaining weights approaching 91 kg. Of this group, the greater amberjack is the largest member. The species is far ranging, inhabiting inlets and shallow reefs down to depths of 350 m in the Mediterranean Sea and Atlantic, Pacific, and Indian Oceans. In the western Atlantic the greater amberjack is distributed from Nova Scotia to Brazil, including the Gulf of Mexico and the

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Caribbean, usually concentrating around reefs, rock outcrops, and wrecks and are generally restricted to the continental shelf.

The almaco jack is found in warm waters on both sides of the Atlantic. In the western Atlantic, they range from Massachusetts to Brazil, but are rare north of North Carolina. The almaco jack usually occurs in deeper water and is reported to be more oceanic in its habits than the greater amberjack (Berry and Smith-Vaniz, 1977).

Saltwater fishermen along the southeastern United States catch almaco jack less frequently than they do greater amberjack. Head boat[2] anglers in the region catch approximately three times more greater amberjack than almaco (R. L. Dixon, pers. comm., NMFS, SEFC, Beaufort Laboratory). Catches of *Seriola* off Miami, Fla. by charter boat[3] fishermen were comprised of 82% greater amberjack, 17.5% almaco, and 0.5% banded rudderfish (Burch, 1979).

Although some amberjacks are caught by commercial fishermen using longlines, pounds nets, gill nets, fish traps, and trawls, most are landed by recreational fishermen who use hook and line. North Carolina charter boat anglers caught 49,485 kg of amberjacks in 1977 (Manooch and Laws, 1979) and 20,625 kg in 1978 (Manooch et al., 1981). Amberjacks (greater and almaco combined) ranked fourth and ninth of all fish caught by anglers fishing from charter boats for the two years. In Florida, the recreational catch of greater amberjack may have exceeded 908,000 kg in 1977 (Berry and Burch, 1979).

Little information is available on the life histories of either species, particularly about their food habits. The National Marine Fisheries Service (NMFS), Southeast Fisheries Center, initiated studies along the southeastern United States in the 1970's to expand the biological data base on pelagic and reef fish stocks. Our study was a cooperative effort by the Coastal Pelagics Task, NMFS, Beaufort Laboratory, and the Reef Fish Program, NMFS, Beaufort Laboratory. Its objective was to identify foods and compare diets of greater amberjack and almaco jack collected in the South Atlantic Bight.

METHODS

Most of the stomachs analyzed in this study were from fish collected from April 1978 to November 1981 at North Carolina and South Carolina recreational fishery ports, although a few fish were caught by anglers between South Carolina and Cape Canaveral, Fla. Samplers, who planned their efforts to coincide with local charter boat and head boat fishing activities, primarily from April through November, met boats as a day's catch was being unloaded. Individual fishermen were asked to participate by letting samplers weigh, measure, and eviscerate their catch. Fish were measured to the nearest millimeter (total length) and weighed to the nearest tenth of a kilogram. Stomachs and gonads were placed in labeled cloth bags or cheesecloth and preserved in 10% formalin.

In the laboratory, stomach contents were identified to the lowest possible taxon and were counted. Frequency of occurrence of materials was determined by counting every stomach that contained at least one specimen or part of a specific item

[2] A boat that furnishes trips and charges on a per passenger basis.

[3] A boat for hire which charges on a fixed daily rate regardless of the number of passengers.

(taxon). Empty stomachs were excluded from computations. The volume of each taxon was obtained by water displacement.

Larval and juvenile fish in the stomachs were identified after they had been cleared and stained following the methods discussed by Dingerkus and Uhler (1977) and by Taylor and Van Dyke (1978). Parasitic nematodes, encountered occasionally in the stomachs, were separated from food items, identified, counted, and preserved for later study. A stomach containing only parasites was considered empty.

All data were analyzed as percent frequency of occurrence, percent of total number, and percent of food volume. Once frequencies, volumes, and numbers of the various foods were obtained, an Index of Relative Importance (IRI) was used to estimate the contribution of major food groups to the diet (Pinkas et al., 1971) and calculated as

$$IRI = (N + V)F,$$

where N = numerical percentage of a food, V = volumetric percentage, and F = percentage frequency of occurrence. Differences in diets, based on IRI values of foods, were evaluated by Spearman Rank Correlation (r_s) (Fritz, 1974). The equation for tied (rankings are equal for two or more food categories) classifications (Fritz, 1974) rather than the equation for untied categories was used:

$$r_s = \frac{\Sigma x^2 + \Sigma y^2 - \Sigma d^2}{2\sqrt{\Sigma x^2\, \Sigma y^2}} \text{ where}$$

$$\Sigma x^2 = \frac{N^3 - N}{N} - \Sigma Tx,$$

$$\Sigma y^2 = \frac{N^3 - N}{N} - \Sigma Ty,$$

$$T = \frac{t^3 - t}{N}.$$

N = numbers of ranks, d = difference between ranks, T = correlation factor for ties, and t = number of observations tied at a given rank.

RESULTS AND DISCUSSION

Stomachs of 81 (72 with food) greater amberjack, 397 to 1,386 mm TL, and 49 (47 with food) almaco jack, 276 to 1,094 mm TL, were examined. Stomach contents of both species were grouped into three principal categories: fish, cephalopods, and crustaceans (Tables 1, 2; Fig. 1). Major representatives of each group are discussed below under separate headings and are analyzed later to identify diet differences. The overall proportion of selected foods to the diet is presented graphically (Fig. 1).

Fish

Fishes occurred in 86% of greater amberjack and 77% of almaco jack stomachs (Tables 1, 2). Prey consisted primarily of species that occur on or near reefs as adults, although some, such as juvenile balistids, are frequently found at the water's surface. In all, 14 families were identified. The most frequently occurring fish

Table 1

Stomach contents of greater amberjack, *Seriola dumerili*, collected from the South Atlantic Bight, April 1978 to November 1981.

Item	Frequency of Occurrence (N = 72)	Percent Frequency	Number of Items (N = 303)	Percent by Number	Volume (ml) (3,484.0)	Percent by Volume
Fish	62	86.11	259	85.48	2,895.5	83.11
Unid. fish	28	38.89	184	60.73	543.0	15.58
Clupeidae	18	25.00	35	11.55	578.5	16.60
Unid. clupeids	13	18.05	27	8.91	398.5	11.44
Etrumeus teres	5	6.94	8	2.64	180.0	5.17
Synodontidae	2	2.78	4	1.32	250.0	7.18
Synodus foetens	1	1.39	3	0.99	210.0	6.03
Trachinocephalus myops	1	1.39	1	0.33	40.0	1.15
Serranidae	4	5.55	5	1.65	137.0	3.93
Unid. serranids	3	4.17	4	1.32	57.0	1.64
Centropristis striata	1	1.39	1	0.33	80.0	2.30
Carangidae	1	1.39	1	0.33	11.0	0.32
Decapterus punctatus	1	1.39	1	0.33	11.0	0.32
Lutjanidae	1	1.39	2	0.66	130.0	3.73
Rhomboplites aurorubens	1	1.39	2	0.66	130.0	3.73
Haemulidae	1	1.39	2	0.66	180.0	5.17
Haemulon aurolineatum	1	1.39	2	0.66	180.0	5.17
Sparidae	3	4.17	6	1.98	291.0	8.35
Stenotomus sp.	3	4.17	6	1.98	291.0	8.35
Sciaenidae	1	1.39	1	0.33	60.0	1.72
Leiostomus xanthurus	1	1.39	1	0.33	60.0	1.72
Labridae	1	1.39	1	0.33	20.0	0.57
Scombridae	1	1.39	1	0.33	145.0	4.16
Euthynnus alletteratus	1	1.39	1	0.33	145.0	4.16
Triglidae	1	1.39	4	1.32	80.0	2.30
Bothidae	6	8.33	8	2.64	431.0	12.37
Syacium papillosum	1	1.39	1	0.33	200.0	5.74
Unid. bothid	5	6.94	7	2.31	231.0	6.63
Balistidae	3	4.17	5	1.65	39.0	1.12
Unid. balistid	1	1.39	2	0.66	9.0	0.26
Monacanthus hispidus	2	2.78	3	0.99	30.0	0.86
Invertebrates	21	29.17	44	14.52	588.5	16.89
Cephalopoda	16	22.22	37	12.21	563.0	16.16
Loliginidae	15	20.83	36	11.88	443.0	12.71
Octopodidae	1	1.39	1	0.33	120.0	3.44
Crustacea	6	8.33	7	2.31	25.5	0.73
Penaeidea	4	5.55	5	1.65	23.5	0.67
Unid. penaeids	2	2.78	2	0.66	17.5	0.50
Sicyonia sp.	2	2.78	3	0.99	6.0	0.17
Albuneidae	1	1.39	1	0.33	1.0	0.03
Portunidae	1	1.39	1	0.33	1.0	0.03

families in greater amberjack stomachs were Clupeidae (25%), Bothidae (8%), Serranidae (5%), Balistidae (4%), and Sparidae (4%). Families that occurred most frequently in almaco jack stomachs were Serranidae (8.5%), Clupeidae (6%), Synodontidae (4%), Scombridae (4%), and Balistidae (4%). Unidentifiable fishes were

Table 2

Stomach contents of almaco jack, *Seriola rivoliana,* collected from the South Atlantic Bight, April 1978 to November 1981.

Item	Frequency of Occurrence (N = 47)	Percent Frequency	Number of Items (N = 158)	Percent by Number	Volume (ml) (1,726.0)	Percent by Volume
Fish	36	76.60	106	67.09	1,542.5	89.37
Unid. fish	23	48.94	33	20.89	250.5	14.51
Clupeidae	3	6.38	15	9.49	130.0	7.53
Unid. clupeid	1	2.13	3	1.90	25.0	1.45
Etrumeus teres	2	4.25	12	7.59	105.0	6.08
Synodontidae	2	4.25	10	6.33	37.0	2.14
Synodus foetens	1	2.13	9	5.70	27.0	1.56
Trachinocephalus myops	1	2.13	1	0.63	10.0	0.58
Serranidae	4	8.51	4	2.53	181.0	10.49
Unid. serranid	1	2.13	1	0.63	6.0	0.35
Centropristis striata	1	2.13	1	0.63	40.0	2.32
Serranus phoebe	2	4.25	2	1.27	135.0	7.82
Haemulidae	1	2.13	1	0.63	80.0	4.63
Haemulon aurolineatum	1	2.13	1	0.63	80.0	4.63
Sciaenidae	1	2.13	1	0.63	100.0	5.79
Unid. sciaenid	1	2.13	1	0.63	100.0	5.79
Scombridae	2	4.25	2	1.27	250.0	14.48
Scorpaenidae	1	2.13	4	2.53	60.0	3.48
Triglidae	1	2.13	2	1.27	44.0	2.55
Bothidae	1	2.13	3	1.90	120.0	6.95
Syacium papillosum	1	2.13	3	1.90	120.0	6.95
Balistidae	2	4.25	31	19.62	290.0	16.80
Unid. balistid	1	2.13	3	1.90	110.0	6.37
Monacanthus hispidus	1	2.13	28	17.72	180.0	10.43
Invertebrates	20	42.55	52	32.91	183.5	10.63
Cephalopoda	12	25.53	13	8.23	72.5	4.20
Loliginidae	11	23.40	12	7.59	69.5	4.03
Octopodidae	1	2.13	1	0.63	3.0	0.17
Crustacea	9	19.15	39	24.68	111.0	6.43
Unid. crustacean	1	2.13	1	0.63	1.0	0.06
Stomatopoda	1	2.13	3	1.90	1.0	0.06
Penaeidea	3	6.38	18	11.39	30.0	1.74
Unid. penaeids	2	4.25	17	10.76	18.5	1.07
Sicyonia sp.	1	2.13	1	0.63	11.5	0.67
Caridea	1	2.13	3	1.90	5.0	0.29
Leptochela serratorbita	1	2.13	3	1.90	5.0	0.29
Scyllaridae	1	2.13	3	1.90	1.0	0.06
Galatheidae	1	2.13	1	0.63	0.5	0.03
Galathea sp.	1	2.13	1	0.63	0.5	0.03
Portunidae	6	12.80	9	5.70	71.5	4.14
Unid. portunids	5	10.64	7	4.43	48.5	2.81
Portunus sayi	1	2.13	1	0.63	15.0	0.87
P. spinicarpus	1	2.13	1	0.63	8.0	0.46
Unid. crab	1	2.13	1	0.63	1.0	0.06

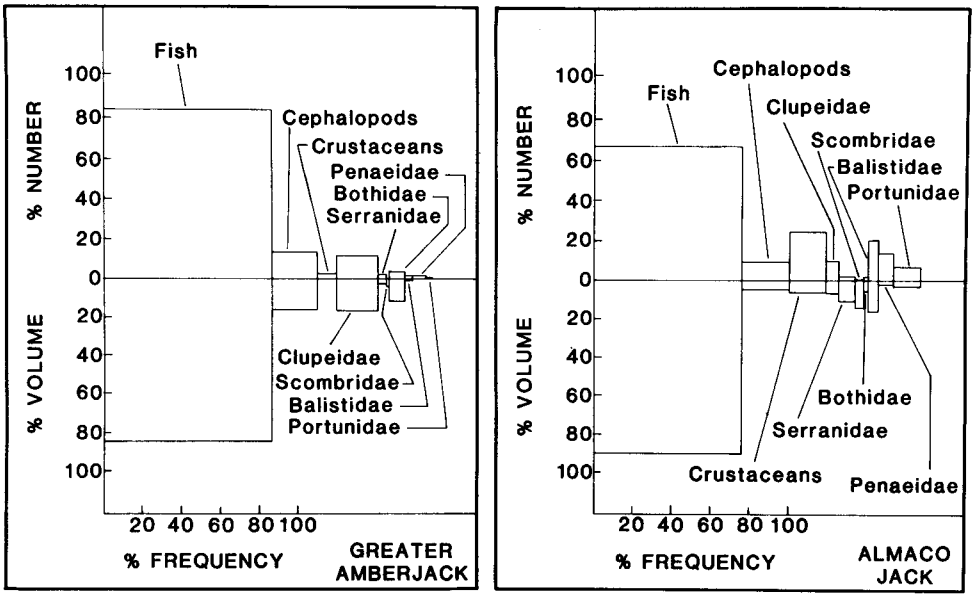

FIG. 1. Relative importance (IRI = (N + V)F) for selected foods of greater amberjack, *Seriola dumerili*, and almaco jack, *S. rivoliana*, used to calculate IRI values.

found in 39% of the amberjack and in 49% of the almaco jack stomachs containing food.

Cephalopods

Cephalopods (Loliginidae and Octopodidae) were the only molluscan prey of both jack species. Large *Loligo* squids were the most important by frequency of occurrence and volume: 20.8% and 12.8%, respectively, for greater amberjack and 23.4% and 4%, respectively, for almaco jack. By comparison, octopodids, represented by *Octopus* sp., appeared in only one stomach of the greater amberjack and none of the almaco jack.

Crustaceans

Crustaceans were more numerous in almaco jacks than in greater amberjacks. By frequency of occurrence, number, and volume, crustaceans comprised 19%, 25%, and 6%, respectively, of the almaco jack diet compared with only 8%, 2%, and 1%, respectively, of the greater amberjack food intake (Tables 1, 2). Some of the crustaceans were shrimps and crabs that live on or near the bottom; others such as portunid crabs, may be found near the water surface in the proximity of floating *Sargassum* (S. Morgan, pers. comm., Univ. of Maryland, College Park). Major taxa in the diet of greater amberjack by frequency of occurrence were Penaeidea (5.6%), unidentifiable penaeids (2.3%), and *Sicyonia* sp. (2.3%) (Table 1). For almaco jack, the most frequently encountered were Portunidae (12.8%), Penaeidae (8.5%), and unidentifiable penaeids (6.4%). Almaco jack stomachs also contained stomatopods and a galatheid crab (Table 2).

In other studies, Randall (1967), who examined eight greater amberjack, 890

Table 3

Index of relative importance (IRI) rankings for selected foods of greater amberjack and almaco jack collected from the South Atlantic Bight, April 1978 to November 1981.

	Greater Amberjack		Almaco Jack	
Item	IRI	Rank[a]	IRI	Rank
Unid. fish	2,967.7	25	1,732.5	25
Clupeidae	703.8	24	108.6	19
Synodontidae	23.6	19	36.0	17
Serranidae	31.0	20	110.8	20
Carangidae	0.9	9	—	3
Lutjanidae	6.1	14	—	3
Haemulidae	8.1	16	11.2	13
Sparidae	43.1	21	—	3
Sciaenidae	2.8	11	13.7	15
Labridae	1.3	10	—	3
Scombridae	6.2	15	66.9	18
Scorpaenidae	—[b]	3.5	12.8	14
Triglidae	5.0	12	8.1	12
Bothidae	125.0	22	18.9	16
Balistidae	11.6	17	154.8	23
Loliginidae	512.2	23	271.9	24
Octopodidae	5.2	13	1.7	9
Unid. crustaceans	—	3.5	1.5	8
Stomatopoda	—	3.5	4.2	10.5
Penaeidae	12.9	18	130.4	22
Scyllaridae	—	3.5	4.2	10.5
Albuneidae	0.5	7.5	—	3
Galatheidae	—	3.5	1.4	6.5
Portunidae	0.5	7.5	126.0	21
Unid. crabs	—	3.5	1.4	6.5

[a] Foods are ranked from highest IRI value (highest rank) to lowest IRI value (lowest rank).
[b] A blank (—) indicates the food items did not occur in the diet of one predator but was identified in the stomachs of the other.

to 1,180 mm FL, from West Indian reefs, found two empty stomachs and six that contained fish—unidentified balistid, *Calamus* sp., *Caranx ruber, Haemulon aurolineatum,* and *Priacanthus arenatus.* One also contained a small piece of coral rubble. In a more thorough study, Burch (1979) analyzed the stomach contents of 364 greater amberjack collected off south Florida. Eighty-five percent contained fish, 11.9% crustaceans, and 15.9% cephalopods. Of the identifiable foods, squids, jacks, portunid crabs, snappers (Lutjanidae), searobins (Triglidae), and herrings (Clupeidae) occurred most frequently. We are not aware of any food studies of almaco jack.

Diet Comparisons

Indices of Relative Importance (IRI), which represent the combined contributions of volume, frequency of occurrence, and numbers of each food item in the diet (Table 3), showed that fishes were very important foods for both species although more so for greater amberjack. The first five categories (ranks) were unidentified fish, Clupeidae, Loliginidae (squids), Bothidae, and Sparidae for great-

er amberjack and unidentified fish, Loliginidae, Balistidae, Penaeidae, and Portunidae for almaco jack. Overall, 14 of the 25 food groups occurred in the stomachs of both species, and 8 of the 10 most important categories for greater amberjack also ranked in the top 10 for almaco jack. The obvious qualitative conclusion is that the species have similar diets, and this observation was supported statistically by testing the data from Table 3, ranked by IRI values, with a Spearman Rank Correlation Coefficient (r_s). The resulting value (0.5538 with 23 d.f.; $p < 0.05$) indicated a moderate correlation between the two sets of data.

However, even with this statistical comparison, we still had a question concerning feeding location in the water column. To test the impression that greater amberjack fed more extensively on benthic organisms such as bothids, reef fishes, crabs, etc. than almaco jack, we used data from Tables 1 and 2 and grouped selected foods into two categories: 1) those usually found on or near the bottom (Bothidae, Triglidae, Scorpaenidae, Labridae, Sciaenidae, Sparidae, Haemulidae, Lutjanidae, Serranidae, and Synodontidae) and 2) those with more pelagic habits (juvenile Balistidae, Scombridae, Carangidae, Clupeidae, squids, and juvenile Portunidae). Percentages by number and volume totaled for the two groups in each predator were compared. As we expected, almaco jack consumed a higher percentage of non-bottom associated foods than did greater amberjack (43.67% and 46.98% by number and volume, respectively, compared with 26.07% and 34.94%). Frequency of occurrence percentages could not be totaled because of the way frequencies are determined. However, examination of the tables reveals little difference in the occurrence of benthic and non-benthic foods for the two carangids.

In summary, the two carangids are large aggressive predators that feed on fishes and large motile invertebrates such as cephalopods and decapod crustaceans. Although some prey species inhabit the upper water column, many are associated with reefs and wrecks. Randall (1967) states that the greater amberjack is a large roving predator that often makes excursions over reefs in quest of fishes. We believe that the almaco jack as well as the greater amberjack make feeding excursions over reefs and during these times feed on fishes and invertebrates.

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