

Gulf and Caribbean Research

Volume 12 | Issue 1

January 2000

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Recommended Citation

Franks, J. S. and K. E. VanderKooy. 2000. Feeding Habits of Juvenile Lane Snapper *Lutjanus synagris* from Mississippi Coastal Waters, with Comments on the Diet of Gray Snapper *Lutjanus griseus*. *Gulf and Caribbean Research* 12 (1): 11-17.

Retrieved from <https://aquila.usm.edu/gcr/vol12/iss1/2>

DOI: <https://doi.org/10.18785/gcr.1201.02>

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FEEDING HABITS OF JUVENILE LANE SNAPPER *LUTJANUS SYNAGRIS* FROM MISSISSIPPI COASTAL WATERS, WITH COMMENTS ON THE DIET OF GRAY SNAPPER *LUTJANUS GRISEUS*

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ABSTRACT Stomach contents analysis was used to quantitatively describe the diets of juvenile lane snapper, *Lutjanus synagris*, and juvenile gray snapper, *Lutjanus griseus*, from the northern Gulf of Mexico. Juvenile snapper were collected by trawling at two estuarine, deep channel sites in Mississippi coastal waters from September 1996 to January 1997. Lane snapper ($n = 53$) and gray snapper ($n = 12$) both consumed a variety of prey organisms, but primary prey were amphipods, decapods (shrimp and crabs), and fishes. The most important prey items for lane snapper based on percent Index of Relative Importance (%IRI) were shrimp remains (44%IRI), the shrimp *Latreutes parvulus* (23%IRI) and fish remains (13%IRI). Fishes of the genus *Anchoa* (43%IRI), shrimp remains (21%IRI) and the amphipod *Corophium* sp. (13%IRI) dominated the gray snapper diet. Intraspecific comparisons of lane snapper diet revealed significant overlap between collection sites, seasons and fish sizes.

INTRODUCTION

Lane snapper (*Lutjanus synagris*) and gray snapper (*Lutjanus griseus*) occur in the western Atlantic from the mid-eastern coast of the United States and Bermuda southward to Brazil, including the Caribbean and the Gulf of Mexico (Gulf) (Hoese and Moore 1998). Although widespread throughout the northern Gulf, these 2 lutjanid species are generally less abundant than in the southern Gulf (Benson 1982, Pattillo et al. 1997). Adults of both species generally inhabit offshore reefs and other hard bottom features, whereas juveniles typically occur inshore and are often found in seagrass beds and over mud bottom (Randall 1967, Acosta and Appeldoorn 1992, GMFMC 1981). In the northern Gulf, juveniles of both species consistently occur within the Mississippi Sound estuary (Wieland 1994, Warren and Perry 1996, Pattillo et al. 1997).

Temperature ranges for lane and gray snapper are similar; however, gray snapper are apparently more tolerant of low salinity waters. Lane snapper are found at temperatures between 15.0 and 27.5°C and salinities between 19.0 and 35.0‰ (Springer and Woodburn 1960), whereas gray snapper are found between 13.0 and 32.5°C (Springer and Woodburn 1960) and between 1.0 and 35.0‰ (Starck 1970). Juvenile lane (15–104 mm standard length, SL) and gray (11–113 mm SL) snapper have been reported from Mississippi coastal waters ranging from 11.5 to 31.5°C and 7 to 33‰ for lane and from 14.8 to 34°C and 5 to 33‰ for gray^a.

Both species support important commercial and recreational fisheries in the northern Gulf (GMFMC 1981). The combined annual commercial (1990–1997^b)

and recreational (1990–1998^c) landings for lane and gray snapper from the Gulf averaged 225,000 kg and over 636,000 kg, respectively. Despite the commercial and recreational importance of lane and gray snapper in the Gulf, their life history and ecological roles in the northern Gulf require further study. Biological and ecological aspects of lane and gray snapper from southern Florida were studied by Springer and Woodburn (1960), Starck (1970), Manooch and Mason (1984), Bortone and Williams (1986), Rutherford et al. (1989a, b) and Chester and Thayer (1990). Dietary studies of gray snapper in south Florida were conducted by Croker (1962), Starck (1970), Rutherford et al. (1983), Hettler (1989) and Harrigan et al. (1989). In the northern Gulf, Shipp (1991) and Johnson et al. (1995) examined age and growth of lane snapper. There are no published life-history studies on gray snapper from the northern Gulf; however, the feeding habits of juvenile gray snapper from northwest Florida were examined by Koenig^d. Information on feeding habits of lane and gray snapper in the northern Gulf is important for understanding the life history of these 2 species whose juveniles occupy estuarine habitat. Thus, the purpose of our study was to quantitatively describe the diet of juvenile lane and gray snapper from Mississippi coastal waters.

MATERIALS AND METHODS

Juvenile lane and gray snapper were collected from the eastern Mississippi Sound with a 5 m otter trawl with 35 mm codend mesh. Lane snapper were collected between November 1996 and March 1997, and gray snapper were collected between September 1996 and January

1997. Trawling was conducted between 0700 and 1500 h, and upon removal from the net, snappers were placed on ice to minimize digestive activity. At the dock, specimens were placed in labeled plastic bags and frozen, then later provided to us for examination.

Specimens were collected at 2 sites: Site 1 was located at the mouth of the East Pascagoula River (30°21'N, 88°34'W) with depth ranging from 10 to 12 m; Site 2 was located at the mouth of Bayou Casotte (30°0'N, 88°31'W), a large bayou located about 3 km east of Site 1, with depth ranging from 13 to 14 m. Both collection sites were located within industrial shipping channels near their confluence with the Mississippi Sound. The dominant substratum at both sites was a mud and shell rubble mixture. Bottom temperatures ranged from 15 to 18°C at the East Pascagoula River site and from 16 to 20°C at the Bayou Casotte site, and salinities ranged from 25 to 30‰ at both sites.

In the laboratory, specimens were thawed, measured to the nearest 0.1 mm SL, blotted dry, and weighed to the nearest 0.01 g. Stomachs were removed and placed in labeled vials containing 95% ethanol. Stomachs were later opened, and the contents were sorted, identified to the lowest possible taxonomic level and counted. In each stomach, all remnants identified as the same taxa were scored as a single prey item unless items obviously came from multiple individuals. Prey which were finely digested were assigned to a higher taxonomic level as "remains" and were included in the contributions of those higher taxa to the diet. Prey items were sorted into pre-weighed aluminum pans, placed in a 55°C drying oven for 18 h, cooled in a desiccator, and weighed to the nearest 0.001 mg using a Cahn electronic microbalance. Parasitic isopods, nematodes and plant material found in stomachs were considered non-food items ingested incidentally in normal feeding and were not used in our description of the diets.

Prey were pooled for all stomachs of each species and were represented as percent numeric abundance (%N), percent of total weight (%W), and percent frequency of occurrence (%F). The above values were used to calculate an index of relative importance (IRI): $IRI = (\%N + \%W) \times \%F$ (Pinkas et al. 1971). Percent IRI (%IRI) was also calculated by dividing the IRI value of each prey taxon by the sum of IRI values (Cortés 1997). Empty stomachs were excluded from the above calculations.

Both the simplified Morisita index of overlap (C_H , Horn 1966) and Horn's index of overlap (R_o , Horn 1966) were used to determine dietary overlap. These indices exhibit less bias than other overlap measures when

sample size (n) and resources (number of prey types in diet) are not constant (Krebs 1989, Cortés 1997). Both indices range from 0.0 (no overlap) to 1.0 (complete overlap), and a value of 0.60 indicates a high degree of overlap (Krebs 1989). Juvenile lane snapper were separated into 3 groups to determine intraspecific diet overlap: collection site (Pascagoula River vs. Bayou Casotte); season (early winter vs. late winter); and fish size (< 75 mm SL vs. ≥ 75 mm SL).

RESULTS

A total of 94 juvenile lane snapper were collected at Site 1 ($n = 61$) and Site 2 ($n = 33$), whereas 16 juvenile gray snapper were collected from Site 1. Lane ($n = 53$) and gray ($n = 12$) snapper with prey in their stomachs ranged from 63.7 to 86.5 mm SL and 71.2 to 151.1 mm SL, respectively. The percentage of empty stomachs was 44% for lane snapper ($n = 41$) and 25% for gray snapper ($n = 4$). Although prey varied between snapper species, most prey taxa in both diets could be grouped into 3 main prey groups: amphipods, decapods and fish.

Diet composition of lane snapper

The diet of juvenile lane snapper was predominately decapods (shrimp and crabs) which comprised 48% of the diet numerically and 78% of the diet by weight (Figure 1, Table 1). Furthermore, decapods occurred with the greatest frequency (70%F) among the main prey groups and exhibited a 69%IRI. Decapod prey consisted of 9 prey taxa; however, the Sargassum shrimp, *Latreutes parvulus* and unidentified shrimp remains together accounted for 88%N and 68%W of the entire decapod prey group (Table 1). Other decapod prey, e.g., palaemonid shrimp and portunid crabs, were of less importance in the diet (Table 1).

Fish and amphipods exhibited similar %IRI values (fish 13%; amphipods 18%), but varied substantially in weight and numeric contribution to the diet (Figure 1). While the total number of amphipods consumed was about 5 times greater than the number of fish consumed, the %W of amphipods (4%) was about 4 times less than that of fish (17%) (Table 1). The amphipod prey group consisted of 6 prey taxa. The combination of *Batea catharinensis* and amphipod remains accounted for 85%N and 88%W, respectively, for the group (Table 1). The %F of amphipods (40%) was nearly twice that of fish (22%), identified only as remains.

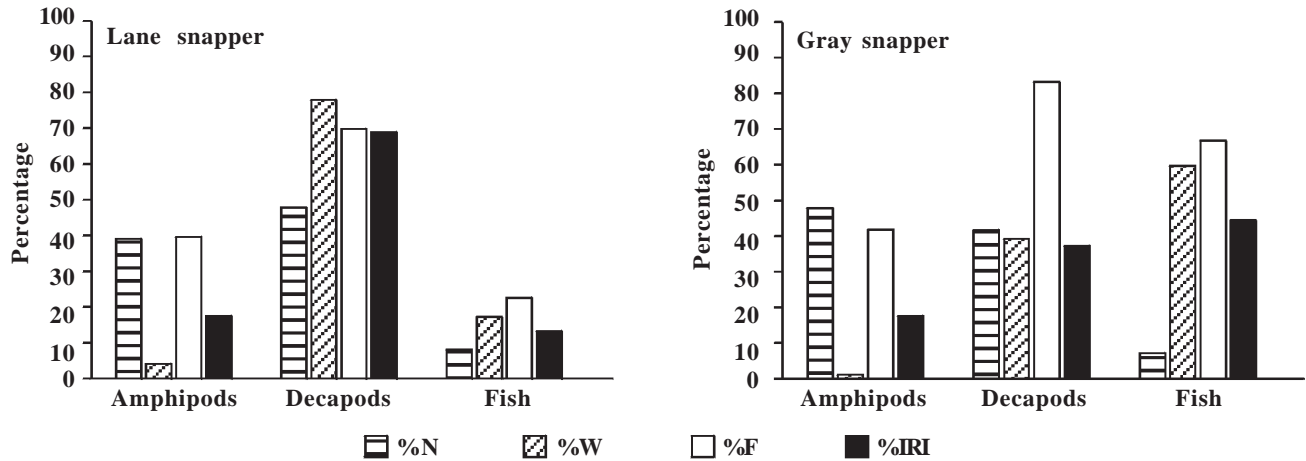


Figure 1. Percent numerical abundance (%N), percent total weight (%W), percent frequency of occurrence (%F), and percent index of relative importance (%IRI) for primary prey categories in the diet of juvenile lane snapper, *Lutjanus synagris*, and juvenile gray snapper, *Lutjanus griseus*, from Mississippi coastal waters.

Diet composition of gray snapper

The diet of juvenile gray snapper was primarily comprised of decapods (37%IRI) and fish (44%IRI) (Figure 1, Table 2). *Anchoa* sp. was the major component of the fish group in both numeric and weight contribution to the diet (Table 2). The decapod prey group (shrimp and crabs) included 11 taxa with shrimp remains the most dominant component (Table 2). Whereas amphipods were numerically abundant (48%N), with *Corophium* sp. and unidentified caprellids the most abundant members, their contribution to the diet by weight was only 1%W. Although *Corophium* sp. exhibited a 13%IRI, amphipods contributed moderately to the overall diet.

Diet Overlap

All 3 intraspecific comparisons of lane snapper showed high degrees of diet overlap (Table 3). Among these comparisons, the greatest dietary overlap occurred between size classes ($C_H = 0.94$; $R_o = 0.91$).

DISCUSSION

Our study provides fundamental information on the diet and food habits of juvenile lane and gray snapper from Mississippi coastal waters. The IRI showed decapods were important foods for both species (lane, 69%IRI; gray, 37%IRI); amphipods were of equal importance in both diets (17%IRI). Fish, comprised mostly of anchovies, were substantially more important in the diet of gray (44%IRI) than lane (13%IRI) snapper, primarily because of their high %W contribution (60%W) and %F (50%F) to the gray snapper's diet.

Many of the prey from snapper stomachs are organisms which comprise the macrobenthic and demersal communities within Mississippi Sound (Christmas and Langley 1973). The occurrence of small anchovies in the stomachs of gray snapper suggests some feeding occurred in the water column.

Among published studies from the Gulf, Springer and Woodburn (1960), Croker (1962), Starck (1970) and Hettler (1989) present the most detailed accounts of the diet of juvenile gray snapper. We found no published studies on the diet of lane snapper from the northern Gulf, and to the best of our knowledge, the only published information on the diet of lane snapper from US Gulf waters is that of Springer and Woodburn (1960). Therefore, our findings apparently represent the first account of diet and food habits of lane and gray snapper from the northern Gulf.

We report palaemonid shrimp (*Palaemonetes*), miscellaneous decapod crustaceans and fishes as being prey of lane snapper, prey that were also recorded for a similar size of juvenile lane snapper from Tampa Bay (Springer and Woodburn 1960). Among studies on lane snapper outside the US Gulf region, Rodriguez-Pino (1962), Randall (1967), Claro (1981) and Rivera-Arriaga et al. (1993) also reported diets primarily of crustaceans and fish for specimens examined from Cuba, the West Indies, Caribbean and Campeche, Mexico, respectively.

We found copepods, amphipods, palaemonid shrimp, mysids, portunid crabs and fishes in juvenile gray snapper stomachs, prey that were also reported by Starck (1970) and Hettler (1989) for juvenile gray snapper from south Florida. Our findings that juvenile gray snapper from 75–150 mm SL preyed heavily upon shrimp and fish are consistent with Starck (1970), Hettler

TABLE 1

Prey items found in stomachs of juvenile lane snapper, *Lutjanus synagris*, from Mississippi coastal waters. Percent frequency of occurrence is based on stomachs containing prey ($n = 53$). Unid. = unidentified.

Prey Items	Number of prey	% Number of prey	Prey weight (mg)	% Prey weight	% Frequency occurrence	Index of Relative Importance	% Index of Relative Importance
Arthropoda							
Copepoda	4	2.51	0.15	0.05	5.66	14.54	0.33
Amphipoda							
<i>Bateacatha rinensis</i>	28	17.61	6.03	2.02	18.87	370.82	8.56
<i>Corophium</i> sp.	4	2.51	0.25	0.08	7.55	19.35	0.45
<i>Erichthonius brasiliensis</i>	2	1.26	0.67	0.22	1.89	2.70	0.06
Unid. Caprellidae	1	0.63	0.06	0.02	1.89	1.18	0.03
<i>Paracaprella tenuis</i>	2	1.26	0.36	0.12	3.77	5.02	0.12
Amphipod remains	25	15.72	4.88	1.63	20.75	360.46	8.32
Mysidacea							
<i>Americamysis</i> sp.	3	1.89	1.53	0.51	3.77	9.16	0.21
Unid. Mysidae	1	0.63	0.74	0.25	1.89	1.62	0.04
Decapoda							
<i>Palaemonetes</i> sp.	1	0.63	3.26	1.09	1.89	3.21	0.07
<i>Palaemonetes vulgaris</i>	1	0.63	41.50	13.90	1.89	27.55	0.64
<i>Latreutes parvulus</i>	33	20.75	94.70	31.72	18.87	992.44	22.90
<i>Alpheus</i> sp.	1	0.63	4.10	1.37	1.89	3.74	0.09
Shrimp remains	33	20.75	63.15	21.15	45.28	1,900.34	43.85
Unid. Portunidae	1	0.63	3.95	1.32	1.89	3.65	0.08
<i>Callinectes sapidus</i>	2	1.26	15.92	5.33	3.77	24.81	0.57
Crab remains	3	1.89	2.95	0.99	5.66	16.47	0.38
Decapoda remains	1	0.63	3.17	1.06	1.89	3.15	0.07
Chordata							
Osteichthyes							
Fish remains	13	8.18	51.23	17.16	22.64	573.14	13.23
Totals	159		298.60			4,333.35	
Stomachs analyzed = 94							
				Stomachs (%) with prey = 53 (56%)			Stomachs (%) empty = 41 (44%)

(1989) and Koenig^d. In agreement with Springer and Woodburn (1960), we found juvenile gray snapper stomachs to contain copepods, annelids and small fishes. Croker (1962) and Rutherford et al. (1983) reported that gray snapper consumed shrimp, crabs and fish, including anchovies which were prevalent in the stomachs of our specimens.

Various studies on the feeding habits of juvenile gray snapper suggest an association with and feeding in seagrasses (Randall 1967, Starck 1970, Odum and Heald 1972, Koenig^d). Although several prey reported here may occur in seagrasses, no submerged vegetation currently occurs or has occurred previously at our study sites (Christmas and Eleuterius 1973). The bryozoan *Amathia alternata* was occasionally collected in large mats or found attached to shell fragments in trawls at

Site 2 (Bayou Casotte). *Amathia alternata* possibly served as habitat for juvenile lane snapper and provided refuge for potential prey organisms.

High levels of dietary overlap were found between lane snapper compared by catch location (Site 1 and Site 2), season (early winter and late winter), and size (4.1–6.0 and 6.1–8.6 mm SL). The 2 study sites were located only 5 km apart, and water temperatures, salinities and depths were similar during collecting. Christmas and Eleuterius (1973) reported the persistence of a “wedge” of high saline, eastern Mississippi Sound water along the bottom in both areas. The similarity between sites might account for the high dietary overlap for specimens of lane snapper from both sites. The limited collection months and the narrow size range of specimens probably account for the high dietary overlap

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TABLE 2

Prey items found in stomachs of juvenile gray snapper, *Lutjanus griseus*, from Mississippi coastal waters. Percent frequency of occurrence is based on stomachs containing prey (n = 12). Unid. = unidentified; T = trace amount (< 0.01).

Prey Item	Number of prey	% Number of prey	Prey weight (mg)	% Prey weight	% Frequency occurrence	Index of Relative Importance	% Index of Relative Importance
ANNELIDA							
Polychaeta							
Unid. Nereidae	1	0.89	0.04	T	8.33	7.46	0.12
MOLLUSCA							
Bivalvia							
Unid. Bivalvia	1	0.89	0.02	T	8.33	7.44	0.12
ARTHROPODA							
Amphipoda							
<i>Batea catharinensis</i>	4	3.54	1.43	0.19	16.67	62.18	1.00
<i>Corophium</i> sp.	37	32.74	5.54	0.73	25.00	836.75	13.41
Unid. Caprellidae	10	8.84	0.90	0.12	16.67	149.36	2.39
Amphipod remains	3	2.65	0.29	0.04	16.67	44.84	0.72
Mysidacea							
<i>Americamysis</i> sp.	2	1.77	0.24	0.03	16.67	30.01	0.48
Decapoda							
<i>Palaemonetes</i> sp.	6	5.31	15.16	2.00	25.00	182.75	2.93
<i>Latreutes parvulus</i>	7	6.19	13.90	1.84	16.67	133.86	2.15
<i>Alpheus</i> sp.	1	0.89	5.11	0.68	8.83	13.08	0.21
Shrimp remains	14	12.39	74.56	9.86	58.33	1,297.84	20.81
<i>Callinectes sapidus</i>	3	2.65	48.18	6.37	25.00	225.56	3.62
<i>Callinectes</i> sp.	1	0.89	10.53	1.39	8.33	18.99	0.30
<i>Eurypanopeus depressus</i>	5	4.42	74.83	9.90	8.33	119.28	1.91
<i>Mennipe adina</i>	1	0.89	5.72	0.76	8.33	13.74	0.22
Unid. Xanthidae	5	4.42	35.66	4.72	25.00	228.50	3.66
Crab remains	3	2.65	2.56	0.34	25.00	74.75	1.20
Decapoda remains	1	0.89	9.97	1.32	8.33	18.41	0.30
CHORDATA							
Osteichthyes							
<i>Anchoa</i> sp.	6	5.31	361.95	47.88	50.00	2,659.50	42.64
Unid. Triglidae	1	0.89	84.04	11.12	8.33	100.04	1.60
Fish remains	1	0.89	5.30	0.70	8.33	13.24	0.21
TOTALS	115		755.93			6,237.52	
Total stomachs analyzed = 16		No. (%) containing food = 12 (75%)			No. (%) empty = 4 (25%)		

of lane snapper between seasons and size groups, respectively.

Information on age, growth, term of residency and patterns of movement of juvenile lane and gray snapper within the Mississippi Sound estuary is lacking. Additionally, there is no information on the size and age of lane and gray snapper at the time of their emigration from the Mississippi Sound estuary to open Gulf waters. Both of our study sites were located within shipping channels which were substantially deeper than adjacent waters. The channels may serve as “conduits” for the

movement of sub-adult lane and gray snapper out of the estuary into offshore waters.

Our findings show that some juvenile lane and gray snapper utilized Mississippi’s estuarine habitat as nursery area. Documentation of juvenile habitat and monitoring the juvenile snapper population along the northern Gulf coast will enhance the ability to assess relationships between habitat and early life history stages of these important fishes, and ultimately may provide indicators useful in assessing recruitment and status of the stocks. Identification of the food habits of juvenile

TABLE 3

Dietary overlap among juvenile lane snapper, *Lutjanus synagris*, from Mississippi coastal waters. Site 1 (Pascagoula River, $n = 25$), Site 2 (Bayou Casotte, $n = 28$). Early winter (Nov./Dec., $n = 26$), Late winter (Jan./Feb./Mar., $n = 27$). Size class A (< 75 mm SL, $n = 24$), Size class B (> 75 mm SL, $n = 29$). The simplified Morisita (C_H) and Horn's (R_o) indices range from 0 = no overlap to 1.0 = complete overlap.

Comparison Group	C_H	R_o
Site 1 vs. Site 2	0.77	0.82
Early winter vs. Late winter	0.71	0.73
Size class A vs. Size class B	0.94	0.91

lane and gray snapper is an important step in developing a better understanding of the life history requirements, estuarine ecology and trophic role of these 2 species within the Mississippi Sound estuarine ecosystem.

ACKNOWLEDGMENTS

We are grateful to Captain R. Broussard of the fishing vessel *Casey* who provided specimens of juvenile snappers. We also thank P. and L. Kaluz of the Biloxi Harbor Bait and Fuel Dock for assistance in our research and support of our fisheries research over many years. Thanks to N. Garber, A. Garber, D. Wilson, and S. LeCroy for their greatly appreciated assistance. Cynthia Moncreiff identified specimens of *Amathia alternata*. Lisa Engel provided access to fisheries data on file at the GCRL. We thank M. S. Peterson for guidance on data analysis and S. VanderKooy and two anonymous reviewers for extremely valuable comments and suggestions. A special thanks to C. Koenig (Florida State University and National Marine Fisheries Service, Panama City, FL) for sharing with us sections of his unpublished manuscript on gray snapper. This study was supported by the GCRL/Institute of Marine Sciences/University of Southern Mississippi, the Mississippi Department of Marine Resources, Biloxi, MS, and the U. S. Fish and Wildlife Service, Sport Fish Restoration Program, Atlanta, GA.

LITERATURE CITED

Acosta, A. and R.S. Appledoorn. 1992. Estimation of growth, mortality and yield per recruit for *Lutjanus synagris* (Linnaeus) in Puerto Rico. *Bulletin of Marine Science* 50:282-291.

Benson, N.G. ed. 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U. S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/51.

Bortone, S.A. and J.L. Williams. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Florida)—gray, lane, mutton and yellowtail snappers. U. S. Fish and Wildlife Service Biological Report 82(11.52), U. S. Army Corps of Engineers, TR-EL-82-4.

Chester, A.J. and G.W. Thayer. 1990. Distribution of spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) juveniles in seagrass habitats of western Florida Bay. *Bulletin of Marine Science* 46:345-357.

Christmas, J.Y. and C.K. Eleuterius. 1973. Phase 2: Hydrology. In: J.Y. Christmas, ed. Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi. Gulf Coast Research Laboratory, Ocean Springs, MS, p. 75-121.

Christmas, J.Y. and W. Langley. 1973. Phase 4: Estuarine invertebrates, Mississippi. In: J.Y. Christmas, ed. Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi. Gulf Coast Research Laboratory, Ocean Springs, MS, p. 255-319.

Claro, R. 1981. Ecology and life cycle of the lane snapper, *Lutjanus synagris* (Linnaeus), on the shelf of Cuba. III. Nutrition. *Cuban Academy of Sciences, Biological Sciences* 6:93-109.

Cortés, E. 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: applications to elasmobranch fishes. *Canadian Journal of Fisheries and Aquatic Sciences* 54:726-738.

Croker, R.A. 1962. Growth and food of the gray snapper, *Lutjanus griseus*, in Everglades National Park. *Transactions of the American Fisheries Society* 91:379-383.

Gulf of Mexico Fishery Management Council (GMFMC). 1981. Fishery management plan for the reef fish fishery of the Gulf of Mexico. August 1981. Gulf of Mexico Fishery Management Council, Tampa, FL.

Harrigan, P., J.C. Zieman and S.A. Macko. 1989. The base of nutritional support for the gray snapper (*Lutjanus griseus*): an evaluation based on a combined stomach content and stable isotope analysis. *Bulletin of Marine Science* 44:65-77.

Hettler, W.F., Jr. 1989. Food habits of juveniles of spotted seatrout and gray snapper in western Florida Bay. *Bulletin of Marine Science* 44:155-162.

Hoese, H.D. and R.H. Moore. 1998. Fishes of the Gulf of Mexico, Texas, Louisiana, and adjacent waters. Texas A&M University Press, College Station, Texas, 422 p.

MISSISSIPPI JUVENILE SNAPPER DIET

- Horn, H.S. 1966. Measurement of overlap in comparative ecological studies. *American Naturalist* 100:419–424.
- Johnson, A.G., L.A. Collins, J. Dahl and M.S. Baker. 1995. Age, growth and mortality of lane snapper from the northern Gulf of Mexico. Proceedings of the Annual Conference, Southeast Association of Fish and Wildlife Agencies, Nashville, TN, Sept. 23–27, 1995, p. 178–186.
- Krebs, C.J. 1989. *Ecological Methodology*. Harper & Row, New York, 654 p.
- Manooch, C.S., III and D.L. Mason. 1984. Age, growth, and mortality of lane snapper from southern Florida. *North-east Gulf Science* 7:109–115.
- Odum, W.E. and E.J. Heald. 1972. Trophic analysis of an estuarine mangrove community. *Bulletin of Marine Science* 22:671–738.
- Pattillo, M.E., T.E. Czapla, D.M. Nelson and M.E. Monaco. 1997. Distribution and abundance of fishes and invertebrates in Gulf of Mexico estuaries, Volume II: Species life history summaries. *Estuarine Living Marine Resources (ELMR) Report No. 11*. NOAA/NOS, Strategic Environmental Assessment Division, Silver Spring, MD.
- Pinkas, L., M.S. Pliphant and I.L.K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. *California Department of Fish and Game, Bulletin* 152:47–63.
- Randall, J.E. 1967. Food habits of reef fishes of the West Indies. Proceedings of the International Conference on Tropical Oceanography, Miami Beach, FL, November 17–24, 1965. *Studies in Tropical Oceanography* 5:665–847.
- Rivera-Arriaga, E., A.L. Lara-Domínguez, J. Ramos-Miranda, P. Sánchez-Gil and A. Yáñez-Arancibia. 1993. Ecology and population dynamics of *Lutjanus synagris* on Campeche Bank. Proceedings of the International Workshop on Tropical Snappers and Groupers, Part II, biology, ecology and distribution. EPOMEX-ICLARM, Campeche, Mexico, October 23–29, 1993, p. 11–18.
- Rodriguez-Pino, Z. 1962. Estudios estadísticos y biológicos sobre la biayaiba (*Lutjanus synagris*). *Notsas Pesqueras, Havana, Cuba* 4:1–91.
- Rutherford, E.S., E.B. Thue and D.G. Buker. 1983. Population structure, food habits and spawning activity of gray snapper, *Lutjanus griseus*, in Everglades National Park. Report 83/02, South Florida Research Center, National Park Service, Homestead, FL.
- Rutherford, E.S., T.W. Schmidt and J.T. Tilmant. 1989a. Early life history of spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) in Florida Bay, Everglades National Park, Florida. *Bulletin of Marine Science* 44:49–64.
- Rutherford, E.S., J.T. Tilmant, E.B. Thue and T.W. Schmidt. 1989b. Fishery harvest and population dynamics of gray snapper, *Lutjanus griseus*, in Florida Bay and adjacent waters. *Bulletin of Marine Science* 44:139–154.
- Shipp, R.L. 1991. Investigation of life-history parameters of species of secondarily targeted reef fishes and dolphin in the northern Gulf of Mexico. Proceedings of the 4th Annual MARFIN Conference, San Antonio, TX, December 1991, p. 80–85.
- Springer, V.G. and K.D. Woodburn. 1960. An ecological study of the fishes of the Tampa Bay area, Florida. State Board of Conservation, Marine Laboratory Professional Papers, Series No.1.
- Starck, W.A., II. 1970. Biology of the gray snapper, *Lutjanus griseus* (Linnaeus), in the Florida Keys. In: W.A. Starck and R.E. Schroeder. Investigations on the gray snapper, *Lutjanus griseus*. *Studies in Tropical Oceanography* 10:11–150.
- Warren, J. and H. Perry. 1996. Interjurisdictional monitoring and assessment of selected Mississippi Marine Resources. Final Report. Mississippi Department of Marine Resources, Biloxi, MS, USA.
- Wieland, R.G. 1994. Marine and estuarine habitat types and associated ecological communities of the Mississippi coast. Technical Report No. 25. Mississippi Museum of Natural Sciences, Jackson, MS.

NOTES

- a. Fisheries assessment and monitoring program, Mississippi, 1989–1998. Unpublished data. Gulf Coast Research Laboratory, Ocean Springs, MS and Mississippi Department of Marine Resources, Biloxi, MS.
- b. National Marine Fisheries Service. Commercial fisheries landings statistics. Gulf states, 1990–1997. NOAA, Sustainable Fisheries Division, Miami, FL.
- c. National Marine Fisheries Service. Marine recreational fisheries survey statistics. Gulf states, 1990–1998. NOAA, Fisheries Statistics and Economic Division, Silver Spring, MD.
- d. Koenig, C.C. Reproductive biology of gray snapper (*Lutjanus griseus*). Unpublished manuscript. Department of Biological Sciences, Florida State University, Tallahassee, FL.