The Effect of Four Diets on the Survival, Growth and Feed Conversion of Juvenile Schoolmaster Snapper (*Lutjanus apodus*)

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ABSTRACT

Juvenile schoolmaster (*Lutjanus apodus*) were cultured in flow-through tanks and fed three formulated (pelleted) diets and a non-formulated diet for ten weeks. Formulated diets included a 43% protein, 21% moisture (semi-moist), salmonid diet; a 44% protein, 10% moisture (dry), salmonid diet; and a56% protein, 7% moisture, marine finfish diet. The non-formulated diet (72%protein, 78% moisture) was a mixture of fish, shrimp and squid. Feed was administered once per day at a rate of 3-4% of biomass, on a dry weight basis.

Fish fed the non-formulated diet had the highest mean absolute and specific growth rates (0.58 g/d, 0.81 %/d) and the lowest mean feed conversion ratio (3.5), based on dry weight of feed, followed by fish fed the marine finfish diet (0.48 g/d, 0.70 %/d, 5.1), the semi-moist salmonid diet (0.30 g/d, 0.48 %/d, 7.4) and the dry salmonid diet (0.28 g/d, 0.45 %/d, 7.9). Pairwise comparisons of absolute growth rates, specific growth rates and feed conversion values indicated significant ($P<0.05$) differences among all treatments except between the two salmonid diets. Growth rates decreased and feed conversion ratios increased throughout the experiment in all treatments. Survival was 100% for all treatments.

A second eight-week experiment was conducted using the semi-moist diet to compare growth of schoolmaster fed once per day with those fed continuously throughout the day. There were no significant differences in mean growth rates among fish fed once per day at 4% of biomass (0.24 g/d, 0.26 %/d), fish fed continuously at 4% of biomass (0.33 g/d, 0.38 %/d) and fish fed continuously at 8% of biomass (0.27 g/d, 0.32 %/d).

The above diets fed once per day to schoolmaster snapper resulted in marginal growth and high feed conversion. Continuous feeding did not improve growth. This research indicates that schoolmaster are not suitable candidates for foodfish culture under the conditions of these experiments.

KEY WORDS: feed conversion, growth, *Lutjanus apodus*, schoolmaster snapper.

INTRODUCTION

In many areas of the Caribbean, landings of marine fish fail to meet market demand (Ryther *et al.*, 1991; Sandifer, 1991). Approximately 16,700 mt of seafood, valued at U.S. $56 million, were imported into the Lesser Antilles in

1987 (FAO, 1987). Although landings may be increased by increased fishing effort, demand generally exceeds total potential catch for high value nearshore species (Tucker and Jory, 1991; Goodwin *et al.*, 1985). Increases in yield must come primarily from currently unexploited resources (Olsen *et al.*, 1984).

Aquaculture could increase seafood production, provide employment, reduce dependence on imports and possibly generate currency through exports. With careful planning and management, aquaculture could be used in stock enhancement programs. The Caribbean region as a whole has favorable conditions for the development of an aquaculture industry but development is restricted by a number of factors including the lack of technical and biological information. Economically successful finfish aquaculture projects have involved culture of freshwater species (Ryther *et al.*, 1991). Commercial efforts in mariculture have involved tilapia (*Oreochromis* spp.) and red drum (*Sciaenops ocellata*) (Tucker and Jory, 1991).

The University of the Virgin Islands Agricultural Experiment Station conducts a program to evaluate the culture potential of selected nearshore Caribbean marine finfish. The program consists of three phases. Feeding experiments are conducted to evaluate growth performance, feed conversion and survival of juveniles fed formulated, high-protein diets. Grow-out experiments are conducted with species selected from the juvenile feeding experiments to evaluate their performance when cultured to market size in tanks and cages. The third phase involves spawning and larval rearing of those species which perform best in the grow-out experiments.

Schoolmaster snappers (*Lutjanus apodus*) were selected for a juvenile feeding experiment based on several characteristics which are desirable in aquaculture species. Schoolmaster are long-lived and have relatively low rates of natural mortality (Manooch, 1987; Acosta and Appeldoorn, 1992; Thompson and Munro, 1983), which suggests that they are hardy and possibly resistant to parasites and diseases. In addition, schoolmaster tolerate a wide range of salinity and have been reported to occur in freshwater (Rivas, 1949). Thompson and Munro (1983) collected ripe and/or recently spent adults from oceanic banks and reefs of Jamaica from Feb.-June and Aug.-Nov., indicating that spawning occurs throughout the year. Schoolmaster are opportunistic or unspecialized carnivores and feed on a wide variety of prey (Randall, 1967; Thompson and Munro, 1983). Demand and price for snappers, including schoolmaster, are high in the Virgin Islands.

It is generally accepted that lutjanids have relatively low growth rates in the wild (Manooch, 1987; Acosta and Appeldoorn, 1992; Thompson an Munro,1983). Little information is available on the growth rates of cultured snappers (Lutjanidae) and their potential use in aquaculture. In this study, an experiment was conducted to evaluate growth, feed conversion and survival of juvenile schoolmaster snapper fed four diets under culture conditions. A second

experiment was conducted to compare growth rates of fish fed once per day (batch) and those fed continuously throughout the day.

METHODS

A flow-though system, comprised of 12 2-m^3 fiberglass tanks, was used in each study. Each tank was covered with 80% shade cloth. Water was pumped from the ocean using a one horse-power (hp) pump, and a 1/2-hp air blower supplied emergency aeration.

Juvenile schoolmaster were collected from an embayment on the north shore of St. Croix, U.S. Virgin Islands over a 52-day period. The habitat consisted of seagrass beds surrounded by mangroves. Eight 1.9-cm mesh traps (122 cm X 40 cm X 40 cm), baited with fish, were placed in 0.5-2 m of water. Soak time ranged from 2-4 days.

The fish were held in tanks until enough individuals were obtained to conduct the first experiment. During the holding period the fish were fed a mixture of ground fish, shrimp and squid. When enough fish were obtained, they were acclimated to pelleted feed by gradually increasing the percentage of pelleted feed in their daily feed ration until a 100% pelleted feed ration was administered.

In the first experiment, ten schoolmaster (mean weight = 53 g, range = 42 g - 65 g) were placed into each tank and cultured for ten weeks (June 1 - August 11, 1993). At the time of stocking, initial total length and weight of each fish was recorded. Condition factor, K, was determined by the formula K = 105 X W / L3 where W was the weight (g) and L was the total length (mm).

Four treatments, consisting of three formulated diets and one non-formulated diet (Table 1), were replicated three times and randomly assigned to the tanks. The formulated diets consisted of sinking pellets (4.0 mm). Two of the diets were formulated for salmonids (BioProducts, Inc., Warrenton, OR). One of these diets (semi-moist, salmonid) contained 43% protein and 21% moisture and the other (dry, salmonid) contained 44% protein and 10% moisture. The third formulated diet (MFF) (developed by John Tucker of Harbor BranchOceanographic Institution and manufactured by Zeigler Brothers, Inc., Gardners, PA) was specifically formulated for warmwater marine finfish and contained 56% protein and 7% moisture. The non-formulated diet contained 72%(based on dry weight) protein and 78% moisture and was composed of 70% fish,20% shrimp and 10% squid. The ingredients were ground, mixed and supplemented with vitamins and minerals. Proximate analysis of the non-formulated diet was determined by Woodson-Tenent Laboratories, Inc., Memphis, TN.

Throughout the experiment the fish were fed once daily at a rate of 3-4% of their body weight based on the dry weight of the individual diets. Growth was monitored by weighing all of the fish individually from each tank at two- week

Table 1. Composition of diets fed to juvenile schoolmaster for ten weeks. Protein, fat, fiber and ash are expressed as a percent of dry weight.

DIET	% PROTEIN	% FAT	% FIBER	% ASH	% MOISTURE
Semi-moist, salmonid	43	15	2	7	21
Dry, salmonid	44	15	3	7	11
MFF	56	11	2	11	7
Non-formulated[a]	72	5	2	13	78

[a]The non-formulated diet was composed of 70% fish, 20% shrimp and 10% squid. The ingredients were ground, mixed and supplemented with vitamins and minerals.

Table 2. Mean values (Ò SEM) for absolute growth rate, specific growth rate and feed conversion ratio (FCR) of juvenile schoolmaster fed three formulated diets and one non-formulated diet for ten weeks. For each column, values followed by the same letter are not significantly different (P>0.05).

DIET	ABSOLUTE GROWTH RATE (g/d)	SPECIFIC GROWTH RATE (%/d)[a]	FCR[b]
Semi-moist, salmonid	0.30 ± 0.01a	0.48 ± 0.01a	7.4 ± 0.1a
Dry, salmonid	0.28 ± 0.02a	0.45 ± 0.03a	7.9 ± 0.6a
MFF	0.48 ± 0.03b	0.70 ± 0.04b	5.1 ± 0.3b
Non-formulated	0.58 ± 0.02c	0.81 ± 0.02c	3.5 ± 0.1c

[a]Specific growth rate (%/d) = (Ln W_2 - Ln W_1 / T) X 100
Where: W_1 = initial mean weight (g)
W_2 = final mean weight (g)
T = time (days)

intervals. Daily feed rations were adjusted to reflect the new weight. Water quality was monitored every two weeks by measuring dissolved oxygen, temperature and flow rate for each tank while salinity and pH values were measured in the system influent.

At the end of the experiment, total length and weight were recorded for individual fish and K was calculated. Absolute growth rate, AGR (g/d), was

determined by dividing weight gain (g) by time (days). Specific growth rate, SGR, was calculated by the formula:

$$SGR\ (\%/d) = (Ln\ W_2 - Ln\ W_1 / T) \times 100$$

where W_1 was the initial weight (g), W_2 was the final weight (g) and T was time (days). Feed conversion ratio, FCR, was determined by dividing total dry weight of the feed administered during the feeding trial by total weight gain of fish.

In the second experiment, ten schoolmaster (mean weight = 78 g, range = 65 g - 91 g) were placed into each of nine tanks and fed the semi-moist diet for eight weeks (August 13 - October 8, 1993). Three treatments, replicated three times, consisted of feeding fish at: 4% of biomass once daily (4%-1X); 4% of biomass continuously throughout the day (4%-CT); and 8% of biomass continuously throughout the day (8%-CT). Spring-operated belt feeders (Zeigler Brothers, Inc., Gardners, PA) were used for continuous feeding over a 12-hr period each day. Procedures for sampling, feed ration adjustments and water quality monitoring, and determining AGR, SGR and FCR were the same as in the previous experiment.

AGR, SGR, FCR, K, dissolved oxygen, temperature and flow rate were compared by one way analysis of variance. Pairwise multiple comparisons were made using the Student-Newman-Keuls method. Treatment means were considered significant at the 0.05 level of probability. All statistical analyses were conducted using Sigma Stat (1992).

RESULTS

Mean values for AGR, SGR and FCR for fish in the first experiment are given in Table 2. Fish fed the non-formulated diet had the highest mean AGR and SGR (0.58 g/d, 0.81 %/d) and the lowest mean FCR (3.5,) followed by fish fed the marine finfish diet (0.48 g/d, 0.70 %/d, 5.1), the semi-moist salmonid diet (0.30 g/d, 0.48 %/d, 7.4) and the dry salmonid diet (0.28 g/d, 0.45 %/d, 7.9) Pairwise comparisons of AGR, SGR and FCR indicated significant ($P<0.05$ differences among all treatments except between the two salmonid diets.

Mean condition factors are given in Table 3. There were no significant differences in initial mean condition factors. Although condition factors decreased throughout the experiment, pairwise comparisons of initial and final condition factors were not significantly different, except for the fish fed the dry salmonid diet (initial = 1.78, final = 1.67). Final condition factors of fish fed th MFF diet (1.74) and the non-formulated diet (1.74) were significantly higher than those of fish fed either the semi-moist salmonid diet (1.68) or the dry salmonid diet (1.67). There was no significant difference in condition factor between the two salmonid diets. Survival for all treatments was 100%.

Table 3. Mean condition factors (± SEM) of juvenile schoolmaster prior to and after ten weeks of feeding three formulated diets and one non-formulated diet. For each row, values followed by the same lower case letter are not significantly different(P>0.05). For each column, values followed by the same upper case letter are not significantly different (P>0.05).

Condition factor*	DIET			
	Semi-moist salmonid	Dry MFF salmonid	Non-formulated	
Initial	1.77 ± 0.03A,a 1.77 ± 0.02A,a	1.78 ± 0.02A,a	1.78 ± 0.01A,a	
Final	1.68 ± 0.01A,a	1.67 ± 0.02B,a	1.74 ± 0.02A,b	1.74 ± 0.00A,b

Table 4. Mean values (± SEM) for absolute growth rate, specific growth rate and feed conversion ratio (FCR) of juvenile schoolmaster fed a 43% protein, 21% moisture diet for eight weeks. Fish were fed at: 4% of biomass once daily (4%-1X); 4% of biomass continuously throughout the day (4%-CT); and 8% of biomass continuously throughout the day (8%-CT). For each column, values followed by the same letter are not significantly different (P>0.05).

TREATMENT	ABSOLUTE GROWTH RATE (g/d)	SPECIFIC GROWTH RATE (%/d)[a]	FCR[b]
4%-1X	0.26 ± 0.02a	0.31 ± 0.04a	12.5 ± 1.8a
4%-CT	0.33 ± 0.06a	0.38 ± 0.07a	10.8 ± 2.3a
8%-CT	0.27 ± 0.05a	0.32 ± 0.06a	26.2 ± 3.1b

[a]Specific growth rate (%/d) = (Ln W_2 - Ln W_1 / T) X 100
Where: W_1 = initial mean weight (g)
W_2 = final mean weight (g)
T = time (days)
[b]Feed conversion ratio was based on dry weight of feed.

Figure 1 illustrates the increase in mean weight during the first experiment. Mean absolute growth rates of fish in all tanks generally decreased (Figure 2) and feed conversion ratios generally increased (Figure 3) throughout the experiment.

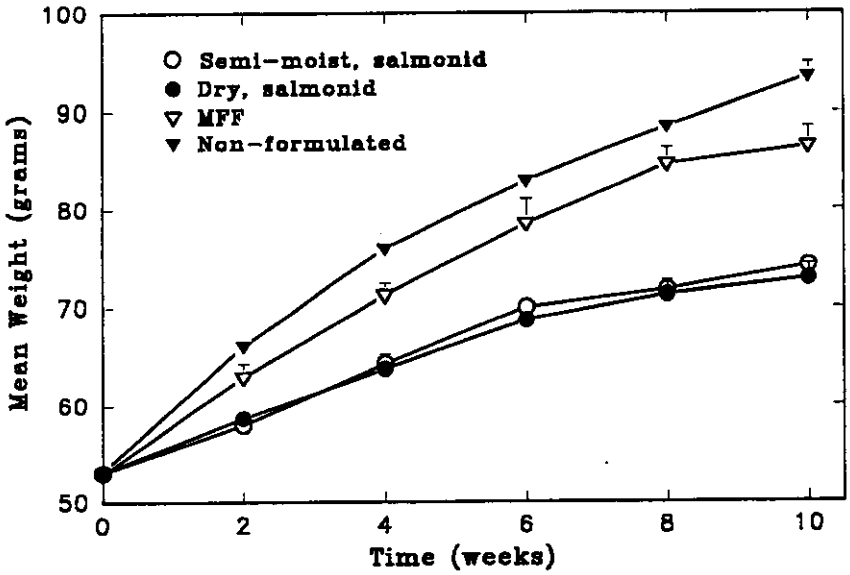

Figure 1. Mean weights of juvenile schoolmaster fed four diets over a ten-week period.

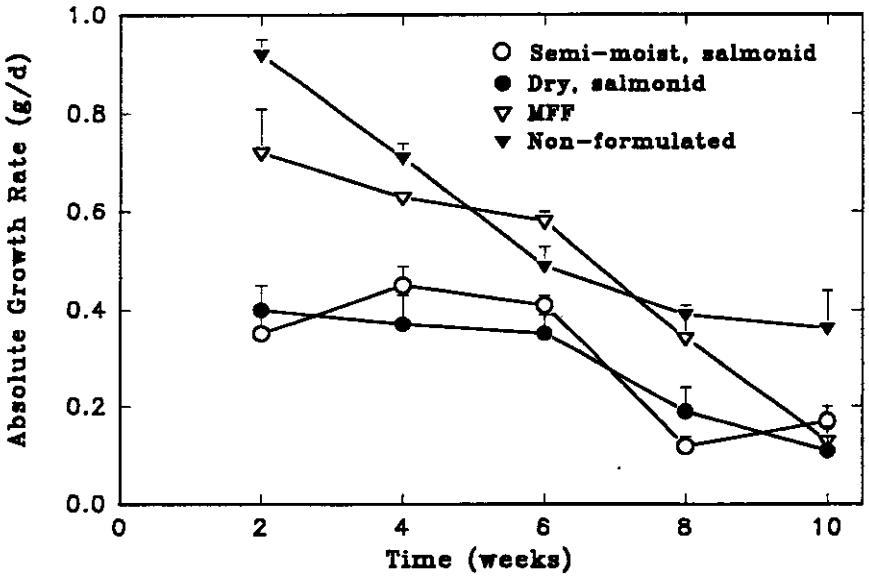

Figure 2. Mean absolute growth rates of juvenile schoolmaster fed four diets over a ten-week period.

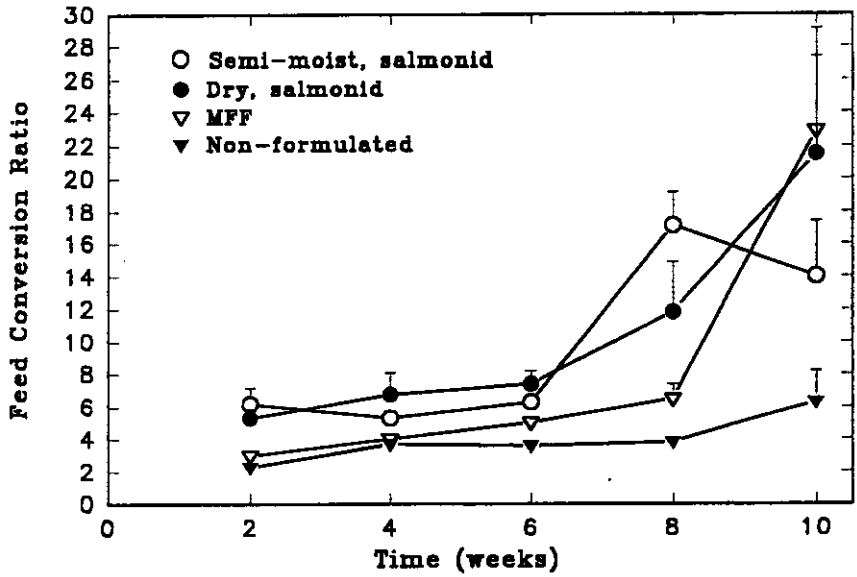

Figure 3. Mean feed conversion ratios of juvenile schoolmaster fed four diets over a ten-week period.

There were no significant differences among treatment means for dissolved oxygen, temperature and flow rate. Dissolved oxygen remained above 5.7 mg/L (range, 5.7 - 7.0 mg/L) during the entire experiment. Temperature range between 28.8°C and 30.0°C, and mean flow rate for all treatments was 20L/min Mean values for salinity and pH of the influent were 35 ppt (range, 35 - 36 ppt) and 8.3 (range, 8.3 - 8.4).

Mean values for AGR, SGR and FCR for the second experiment are given in Table 4. Fish fed 4%-CT had the highest mean AGR and SGR (0.33 g/d, 0.3 %/d)followed by fish fed 8%-CT (0.27 g/d, 0.32 %/d) and fish fed 4%-1X (0.2 g/d,0.31 %/d). There were no significant differences among treatment means for AGR and SGR. Fish fed 8%-CT had a significantly higher mean FCR (26.2 thenfish fed 4%-CT (10.8) or fish fed 4%-1X (12.5). There was no significant difference in mean FCR between fish fed 4%-CT and fish fed 4%-1X. Survival for all treatments was 100%.

There were no significant differences among treatment means for temperature (mean, 27.7°C; range, 26.6°C - 28.8°C) and pH. Mean and range values for flow, salinity and pH were the same as in the first experiment. The mean dissolved oxygen concentration for the 8%-CT treatment (4.2 mg/Lwas significantly lower than the mean concentrations for the 4%-CT treatment

(5.7mg/L) or the 4%-1X treatment (5.8 mg/L). Dissolved oxygen concentrations forthe 8%-CT treatment ranged from 2.6 - 5.6 mg/L.

DISCUSSION

All diets were readily accepted by the schoolmaster in the first experiment. Fish fed the higher protein diets (non-formulated and MFF) had higher growth rates and lower feed conversion ratios than those fed the lower protein (salmonid) diets. Throughout the experiment, the fish did not appear stressed and no diseases or parasites were observed. Water quality remained consistent due to the flow-through nature of the system (14 exchanges /tank/day).

The decrease in growth rates and increase in feed conversion ratios of fish in all treatments is not fully understood. Schoolmaster are reported to reside in close proximity to reef structures during the day and disperse at night to feed (Longley and Hildebrand, 1941; Starck and Davis, 1966), although Randall (1967) stated that they also feed heavily during daylight hours. During the experiment, fish were fed once during daylight hours and, except for a central standpipe, the culture tank did not provide cover for the fish. Aggressive behavior was observed occasionally during feeding.

Frequent sampling intervals (every two weeks) may have affected growth and feed conversion somewhat, although fish readily consumed feed shortly after (<1 hr) being handled and did not appear stressed.

There may have also been some nutritional factor missing in the diets. Thouard *et al.* (1990) reported a growth rate of 0.34 g/d (250 grams in 24 months) for schoolmaster fingerlings cultured in cages and fed a formulated pelleted diet. Although specific details were not presented, the fish suffered from a nutritional disease. The ingredients of the non-formulated diet used in the first experiment were chosen to approximate the diet of schoolmaster snappers in the wild. Supplemental vitamins and minerals were added to insure a complete diet. As with fish fed the pelleted diets, those fish fed the non-formulated diet had declining growth rates.

Multiple feedings of daily rations are preferred over feeding once per day and generally result in higher growth rates for catfish, tilapia, salmon and trout (Lovell, 1989) as well as pompano and yellowtail (*Seriola quinqueradiata*) (Bardach *et al.*, 1972). This is especially true for larval and juvenile fish. Schoolmaster snappers fed 4% of body weight continuously throughout the day did not have significantly higher growth rates than those fed at the same rate once daily. The daily feed ration of 8% of body weight was more than the fish could consume and resulted in uneaten feed accumulating in the tank. This resulted in low concentrations of dissolved oxygen.

Low growth rates and marginal feed conversion suggest that schoolmaster are not suitable candidates for foodfish aquaculture under the conditions of these

experiments. A better understanding of behavior and nutritional requirements may improve growth and feed conversion performance.

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LITERATURE CITED

Acosta, A. and R.S. Appeldoorn. 1992. Estimation of growth, mortality an yield per recruit for *Lutjanus synagris* (Linnaeus) in Puerto Rico. *Bull. Mar. Sci.* **50**(2):282-291.

Bardach, J.E., J.H. Ryther and W.O. McLarney. 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. John Wiley and Sons, Inc., New York, NY. 868 pp.

FAO. 1987. FAO Yearbook of Fisheries Statistics. Vol. **65**. Food and Agriculture Organization, Rome.

Goodwin, M., M. Orbach, P.A. Sandifer and E. Towle. 1985. Fisheries sector assessment for the Eastern Caribbean: Antigua/Barbuda, Dominica Grenada, Montserrat, St. Christopher/Nevis, St. Lucia, St. Vincent and Grenadines. U.S. Agency for International Development, Regional Development Office, Caribbean. 141 pp.

Longley, W.H. and S.F. Hildebrand. 1941. Systematic catalogue of fishes of Tortugas, Florida. *Carnegie Inst. Wash. Publ.* **535**. 331 pp.

Lovell, T. 1989. Nutrition and Feeding of Fish. Van Nostrand Reinhold, New York, NY. 260 pp.

Manooch, C.S., III. 1987. Age and growth of snappers and groupers. Pages 329-372 in J.J. Polovina and S. Ralston, eds., *Tropical Snappers and Groupers: Biology and Fisheries Management*, Westview Press, Inc. Boulder, CO.

Olsen, D.A., D.W. Nellis and R.S. Wood. 1984. Ciguatera in the eastern Caribbean. *Mar. Fish. Rev.* **46**(1):13-18.

Randall, J.E. 1967. Food habits of reef fishes of the West Indies. *Studies in Tropical Oceanography.* **5**: 665-847.

Rivas, L.R. 1949. A record of the lutjanid fish (Lutjanus cyanopterus) for the Atlantic coast of the United States with notes on related species of the genus. *Copeia* **1949**:150-152.

Ryther, J.H., R.L. Creswell and D.E. Alston. 1991. Historical overview: aquaculture in the Caribbean. Pages 9-29 in J.A. Hargreaves and D.E. Alston, eds., *Status and Potential of Aquaculture in the Caribbean*, World Aquaculture Society, Baton Rouge, LA.

Sandifer, P.A. 1991. Species with aquaculture potential for the Caribbean. Pages 30-60 in J.A. Hargreaves and D.E. Alston, eds., *Status and Potential of Aquaculture in the Caribbean*, World Aquaculture Society, Baton Rouge, LA.

Sigma Stat. 1992. Sigma Stat User's Manual. Jandel Scientific, San Rafael, CA.

Starck, W.A. and W.P. Davis. 1966. Night habits of fishes of Alligator reef, Florida. *Ichthyologica* **38**:313-356.

Thompson, R. and J.L. Munro. 1983. The biology, ecology and bionomics of the snappers, Lutjanidae. Pages 94-109 in J.L. Munro, ed., *Caribbean Coral Reef Fishery Resources*, International Center for Living Aquatic Resources Management, Manila, Philippines.

Thouard, E., P. Soletchnik and J.-P. Marion. 1990. Selection of finfish species for aquaculture development in Martinique (F.W.I.). *Aquaculture* **89**:193-197.

Tucker, J.W. and D.E. Jory. 1991. Marine fish culture in the Caribbean region. *World Aquaculture* **22**(1):10-27.