An Experimental Hatchery Project: Studies of Propagation, Culture and Biology of Snook (Centropomus undecimalis)

RANDY E. EDWARDS and BRUCE D. HENDERSON
Rosenstiel School of Marine and
Atmospheric Science
University of Miami
Miami, Florida 33149

ABSTRACT

In response to serious declines in the abundance of a popular Florida gamefish, the snook (Centropomus undecimalis), an experimental hatchery project was initiated. The goals of the project are to develop prototype techniques and systems for propagating and culturing snook, while at the same time obtaining badly needed scientific information on the biology and ecology of the species. Intensive culture techniques, in which larvae were reared on a diet of cultured rotifers (Brachionis plicatilus) and brine shrimp (Artemia), successfully produced up to 2,000 35-day-old, weaned juveniles in 380-liter tank systems, and thus established the feasibility of snook culture.

Before snook can be routinely and economically produced for restocking programs, several additional problems must be solved and include: 1. Elimination of various pathological conditions arising in fingerling grow-out period. 2. Quantification of survival and fishery contribution of stocked fingerlings. 3. Development of systems that are labor and cost efficient. In addition to developing hatchery techniques, the project is heavily involved in studies of the biology and ecology of snook and other marine fish. The dual potential for experimental fish culture projects to work toward solution of applied, mission oriented, fisheries problems, while at the same time performing basic research, is discussed. The general philosophy, potential and current state of marine fish propagation for stocking programs is also discussed.

INTRODUCTION

Snook Biology

The common snook (Centropomus undecimalis) is a large (up to 24 kg), relatively non-migratory (Bruger, 1980) inshore fish whose range extends from southern Florida to Rio de Janeiro, Brazil, including the southeastern coast of the Gulf of Mexico, most of the Antilles, and Caribbean coast of Central and South America(Fischer, 1978). In Florida, snook are most abundant in bays and estuaries, but are also found in substantial numbers in a variety of habitats ranging from inland freshwaters to offshore coral reefs. In Florida the primary snook spawning season extends from April through September, with a peak around June. Large females can spawn upwards of a million small (0.7

mm), pelagic eggs which hatch within one day. Yolk-sac larvae utilize their yolk and oil globule for growth and energy until they begin to feed at around three days after hatching (3 DAH). Metamorphosis begins at around 9-12 DAH, with gradual attainment of adult characteristics almost totally completed at around 25 mm SL (Lau and Shafland, 1982) in about 40 DAH (Chapman et al., 1982). Larvae and postlarvae move from the spawning grounds, near the Atlantic Ocean or Gulf of Mexico, up estuarine salinity gradients to shallow, marshy, low-salinity nursery habitats which are often tens of kilometers away from the sea. Metamorphosed juveniles are most frequently found in freshwater or low-salinity habitats at the margins of estuaries (Marshall, 1958; Fore and Schmidt, 1973; Gilmore et al., 1983; R.E. Edwards, unpublished). Juveniles recruit to these nurseries beginning at about 20 mm SL and remain there for about two or three months until they are about 100 mm SL (Gilmore et al., 1983).

State of the Fishery

Snook was legally declared a gamefish in 1957 and commercial harvest has since been prohibited in Florida (Marshall, 1958). Recreational angler surveys (Marco Applied Ecology Station, 1975; Carroll, 1983) have shown that snook is one of the most popular and highly sought inshore gamefish in southern Florida. However, during the last decade, dramatic declines in snook abundance have been perceived by anglers and have been scientifically documented. For example, Bruger (1983) estimated that between 1977 and 1981 the population of mature snook in the Marco Island/Naples region of southwestern Florida had declined by about 70%. Similarly, Carroll (1983) found that snook catches in the St. Lucie Estuary on the southeastern coast had dropped to about 2% of the total recreational harvest, whereas in 1956-1957 they had accounted for over 26%.

Causes of Snook Population Declines

The cause of snook population declines in Florida is not known with certainty, and there may not be a single cause. Since Florida snook are at the northern edge of their range, extremely cold weather can cause extensive snook kills (Storey and Gudger, 1936) when water temperature falls below their lethal limit, which is about 14°C for juveniles (Shafland and Foote, 1983) and adults (R.E. Edwards, unpublished observations). Therefore, cold weather may have contributed to the declines. Destruction or pollution of adult habitat is another possible cause, although adult and late-juvenile snook are extremely flexible in their ability to utilize diverse habitats (Gilmore et al., 1983). Increased fishing pressure has almost certainly resulted in decreased snook population levels, but whether it accounts for a large part of the decline is uncertain.

Although none of the above potential causes can be totally discounted, and in fact it is likely that they all are contributory, observations from Everglades National Park (ENP)

suggest that they are not the primary factor. In ENP, which historically has been prime snook habitat and a center of abundance, declines over time have paralleled those in other areas, even though habitat destruction and pollution did not occur in ENP, extensive cold kills were not observed, and fishing effort in ENP substantially declined during the period (E. Rutherford, personal communication). The evidence is circumstantial, but it appears that the snook population declines may be largely attributable to insufficient recruitment which in turn is attributable to the species' unusual life history, in which availability of low-salinity nursery habitat can be a limiting factor. During the period of decline, anglers almost universally noticed the rarity of subadults (i.e., < 50 cm), whereas previously they were very common. There have been recent reports from southwestern Florida of increased catches of subadult snook of sizes that correspond to the 1982 and 1983 year classes: coupled with the fact that in the late summer of these two years, for the first time in many years, there was substantial freshwater input and extensive areas of low salility in these estuaries (Edwards, 1983 and unpublished observations), supports the hypotheses that snook recruitment is limited by availability of low-salinity nursery habitat.

Hatchery Rationale and Objectives

In 1983 a group of concerned conservationists and recreational fishermen formed a non-profit organization, the Atlantic Gamefish Foundation, whose goal was to raise the necessary funds and to otherwise support an Experimental Hatchery program at the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS). The program's mission was to perform research on the biology and ecology of important marine fishes, particularly with regard to efforts to conserve and enhance fisheries through artificial propagation and stocking programs. Snook was targeted as the first species to be investigated, largely because of the serious condition of snook fisheries in Florida. Equally important to the selection was the fact available scientific information indicated that a snook stocking program, by bypassing the life-history bottleneck arising from limited availability of early-juvenile nursery habitat, could be expected to have a significant and positive impact on snook populations and fisheries. Additionally, despite the fact that snook are highly sought, the annual recreational harvest of snook is not large. In 1948, the peak year of the commercial snook fishery, the total commercial catch was estimated at about 800,000 lb (363,000 kg) (Volpe, 1959). If it is liberally assumed that an equal amount was taken by recreational fishermen and that average size was 8 pounds, the 1948 peak catch can be estimated to have been around 200,000 snook. Given that snook harvest has declined from those peak years, a hatchery/stocking program could make a significant contribution even if only a few tens of thousands of stocked snook were recruited to the fishery each year.

Snook Project Objectives

The project objectives were to determine if artificial snook propagation, culture and stocking was biologically and technically feasible, and to concurrently perform basic research on snook biology and ecology, which in itself could be extremely useful to efforts to manage snook fisheries. If propagation and culture were determined to be feasible, the project was then to go on to developing, on an experimental basis, prototype hatchery production techniques and systems which, ultimately, would be employed by appropriate governmental agencies for routine and continuing hatchery/stocking programs.

The RSMAS snook project had the advantage of the considerable groundwork that had been laid by the Florida Game and Freshwater Fish Commission (FGFFC) which from 1974 to 1981 endeavored to propagate snook as a supplemental gamefish for stocking Florida freshwater where snook can grow but not reproduce. The FGFFC had excellent success in developing spawning techniques (Ager et al., 1976), but larval culture results were disappointing. A few thousand metamorphosed juveniles were obtained from sporadic outdoor cage cultures (Chapman et al., 1982), but few larvae could be reared through metamorphosis in laboratory culture systems (Shafland and Koel, 1979). Therefore, the first objective of the RSMAS Experimental Hatchery Snook Project was to determine if snook larvae could be mass cultured by intensive, tank-culture methods, and furthermore to determine if they could be grown through metamorphosis using cultured food organisms alone. If these objectives could be attained, it was felt that the feasibility of hatchery production of snook would be established.

METHODS

Spawning

Spawning methods closely followed those developed by FGFFC (Ager et al., 1976). Wild adults were collected by hook and line, and their sex and gametogenic condition was usually assessed in the field from samples taken by genital catheterization. Prospective spawners were transported to the laboratory where females were injected intramuscularly with a single dose of human chorionic gonadotropin at 1100 IU kg^{-1}, usually administered the same day as capture or within two days. Males received no hormone injection. Males were usually collected within a few days of spawning, although some produced viable sperm in sufficient quantities for fertilization after two weeks in captivity. Milt could also be taken from males collected prior to the spawning season and maintained for several months in brookstock tanks. Prior to handling, fish were anaesthetized with tricain methane sulfonate (MS-222). Ova hydration and ovulation by injected females was monitored by sequential catheterization using criteria similar to Ager et al (1976) to determine the proper time for forced spawning. Ova were manually stripped and collected in a graduated beaker. Just

prior to stripping, milt was collected by catheterization with a capillary micropipette. From 50 to 100 µl of milt was usually collected and was sufficient to fertilize up to a million ova. Milt was collected from two or three males if possible. Using the so-called wet method, ova were poured into a shallow glass tray filled to a depth of about 1 cm with seawater into which milt was immediately delivered from micropipettes while gently stirring. Ova were retained in the tray for at least 5 minutes before they were transferred to 300-400 ℓ incubation tanks (32-35°/oo) maintained at 28 ± 0.5°C. Light aeration was supplied. Hatching occurred after about 15 hours.

Larval Culture

Larval culture systems consisted of 380-ℓ fiberglass tanks (75 cm dia x 75 cm high) with slightly rounded bottoms and central standpipes. Tanks were filled with gravity-settled and/or filtered seawater (32-35°/oo). Temperature was maintained at 28 ± 0.5°C by 150-W immersion heaters in each tank. A single airstone in each tank provided aeration, which initially was a small stream of fine bubbles, but was increased as larvae grew and attained greater swimming ability. Each tank was illuminated 14 hr/day by two 20-W cool-white fluorescent tubes suspended 20 cm above the water surface providing about 3,000-5,200 lux at the water surface.

Tanks were stocked with either advanced embryos (approx. 2 hours prior to hatch) or hatched yolk-sac larvae (usually less than 24 hours after hatching). Direct counting, volumetric methods, or aliquot methods were used to enumerate embryos. Since optimal stocking density (stocking density that results in maximum larval production per tank) has not been rigorously determined, we usually stocked about 16 larvae/ℓ (around 6,000 larvae/tank), although we performed experimental rearings using stocking densities ranging from 6 to 24/ℓ.

Snook larvae were cultured using semi-static greenwater culture techniques. (Houde and Taniguichi, 1981), in which cultured phytoplankton (two or more liters per tank, depending on culture density and tank condition) was added each day. Chlorella sp., Anacystis sp., and Isochrysis galbana (Tahitian strain), individually or mixed, were used successfully. Each day, starting at 2 or 3 DAH, each tank had 10-15% of its volume replaced with new seawater. Tank bottoms were siphoned each day after 5 DAH to remove sedimented plankton, feces and other detritus.

In initial rearing experiments, larvae were fed size-graded (Houde and Taniguichi, 1981) wild zooplankton (mostly copepods), rotifers (Brachionus plicatilis) supplemented (25%) with wild zooplankton, or rotifers followed at 12 DAH by additions of Artemia nauplii. Artemia nauplii were added to the zooplankton-fed tanks beginning at 20 DAH. The rotifer-Artemia regime (Fig. 1) was used in subsequent rearings. Rotifers were grown in yeast-fed tanks outdoors, or in indoor, intensive-culture systems fed with cultured Isochrysis galbana or Anacystis so. (R.E. Edwards, in prep.). Juvenile Artemia were

cultured in outdoor tanks in which they fed on wild microalgae, added micronized rice bran (Sorgezeloos et al., 1980) and/or added cultured phytoplankton. Metamorphosing snook larvae were fed juvenile and adult Artemia. Beginning at 32 to 35 DAH, finely minced penaeid shrimp was offered. Weaning to the minced diet was usually completed in 2 or 4 days. After weaning, juvenile snook were transferred to larger grow-out systems.

Food (zooplankton, rotifers and Artemia nauplii) concentrations in the rearing tanks were estimated from 50-ml aliquots taken 2 to 4 times each day. Food additions were quantified by counting one to three 1-ml aliquots of concentrated food organisms before adding measured volumes to rearing tanks. Rotifer and zooplankton concentrations were maintained near 3/ml when possible, with 1/ml considered to be a minimal acceptable concentration. Artemia nauplii concentrations were maintained at about 1/ml. Artemia juveniles were offered ad libitum by adding them several times each day. Their constant availability to snook larvae was monitored visually.

Table 1. 1984 rearing experiments

Tank	Stocking Density	Food	30-DAH Survival
6-84-1	6/liter	*Zooplankton	1200
6-84-2	6/liter	*Zooplankton	600
6-84-3	12/liter	*Zooplankton	2050
6-84-4	12/liter	*Zooplankton	200
6-84-5	24/liter	*Zooplankton	1500
6-84-6	24/liter	*Zooplankton	850
7-84-1	12/liter	*Zooplankton	2000
7-84-2	12/liter	*Zooplankton	100
7-84-3	12/liter	*Rotifers (75%)+Zooplankton (25%)	1050
7-84-4	12/liter	*Rotifers (75%)+Zooplankton (25%)	800
7-84-5	12/liter	Rotifers-Artemia (12 DAH)	1850
7-84-6	12/liter	Rotifers-Artemia (12 DAH)	1200

* Supplemental Artemia feeding begun at 20 DAH.

RESULTS

The results of the 1984 rearings, which included rearings utilizing wild zooplankton, rotifer + zooplankton, and rotifer-Artemia diets, are presented in Table 1. In 1985, three spawns produced 26 rearing trials, all of which utilized the rotifer-Artemia feeding regime (Fig. 1). At least 14 trials were estimated to have at least 500 surviving larvae at 30 DAH. Five other spawns were obtained, but because of low hatching percentage, were abandoned, combined, or otherwise subjected to nonstandard methods. Substantial numbers of 30 DAH were obtained from these marginal spawns. Survival at 30 days after hatching

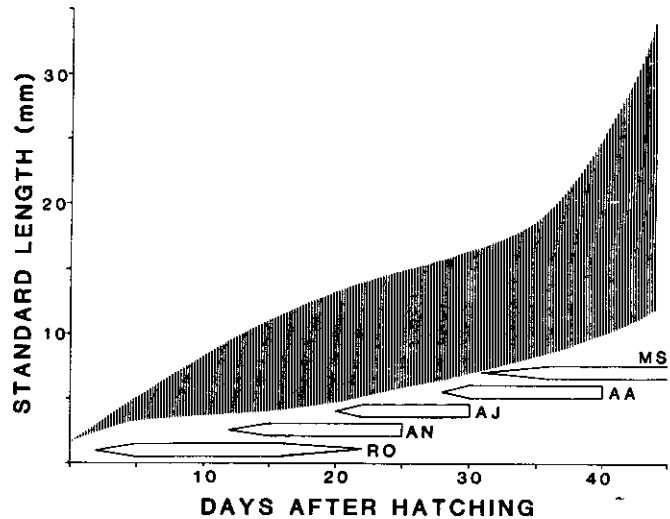

Figure 1. Feeding regime for tank-reared snook larvae. Shaded area depicts approximate ranges of standard lengths (SL). Foods offered were: RO - Rotifers, Brachionus plicatilis (50-120 m); AN - Artemia nauplii (newly-hatched): AJ - Artemia juveniles (3-8 days old); AA - Artemia adults (3.5 mm TL); MS - Minced shrimp (Penaeus sp.).

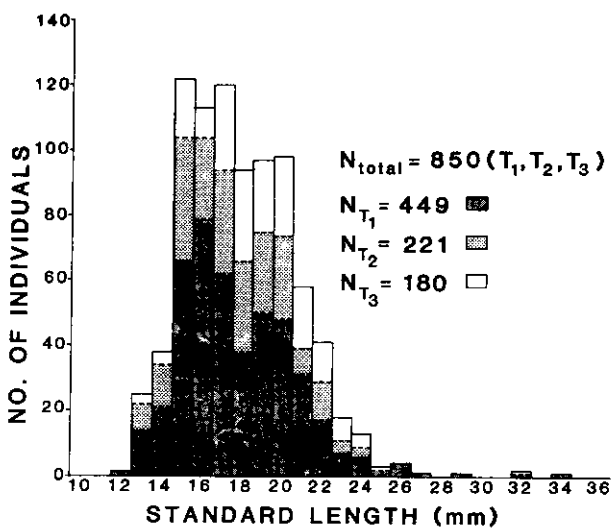

Figure 2. Length/frequency of tank-reared snook at 44 DAH. T_1, T_2, T_3, are three independent rearing trials.

was selected as a milestone because at 30 DAH larval rearing is essentially complete (metamorphosis is substantial, postlarvae accept large adult Artemia and no longer demand plankton or juvenile Artemia) and weaning to a diet of minced shrimp can be started. Additionally, 30 DAH generally preceded a period of high mortality which is still unexplained, but as discussed below, does not appear to be due to larval rearing conditions.

Although weaning could be initiated as early as 30 DAH, acceptance of the non-living food by the majority of the individual fish usually did not occur until after 35 DAH. This was largely due to the great size diversity among larvae of the same age and in the same tank (Fig. 1). Size diversity continued through the early-juvenile stage (Fig. 2) and is a significant feature of this culture method.

In 1984, over 2000 snook fingerlings (4-12 cm TL) were stocked in what was the first marine fish stocking in Florida history. In 1985 it is anticipated that 3000 to 4000 fingerlings (> 7 cm) will be stocked.

DISCUSSION

The fact that over 20,000 juvenile snook were produced in experimental systems indicates that intensive tank rearing of snook larvae is biologically and technically feasible. The fact that snook larvae could be reared on a diet of cultured organisms indicates that intensive tank culture for hatchery production is also feasible.

The major limiting factor in the larval culture experiments was the large number of rotifers that were required. For example, at 12 or 13 DAH - just prior to the time that most larvae begin to accept Artemia nauplii, over three million rotifers per day can be required to maintain one 380-l rearing tank. In 1985, rotifer culture facilities were not constructed in time for the rearing season, so indoor culture was limited by facilities. Outdoor, yeast-fed cultures provided interim, supplemental rotifer production, but were inconsistent and unreliable. During many larval rearing trials, rotifer cultures did not attain or maintain required production levels. Consequently, rotifer concentrations in numerous successful and unsuccessful trials fell below the designed 1/ml minimum concentration for periods up to several days, and negatively affected survival. Overall, however, our experience indicates that if sufficient rotifers are reliably available, very large numbers of snook larvae can be reared to metamorphosis using our intensive, tank-culture techniques.

The major barrier to production of large numbers of stockable fingerlings has been a pathological condition that usually begins after weaning and metamorphosis, but which has also been observed as early as 26 DAH, and which results in high mortality. The cause of the mortality has yet to be ascertained. The condition is characterized by waves of mortality, starting at first with robust, healthy-appearing fish, which often become disoriented before death. The only visible symptoms are congestive reddening of the nasal area, pectoral and pelvic fin

bases, or under the operculum; and what appears to be unusually high fat deposition in the body cavity, particularly near the liver. A team of experts is currently evaluating the problem, but so far has only succeeded in discounting typical bacterial infection (e.g., Vibrio) as the likely cause. Clearly, this problem must be solved before large-scale production can be expected.

Cannibalism is another cause of mortality, but is yet to be quantified. The size disparity between fish of the same age within the same tank (Fig. 2) makes high rates of cannibalism possible. Cannibalism by snook larvae was observed as early as 15 DAH. Discrepancies between accumulated numbers of daily mortalities removed from tanks and periodic enumeration of larvae and early juveniles were probably due to cannibalism. However, it is not known whether the cannibalized individuals were already weakened or killed by the pathological condition and whether they would have been cannibalized otherwise.

Although mass rearing of snook larvae through metamorphosis using intensive, tank-culture techniques is clearly feasible, it should be pointed out that larval culture using systems of this scale (i.e., 400 l) is extremely labor intensive. We used this scale because it allowed more experimentation (i.e., more treatments and more replicates) than would be possible using larger systems. Ultimately, however, practical and cost-effective mass-culture of snook larvae in tanks will require systems scaled to much larger dimensions. The feasibility and practicality of production of large numbers of marine fish using intensive, tank-culture, techniques is demonstrated by Japanese hatcheries which yearly produce millions of marine fish fingerlings this way (Cowan, 1981; Kuronuma and Fukusho, 1984). However, very large systems (25-100 metric tons/tank) have evolved as the preferred scale for high-production intensive-culture of species such as red seabream (Pagrus major) of which over 200 million fingerlings are produced each year (Kuronuma and Fukusho, 1984). This scale is over two orders of magnitude larger than our experimental (0.4 metric ton) systems, and, therefore, it can be expected that production snook culture systems should probably be at least several metric tons in size.

Our snook culture studies have been motivated by the desire to enhance or restore snook fisheries. The concept of enhancing natural populations of marine fish through hatchery activities is not new, dating back over a century, and recently such efforts have experienced a resurgence (see Richards and Edwards (in press) for a review). The common denominator of most of the modern marine hatchery/stocking programs is that they are directed at enhancing fish populations that are believed to be recruitment limited, and their rationale is that fingerling stocking can increase recruitment to populations that are otherwise not presently limited. In Florida, it is likely that snook populations have been and will continue to be limited by insufficient recruitment caused by destruction and/or alteration of early-juvenile, nursery habitat. If this is the situation, then enhancement programs that stock larger, late-juvenile

fingerlings, that are able to utilize other existing and undersaturated habitats, should significantly increase adult snook populations. In Texas, more than two million red drum (Sciaenops ocellata) fingerlings are being stocked annually (Matlock, 1984) to enhance recruitment which is believed to be at least partially limited by numbers of eggs and larvae transported into coastal lagoon nurseries from the Gulf of Mexico coastal waters where red drum spawning is thought to occur. The extensive and expanding Japanese marine stocking program, which includes at least 12 species, for which a total of over 9 million fingerlings are produced annually, is an effort to mitigate the effects of pollution and destruction of inshore nursery habitats (Cowan, 1981).

The impacts of recent marine stocking programs have yet to be fully evaluated, but preliminary indications (Matsumiga and Kiso, 1982, Matlock et al., 1984) are encouraging. In the future, it is very likely that hatchery production of marine fish for stocking will be increasingly applied with increasing success in solving fisheries problems.

LITERATURE CITED

Ager, L.A., D.E. Hammond and F. Ware. 1976. Artificial spawning of snook. Proc. Ann. Conf. Southeast Assoc. Game Fish Comm. 30:158-166.

Bruger, G.E. 1980. Preliminary analyses of snook Centropomus undecimalis, population dynamics in the Naples-Marco Island region of southwest Florida. Fla. Sci. 43 (Suppl.): 25 p. Abstract.

_____ 1983. Overview of snook population dynamics. Summary of Proceedings, Snook Sym. (Nov. 20, 1982): 5 p.

Carroll, J.D. 1983. Creel survey of the St. Lucie Estuary as related to snook. Summary of Proceedings, Snook Sym. (Nov. 20, 1982): 7 p.

Chapman, P., F. Cross, W. Fish and K. Jones. 1982. Final report for sportfish introduction project. Study I. Artificial culture of snook. Fla. Game Freshwater Fish. Comm. 36 p. Mimeo.

Cowan, L. 1981. Hatcheries-the basis of modern Japanese mariculture. Aust. Fish. 40: 20-55.

Edwards, R.E. 1983. Effects of seasonal salinity transition on estuarine benthic nutrient fluxes. Amer. Soc. Limnol. Oceanogr. 46 Ann. Meet. Abstract.

Fischer, W. (ed.). 1978. FAO species identification sheets for fishery purposes. Western Central Atlantic (Fishing Area 31). Vol. II.

Fore, P.L. and T.L. Schmidt. 1973. Biology of juvenile and adult snook, Centropomus undecimalis, in the Ten Thousand Islands, Florida. Ch. 16 in Ecosystems analyses of the Big Cypress Swamp and estuaries. U.S. Env. Pro. Ag., Surveillance and Analysis Div., Athens, GA. 18 p.

Gilmore, R.G., C.J. Donohoe and D.W. Cooke. 1983. Observations on the distribution and biology of East Central Florida population of the common snook Centropomus undecimalis

(Bloch). Fla. Sci. 46:313-336.
Houde, E.D. and A.K. Taniguichi. 1981. Marine fish larvae growth and survival. Report No. EPA-600/3-81-052. U.S. Env. Pro. Ag., Narragansett. 66 p.
Kuronuma, K. and K. Fukusho. 1984. Rearing of marine fish larvae in Japan. Inter. Dev. Res. Centre, Ottawa, Canada. 109 p.
Lau, S.R. and P.L. Shafland. 1982. Larval development of snook, Centropomus undecimalis (Pisces: Centropomidae). Copeia 1982:618-627.
Marco Applied Ecology Station. 1975. Characteristics of the sportfishery in the Ten Thousand Islands area of Florida from June 1, 1971-June 30, 1974. Marco Island, Florida. 62 p. (Mimeo).
Marshall, A.R. 1958. A survey of the snook fishery of Florida, with studies of the principal species, Centropomus undecimalis (Bloch). Fla. St. Bd. Conserv. Tech. Ser. (22): 37 p.
Matlock, G.C. 1984. A summary of 7 years of stocking Texas Bays with red drum. Tex. Pks. Wildlf. Dept., Coastal Fish. Br. Mgmt. Data Ser. (60): 14 p.
_____, B.T. Hysmith and R.L. Colura. 1984. Returns of tagged red drum stocked into Matagorda Bay, Texas. Tex. Pks. Wildlf., Coastal Fish. Br. Mgmt. Datas Ser. (63): 6 p.
Matsumiga, Y. and K. Kiso. 1982. Movements and adaptation process of artifically reared sea bream after release in Shijiki Bay, Hirado Island Bull. Seikai Reg. Fish. Res. Lab. 58:89-98.
Richards, W.J. and R.E. Edwards. in press. Stocking marine species to restore or enhance fisheries. in R.H. Stroud (ed.). The role of fish culture in fishery management. Amer. Fish. Soc.
Shafland, P.L. and K.J. Foote. 1983. A lower lethal temperature for fingerling snook, Centropomus undecimalis. Northeast Gulf Sci. 6:175-177.
_____, and D.H. Koehl. 1979. Laboratory rearing of the common snook. Proc. Ann. Conf. S.E. Assoc. Fish. Wildl. Agencies. 33: 425-431.
Sorgeloos, P., M. Baeza-Mesa, E. Bossuyt, E. Bruggeman, J. Dobbleir, D. Versichele, E. Lavina and A. Bernardino. 1980. Culture of Artemia on rice bran: The conversion of a waste-product intok highly nutrative anaimal protein. Aqua. 21:393-396.
Storey, M. and E.W. Gudger. 1936. Mortality of fishes due to cold at Sanibel Island, Florida, 1886-1936. Ecol. 17:640-648.
Volpe, A.V. 1959. Aspects of the biology of the common snook, Centropomus undecimalis (Bloch) of southwest Florida. Fla. St. Bd. Conserv. Tech. Ser. (31): 37 p.