Comparison of Some Developmental, Nutritional, Behavioral, and Health Factors Relevant to Stocking of Striped Mullet (Mugilidae), Sheepshead (Sparidae), Common Snook (Centropomidae), and Nassau Groupers (Serranidae)

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Striped mullet (*Mugil cephalus*, family Mugilidae) are temperate to tropical (Table 1), euryhaline (Table 2), schooling, very omnivorous, coastal fish that eat detritus and a wide range of other organic material. Sheepshead (*Archosargus probatocephalus*, family Sparidae) are temperate to tropical, euryhaline, territorial, omnivorous, coastal fish that are more specialized in feeding; crustaceans and mollusks are important in their diet. Common snook (*Centropomus undecimalis*, family Centropomidae) are tropical, euryhaline, schooling, carnivorous, coastal fish that eat mainly fish and crustaceans. Nassau groupers (*Epinephelus striatus*, family Serranidae) are tropical to temperate, moderately stenohaline, territorial, carnivorous, reef fish that eat mainly fish, crustaceans, and molluscs. We (Tucker, 1998) have raised these species to ages of more than 7, 13, 15, and 15 years (mullet, grouper, sheepshead, snook, respectively).

Table 1. Suitable temperatures (° C).

Species	Spawning	Larvae	Juveniles
Striped mullet	23	26	28
Sheepshead	23	27	28
Common snook	26	27	28
Nassau grouper	26	27	30

Table 2. Suitable salinities (ppt).

Species	Spawning	Best for larvae	Range for larvae	Best for juveniles	Range for juveniles
Striped mullet	32	26	17-36	[illegible]	0-55
Common snook	32	32	[illegible]	0	0-35
Sheepshead	35	[illegible]	15-36	[illegible]	<1-44
Nassau grouper	35	32	27-38	30	15-37

In Florida, striped mullet spawn offshore during December-February, sheepshead nearshore during March-April, common snook nearshore and in bays during April-October, and Nassau groupers on reefs during March-April. Nassau groupers spawn during the winter in the Caribbean region and summer at Bermuda.

Eggs and larvae are planktonic. Striped mullet eggs are ~940 µm in diameter and hatch in ~34 h at 24[illegible] C. They become juveniles 35-45 mm TL at ~28 days after hatching (dah). Sheepshead eggs are ~820 µm in diameter and hatch in ~28 h at 23[illegible] C. They become juveniles 14-20 mm TL at ~39 dah. Common snook eggs are ~750 µm in diameter and hatch in ~17 h at 28[illegible] C. They become juveniles 35-40 mm TL at ~35 dah. The life history of snook is very similar to that of barramundi (*Lates calcarifer*), except for later transformation (17-25 mm TL at 25 dah for barramundi). Nassau grouper eggs are ~1 mm in diameter and hatch in ~26 h at 26[illegible] C. They become juveniles 35-50 mm TL at 46-70 dah. The best reported survival in hatchery tanks has been 5.0% for Nassau grouper (egg-98 dah), 7.0% for common snook (hatchling-55 dah), 39.7% for sheepshead (egg-100 dah), and 52% for striped mullet (hatchling-60 dah).

Juveniles of all but Nassau grouper will thrive in hard fresh water. Nassau groupers typically are reef fish (Table 3). We used floating milk crates to accelerate transformation of larvae to juveniles in the hatchery. The others are coastal fish but can be found on islands with freshwater rivers. From the early juvenile stage, striped mullet are strictly schooling fish. Common snook form loose schools. Nassau groupers school as juveniles but become territorial as they mature. Sheepshead are territorial from the juvenile stage onward.

Table 3. Typical habitats.

Species	Larvae	Juveniles	Adults
Striped mullet	Coastal offshore	Shallow coastal	Shallow coastal & estuaries
Sheepshead	Coastal offshore	Structures, grassbeds	Structures, grassbeds
Common snook	Coastal offshore	Shallow vegetation	Shallow coastal & estuaries
Nassau grouper	Deep offshore	Backreef	Forereef

Striped mullet are extremely active omnivores (small foods, including detritus), almost constantly swimming and feeding over wide areas. Sheepshead are less active, spending long periods feeding over smaller areas, mainly on crustaceans, mollusks, and some algae. Common snook are less active, with short intense feeding periods on fish and crustaceans. They mostly hover and save energy when not feeding. Nassau groupers are least active and relatively sedentary, with short feeding periods, often opportunistic, on fish, crustaceans, and molluscs.

Striped mullet are especially susceptible to ectoparasites and scale loss (from handling) leading to vibriosis. Common snook are resistant to parasites and other diseases unless they are handled, in which case they become more susceptible to scale loss and vibriosis. Nassau groupers are susceptible to some ectoparasites like monogenean flatworms, but are very resistant to handling. Sheepshead are very resistant to diseases and handling. All of these species except groupers can be stocked in fresh water to avoid vibriosis and some parasites, but stocking in salt water can help avoid fungal infections.

Since 1996, we have used probiotic bacteria combined with improved environmental control to enhance health, survival, and growth of larvae of several species (Kennedy *et al.*, 1998). One impediment to snook farming has been the need for refining larval culture techniques to increase survival, especially during the first week. When rearing water was inoculated with *Bacillus* species isolated from healthy hatchery-reared snook, survival from hatching to 55-day-old juveniles was increased from the 1-2% reported previously to 7.0%. It is expected that effective control of cannibalism will further increase survival to at least 10-15% (tens of thousands times higher than in nature). With consistent egg quality and management, this level of survival would make large-scale rearing of snook feasible.

For stocking in grow-out tanks or small protected ponds and cages, fully developed juveniles ~50 mm TL are a good minimum. For less protected ponds and cages, the fish should be larger. For stocking in natural environments, the larger the fish the better. It is important to stock them at a size beyond which habitat (Table 3) and/or food scarcity are not limiting. As snook grow from 25 mm to 250 mm TL, they depend on shelter from shallow weeds, then mangroves, then grassbeds (or equivalents). As Nassau groupers grow from 50 mm to 250 mm TL, they move from shallow backreefs to shallow forereefs. Sheepshead live close to or in natural or artificial structures from the early juvenile stage onward. Mullet tend to stay in large schools in open water (shallow and deep) from the early juvenile stage onward.

Much behavior in these fish is innate. Striped mullet are foragers, always ready to flee. Sheepshead are grazers, not easily disturbed. Common snook are raptors, alert and suspicious of any movement or change in light. Nassau groupers are ambushers, bold and curious around humans unless mistreated. As they transform, reared striped mullet swim around the tanks in a school as if migrating. They seem just as fearful as wild mullet and thoroughly scour the tank walls and bottoms for food. When released in a shallow estuary, mullet swam away in a school. Once common snook are juveniles, they are almost as shy as mullet but stay near the bottom except when feeding. When released in shallow estuaries, snook swam away in small groups, hid between mangrove roots, and soon began chasing prey-size wild fish. Once sheepshead are juveniles with well-developed incisors, they thoroughly scrape algae from the tank walls. When released in a shallow estuary, they individually swam between mangrove roots and soon began scraping food from the roots. Nassau groupers are very adaptable during rearing, and will even eat directly from a person's hand immediately after being moved between tanks. Wild juveniles ate pellets from our hands within 2 h after capture. After being raised on dry pellets for 2 years, juveniles showed no hesitation in eating live goldfish, minnows, and fiddler crabs, and needed only a few hours to eat live shrimp when first

offered. At about the same time, several of them learned to knock large isopods off the tank wall several cm above the water by spitting streams of water like archerfish, and then ate them. When released on a 15-m reef after spending several days in a holding cage (Roberts *et al.*, 1995), reared Nassau groupers immediately went to a cleaning station to have parasites acquired in the cage removed from their mouths and gills by cleaner gobies and shrimp (like wild groupers). They soon settled into the reef, and within 2 d hunted alongside a moray eel and an octopus (like wild groupers).

Preconditioning can help released fish adapt more quickly. However, the swimming, feeding, social, and fright behaviors of these four species when reared are surprisingly similar to those of wild fish. In addition to providing biological needs and minimizing predation, good choice of release habitat can help limit stress and disease.

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