Feature Article

A Goliath Success Story for Marine Conservation in Florida

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Amid all the foreboding news of declining marine resources (Dayton et al. 2002, Myers and Worm 2003, Pew Oceans Commission 2003, US Commission on Ocean Policy 2004) worldwide shines a bright spot in the southeastern U. S. for an impressive beast. The goliath grouper (*Epinephelus itajara*)—still critically endangered throughout the Tropical eastern and western Atlantic (IUCN 2007). -- is making a comeback after 18 years of protection (Kinglsey 2004, Porch et al. 2006, Cass-Calay and Schmidt 2008). This is the good news.

The not-so-good news is the continuing uncertainty about the impacts of illegal fishing, catch-release mortality, and habitat loss (particularly juvenile mangrove habitat). The fishery closure reduced fishing mortality by somewhere between 50% and 90% (Kingsley 2004, Porch et al. 2006). A good start, but it makes it difficult to determine the actual status of the adult population, and nearly impossible for the National Marine Fisheries Service (NMFS) to develop management measures aimed at either rebuilding the fishery, ending overfishing, or both, as required by the Sustainable Fishery's Act (SFA). Thus, goliath grouper populations remain listed as overfished.

A meeting of scientists, managers, and user groups convened in March 2003 by NMFS and the Florida Fish and Wildlife Research Institute (FWRI) to address these issues (Kingsley 2004) resulted in the development of a list of research areas required to meet the SFA mandate. Among the key issues identified were: (1) defining age structure of existing populations; and (2) estimating population size through regional surveys around the state using visual techniques and tag and re-sight methods. A follow-up meeting on 6 August 2007 (FWRI, St. Petersburg, FL) focused on identifying data gaps needed to develop an adequate stock assessment. Stock assessment models rely heavily on regional demographics, particularly on age structure. A key issue resulting from that meeting was the importance of addressing the data quality of non-consumptive sampling. A group of scientists from universities (Florida State University, University of Florida, and University of South Florida), a state agency (FWC), and a federal agency (NMFS) joined forces to provide stock assessment biologists with the data they need to reduce uncertainty about population status and to evaluate the ecological role of goliath grouper in Florida. Much of the information presented here results from that body of work.

From 1999 to 2001, Koenig et al. (2007) used non-destructive sampling of juvenile goliath grouper in southwest Florida to determine the age structure, as well as the absolute population density, survival, home range, and recruitment patterns to the adult population, and confirm the critical importance of man groves as nursery habitat for goliath grouper. We modified these methods for adults, recognizing that adults are somewhat more difficult to catch and sample, and demonstrated that the method can be used throughout the species range, and has broad applicability for use on other threatened species, such as Nas sau grouper. Thus, we demonstrated that dorsal fin spines could be used effectively for non-consumptive ageing of juveniles (Brusher and Schull 2008) and dorsal fin rays were reliable for adult ageing, at least up to the late teens, the oldest ages we sampled (Murie et al. 2008). Also, using lasers to estimate fish sizes underwater, we found that regional size distributions are similar, with mean sizes ranging from 132 cm to 152 cm and maximum sizes per region from 160 to 220 cm. The maximum size for goliath grouper is thought to be 240 cm, but larger sizes are likely (Robins and Ray 1986).

Fecundity estimates are a bit more difficult to obtain non-destructively. Traditionally, the gonads are excised from dead fish and processed histologically to derive the appropriate estimates. However, we recently determined the diel timing of spawning and there is a chance that sampling the spawning aggrega tions will give us the necessary estimates directly. In 2005, we decided to try the novel approach of using

sound, rather than direct observation to pinpoint spawning time (Mann et al. 2008). Using both active and passive acoustics, we found strong evidence that the aggregated goliath grouper spawned on dark nights between the hours of 10 PM and 4 AM. We subsequently (September 2008) verified this nocturnal spawning pattern by collecting goliath grouper eggs from Atlantic and Gulf spawning aggregations and verifying their identity genetically. We intend to continue this work in the future and to use the information to make direct fecundity estimates.

Much of the goliath grouper recovery in Florida appears to have its origins in southwest Florida, where there is extensive high quality mangrove habitat inshore to support juveniles, especially in the Ten Thousand Islands (Koenig et al. 2007) and relatively abundant spawning aggregations offshore (Figure 1, Koenig unpublished data). The juvenile abundance increased throughout the Everglades National Park (which includes much of the Ten Thousand Islands) steadily in the late 1990s, and them dramatically between 2002 and 2006 (Cass-Calay and Schmidt 2008). This trend is likely to continue due to the dual recoveries of the adult population and the quality of mangrove habitat resulting from habitat restoration of the Everglades and Florida Bay.

Juvenile fish migrate outward from the nursery habitat as they mature. The juveniles from the Ten Thousand Islands moved either to reefs in the immediate area offshore, toward the Florida Panhandle, or toward the east coast of Florida (Koenig et al. 2007, and unpublished data). This pattern is born out in surveys of adult goliath grouper abundance, based on a compilation of our own diving surveys conducted throughout Florida coastal waters and those of volunteer-reported surveys compiled by REEF (Reef Environmental Education Foundation). These surveys (which had very similar results) indicate a regional pattern of abundance in which fish are relatively abundant in the southwest and the south central eastern region (Palm Beach Co.), but relatively sparse elsewhere (Figure 2). While adults exhibit very strong site fidelity, with 86% (138/160 total) of adult recaptures moving less than 1 km (Koenig unpublished data), this suggests that density-dependent factors may act to drive adults out from the southwest region to other areas.

Regardless of these data, some commercial and recreational fishermen want NMFS to reopen the fishery at some level, while other interested parties (including Environmental Defense, Gulf Restoration Network, the Ocean Conservancy, Ocean Futures Society, and Reefkeeper International, and various ecotourism diving interests) want NMFS to adhere to the SFA mandate and keep the fishery closed and manage it at 50% SPR (Spawning Potential Ratio), the designated level for fishes like goliath grouper that are highly vulnerable to fishing.

Most of the call to reopen the fishery is based on the perception that goliath grouper predation on reef fish—particularly grouper and snapper-- negatively impacts the resource. Because goliath grouper are large, goes the perception, they must consume overwhelming quantities of prey. There are no scientific data to back up this assumption and a considerable amount to contradict it. Our data, based on sampling the diet of about 250 goliath grouper (mostly large juveniles and 30 adults), show that despite their size, goliath grouper feed at a rather low trophic level, largely composed of crustaceans (crabs and shrimp) and slow-moving fish such as toadfish (Figure 3), with an overall isotopic signature (mean ^{13}C values -10.3 ‰ and mean ^{15}N values = 11.0 ‰) closer to that of pinfish than to top-level predators. This agrees with historical accounts of adult goliath grouper diets in the Bahamas, the West Indies, and the Gulf of Mexico (Beebe and Tee-Van 1928, Erdman 1956, Randall 1967, and Bullock and Smith 1991), which include primarily crustaceans with fish species such as catfish, angelfish, filefish, burrfish, parrotfish, stingray, spadefish, cowfish, and porcupine fish, but no groupers or snappers. Also, the large size of a goliath grouper is not *prima facie* evidence of a high rate of food intake. All else being equal, large fish eat more than small fish, but, a single large fish requires lower daily food intake than an equivalent mass of smaller fish of the same species. This pattern exists for all fish because both growth rate and metabolic rate decline with fish size (Brett and Groves 1979). Although food-intake rates have not been directly estimated for goliath grouper, we can safely assume that they are low based on the fish's sedentary life style.

Goliath grouper have likely been a dominant component of the reef communities of Florida for millions of years, but fishing and habitat destruction have taken their toll since the early part of the 20th Century (McClenachan 2009). The historical influence of these once abundant, large secondary consumers on the reef systems of south Florida can only be imagined (Zabel et al. 2003) primarily because we have virtually no knowledge of the state of Florida's reef ecosystems prior to man's influences on habitat (Ogden 2005) and fish populations. In the interest of conjecture, then, we suggest that there are two primary ecological influences that goliath grouper might have: first as a natural control of invasive species, such as lionfish, and second as an architect of reef design. As a recovered population, they may also have a positive economic effect on diver ecotourism.

Trophic patterns suggest that goliath grouper exerts predation pressure on both crustaceans and slow-moving fish species whose major defenses are venomous spines. Such food preferences are pre-adaptive for foraging on invasive venom-spined species such as lionfish. There is anecdotal evidence that lionfish populations on the east coast of Florida decreased as goliath grouper populations increased, and there are reef surveys showing a negative correlation between lionfish abundance and goliath grouper abundance, but as yet there are no experimental data supporting this conjecture. Goliath grouper might also be important in their ability to uncover storm-smothered reefs and ledges, because they are capable of limited excavation (Koenig, unpublished data). Because of the altered state of Florida reef communities and the early stage of goliath grouper recovery, their ecological influence remains unclear.

What is clear, however, is the great opportunity bestowed on Florida's diving ecotourism industry by the presence of these huge reef fish that can be viewed at close quarters in the natural environment. It seems that the economic benefits of goliath grouper have not been realized yet. Nowhere in the world can dozens of huge, but harmless reef fish be viewed at arm's length. The diving industry of Florida is just beginning to realize the enormous resource available to them. And, although valuation of tourist-related diving activities in Florida is unknown at this time, it is likely that the industry will grow and realize that live goliath grouper are economically more valuable than dead ones. Therefore, management for goliath grouper should consider, in addition to fishing, the benefits to the diving industry.

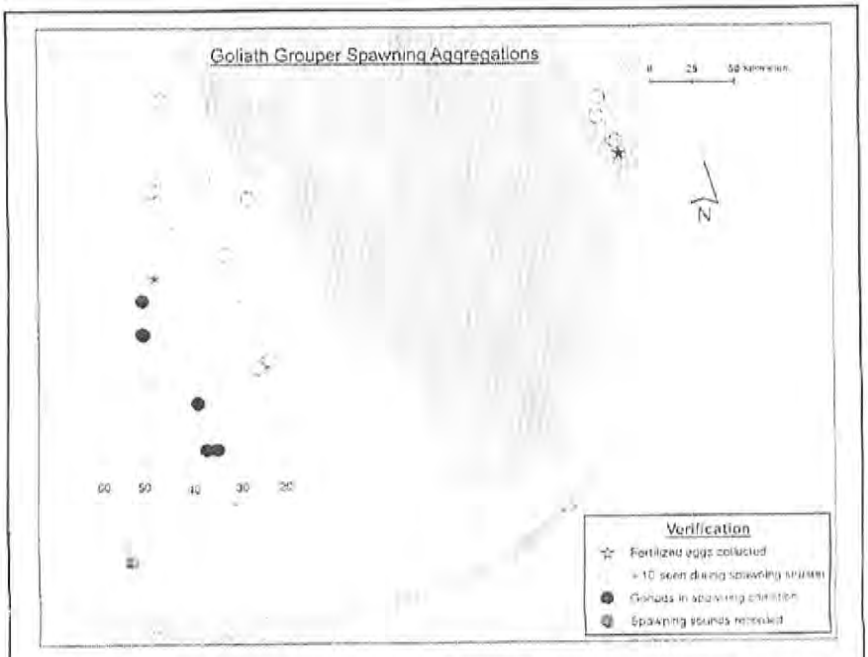

Figure 1. Distribution of actual and presumptive goliath grouper spawning aggregations in south Florida.

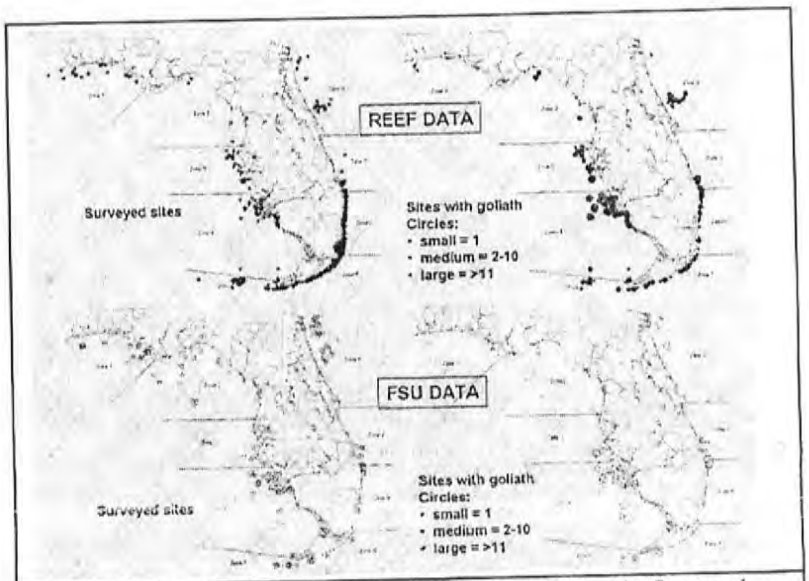

Figure 2. Regional site densities of goliath grouper in Florida. Surveyed sites are on the left and densities are on the right. REEF's (Reef Environmental Education Foundation) data in upper right image and FSU's (Florida State University) data in the lower right image show similar patterns of abundance.

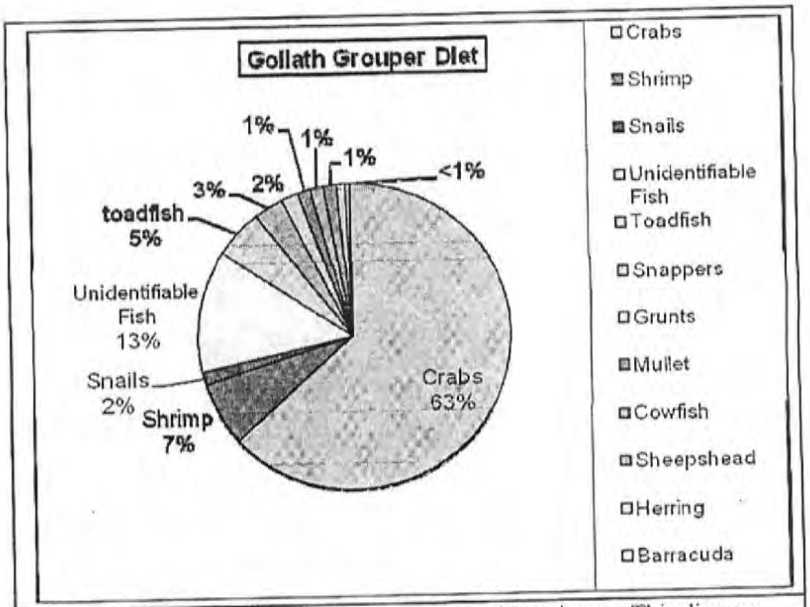

Figure 3. Goliath grouper diet by percentage of prey items. This diagram represents stomach samples from about 250 individuals from south and southwest Florida.

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