

Goliath grouper issues in Florida: fact or fiction.

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Goliath grouper (*Epinephelus itajara*), a large reef fish with populations in tropical Atlantic waters, is vulnerable to overexploitation and local extinction and is classified as critically endangered throughout most of its range by the World Conservation Union (IUCN). Yet populations in southeastern U. S. waters are recovering after both the South Atlantic and Gulf of Mexico Fishery Management Councils and Florida Fish and Wildlife Conservation Commission mandated total protection for this heavily exploited and overfished species in 1990. The question is: can managers of fisheries in Florida waters ignore the global status of this species?

As scientists who have studied this species for over a decade and a half and reviewed the literature and reports of colleagues and other scientists throughout the world (e.g., Bullock et al. 1992, Sadovy and Eklund 1999, Frias-Torres 2006, Koenig et al. 2007, Felix-Hackradt and Hackradt 2008, Brusher and Schull 2009, Craig et al. 2009, Gerhardinger et al. 2009, Mann et al. 2009, McLeanachan 2009, Murie et al. 2009, Graham et al. 2009, Evers et al. 2009, Cass-Calay and Schmidt 2009), we say no. The science-free perceptions and very vocal pronouncements of various groups about the biology, behavior, and population status of this species, while loud and strong, should not trump the best available scientific evidence in making management decisions. Our objective in this brief document is to juxtapose the scientific evidence following from this body of research with the most pervasive opinions voiced in the southeastern United States.¹

The Opinion: Goliath groupers compete directly with recreational reef fish fishermen for and substantially reduce the populations of groupers and snappers on reefs in south Florida.

The Science: There are two lines of evidence against this view provided by dietary and trophic studies of goliath grouper and videographic surveys of the distribution and abundance of reef fish on reefs off southwest Florida, the center of goliath grouper abundance.

In the stomach contents of over 200 goliath groupers sampled from South Florida we found no groupers and very few snappers. Only three percent of the prey items were snappers (Figure 1), and these were all gray snappers occurring in the mangroves in close proximity to the juvenile goliath grouper.

Stomach contents represent prey eaten just prior to capture, or a short-term view of diet. However, for an understanding of diet over the long term, and goliath grouper's position in the food web (i.e., trophic level) we used stable isotope analysis (Koenig and Coleman 2009). Results showed a relatively low position in the food web, similar to that of South Florida pinfish (*Lagodon rhomboides*; Chasar et al. 2005). Thus, goliath grouper must typically feed on lower trophic level species, not on those species occupying higher trophic levels, such as groupers and snappers.

¹ For further details, please refer to our report, "Population density, demographics, and predation effects of adult goliath grouper" (Koenig and Coleman 2009) and other papers referred to in this document.

In our reef surveys of southwest Florida, we found a significant positive relationship between the number of snapper (all species combined) and the number of goliath groupers present on surveyed sites; that is, the higher the number of goliath grouper occupying a reef, the higher the number of

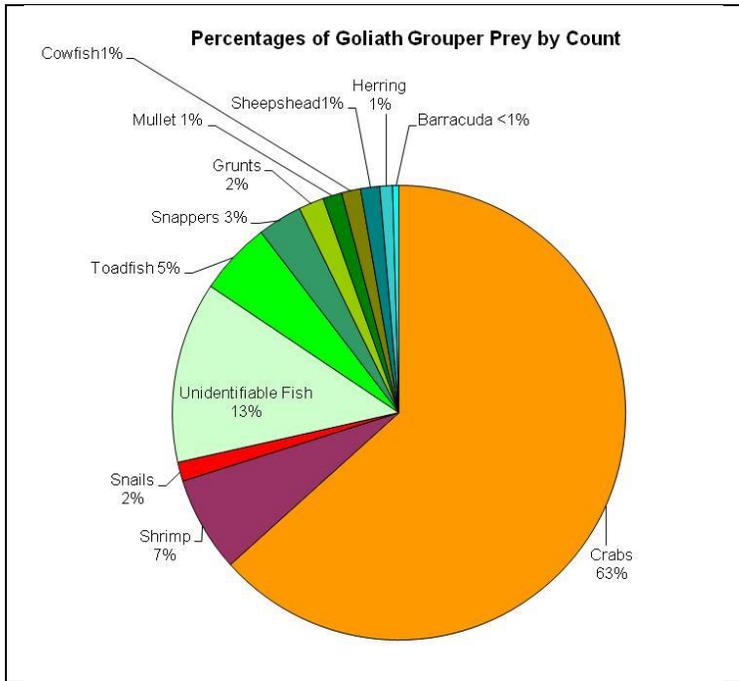


Figure 1. Main prey items in the diet of goliath grouper sampled from South Florida.

grouper compete directly with lobster fishermen by eating many lobsters in South Florida.

snappers on that reef (Figure 2). We found no significant relationship between the number of adult goliath grouper and the number of individuals of other groupers on the same sites. These data support the diet studies showing that few if any snappers and groupers are eaten by adult goliath grouper. Further, we found that most of the snappers and groupers on sites with goliath groupers were smaller than the minimum-fishery-size limit which suggests either that goliath grouper, if they do eat these fish, concentrate only on those exceeding the minimum size limit, or alternatively, that the fishery itself is responsible for removal of economically important species.

The Opinion: Goliath

The Science: Our stomach content data, sampled from goliath grouper in areas of high

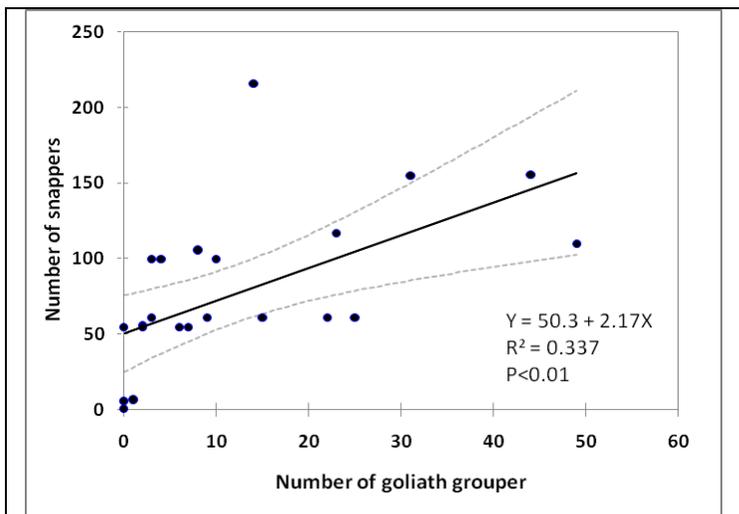


Figure 2. Regression of number of snapper individuals (all species) on goliath grouper density (no. per reef site) off southwest Florida on high-relief sites. Dashed lines denote 95% confidence limit.

eat within an ecological context?

lobster abundance, provide strong evidence against this view. Using the same stomach content data, we found only one lobster (less than 1% of the dietary items). The diet consisted mostly of crabs and slow-moving bottom-dwelling fishes such as toadfish (Figure 1).

The fact is that lobsters are preferred prey for many species, including sharks, rays, triggerfish, and grouper (including goliath grouper). When determining the impact of a predator on a particular prey population, however, the question is not what *can* the predator eat, or even, what prey does the predator prefer? The appropriate question is: what *does* the predator

The supposition that lobster form an important component of the goliath grouper diet follows from a report written by Jack Randall (Hawaii Biological Survey) about reef species sampled from the West Indies in the 1960s (Randall 1967). In this report, Randall indicated that a high percentage of the goliath grouper diet consisted of spiny lobsters. At that time (1959 – 1961) and in that place (St. John , VI), lobsters were abundant (Randall, personal communication), so the observation of goliath grouper feeding on them is not surprising. But between 1960 and about 1998, lobster landings tripled throughout the region, including Florida (FAO 2001). Today, in many areas of the Caribbean, lobster populations are severely overexploited while there are limited data about population health, abundance, and fisheries to help inform fishery management practices (FAO 2009). In the Florida Keys, where the fishery for lobsters is intense, it is doubtful that goliath grouper can affect the fishery catch significantly, and our data support this view.

The Opinion: Goliath grouper, because of their large size, require huge amounts of food to survive and eat indiscriminately, reducing biodiversity on reefs.

The Science: While it is true that adult goliath grouper are large, they are also extremely sedentary, rarely leaving home sites except to migrate to spawning sites. Their method of predation is to sit and wait for prey, and then use a suction method, common to all groupers and many other reef fish, to draw prey into their mouths.

To estimate the food consumption rate of goliath grouper, we developed a bioenergetics

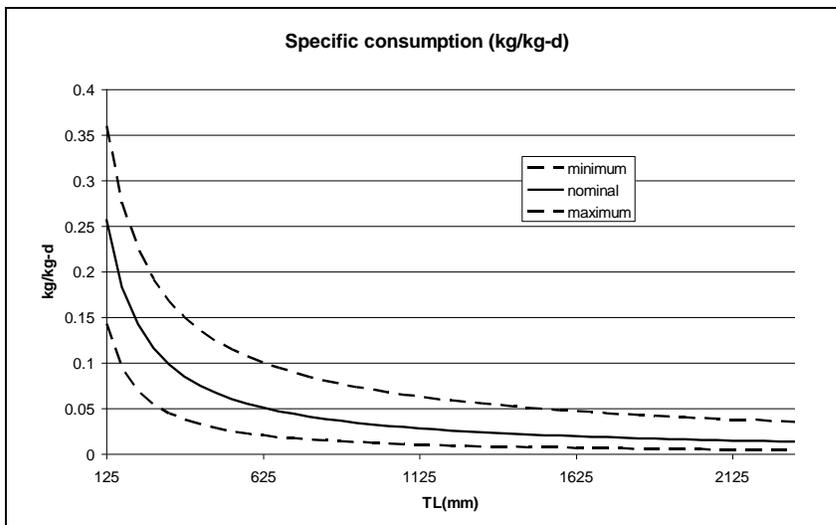


Figure 4. Modeled consumption rates of goliath grouper relative to total length (TL). Graph shows that as the fish grows their weight-specific consumption rates decline. Thus, a large individual eats much less per body mass than a small individual. Dashed lines indicate upper and lower limits to consumption rates.

model. While the model is preliminary, it shows that adult goliath grouper require only small amounts of food for maintenance (Figure 4) because of their low metabolic rates and slow growth rates, which become progressively slower as the fish increase in size.

If goliath grouper ate everything on the reef, we would expect to see lower biodiversity with higher goliath grouper abundance. However, the exact opposite is true. Our data indicate that biodiversity is higher overall in areas with greater numbers of goliath grouper; that is, the relationship

between the number of fish species and the abundance of goliath grouper is a positive one (Figure 3).

The Opinion: Our reefs are “out of balance”; goliath grouper have to be “thinned out” to regain that balance.

The Science: Many Florida reefs are out of ecological balance. Indeed, this is a world-wide phenomenon that is related to the combined effects of overfishing, coastal development, pollution, and climate change, not to the presence of goliath grouper. Altered ecological balance will not be

regained by reducing the abundance of goliath grouper, a native species that is recovering from intense overfishing, but by allowing other overfished species to recover while attempting to reduce a variety of human-induced impacts. Those fishers with decades of experience on Florida reefs know this to be true. It is the newcomers with less experience who perceive overfished reefs as “normal”. Scientists call this phenomenon “shifting baselines” because the perception of “normal” changes with each successive generation.

The Opinion: Goliath grouper are dangerous to divers.

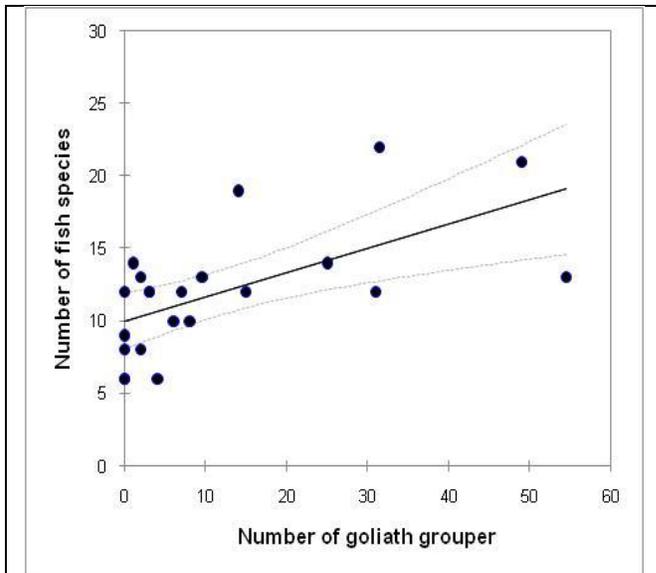


Figure 3. Regression of species richness (all reef fish) on goliath grouper density (no. per reef site) off southwest Florida on high-relief sites ($R^2 = 0.38$; $P < 0.01$). Dashed lines denote 95% confidence limit.

The Science: Some divers have reported being bitten by goliath grouper. In most cases, the diver had a stringer of speared fish that were the likely target of the grouper, rather than the diver. However, considering that goliath grouper have very small teeth and a very weak bite (they feed by sucking prey into their mouths, not by biting it, like a shark), the worst wound that could be inflicted by a goliath grouper would amount to scratches, not serious injuries.

Our observations suggest that the frequency of goliath grouper bites is vanishingly small. We have interacted directly with over 5000 adult goliath grouper in the water, and have tagged over 2100 large individuals with spearguns. During all these interactions, we have experienced only a single harmless nip on the hand by one individual that we had cornered under a ledge and were harassing intensely to try to induce it to produce

sounds (booms) for our underwater hydrophone recordings.

The Opinion: There must be a periodic kill of hundreds of adult goliath grouper to obtain data on size, age, and reproductive condition necessary for stock assessment.

The Science: None of these data require the destruction of the fish. All can be obtained through careful sampling of individuals.

Size is a simple measure to obtain non-destructively. We do this underwater with a video camera mounted with a double laser system. The laser system produces beams that are adjusted to be parallel. With the camera and lasers on, the beams are projected onto the sides of a fish oriented perpendicular to the beams (Figure 5). Later, in the lab, the fish can be measured because the distance between the laser dots projected onto the fish is known.

Age is most often determined from fishery catches by removing otoliths (concretions similar to limestone in the ear chambers of fish; otoliths function in equilibrium and hearing) from individual landed fish. However, age can also be determined non-lethally from dorsal fin rays (Figure 6).

These cartilaginous rays can be cut from the fish after it is captured; the fish can then be tagged and released unharmed, and the removed fin rays grow back in several months. Like otoliths, fin rays lay down annual rings, similar to the rings of a tree, and these can be used to age the fish. Murie et al. (2009) have published on the use of dorsal fin rays for goliath grouper aging.



Figure 5. Laser dots on the side of an adult goliath grouper are used for obtaining size information. These dots are 10 cm apart. fishing community.

We have received considerable support from recreational and commercial fishermen interested in participating in non-consumptive research projects that involve use of non-destructive sampling of goliath grouper. This type of project would provide a considerable amount of data on regional age and size structure, data on regional and seasonal diet, and movement data because captured fish could be tagged before releasing them. As an added bonus, this volunteer program would provide an opportunity for researchers to educate the fishermen on the recent scientific research on goliath grouper and further dispel the myths circulating within the

While the goliath grouper population is in recovery, the current status is unknown, as is the potential impact of removals of hundreds of adult fish. Certainly the opportunity to educate fishermen in general marine ecology and goliath grouper biology and conservation practices should far outweigh the completely unnecessary destruction of individuals.

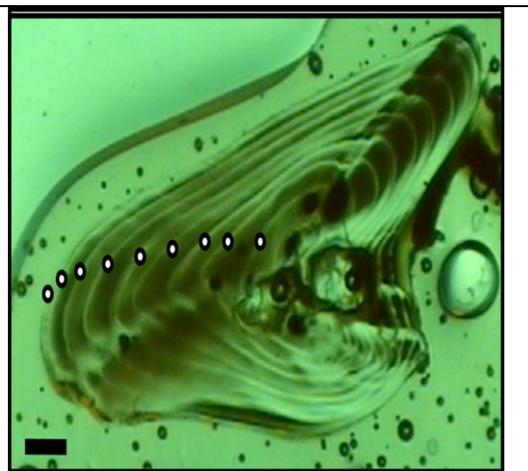


Figure 6. Cross section of a dorsal fin ray of an adult goliath grouper showing the annual rings (indicated by small circles) of this 9-year-old adult. Image by Debra Murie (University of Florida).

Reproductive data can also be collected from goliath grouper non-lethally, and economically to provide stock assessment biologists with the necessary information to assess recovery of the stock. To determine reproductive state, sex, and sexual pattern (e.g., gynochorist or hermaphrodite), we take gonad biopsies by inserting a small tube into the genital opening and vacuuming out a small piece of the gonad tissue. This tissue is then prepared for viewing under the microscope to determine reproductive condition. It is also possible to estimate the mass of the ovary in females in spawning condition and, coupled with spawning frequency, estimate fecundity. Spawning frequency is estimated non-destructively on the aggregations by using methods discussed in Mann et al. (2009). In brief, fish were externally tagged with a short-interval depth-sensing tag and monitored for several weeks. Because spawning fish ascend above the reef, the spawning frequency of an individual can

be determined directly by the frequency of female ascents.

We also can estimate directly the reproductive output and timing of spawning by collecting eggs using an array of nets deployed downstream from spawning sites, as we have done off the Atlantic and Gulf coasts of Florida (see Koenig and Coleman 2009). Details of the spawning behavior and timing of goliath grouper spawning can be found in Mann et al. (2009).

Discussion:

Goliath grouper is a native species that evolved on reefs on both sides of the Atlantic over millions of years. It is a natural and integral component of Florida's reef ecology and thus is not disruptive to the reef community. Truly disruptive species include such non-native species as the Indo-Pacific lionfish (*Pterois volitans*), a species introduced to western Atlantic in the early 1990s. Lionfish are active predators of newly recruiting fish to native reefs, wreaking havoc on reef populations (Albins and Hixon 2008). Part of the problem is the absence of checks and balances on lionfish population expansion through control by predators or other factors. Yet there are few eradication plans for this species because the economic impact has not been determined.

All the scientists who have studied the behavior and ecology of goliath grouper acknowledge their optimism over the ongoing recovery of this species in Florida. Other fish species similarly fished to economic extinction have not fared so well. For example, the giant sea bass (*Stereolepis gigas*) population of the Eastern Pacific has not recovered despite nearly 30 years of limited protection. (<http://www.arkive.org/black-sea-bass/stereolepis-gigas/info.html>). This species is similar to goliath grouper in that it is large and feeds primarily on crabs and slow-moving fishes.

Still, the optimism is guarded because the level of goliath grouper recovery remains unknown and the time trajectory for complete recovery uncertain. A key element in recovery of goliath grouper populations in Florida is the availability of high-quality mangrove habitat in southwest Florida (Koenig et al. 2007, Koenig and Coleman 2009). Juveniles spend their first 5 to 6 years of life in this habitat and it was here in the juvenile population that the first signs of recovery appeared (Cass-Calay and Schmidt 2009).

Optimism is also dampened by the fact that the south Florida ecosystem has been altered to such a high degree over the last 100 years (Ogden et al. 2005), that suitable mangrove nursery in all probability presents a bottleneck to the production of this species (Koenig et al. 2007). Also, losses due to release mortality and illegal harvest result in continued overfishing (Porch et al. 2006). Because of these issues and the inherent vulnerability of goliath grouper to fishing pressure, caution should be the hallmark of any management decision. The fact that a number of very vocal people consider goliath grouper a nuisance species speaks worlds about the poor job we have done collectively as scientists and managers to educate the public about marine systems. The fact that managers would seriously consider destructive sampling of a species known to be critically endangered elsewhere in their range suggests adherence to political rather than ecological or conservation principles.

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