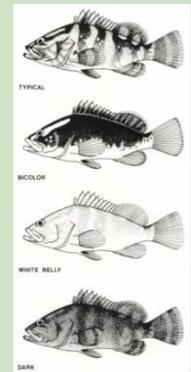


Life History Characteristics & Management Recommendations For The Nassau Grouper Population In Belize



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Introduction

The Nassau Grouper (*Epinephelus striatus*) belongs to the family of marine fishes known to scientists as the Serranidae, which includes other Groupers like the Black, Yellow Fin & Tiger Groupers, as well as Jimmy Hind, Jew Fish, Hamlets, Sea Basses & Basslets. Nassau Grouper are native to the Caribbean and tropical western Atlantic Ocean.



Nassau Grouper Range (Adapted from Sadovy & Eklund, 1999)

Most Serranids have a lower jaw which projects well forward and all have large mouths, which helps them ambush-capture crustaceans & other fishes as food. The size range of fishes in this family is highly variable, and includes species as small as five inches, like the Tobaccofish; to species as large as 8 feet, like the Jewfish. Virtually all of the larger Serranids are a highly valued as food, and are fished commercially by artisanal & sport fishermen alike.

Nassau Groupers were at one time fished by the tens of thousands per year from Belizean territorial waters, but the catch has been steadily declining over time and was less than one thousand fishes in 2001. A decline like this indicates that Belize's native population of Nassau Grouper may soon face extinction.

Green Reef Environmental Institute is a private, non-profit organization based in Belize that is working to prevent the Nassau Grouper's extinction in Belize. To this end, Green Reef initiated a Nassau Grouper Recovery & Advocacy Program with the objectives of developing up-to-date information about stocks, economic alternatives to fishing, community education programs, and legislation to protect this highly threatened species.

The aim of this booklet is to provide general information about the life history, ecology & biology of the Nassau Grouper, as well as Green Reef's recent field assessments and practical recommendations for increasing local populations of this species for the benefit of all Belizeans.

Life History & Habitat

Nassau Grouper have a complex life history cycle, because they live in & depend on different habitats during different parts of their lives. They also use different types of food as they grow and must avoid different types of predators specializing in eating Nassau's as food. These life history & habitat characteristics can be summarized as follows:

SUMMARY NASSAU GROUPEL LIFE HISTORY CHARACTERISTICS

----- Life History Stage -----

	Eggs & Larvae	Juveniles	Sub-Adult & Adult	Spawning Adults
Habitat	Open Ocean, Surface Waters	Mangrove & Coarse Rubble	Reef Crevices & Abyssal Depths	Spur & Groove Reef Promontories
Feeding	Plankton	Small Crustaceans & Fishes	Large Crustaceans & Fishes	None
Predators	Whale Sharks	Most Piscavores	Toothed Sharks, Man	Toothed Sharks, Man

Third, and also critically important, all known aggregation sites, including those specifically in use by Nassau Grouper, should be designated as species-specific protected areas, thereby forever guaranteeing all of Belize's Nassau Grouper aggregation sites a place in the public domain for the enjoyment & benefit of all Belizeans. Such sites would not be expected to exceed a few square miles in area, and should accommodate multiple use activities to afford fishermen access to commercial marine species, which do not specifically use the area for aggregation spawning.

Fourth, the 40+ fishermen who continue to fish Nassau Grouper at aggregation sites should be assisted with the development of alternative income earning activities that can provide a greater return on investment than is currently realized from capture of Nassau Grouper at spawning aggregation sites. The 2000 - 2001 Nassau Grouper catch was estimated to have a wholesale value to fishermen of approximately US \$ 8,000, inclusive of fish fillets & roe, which is entirely sold in Belize.

Assuming that at least four aggregation sites identified by Green Reef remain in use by Nassau Grouper, and that each could support about 20 tourist visitations per season; the entire value of the 2000 - 2001 catch could be replaced by an average visitation fee of US \$ 100 per dive-tourist. Given that the average dive-tourist spends several thousand US \$ just to arrive & stay in Belize, such visitation fess may well provide a practical and valuable inducement for Belize's remaining Nassau Grouper fishermen to abandon the fishery and allow the population's return.

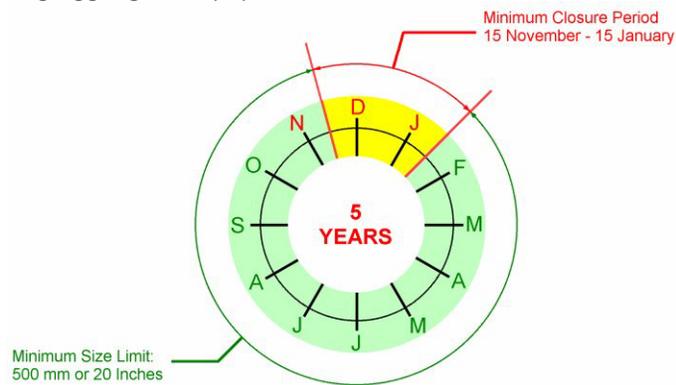
Management Recommendations

So, what can be done to increase the Nassau Grouper population and prevent its local extinction?

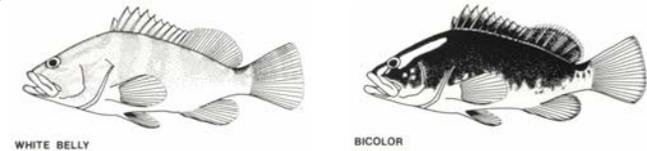
First and foremost, the practice of fishing spawning aggregations in general, and Nassau Grouper aggregations in particular, must be stopped. Such fishing only provides short-term profit to a few individuals, because it virtually guarantees the long-term collapse of any fishery in which it is practiced. For this reason, the fishery should be closed from the 15th of November to the 15th of January each year, during which time no Nassau Grouper should be held, sold or exported.

Second, and equally important, fishing pressure on immature & newly mature Nassau Groupers must be reduced, in order to allow them to add to the population by spawning. For this reason, Nassau Grouper having less than 20 inches (500 mm) Standard Length (nose to tail, before the fin), should not be held, sold or exported at any time.

These measures (summarized below) should be adopted for a minimum period of 5 years in order to allow at least one generation of Nassau Grouper to mature and join Belize's spawning aggregation population.



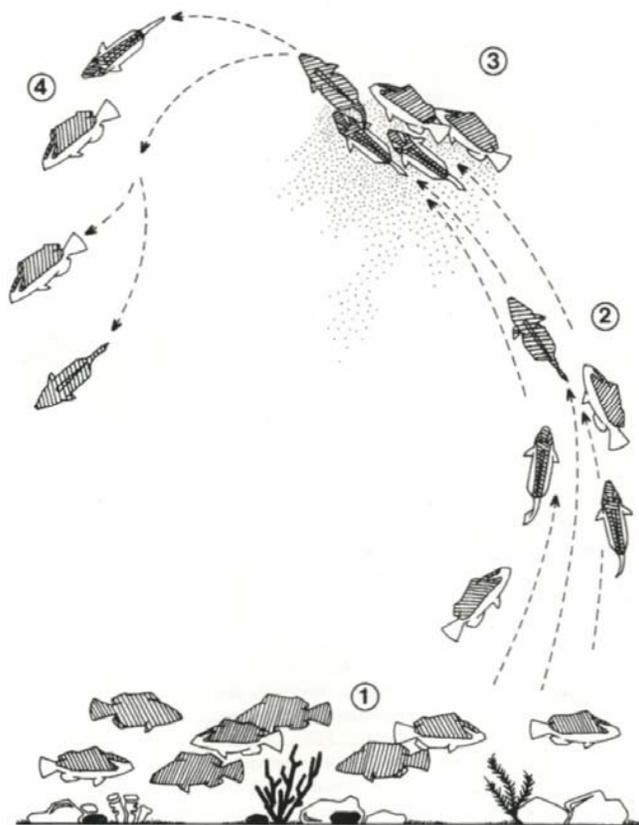
Nassau Grouper also have complex mating behavior, which involves the 'gathering' of mature fishes from distant locations at highly specific 'spawning aggregation sites'. These aggregations take place during the last full moons of each year, with peak visitation usually occurring 5 to 10 days after the 13th full moon. Individual sites are thought to have at one time been visited by more than 10,000 Nassau Groupers during a single aggregation event. The aggregation sites themselves are usually located in about 30 meters of water at the edge of a spur & groove reef lying next to the abyss.



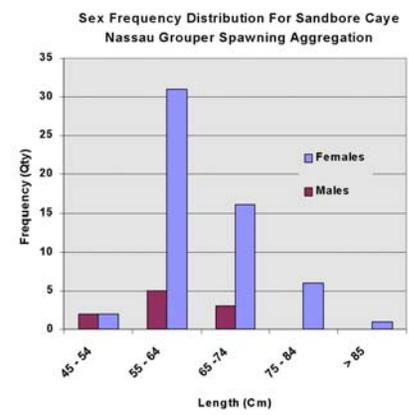
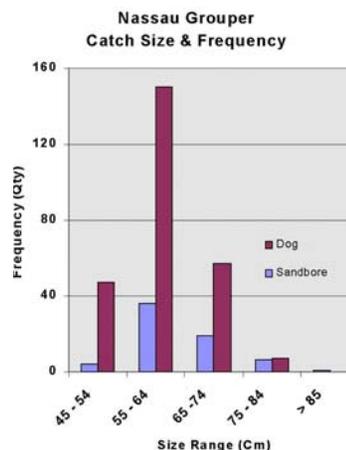
(Diagrams adapted from Sadovy & Eklund, 1999. Photograph by Andy Stockbridge)

Male & female Nassau Groupers arrive at aggregation sites in their typical (unisex) color pattern. Males show they are mature enough to spawn by darkening in color, and females by lightening in color. Females tell males they are ready to spawn by changing color again to a bi-color pattern.

Spawning usually occurs near to sunset. At this time, fish start milling about a few meters above the promontory substrate, and an increasing number of females express bi-coloration (see '1' below). Several bicolor females may start nudging & pushing a solitary male in dark coloration, with the resulting, small sub-group then ascending into the water column (2). Such groups are led by a single dark male, and followed by a few to several bicolor females. Subsequently, the sub-group releases sperm & eggs into the water column (3). Then the group disbands (4) and returns to promontory floor. The fertilized eggs then simply float away in the current, to all parts of the Nassau Grouper's Range.



Spawning Behavior of Nassau Grouper (Adapted from Sadovy & Eklund, 1999)

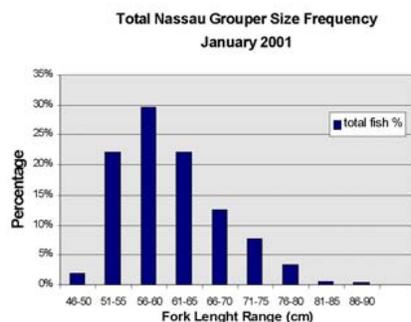


A Tale Of Two Sites:

The upper chart describes the fishing impact on the Sandbore & Dog Flea Caye aggregation sites. Although the relative size distributions between the two sites are similar, a much larger number of newly maturing fishes were removed from the much smaller aggregation at Dog Flea Caye. The lower chart established that the largest fishing impact was on females, due to the pre-existing sex ratio of the population. Such fishing pressure is likely to have driven the Dog Flea Caye site to extinction during the 2000 - 2001 survey season.

A total of 715 Nassau Groupers were captured with traps, and hook & line using 183 man-days during the January 8th 2001 aggregation moon, for a national CPUE of approximately 4.5 fish/man-day (including the 2001 catch from Glovers Reef).

The size frequency of 391 individuals from the Sandbore & Dog Flea Cays catch is shown below. Age/size data summarized by Sadovy & Eklund (1999) for Bahamian Nassau Grouper suggest that Belize's 2001 catch may largely have consisted of individuals between 5 & 13 years of age.



The sex ratio of 79 individuals sampled from this catch was female dominant by a factor of approximately 6:1. This ratio also corresponded very closely with the light/dark phase ratio observed at the Sandbore Caye aggregation site; and the general observation of light phase dominance at all four aggregation sites surveyed.

These observations were quite different from those reported for 1999 - 2000 Glovers Reef aggregation by Salas & Ballesteros (1999), who reported twice the CPUE, nominal light phase expression; high levels of dark & bi-color expression; and lower female dominance of 3:1.

The finding that sex ratios may vary between aggregation sites suggests that different sites may have different reproductive success; and supports the proposition of Carter *et al* (1994) that male abundance influences CPUE estimates. From these observations, it follows that fishing probably impacts the aggregation by reducing male abundance first.

Nassau Grouper become sexually mature at approximately 500 mm (20 inches) standard length, and achieve this size between 5 and 10 years of age. They can live from 15 to 20 years of age in nature, and a single large female can produce 5 to 6 million eggs during a single spawning period.

Nassau Groupers were once thought to be hermaphroditic, or capable of changing sex during the course of their lifetime. However, current thinking holds that Nassau's undergo direct development as either male or female individuals right from the egg, and remain a single sex throughout their entire lives. A small percentage of immature individuals may express bi-sexual characteristics in having both eggs & sperm producing organs, but these individuals usually metamorphose into a single permanent sex at maturity.

Most scientists believe that currents have played an important historical role in aggregation site selection, because currents help to disperse young, which lowers inbreeding & predation risk. However, little is known about how Nassau Grouper and other aggregating Serranids actually find their specific aggregation sites, or whether they are capable of spawning at more than one site.

One or more mechanisms may be used to locate the sites, such as chemical imprinting (which means they actually smell the site itself), pheromone currents (they smell each other), sounds (they hear each other), and/or magnetic fields (which means they have some kind of internal compass, like migrating sea turtles, birds & whales).

The answers to these questions are important because they can tell us whether or not a site that has been fished to extinction can ever come back into use again once the area is protected; and/or tell us how to re-introduce Nassau Grouper to sites that have become extinct from over fishing.

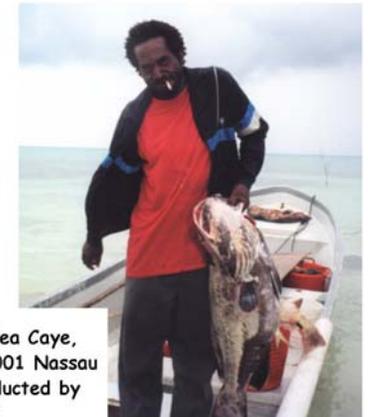
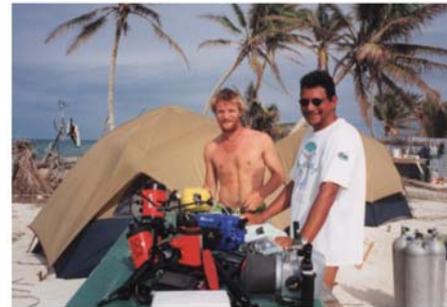
Green Reef Research

The primary reason for the Nassau Grouper's decline throughout the Caribbean has been attributed to selective over-fishing of spawning aggregations. These aggregations have experienced near total collapse from over-fishing in Puerto Rico, Cayman Islands, Bermuda, US Virgin Islands, Mexico, and the Dominican Republic.

During the 1950's, annual grouper catches in Belize were as high as 100,000 lbs (McField *et al*, 1996), and during the 1960's, Nassau Groupers were fished a rate of about 2 tons per day from a single aggregation site at *Caye Glory* (Craig, 1969). As late as 1994, groupers comprised more than 30 % (38,383 Lbs) of the total finfish exported from Belize, of which, 64 % (24,764 Lbs) consisted of Nassau Grouper. More recently, a single aggregation site at *Glovers Reef* was surveyed by the Wildlife Conservation Society (WCS), and found to be comprised of just 3,100 adults, from which fishermen had removed 219 individuals during the same season (Salas & Ballesteros, 1999).

The declining catch of Nassau Grouper has led to the common belief that this Serranid no longer aggregates at most of the localities from which it was formerly known in Belize. Attempts to close the fishery have failed however, because the few fishermen who continue to fish Nassau Grouper from aggregation sites argue that this species is not declining, but simply moving to different sites from year to year. These circumstances clearly identified the need for a national survey of Nassau Grouper aggregation sites, and so funding was sourced by Green Reef to identify the status of Nassau Grouper Aggregation Sites in Belize.

To do this, Green Reef began by reviewing historical records for reports of Nassau Grouper catches, and interviewed active & retired fishermen about their memories of historical catches & aggregation sites fished in years gone by.



Activities at Dog Flea Caye, During the 2000 - 2001 Nassau Grouper Survey Conducted by Green Reef



The visual survey produced a number of critical findings:

- First, the survey established that Nassau Grouper no longer aggregated at 3 of the 8 historical spawning sites inspected.
- Second, the survey established that 4 of the 6 aggregation sites observed to be in use by Nassau Grouper are close to extinction, with 2 sites having less than 50 individuals, and 2 sites having less than 500 individuals. The breeding populations at three of these sites continue to be captured by fishermen. More than half of the adults aggregating at one of these sites (Dog Flea Caye), were captured by fishermen during the survey.
- Third, the survey established that just 2 of the 6 aggregation sites in use by Nassau Grouper were intact, with one of these sites (Sandbore Caye) estimated to have 4,000 - 6,000 adults; and the other (Glovers Reef) estimated to have about 2,700 adults still returning to spawn.
- Fourth, larger adults were observed to participate conditionally in aggregation spawning, by arriving at the aggregation site about 5 days after the full moon, and participating in spawning only when sufficient numbers of younger fishes were present.
- Fifth, the survey also found that many other species of fishes, including Black, Yellowfin & Tiger Groupers, White & Black Margets, Dog Snappers and Horse-Eye Jacks form spawning aggregations at these sites during the same period.

Between & after dives, each team interviewed fishermen, and collected information on their origin, experience, fishing effort, market sold to, anticipated price, and a sub-sample of the daily catch was measured for fork length, weight, sex & egg weight.



Artisanal fishermen at work



Fish holding pens



Nassau's being held for slaughter



Cleaning the catch by hand



Sun-drying the catch for market

The Nassau Grouper Catch At Caye Glory, Belize

Alan Craig published 'The Geography Of Fishing In British Honduras And Adjacent Coastal Waters' in 1966, and recorded this stunning pictorial essay of the Nassau Grouper catch at Caye Glory. More than 300 boats fished the site during the 1964 - 1965 aggregation period, and brokers came from as far away as Guatemala City & Tegucigalpa to purchase the catch.

These interviews resulted in the identification of 13 sites known Nassau Grouper aggregation sites in Belize. A short-list of 7 sites were subsequently elected for inspection during the 2000 - 2001 aggregation period, with the knowledge that WCS would be surveying the Glovers Reef Aggregation site for the same period. One additional location at Caye Bokel, Turneffe Reef was also surveyed because the site demonstrated environmental characteristics similar to other aggregation sites, but had no reputation as an aggregation site with fishermen. All together, the 2000 - 2001 visual survey encompassed the following 9 sites (with numbers corresponding to map shown on the facing page):

Lighthouse Reef:

- Sandbore Caye (10)
- Half Moon Caye (4)

Glovers Reef:

- North Channel (8)

Turneffe Reef:

- Dog Flea Caye (9)
- Caye Bokel (Unnumbered)

Barrier Reef:

- Ambergris Caye (11)
- Caye Glory (3)
- Gladden Spit (7)
- Sapodilla Caye (12)

The survey was conducted by organizing locally experienced, volunteer divers into site-specific survey teams. Each team consisted of one Dive Master, one or more dive-certified assistants, a boat captain, and one or more local fishermen as deck hands (~5 persons). Each team was equipped with hand-held, underwater video cam-corders, and a generalized data collection scheme was established that called for recording of locations with GPS, measurement of aggregation depth; estimation of the number of individuals present, their percent color-phase expression & behavioral activity; measurement of water temperature; estimation of current direction & speed; visibility; coral cover & condition; and notations as to the number & variety of any other schooling or aggregating species that may be present. The findings of the visual survey for each site inspected are summarized on the facing map of Belize.

