

Size, Sex Ratio, and Fecundity of Nassau Grouper (*Epinephelus striatus*) Landed during Spawning Season in the Central Bahamas

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ABSTRACT

This collaborative research was initiated to collect basic fisheries data on Nassau grouper (*E. striatus*) landed in New Providence and Long Island. Although The Bahamas has a comprehensive fisheries management plan in place for *E. striatus*, there are few programs in place to judge the success of size limits, regulation on gear used, limited closures of spawning sites and some marine fisheries reserves. Data was collected on whole fish landed by day fishers in four categories:

- i) Profile of the fishers including age, length of time fishing and economic dependence on fishing,
- ii) Capital investment of fishers in boats and equipment,
- iii) Catch data for the day including total number of species caught, fishing location, and time spent fishing, and
- iv) The whole weight, length, gonad weight, and gonad sample from *E. striatus* landed.

From 24 November 1999 to 15 February 2000, 311 groupers were measured and weighed at points of landing, 258 gonad samples collected, and 26 fishermen interviewed. Of all fish landed, over 30% were immature, with a 1:1 sex ration between the remaining identified males and females. Female gonads were examined and identified as one of five stages from immature, maturing, ripening, ripe, and spent. Most females examined were "ripening" with a mean oocyte diameter of 1200 microns. No ripe females were landed, and only a small number of spent females were collected. Mean length of all females was 637 mm, but spent females were significantly larger at a mean total length of 673 mm. Of all fish with a gonad-somatic index of greater than 10%, females outnumbered males almost 2:1.

KEYWORDS: *Epinephelus striatus*, grouper, spawning

INTRODUCTION

The Nassau grouper (*Epinephelus striatus*) represents the most important finfish resource in the Bahamas. This species is recognized not only for its commercial value and cultural importance in the Bahamas, but also its ecological contribution to healthy coral reefs as a top reef predator. With the establishment of the Exuma Cays Land and Sea Park in the central Bahamas in 1986 as a marine fisheries reserve, the country had some base-line information on the size and abundance of groupers on unfished reefs. For the past 14 years, managers and the general public have grown more concerned about the decline in the abundance of large groupers on coral reefs outside this park, and the decline in the number of groupers reported at known (and fished) spawning aggregations. The Department of Fisheries (DOF), Government of The Bahamas, has recently closed fishing on some spawning aggregations and proposed five new marine fisheries reserves to protect grouper stocks in the country (DOF 2000). This paper reports a field investigation to document size, sex ratio and fecundity of locally landed catch on the islands of New Providence and Long Island.

The Nassau grouper is a large serranid that is widely distributed throughout the western tropical Atlantic. Its role as a top predator of reef communities makes it an important but vulnerable species for the health of coral reefs. This species is targeted for both recreational and commercial fishing, and populations of *E. striatus* are depleted or locally extinct throughout much of its tropical northwestern Atlantic range (Sadovy 2000). A comprehensive program to conserve grouper stocks in The Bahamas requires fisheries-dependent and independent data.

Fecundity and sex ratio of female groupers entering spawning aggregations is critical to know, but tedious in data collection. In The Bahamas, most of the fishing effort for grouper occurs from November to February, and fishers target the spawning aggregations. Most fishers use spear and surface-supplied air (hookah) and can fish very efficiently over a broad depth range along the carbonate platform margins. Larger boats that land their catch for commercial export typically return landing points after a week or more fishing with frozen eviscerated fish. A sizable fishing fleet of smaller boats operates from the islands on New Providence (with the capital city, Nassau) and Long Island. These fishers return daily with whole fish that can be measured and used for fecundity monitoring. Fishing pressure on groupers in the Bahamas is significant and increasing, but this area is considered one of the healthiest stocks in the wider Caribbean in terms of fish abundance and size. In 1999, 841,044 pounds of grouper were landed in the commercial export market, with a value of almost \$B 2,000,000 (DOF, 2000). Local landings and recreational catch are not accounted for.

Nassau grouper is very vulnerable to heavy exploitation; these fish are large in size, slow growing and conveniently aggregate for reproduction. Overfishing can theoretically change the population dynamics of a species by decreasing abundance, and selecting the largest and most fecund individuals. The Nassau groupers in the central Bahamas may represent a discreet metapopulation of reef fishes. There is likely no location with more field research completed on this species. Research has

been done on describing:

- i) The location and behavior of spawning aggregations (Colin 1992),
- ii) The abundance of groupers on reef habitats (Sluka et al. 1996),
- iii) The distribution and collection of post-settlement groupers (Eggleston, 1995),
- iv) The energetics, activity and behavior of juveniles (Sullivan and de Garine 1994),
- v) Home range and migration (Bolden unpub), and
- vi) The development of new microsatellite markers for examining population subdivision within the range of the Nassau grouper for evidence of stock separation (Stevenson, et al. 1997).

Much information has been collected on the biology and ecology of this species. However, if the policy of closing spawning aggregation to fishing was to be imposed, data needed to demonstrate that fishing practices were not only impacting the abundance of fish at spawning aggregations, but that the individual groupers were smaller, less fecund, and not present in a 1:1 sex ratio.

MATERIALS AND METHODS

The goal of this project was to twofold:

- i) To collect sufficient gonad samples to characterize size/fecundity relationships in Nassau groupers landed in New Providence and Long Island by day fishers, and
- ii) To develop the method for monitoring size and fecundity changes in *E. striatus* in response to management actions such as closures of spawning aggregations.

There were two data forms used:

- i) A fisher interview form with three parts, and
- ii) A fish survey data sheet for recording fish measurements and gonad sample number.

This information was put into a relational database (ACCESS) to relate information of groupers, fishers and locations of catch (Table 1).

The following equipment was prepared for each sampling trip: cooler with ice, sample jars, labels for gonad samples, data sheets on water-resistant paper with fisher identification numbers, fish measuring board, large fish scale (25 kg), smaller scales for gonad weights (1000g and 100 g), ziplock bags for weighing gonads, marker pen and tape for labeling fish, latex gloves, scissors for dissection and magnifying glass for visual inspection of fresh gonad tissue. Identification codes were used to keep fisher identity anonymous in data reporting.

During the data collection, whole landed fish were measured and tagged, as they were unloaded. Lengths were then recorded in millimeters by holding the tail flat to measure total length then flexing caudal rays to determine standard length. Often the dissection and collection of gonad material could not be done until the fish was sold as vendors preferred to present whole fish to customers. Data collection could

take several hours for this reason. Field notes were reviewed within two days of collection and complete summary completed in the database. Gonad samples were collected from fresh fish, and kept on ice during the surveys, Bouin's fixative was added in the laboratory that same day to just cover sample, samples were kept small enough to be well saturated with fixative inside of sample jars. Bouin's fixative was prepared as 75% saturated picric acid solution, 20% buffered formalin and 5% Glacial acetic acid. An attempt was made to collect a small cross-section of the gonadal tissue. Gonad samples were examined under a microscope using an ocular micrometer. The micrometer was calibrated to give oocyte diameter in microns. 100 oocytes from each sample were measured, and female groupers were ranked according to maturity stages (FAO 1979, Table 2). Diameters of preserved oocytes could be assigned to the stages.

Table 1. Information needed to relate fishers to catch and location for monitoring size, sex ratio and fecundity of Nassau groupers fished from spawning aggregations.

FISHERS	FISH	CATCH LOCATION
<u>Personal information</u> # of years fishing, age % income from fishing, Months of year fishing, Targeted species, Boat ownership	<u>Length</u> in millimeters Total, standard	Record location where the fisher was that day as reported by fishermen – using local names. Later this information can be related to the Department of Fisheries regions and to known aggregation locations Record the depth of fishing as reported by the fisher Record whether fisher was located in an aggregation, many fishers report a "cluster" or aggregation of large groupers numbering from 5 to 50 individuals.
<u>Daily Catch Data</u> Catch per Effort Information Date of catch, Total number of finfish, Gear Used Catch location, Hours Fishing, Species Caught Number of Nassau grouper	<u>Total Weight</u> in kg	
<u>Opinion on status of fishery</u> Four questions	<u>Gonad Weight</u> in grams Gonadal-Somatic Index	
	<u>Gonad Sample</u> Sex, Fecundity Histology	

Table 2. A five-point maturity scale for potential spawners with an estimate of oocyte diameter from this study.

STAGE	STATE	DESCRIPTION	SIZE OF OOCYTES
I	Immature	Gonad about 1/3 of the length of the body cavity. Ova not visible to the naked eye	Ova not measured
II	Maturing virgin or recovering spent	Ovaries about ½ of body length of body cavity, Ovary pinkish, ova may be just visible to the naked eye,	Gonad up to 7% of body weight, Ova up to 150 microns
III	Ripening	Ovary about 2/3 of body cavity, pinkish yellow with obvious granular texture – Ova not translucent	Gonad from 7 to 20% of body weight Ova 150 to 1500 microns
IV	Ripe	Ovaries over 2/3's the length of the body. Ova hydrated and translucent in color	Gonad over 23% of body weight Ova greater than 1500 microns
V	Spent	Ovary shrunken to about ½ of body cavity length. Walls of gonad loose, ova size very variable, remnants of opaque ova	Ova diameters variable

RESULTS

Sampling of daily catches was carried out at two landing locations in New Providence: Montagu Ramp and East Street South. Four days were spent sampling the daily catch from Long Island fishers. In both sites, local fishers cooperated with field staff to allow their catches to be weighted and measured.

From 24 November 1999 to 15 February 2000, 311 groupers were measured and weighed at points of landing, 258 gonad samples collected, and 26 fishermen interviewed. Of all fish landed, 80 groupers were identified as females, 57 were males, with 64 fishes immature (Stage 1). 16 spent individuals were collected from the Long Island fishers (Figure 1). No ripe or spent groupers were seen from the sampling in New Providence. The average total length of females was 637 ± 49 mm, males collected were slightly larger at 644 ± 58 mm, and spent individuals were significantly larger at 673 ± 35 mm. Immature groupers were significantly smaller with a mean total length of 528 ± 61 . The smallest individual grouper that could potentially spawn (Stage 2- 3) was 560 mm. The legal size limit for groupers in the Bahamas is set at 3 pounds total body weight (1.9 kg). No groupers landed were smaller than the legal size, with the smallest fish sampled being 2.0 kg or 415 mm

total length. The largest grouper landed was 12.3 kg or 774 mm total length. All males and females were present in a sex ratio of males to females of 1:1.4. However, if only ripening and ripe individuals were considered, male to female ratio was 1:2. Female gonads were examined and identified as one of five stages from immature, maturing, ripening, ripe, and spent. Most females examined were "ripening" with a mean oocyte diameter of 1200 microns. No ripe females were landed, and only a small number of spent females were collected from Long Island. Mean length of all females was 637 mm, but spent females were significantly larger at a mean total length of 673 mm. Of all fish with a gonad-somatic index of greater than 15%, females outnumbered males almost 2:1.

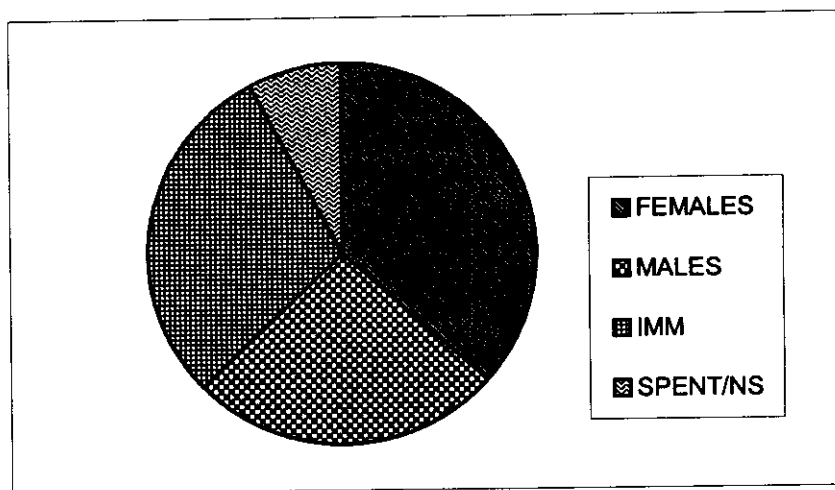


Figure 1. Distribution of male, female, immature and spent groupers sampled from daily catches landed in the central Bahamas during the spawning aggregations.

Fishers reported targeting aggregations, but the definition of "aggregation" was quite broad. "Aggregations" are defined by the fishers as any group of five or more fishes; they report that aggregations form in November, and occur at many locations along the platform margin, with 5 to 50 groupers "clustered" along the drop-off. Their fishing depths were reported to be from 40 to 120 feet (12 to 38 meters). Within a particular catch (representing one aggregation, or individual groupers in the same vicinity) there was a mixture of males, females and immature individuals.

Looking at all female groupers, the gonad-somatic index (percent gonads of total body weight) and the oocyte diameter could be used to cluster the fish in Stage 1 (Immature), Stage 2 (Maturing) and State 3 (Ripening). No ripe individuals were collected (Figure 2).

Figure 2 illustrates the overlap in size range for groupers in the different stages of reproduction. Stage 3 (Ripening) females ranged from 560 mm to over 750 mm

(Figure 3) with Gonad-Somatic indices (GSI = gonad weight to total body weight) ranging from 10 to 23 %. Larger fishes had a larger GSI (Figure 4) and fecundity scaled with size. Using the mean diameter of Stage 3 oocytes, about 475 eggs would be in one gram of gonadal tissue. The smallest ripening females were developing approximately 199,900 eggs (a 4.2 kg individual with a GSI of 10%) compared to the largest individual developing 1,170,960 eggs (12.3 kg fish with a GSI of 20%).

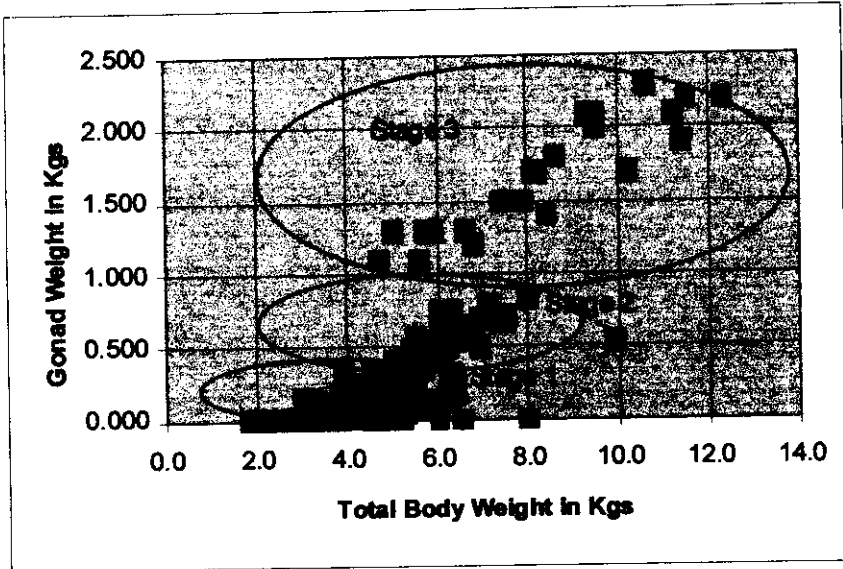


Figure 2. Distribution of body weight to gonad weight for female and immature groupers sampled from daily fishing of winter aggregations.

DISCUSSION

Nassau grouper fisheries throughout the Caribbean have collapsed over the past 30 years primarily from lack of reproductive output and recruitment (Bohnsack 1990). The trends observed have included dramatic decreases in the abundance and size of individual Nassau groupers caught at spawning aggregations. Very little information exists on size distributions of fishes on Bahamian aggregations, but there are clear reports on decline in the abundance of fishes at such aggregations (Sadovy, 2000), Sadovy, 1994). Reports on Nassau grouper sexual development and reproduction (Sadovy and Colin 1995) have emphasized the variability in populations examined, and speculated on the social or intra-specific interactions impacting sex reversal and participation on individuals in aggregations. Long term observations of groupers on reefs in The Bahamas confirm overlapping home ranges and close association of large adults and smaller sub-adults (Sluka and Sullivan

1996). The mixed size range and gonadal development state of fishes collected in this study again support the social nature of winter aggregation behavior in Nassau groupers, and the plasticity of sexual development.

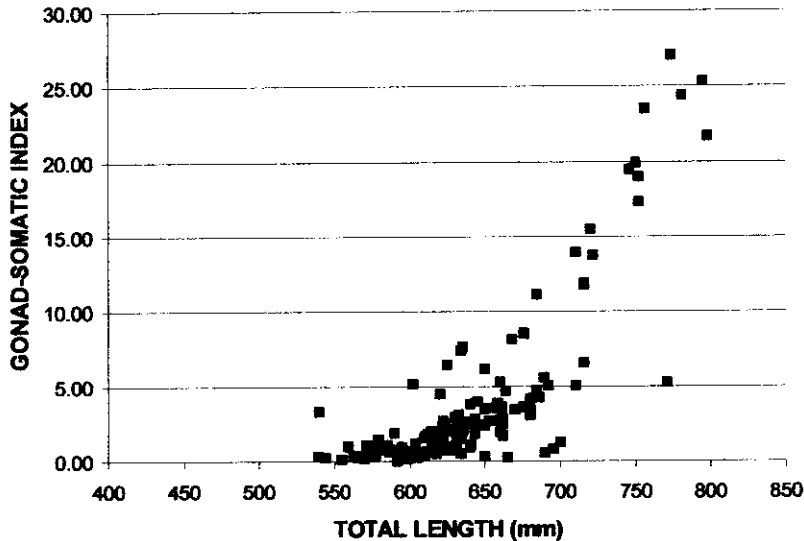


Figure 3. Mean oocyte diameter in microns plotted against total body length in millimeters for female groupers fished from winter spawning aggregations.

New Providence island is within range of day fishing for five reported Nassau grouper spawning aggregation sites, the two largest being reported off High Cay, Andros Island and in the northern Berry Islands. Fishers caught "aggregations" of groupers in many other locations, and reported movements of fish along the platform margin throughout the winter fishing months (November through February). The collection effort targeted the days before and week following the full moon to maximize our chances of collecting spawning groupers. Immature individuals were caught with ripening individuals, but very few fish were landed in a pre-spawning condition (Stage 4) and only a small number in spent condition (Stage 5). The near spawning and spent individuals were only collected from day fishers operating from Long Island, and these fishers were targeting a known spawning aggregation. It was surprising to observe that the majority of groupers landed in New Providence were not in spawning condition, but were associated with some sort of migration aggregation. More information about the seasonal movements of groupers to and from reef areas is critical to understanding the significance of these smaller aggregations targeted by fishers. This lack of larger aggregations and spawning individuals may already indicate a disruption of spawning aggregations by fishing.

Sadovy (2000) has reported that overfishing of large Nassau grouper spawning aggregations (reported in 100,000's of fishes) causes the aggregating fishes to move deeper and spread out over a much larger area in successive years. This dispersal of spawning aggregations makes estimating their size (in number of fishes) more difficult.

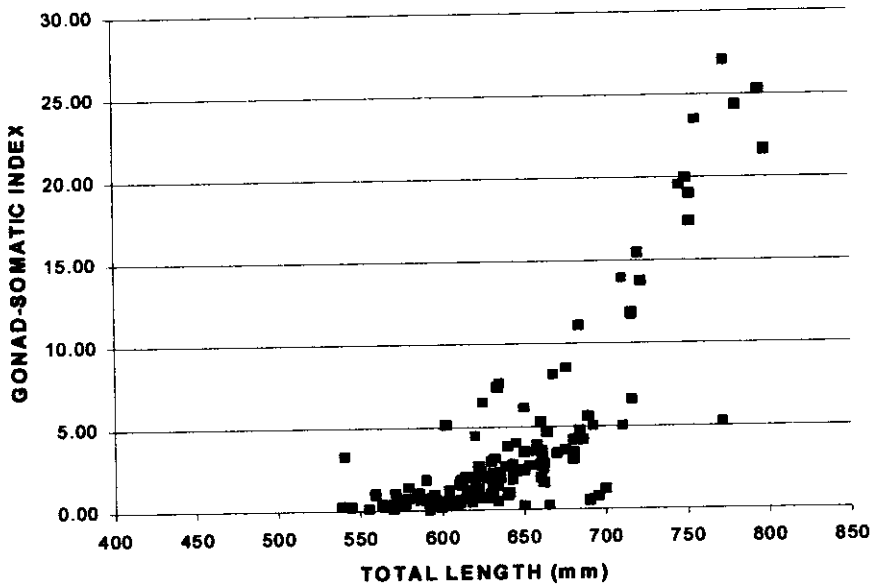


Figure 4. Gonad Somatic Index plotted against total length (mm) for groupers landed during winter spawning aggregations. Smaller groupers at a similar stage of oocyte development had much smaller GSIs.

In summary, this project was labor-intensive and time-consuming to accommodate fishers' schedules for cleaning grouper, but represents a relatively simple and low-technology protocol for monitoring the status of grouper stocks from land. This effort can compliment larger research initiatives that target a specific spawning aggregation. The local grouper fishery in the Bahamas is very dependent on demand and weather, thus fishing activities and intensity can be unpredictable from week to week. A simple, flexible program that can work with local fishers can help elucidate important information on the movement and behavior of the Nassau grouper. This monitoring is to be proposed as an annual program to compliment a larger Nassau grouper conservation initiative.

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