Bluestriped Grunt (*Haemulon sciurus*) in Bermuda: Age, Growth, and Reproduction Studies

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ABSTRACT

Samples of Bluestriped Grunt (*Haemulon sciurus*) from Bermuda, primarily obtained between 2001 and 2008 while investigating a potential spawning aggregation, were analysed for age, growth and reproductive characteristics. Individuals were aged from 2 to 23 years and ranged in size from 18.2 to 35.1 cm fork length (FL). Size-at-age was highly variable, with size ranges spanning up to 6 cm for a given year class, and this was reflected in otolith weights. Therefore, otolith weight is not a good proxy for age in this species. The 3+ year class was the first class of mature individuals that was abundant in the samples collected from the aggregation site, and 4- and 5-year old fish were more abundant than 3-year old fish. This suggests that the average age of first reproduction for Bluestriped Grunt in Bermuda is 3 to 4 years. Average size of 3+ fish was 25.4 cm, and maximum size was 28.4 cm. Average and maximum sizes of 4+ fish were 26.3 cm and 30.4 cm respectively. Based on these data, a minimum legal size for retention of captured Bluestriped Grunts in Bermuda may be set at 28 cm / 11" FL. The maximum weight recorded from these samples was 821 g, and the length-weight relationship derived from these data is $W = 0.0126 \times L^{3.1315}$, where W = whole weight (g) and L = fork length (cm).

KEY WORDS: Bluestriped Grunt, *Hameulon* sciurus, age and growth, Bermuda

El ronco carite (*Haemulon sciurus*) en Bermuda: Estudios sobre Edad, Crecimiento y Reproducción

En el presente trabajo se analizan las muestras del ronco carite (*Haemulon sciurus*) de Bermuda obtenidas primeramente entre los años 2001 y 2008 durante la investigación de una agregación reproductiva potencial, para determinar las características de edad, crecimiento y reproducción. La edad de los individuos se encontraba entre los 2 y 23 años y la talla oscilaba entre los 18.2 y 35.1 cm longitud de bifurcación (LB). La talla por edades fue altamente variable, con oscilaciones que abarcaban hasta 6 cm para una clase específica y esto se reflejaba en los pesos del otolito. Por ello, el peso del otolito no es una buena representación para la edad en esta especie. La clase de tres años en adelante fue la primera clase de individuos maduros que abundaba en las muestras recolectadas a partir del sitio de agregación, y los peces de 4 y 5 años de edad fueron más abundantes que los peces de 3 años de edad. La edad promedio en la primera reproducción para el ronco carite en Bermuda se considera entonces entre 3 y 4 años. La talla promedio de los peces de 3 años de edad en adelante fue de 25.4 cm y la máxima de 28.4 cm. La talla promedio y máxima de los peces de 4 años de edad en adelante fue de 26.3 cm y 30.4 cm respectivamente. Basados en dichos datos, una talla legal mínima para la retención del ronco carite capturado en Bermuda pudiera fijarse en 28 cm /11 (LB). La relación peso-longitud derivada de esos datos es $W = 0.0126 \times L^{3.1315}$, donde W = peso total (g); L = longitud de bifurcación (cm).

PALABRAS CLAVES: Ronco carite, *Hameulon* sciurus, edad y crecimiento, Bermuda

Dynamique D'un Emplacement D'agrégation des Mérous (Serranidae) en Jardines de la Reina, Cuba

Pour plus qu'un siècle, seulement un papier au sujetdes agrégations engendrante a été édité au Cuba et il est basé sur l'information anecdotique. Cette recherche indique des résultats sur la dynamique temporelle d'agréger des mérous (Serranidae) en Jardines de la Reina, où la plus grande reservation marine des Caraïbes est localisée. Cet emplacement, à la frontière de la profondeur de m de l'étagère (30 à 40) cubaine, est un habitat de dent et de cannelure avec la couverture de corail élevée et les courants forts. Des aperçus ont été effectués entre janvier et le décembre 2004, entre 16:00 et les heures de 18:00 au moyen de recensements visuels. Entre janvier et avril, une augmentation de l'abondance de trois espèces de mérou : mérou noir (*Mycteroperca bonaci*) (moyen de 63 individus en janvier et de 34 en avril), mérou de truite saumonnée (*M. venenosa*) (signifiez de 39 individus en février) et mérou de tigre (*M. tigris*) (signifiez de 35 individus en février, de 49 en mars et de 52 en avril). On a observé des maximum de l'abondance pour toutes les espèces au sujet du huitième jour de la pleine lune, avec des diminutions brusques à partir du neuvième jour dorénavant. Bien qu'on n'ait observé aucun dégagement de gamete, les nombreux individus des trois espèces ont montré les abdomens dilatés et le comportement préreproducteur de cour, suggérant l'existence d'un emplacement engendrant d'agrégations. Le reste de l'abondance d'année était en-dessous de sept spécimens par aperçu. Cette information est la première de sa sorte au Cuba et coïncide avec ce qui est anecdotally rapporté pour ces espèces dans la littérature.

MOTS CLÉS: Agrégation des poissons, recensements visuels, mérous

INTRODUCTION

The Bluestriped Grunt, *Haemulon sciurus*, is a species of minor to moderate importance in the commercial and subsistence fisheries of the wider Caribbean region (Munro 1983, Gaut and Munro 1983, Sumaila *et al*. 2007, Froese and Pauly 2009). In Bermuda, where the commercial fishery is dominated by pelagic species, the Bluestriped Grunt is a relatively minor component of commercial landings. Of the reef associated species, it has ranked an average of 16th in the landings by weight from 1996 through 2008. The species is presumed to be relatively important in the local recreational / subsistence fishery, but there are no quantitative data available to confirm this.

Commercial landings of Bluestriped Grunt in Bermuda over the past 15 years have fluctuated between 1,024 and 5,269 kg/yr, affected by changes in both fishing practices and management measures, and four phases are apparent. Landings from the early 1990s averaged 2,463 kg/yr, but increased to an average of 3,643 kg/yr in the late 1990s through 2000. Approximately 11,617 individual fish were harvested in 2000 by commercial fishers alone. From 2001 through 2006, landings declined to an average of 2,255 kg/ yr. Landings were fairly well distributed throughout the year until 1998, but between 1999 and 2006 an average of 59 % of the total annual landings was harvested during the month of May, when fish appeared to be aggregated for spawning. Following the initiation of management measures at the aggregation site in 2007, annual landings fell to an average of 1,569 kg. (Refer to Trott *et al.* this volume for a discussion of this apparent spawning aggregation.)

The relatively minor status of the Bluestriped Grunt in fisheries landings means that no data were available on the local population, and relatively few studies exist from the wider Caribbean region. The maximum reported length of the Bluestriped grunt is 46 cm total length (TL) (Claro 1994), and adults typically range in size from 20 – 35 cm fork length (FL) (Humann 1992, Carpenter 2002). In the Caribbean, maturity is achieved at an age of approximately 2 – 3 years and a size of 18 – 22 cm FL (Gaut and Munro 1983), although mature individuals have been found as small as 12 cm for males and 14 cm for females (García-Cagide *et al.* 1994). There, peak spawning is reported from January through April. In Bermuda, reproductive individuals are typically found in May and June and there have long been anecdotal reports of aggregating behaviour at this time of year. Typical life span of this species is approximately 10 years, and the maximum reported age found in the literature was 12 years (Froese and Pauly 2009). The maximum recorded weight of this species is 750 g (Cervigón *et al.* 1992).

As a result of the changing practices of the commercial fishing industry, and amidst reports of large numbers of non-commercial fishers fishing the aggregation site, there was a need to assess the status of the Bluestriped Grunt population in Bermuda. The aim of this investigation was to establish baseline size and age structures, as well as age at maturity, and to calculate growth rates and production parameters. The ultimate objective was to use this information to establish fisheries management regulations to ensure the sustainable harvest of this species in Bermuda waters.

METHODS

Samples of Bluestriped Grunts were collected from commercial fishers and through targeted fishing, using a combination of hook and line and small benthic traps, at the site of what was believed to be a spawning aggregation. A total of 908 individuals were sampled, primarily between

2001 and 2008, with some additional samples included from 1995. All individuals were measured (Fork Length – FL) to the nearest mm, and gender and reproductive stage were determined macroscopically when possible (825 individuals).   Most samples obtained were processed carcasses, but whole weight was obtained for 189 individuals.

Sagittal otoliths from 338 individuals from a range of sizes were extracted. Prior to processing, all otoliths were weighed to the nearest 0.0001 g using a precision Ainsworth M310 balance in order to evaluate whether otolith weight was a good proxy for age in this species. Otoliths were processed as described in Luckhurst *et al.* (2000) to provide mounted transverse sections of the core. Bands of varying density forming distinct rings were visible in the otolith structure when viewed under high power light microscopy and, in the absence of an opportunity for validation, these were presumed to represent annuli. Each otolith was read independently by three individuals to determine the age of the fish. In the few cases of discrepancy, otoliths were reread and a final value reached through discussion and consensus.

RESULTS

Individual Bluestriped Grunts sampled ranged in size from 18.2 to 35.1 cm fork length (FL) and the size structure of the sample, pooled across sample years, had a near normal distribution (Figure 1). The modal class was 28 cm, which included fish between 28.0 and 28.9 cm FL (Figure 1). The smallest individuals sampled (FL < 23 cm) were those caught in the benthic traps, and it appears that the Bluestriped Grunt recruits to the local commercial hook and line fishery at a size of 23 – 24 cm FL.

Fish were aged from 2 to 23 years, with the overall age structure of the sample exhibiting the expected rapid increase associated with recruitment to the exploited population, followed by exponential decline associated with mortality (Figure 2). The 3+ year class was the first class of mature individuals that was abundant in the
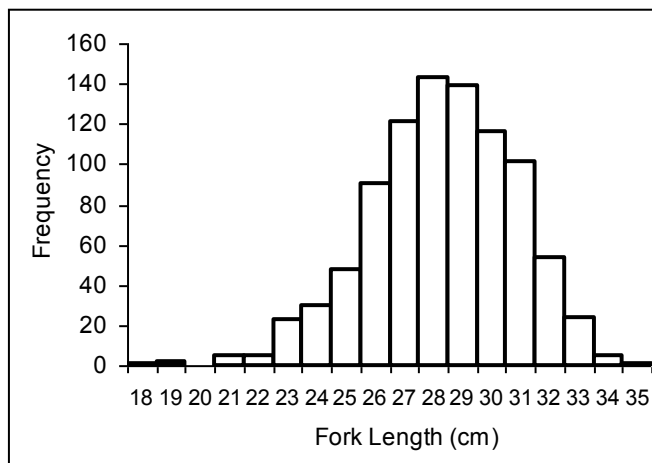

Figure 1. Size structure of the population of Bluestriped Grunts sampled, pooled across sampling years. n = 908

samples collected from the aggregation site, and 4- and 5-year old fish were more abundant than 3-year old fish (Figure 2). This suggests that the average age of first reproduction for Bluestriped Grunt in Bermuda is 3 to 4 years. The modal age was 5 years, with minor sub-modes at 12 and 18 years noticeable above the gradient of expected decline (Figure 2). Fish sampled in 2006 made the largest contribution to this analysis, and the age distribution of specimens from that year was examined for indications of unusually strong or weak year classes based on back calculation (Figure 3). With a sample size of 159 individuals, this distribution suggests that 2003, 1994, 1989 and 1988 were all years of strong recruitment and / or survivorship, while 2002, 1999, and much of the 1990s were periods of poor recruitment and / or survivorship.

A strong relationship was found between otolith weight and age (Figure 4) but, despite an R^2 of 0.87, there was considerable variability in otolith weight at a given age and this could not be reduced by transforming the data or using alternative models. There was such overlap between the weight ranges of consecutive age classes that, when the
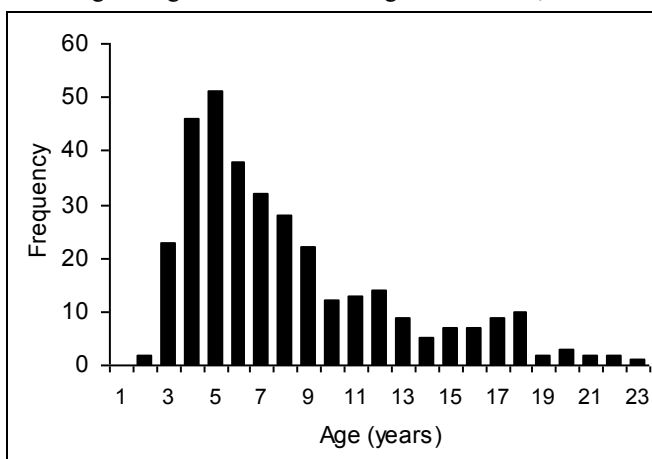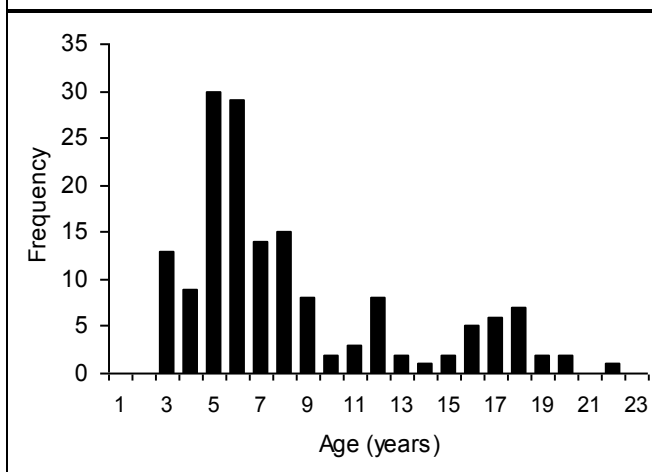
equation generated by the otolith weight versus age regression was used to calculate ages from weights, more than 28 % of ages were incorrect by a margin of 2 or more years.
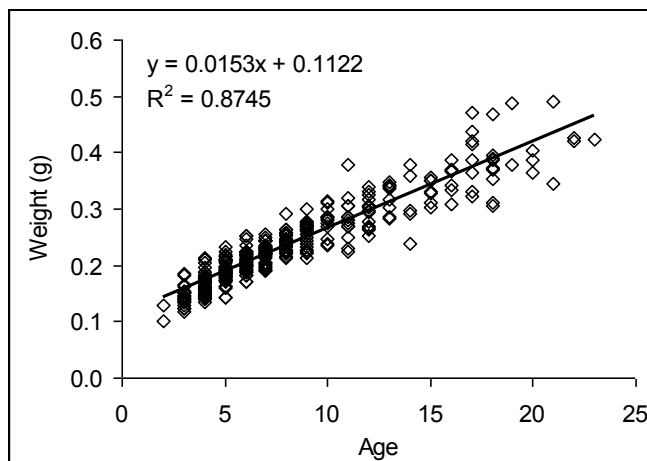

Figure 4. Otolith weight versus age for Bluestriped Grunts in Bermuda. Note the wide spread of weights for any given age. n = 338

Length-at-age was highly variable, with size ranges spanning up to 6 cm for a given year class (Figure 5). Although a greater proportion of older fish were female, the growth trajectories for males and females were visually identical and, in the absence of any previous indications of sexual dimorphism in this species, all specimens were pooled for growth analysis. L_∞ was calculated using a Ford-Walford plot, and von Bertalanffy growth parameters for the model $L(t) = L_\infty \times \{1-exp[-K \times (t-t_0)]\}$ were estimated using FiSAT II. Unconstrained iterations of the model returned values for L_∞ ranging between 30.9 and 31.9. Based on the results of the Ford-Walford plot, L_∞ was set at 31.4 cm, the instantaneous growth rate, K, was estimated to be 0.32 ± 0.033 SE, and t_0 was estimated at -1.80 ± 0.529 SE. Average size of 3+ fish was 25.4 cm, and maximum size was 28.4 cm, while average and maximum sizes of 4+ fish were 26.3 cm and 30.4 cm, respectively. Average and maximum sizes of the 5+ modal class were 27.9 cm and 31.5 cm respectively. Average size equaled L_∞ at 13 years (Figure 5).

The maximum weight recorded from these samples was 821 g, for a fish of 34.2 cm FL, and the length-weight relationship presented in Figure 6 follows the model $W = 0.0126 \times L^{3.1315}$, where W = whole weight (g) and L = fork length (cm). There was no significant difference in the relationship based on gender so all specimens were pooled for this analysis.

The sample contained 534 males and 291 females. This uneven ratio is attributed to differences in susceptibility to the fishing gears used, or differences in feeding behaviour, and therefore the likelihood of taking bait, during the reproductive period, which was when most of the sampling was undertaken. All analyses were checked

Figure 2. Age structure of the population of Bluestriped

Figure 3. Age structure of Bluestriped Grunts sampled in 2006. n = 159.

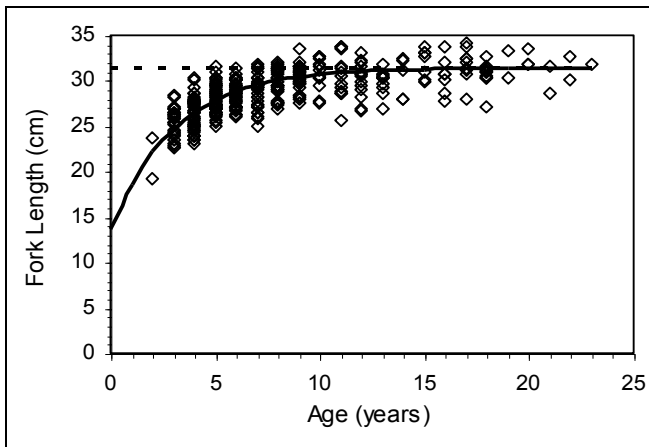for sex-related biases and indications of dimorphism, but none were found.

Figure 5. Length at age for Bluestriped Grunts in Bermuda, with von Bertalanffy growth curve (solid line) and L∞ (dashed line) marked. n = 338. See Results section for von Bertalanffy equation.

DISCUSSION

The overall size and age distributions of the sample analyzed are fairly normal given the exploitation patterns described for this species in recent years. However, back calculation based on the most recent year with an adequate sample size shows some variability in recruitment success and / or survivorship over the long term. Poor year classes may be attributed to a wide variety of factors, including environmental variability, but further investigation into whether there are any associations between these poor year
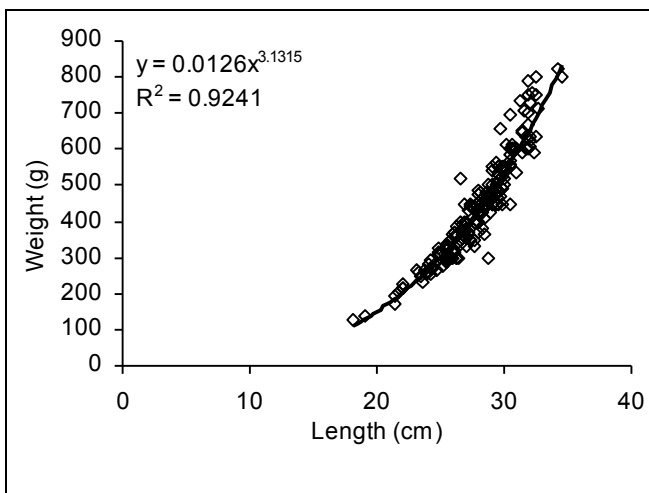

Figure 6. Length-weight relationship for Bluestriped Grunts in Bermuda. n = 189

classes and excessive fishing at the aggregation site is warranted. The maximum fork length of 35.1 cm obtained in these samples is considerably lower than the maximum reported length of 46 cm TL (= 44.5 cm FL), but the size range of the individuals sampled corresponds well with that given for typical adults. However, the maximum age of 23 years is considerably greater than the previously reported maximum age of 12 years for this species (Froese and Pauly 2009). The variability of otolith weight at a given age reflects the broad size ranges in each age class, and it has been determined that otolith weight is not a good proxy for age in this species.

The estimated instantaneous growth rate, K, of 0.32 is similar to the value of 0.3 obtained for this species by Appeldoorn (1992) in Puerto Rico, but greater than the values of 0.22 and 0.26 obtained for Cuba and Jamaica respectively (Valle *et al.* 1997, Gaut and Munro 1983), despite the fact that all of these studies used a greater L∞. The parameters of Length-Weight model fall well within the range reported by studies on Fishbase (Froese and Pauly 2009), being most comparable to values obtained in the Florida Keys and the U.S. Caribbean (Bohnsack and Harper 1988).

The sizes at which sexual maturity is achieved are much greater than those reported for the Caribbean. Based on these data, a minimum legal size for retention of captured Bluestriped Grunts in Bermuda may be set at 28 cm / 11" FL. This limit would include almost all 3+ fish and over half of the 4+ fish, and approximately 36 % of the fish sampled from commercial fishers.

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