Preliminary Age Estimates of White Grunt (*Haemulon plumieri*) in Antiguan Waters

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ABSTRACT

The distribution of white grunt (*Haemulon plumieri*) is limited to the western Atlantic Ocean, where it occurs from Virginia to the eastern Gulf of Mexico, the Caribbean Sea and south to Brazil. Although it is a dominant component of the reef fisheries and subsistence catches of the Eastern Caribbean islands including Antigua, data collection on this species has been limited to catch and effort estimates. Very little research has been completed on important aspects of the biology such as growth and reproductive rates of resident populations. Therefore, in order to begin collection of demographic data on grunt stocks in Antigua an aging study was completed. This study investigated growth zones in sagittal otolith cross-sections obtained from 236 fish caught in three localities around the island. The sampled fish ranged in total length from 159 mm to 309 mm. The oldest and youngest individuals were estimated to be one and fourteen years old respectively.

KEY WORDS: White grunt, Antigua, demographic data, aging, sagittal otoliths

Estimación del Edad del Ronco Blanco (*Haemulon plumierii*) en las Aguas Alrededor Antigua

La distribución del ronco blanco es limitada al oeste del Océano Atlántico, donde ocurre desde La bahía de Chesapeake hasta el este de Golfo de México, el Mar Del Caribe y el sur de Brasil. Ha sido introducida a Bermuda. Aunque es un de los especies que predomina el los industrias pesqueras del filón y en la pesca comercial de las islas del Caribe del este incluyendo Antigua, la colección de datos sobre este especie ha sido limitado a estimaciones de la pesca y el esfuerzo. Muy pocos estudios han sido completados sobre los aspectos importantes de la biología como tasas de crecimiento y tasas de reproducción de las poblaciones residentes. Entonces para empezar a coleccionar datos demográficos sobre los roncos blancos en Antigua un estudio que estaba envejeciendo fue completado. El estudio investigo zonas de crecimiento en secciones representativas de otolith sagital obtenidos de 236 peses recogidos en tres lugares alrededor de la isla. La muestra de peces fue de largos de 140mm a 283mm FL. Los individuos más viejos fueron estimados a trece anos y los más jóvenes a dos anos.

PALABRAS CLAVES: Ronco blanco, Antigua, datos demográficos, envejeciendo, otolith sagital

INTRODUCTION

The white grunt (*H. plumieri*) was chosen as the focal species in this study. White grunt are a major component of the reef fish fauna in the eastern Atlantic and have a distribution which stretches from Virginia in the north to Brazil in the south. In addition, white grunt stocks can be found in the Gulf of Mexico and Central America (Potts and Manooch 2001). This species was chosen because of its importance to regional reef fish catches and the fact that it is a functionally dominant species in the Caribbean reef ecosystem. Additionally, it is the Haemulidae species landed in the greatest numbers in the subsistence reef fishery in Antigua; the study site. In fact, in Antigua, a number of fishers specialize in catching white grunts. Within the Lesser Antilles, no quantitative stock assessments have been completed on this species, in part, because little biological information exists regarding its growth rates and reproduction. To properly manage *H. plumieri* stocks it is important that we understand the dynamics of this species, in particular its growth parameters, age structure and maximum longevities (Andrews *et al*. 2002).

Growth can be defined as an increase in the energy content of an organism's body as a result of food intake (Brett 1979, Jobling 1994). Growth parameters are key measures of the relationships between organisms and their environment and their success within these environments (Claro and García-Arteaga 2001). These parameters are strongly associated with abiotic environmental factors and reflect food ingestion, assimilation, and transformation within the organism (Brett 1979). Research done on fish populations has demonstrated that fish growth can vary substantially over spatial and temporal scales and these differences influence the demography of fish populations (Doherty and Fowler 1994).

A number of factors affect the rate of somatic growth in fish including genetics, geographic distribution, food availability, presence of predators, fishing pressure, and other abiotic and biotic aspects of the environment such as water temperature, salinity, and dissolved oxygen. Genetic variation in growth has been found in a number of fish species including salmonids (Kinghorn 1983) and cyprinodontids (Schultz *et al.* 1996). The differences seen in growth rates of fish with latitude may be the result of temperature adaptation. Fish that occur at higher latitudes grow faster at low temperatures with the opposite being true for fish that live at lower latitudes (Conover *et al.* 1997).

Additionally, Roberts (1995a) and Halpern and Warner (2002) have shown that fishing pressure has a tremendous influence on the demography of targeted species in many reef systems. Fishing affects the size and age structure of populations because many fishing gears act selectively on larger older individuals. Removal of these bigger fish from the fishery may lead to enhanced growth rates of the remaining smaller fish resulting over time in populations with larger individuals for a given age (Russ 1991).

The overall goal of this paper was to provide a first account of the age and growth of white grunt in Antiguan waters. In addition, the null hypothesis, there is no difference in the size at age of grunts caught at three different study sites, was tested. Growth was described using age data from sectioned otoliths fitted to the von Bertalanffy growth function. The estimated growth parameters for white grunts caught in Antiguan waters were compared to individuals caught at other geographic locations in order to give a more comprehensive picture of the age structure and growth of white grunts.

METHODOLOGY

The white grunts used in the study were collected at three sites around the small Eastern Caribbean island of Antigua. These sites were located on the northeastern, the southwestern and southeastern coasts of the island (Figure 1). The study individuals were caught using gill nets or fish traps around natural reefs in waters 10 to 30 m deep. Once landed, the total length (TL) and fork length (FL) of each individual were measured to the nearest millimeter (mm) and weight was measured to the nearest gram. In addition, data on the area of capture and date of capture were recorded for each sample. The left and right sagittal otoliths were extracted from the head of each fish, rinsed in water, and stored dry in coin envelopes until they were sectioned.

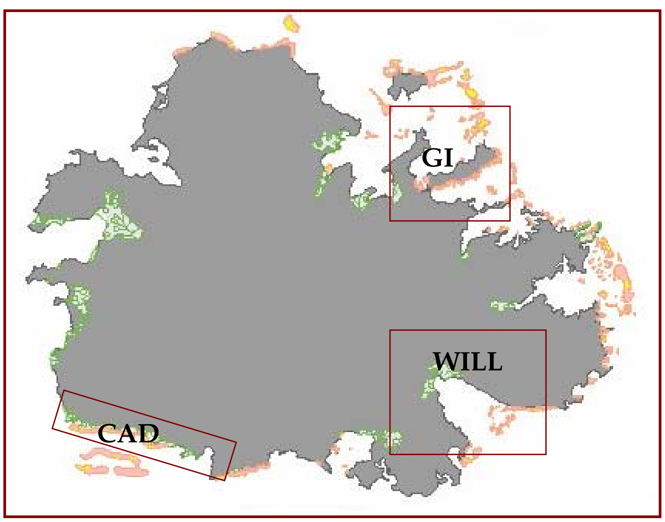

Figure 1. Map of Antigua showing the study sites; GI - Guiana Island, CAD – Cades Bay, and WILL – Willoughby Bay.

The left sagitta was preferably used for age estimation; however, if it was broken, lost or destroyed during processing the right was used. For age analysis, three transverse (dorsoventral) sections were taken from each otolith using a low speed saw. One section was made on either side of the core, and the other encompassed the core. Sections were mounted on glass slides with thermal cement. Without knowledge of fish size, site or capture date and using a compound microscope equipped with transmitted light, two readers independently counted annuli on each otolith section at 4x magnification. Clove oil was applied to each section to enhance the readability of the zones. If there was a discrepancy in the counts between readers, the section was re-examined.

Data Analysis

In order to test the null hypothesis that there was no difference in size at age for grunts caught at the three different sites an analysis of variance was completed. Growth curves were generated from size-at-age data obtained from the analysis of the 236 otoliths. In order to describe the growth pattern the von Bertalanffy growth equation $L_t = L_\infty [1-e^{-K(t-t0)}]$ was fitted to observed age-length data with nonlinear regression procedures. To further describe the growth pattern of white grunt, the natural log regression of fish weight on fish length (weight length relationship) was performed and transformed to $W=a(L)^b$, where W = weight in grams, and L = total length in mm.

RESULTS

Of the 236 white grunts used in the study, 153 were caught on the north eastern coast (GI), 53 on the south western coast (CAD), and 30 on the south eastern coast (WILL) of Antigua (Figure 2). The individuals caught at GI ranged in length from 172 mm to 270 mm fork length, 195 mm to 304 mm total length, and 100 grams to 475 grams in total weight. Those from CAD were 163-265 mm (FL), 186 - 301 mm (TL) and 100 - 450 grams in weight and the ones from WILL 140 - 283 mm (FL), 159 - 309 mm (TL) and 100 - 475 grams (Table 1).

Sectioned sagittal otoliths were examined to determine the ages of the white grunts caught at the three sites. When viewed with transmitted light, white grunt otoliths had opaque (dark) annuli that alternate with translucent (light) zones (Figure 3). However, in some individuals the annuli were indistinct and irregular in appearance, which made age estimation difficult. Of the 236 sectioned otoliths from white grunts landed in Antigua, 234 (99%) of the otoliths were assigned ages from 1 - 14 years (Figure 4). Between these two extremes there was generally an even spread of ages. Three years was the most common age (73 individuals were three years old), while there were no thirteen year old fish.

Differences in the size at age of white grunt captured in the three geographical locations were not statistically different using ANOVA performed on the total length data ($F = 0.66$; $p < 0.05$) for all ages.

The von Bertalanffy growth curve was estimated using the total length data of the 236 white grunts. The resulting growth equation was $L_t = 282[1\text{-}e^{-0.36(t+3.02)}]$ where $L_\infty = 282$ and $K = 0.36$. For white grunt caught in Antiguan waters the weight-length relationship was best described by Ln (W) = -21.51 + 15.79 Ln (L), where W = whole weight in grams, L + total length in mm, n = 236 and $r^2 = 0.89$ (Figure 5). The transformed equation is $W = 4.55 \times 10^{-10} (L)^{15.79}$.

Table 1. The range of lengths and weights of white grunts caught at each of the three sites in Antigua

Site Name	Fork Length (mm)	Total Length (mm)	Weight (grams)
GI	172-270	195-304	100-475
CAD	163-265	186-301	100-450
WILL	140-283	159-309	100-475

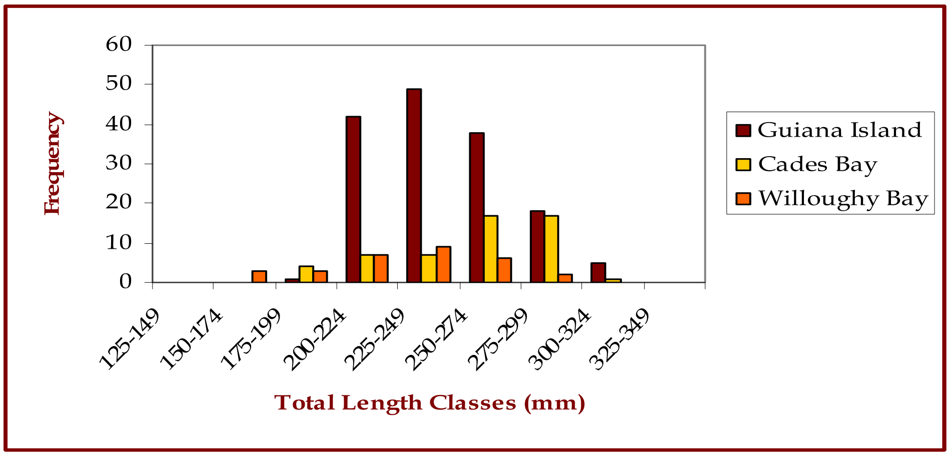

Figure 2. Length frequency analysis of grunts caught in Antigua

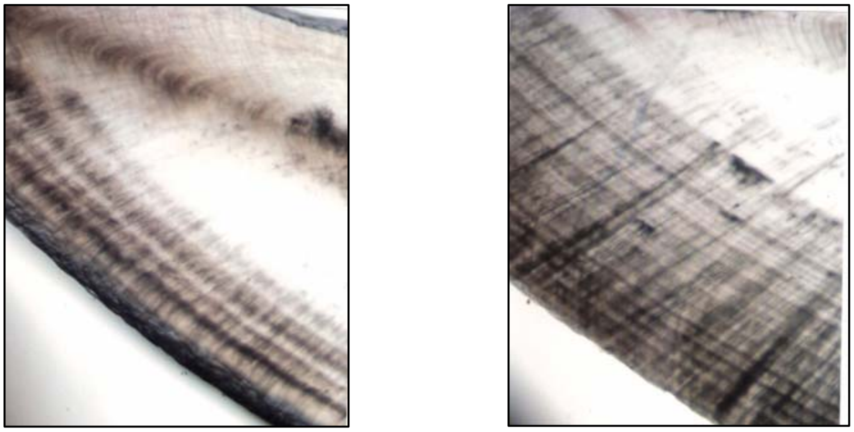

Figure 3. Otolith sections of a 4 year old and a 14 year old white grunt caught in Antigua

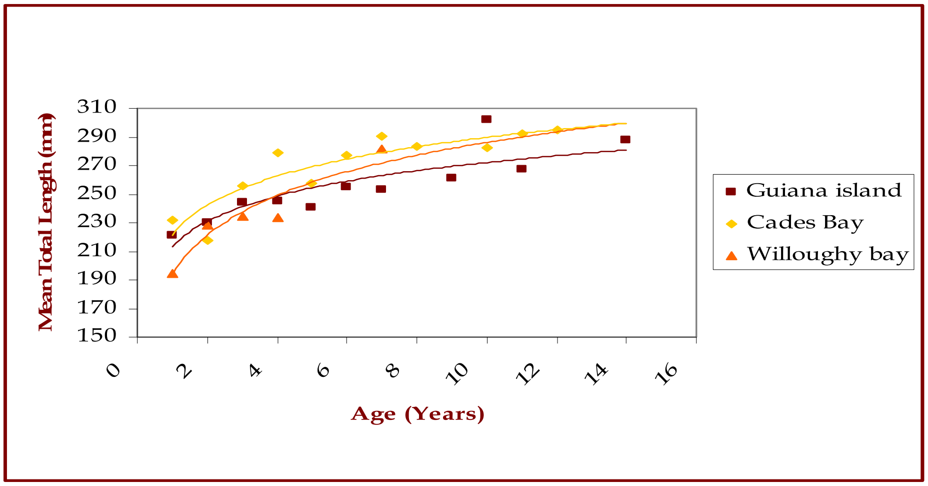

Figure 4. Mean observed total lengths (mm) of white grunts in Antigua

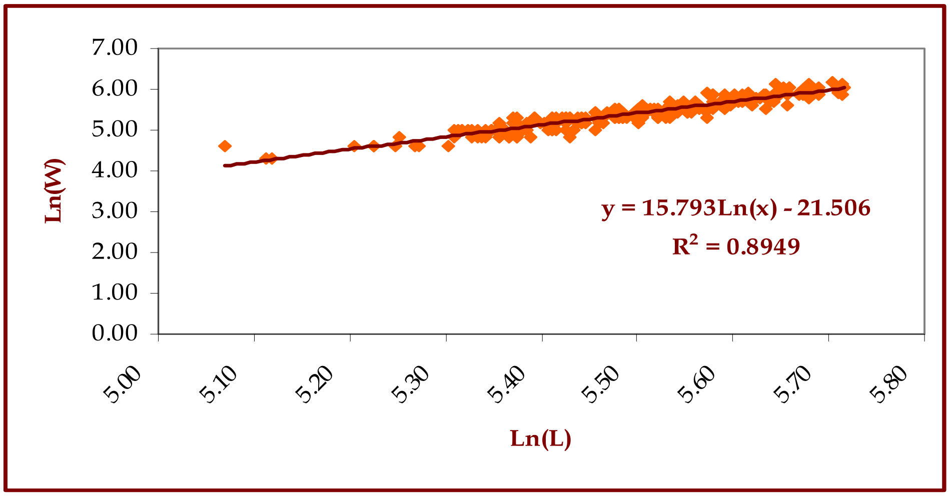

Figure 5. Length-weight relationships for grunts caught in Antiguan waters

DISCUSSION

White grunts for this preliminary study were collected from subsistence fishermen at three sites around Antigua. Fish traps and gill nets were used to trap these individuals. Because the data used in the study were from grunts collected during the months of August, September and October, it does not give a total picture of the grunt populations around Antigua. However, a more in depth study incorporating data from individuals collected through out the year is in progress.

Though the sample size in this study is smaller than other similar studies, the data collected gives a good representation of the size range of grunts at the three sites in Antigua. The representative number of samples from each area was skewed towards Guiana Island with the sample sizes from this area representing approximately 65% of the total number of samples collected. However, this bias in the sampling towards one area did not negatively affect the data analyses or the results since all the data were pooled. The grouping of the data as one unit was warranted because the ANOVA showed that there was no significant difference between the sites when mean size at age was used as the criteria for comparisons.

The oldest grunts sampled were estimated to be 14 years. Although this was the oldest fish recorded, older white grunts have been caught at other geographic locations including southeast Florida (Potts and Manooch 2001) and Puerto Rico and the Virgin Islands (Sadovy *et al*. 1989). For both of these studies the oldest fish caught reached a maximum of 15 years. Another study done by Murie and Parkyn (2005), found that female white grunts caught along the central region on the Gulf coast of Florida reach a maximum age of 18 years. Not withstanding the fact that these studies show white grunt longevity that exceeded our estimate of 14 years it is probable that grunts in Antigua also live to 15 years and older. More vigorous sampling spread out throughout the course of the year may identify grunts older than 14 years.

Our estimates of the von Bertalanffy growth model parameters do not closely reflect that of some of the other studies completed on white grunts to date (Sadovy *et al.* 1989, Potts and Manooch 2001, Murie and Parkyn 2005) (Table 2). This may be due to a number of reasons, one of them being genetic differences. Within its geographical range, Chapman (1998) has identified three separate stocks of white grunts. A northern lineage found from the Carolinas south to the Florida Keys, and in Panama City; a southern lineage found in the Florida Keys, Yucatan, Belize and Puerto Rico; and a third lineage found exclusively in Trinidad (Chapman 1998).

Geographical differences may be another factor contributing to the differences seen between our study and other grunt age and growth studies. The geographic range of white grunt is limited to the western Atlantic Ocean, from Virginia to the eastern Gulf of Mexico and Caribbean Sea, south to Brazil (Hoese and Moore 1998). Over this range, populations of *H. plumieri* encounter a wide range of water temperatures and occur at a vast range of local densities. Over such a latitudinal gradient, ectotherms can be expected to show predictable patterns of variation in growth rates, mean size, and longevity.

In addition to the genetic and geographical differences in growth, differences in growth between years may be one of the other factors contributing to the discrepancies between the results of this study and that of the others mentioned above.

Although this study gives only a preliminary analysis of the age structure of the resident grunt populations in Antigua, it furnishes background information that can be used in stock assessments of the species and subsequently the implementation of appropriate management measures.

Table 2. Comparison of growth data for grunts studies completed to date in other geographic localities

Geographic Location	Max Age (yrs)	von Bertalanffy Growth Equations	Reference
Antigua	14	Lt = 282[1-e-0.36(t+3.02)]	This study
Southeast Florida	15	Lt = 327[1-e-0.19(t+4.21)]	Potts and Manooch, 2001
Central region on the Gulf coast of Florida (females)	18	Lt = 295[1-e-0.30(t+3.44)]	Murie and Parkyn, 2005
North and South Carolina	13	Lt = 591[1-e-0.08(t+4.21)]	Potts and Manooch, 2001
Puerto Rico & Virgin Islands	15	Lt = 321[1-e-0.34(t-0.33)]	Sadovy *et al*., 1989

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LITERATURE CITED

Andrews, A.H., G.M. Cailliet, K.H. Coale, K.M. Munk, M.M. Mahoney, and V.M. O'Connell. 2002. Radiometric age validation of the yelloweye rockfish (*Sebastes ruberrimus*) from southeastern Alaska. *Marine & Freshwater Research* **53**:139-146.

Brett, J.R. 1979. Environmental factors and growth. Pages 599-675 in: W.S. Hoar, D.J. Randall, and J.R. Brett (eds.) *Fish Physiology*. Academic Press, London, England .

Chapman, R.W. 1998. Identification of stock structure in black sea bass and white grunt in the South Atlantic Coast and Gulf of Mexico. 11th Annual Marine Fisheries Initiative (MARFIN) Conference, December 9-10, Tampa, Florida USA.

Claro, R. and J.P. García-Arteaga. 2001. Growth patterns of fishes of the Cuban shelf. Pages 149-178 in: R. Claro, K.C. Lindeman, and L.R. Parenti (eds.) *Ecology of the Marine Fishes of Cuba.* Smithsonian Institution Press. Washington, D.C. USA.

Conover, D.O., J.J. Brown, and A.Ehtisham. 1997. Countergradient variation in growth of young striped bass (*Morone saxatilis*) from different latitudes. *Canadian Journal of Fisheries and Aquatic Sciences*. **54**:2401-2409.

Doherty, P.J., and A.J. Fowler. 1994. An empirical test of recruitment limitation in a coral reef fish. *Science* **263**: 935-939.

Halpern, B.S. and R.R. Warner. 2002. Marine reserves have rapid and lasting effects. *Ecological Letters* **5**:361–366.

Hoese, H.D. and R.H. Moore. 1998. *Fishes of the Gulf of Mexico, Texas, Louisiana, an Adjacent Waters, 2nd Edition.* Texas A&M University Press, College Station, Texas USA. 422 pp.

Jobling, M. 1994. *Fish Bioenergetics.* Chapman & Hall. Boundary Row, London, England. 309 pp.

Kinghorn, B.P. 1983. Genetic variation in food conversion efficiency and growth in rainbow trout. *Aquaculture* **32**:141-155.

Murie, D.J. and D.C. Parkyn. 2005. Age and growth of white grunt (*Haemulon plumieri*): a comparison of two populations along the west coast of Florida. *Bulletin of Marine Science* **76**:73-93

Potts, J.C., and C.C. Manooch III. 2001. Differences in the age and growth of white grunt (*Haemulon plumieri*) from North Carolina and South Carolina compared with southeast Florida. *Bulletin of Marine Science* **68**(1):1-12.

Roberts, C.M. 1995a. Rapid build-up of fish biomass in a Caribbean marine reserve. *Conservation Biology* **9**:815–826.

Roberts, C.M. 1995b. Effects of fishing on the ecosystem structure of coral reefs. *Conservation Biology* **9**:988–995.

Russ, G.R. 1991. Coral reef fisheries: effects and yields. Pages 601-635 in: P.F. Sale (ed.) *The Ecology of Fishes on Coral Reefs*. Academic Press, San Diego, California USA.

Sadovy, Y., M. Figuerola, and A. Ramán. 1989. The age and growth of the red hind *Epinephelus guttatus* and the white grunt *Haemulon plumeiri* in Puerto Rico and the U.S. Virgin Islands. Report to the Caribbean Fishery management Council, August 1989, San Juan, Puerto Rico. 66 pp.

Schultz, E.T., K.E. Reynolds, and D.O. Conover. 1996. Countergradient variation in growth among newly hatched *Fundulus heteroclitus*: geographic differences revealed by common-environment experiments. *Functional Ecology* **10**: 366-374.