A Preliminary Investigation of the Age and Growth of Gray Snapper, *Lutjanus griseus*, in Louisiana Waters

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ABSTRACT

The gray snapper, *Lutjanus griseus*, is a temperate – tropical reef fish that is found along the Gulf of Mexico And Atlantic coasts of the southeastern United States. The fishery for gray snapper is rapidly developing in south Louisiana with the advent of seasonal restrictions on the established red snapper, *L. campechanus*, fishery. We examined the age and growth of gray snapper in Louisiana with the use of cross-sectioned sagittal otoliths. A total of 374 specimens, (202 males, 156 females, 14 juveniles, 2 unknown sex) were opportunistically sampled from the recreational fishery from July 2001 to August 2002. Males ranged in size from 308 to 732 mm TL and from 0.28 kg to 5.6 kg TW while females ranged from 298 to 756 mm TL and from 0.34 kg to 5.6 kg TW. A combined TL-TW regression for males and females was fit on log transformed data as $TW = 1.15 \times 10^{-8} (TL)^{2.96}$ ($r^2 = 0.97$). Edge analysis of sectioned otoliths suggests opaque annulus formation during the winter months. Age estimates ranged from 3-28 years for males and 2-25 years for females. Von Bertalanffy growth models derived from total length at age are $L_t = 654.4\{1 - e^{[-0.22(age+0.18)]}\}$ for males and $670.2\{1 - e^{[-0.19(age+0.28)]}\}$ for females. Each model also included 14 unsexed age-0 fish to provide points at the lower end of the curve to better reflect early growth.

KEY WORDS: Gray snapper, growth, otolith

Evaluación Preliminar del Edad y Crecimiento del Pargo Gris (*Lutjanus griseus*) en Aguas de Lousiana

El pargo gris, Lutjanus griseus, es un pez arrecifal de clima templado – tropical que se encuentra comúnmente en la costa del Golfo de México a traves del sureste de los Estados Unidos. La pesquería del pargo gris esta siendo desarrollada rápidamente en el sur de Lousiana debido a las vedas estacionales para la pesquería del huachinango *(Lutjanus campechanus)*. Se examino la edad y el crecimiento del pargo grisen Louisiana mediante el uso de secciones sagitales de otolitos. Un total de 820 individuos (436 machos, 379 hembras, 5 sexo indeterminado) fueron muestreados oportunistamente de la pesquería recreativa de Luisiana durante los años de 1998 a 2002 para datos morfometricos y otolitos. Los machos variaron en tamaño de 222 – 693 mm de talla total y de 200 a 5,670 gr. de peso total. Mientras que las hembras variaron de 324 – 756 mm. de talla total y de 460 a 5,850 gr. en peso total. El análisis de covarianza no indicó diferencia significativas en coeficientes de regresion entre sexos, por lo tanto se uso una regresion de tendencia de longitud combinada con peso para machos y hembras de la manera siguiente: 4.47 X 10^{-8} (TL^2.81) ($r^2 = 0.92$). El análisis de otolitos sugiere la formación de anillos opacos durante el invierno. Las edades estimadas mediante otolitos variarion de 1 a 28 años. La curva de crecimiento de Von Bertalanffy basados en longitud total resulto en una estimacion de la edad LT = 634.7{1 – E^[-0.22(edad)]} ($r^2 = 0.67$) para machos y 650.3{1 – E^-0.21(edad)]} ($r^2 = 0.67$) para hembras. La ordenada al origen fue forzada a cero para reflejar mejor el crecimiento en vida temprana. Casi un tercio de todos los machos y hembras fueron de 6 a8 años de edad con reclutamiento a la pesquería recreativa del Golfo ocurriendo a la edad 6 años.

PALABRAS CLAVES: Pargo gris, *Lutjanus griseus*, edad y crecimiento

INTRODUCTION

The gray snapper, *Lutjanus griseus*, is a temperate - tropical reef fish that is found along the Gulf of Mexico and Atlantic Ocean of the Southeastern United States. The fishery for gray snapper is rapidly developing in south Louisiana with the advent of seasonal restrictions on the established red snapper fishery.

Some background information on early life history (Rutherford et al. 1989; Domeier et al. 1996), age and growth (Manooch and Matheson 1981, Johnson et al. 1994), and reproduction (Domier et al. 1996) on this species is available for South Florida waters and small portions of the northern Gulf of Mexico, but comprehensive age and growth data from the Louisiana fishery is nonexistent.

Accurate interpretation of presumed otolith annuli is crucial to successful management of the gray snapper. Our goal was to collect gray snapper on a seasonal basis from the recreational fishery to determine timing of opaque zone formation in otoliths and develop an age-size distribution for this species off the coast of Louisiana.

METHODS AND MATERIALS

Louisiana State University Coastal Fisheries Institute personnel sampled gray snapper from July 2001 to August 2002 at charter boat facilities in Fourchon, Louisiana. Morphometric measurements (fork length (FL) and total length (TL) in mm, total weight (TW) and eviscerated body weight (BW) in g) were taken, both sagittal otoliths were removed, and sex was determined for each specimen. For specimens for which TL was unavailable, TL was estimated from FL with the equation TL = 1.048(FL) + 8.35 (linear regression, df = 275; $p < 0.001$; $r^2 = 0.98$).

Male and female TL - TW regressions were calculated from natural log transformed data with the model ln TW = m (ln TL) + b. Regression coefficients were compared between sexes with analysis of covariance (ANCOVA) and test for homogeneity of slopes. Age, TL, and TW frequency distributions were examined in 1 yr, 25 mm, and 0.2 kg increments, respectively. Komolgorov-Smirnov two-sample tests (Sokal and Rohlf 1981) were used to test for differences between sexes in each of the frequency distribution comparisons.

Right and left otoliths were weighed to the nearer 0.1mg. The left otolith was sectioned with a Hillquest, model 800, thin-sectioning machine with a slightly modified procedure borrowing petrographic techniques from geology as first described by Cowan et al. (1995). In instances where the left otolith was unavailable, the right was substituted. Otolith cross-sections were examined with a dissecting microscope with transmitted light and polarized light filter. Annuli, or opaque increments, were enumerated along the ventral side of the sulcul groove. Two readers performed increment counts independently without knowledge of capture date or morphometric data. In instances where the initial count differed the otolith section was re-examined by both readers.

Ages were estimated from increment count and edge condition (Beckman et al. 1991) with the equation described in Wilson and Nieland (2001). A birth-date of 1 July was set when calculating age to coincide with previous research indicating that gray snapper spawn from May to September with peak spawning activity occurring in mid-July (Allman and Grimes 2002). Annulus counting error between the two readers was evaluated after the second readings of otolith sections were completed. Reproducibility of the resultant age estimates was evaluated with the coefficient of variation, index of precision (Chang 1982), and average percent error (Beamish and Fournier 1981). The periodicity of opaque increment formation was examined with edge analysis and by plotting the proportions of opaque otolith margins by month of capture (Beckman et al. 1988, Campana 2001).

Theoretical growth parameters derived from TL at age were estimated with the von Bertalanffy growth model and nonlinear regression with least squares based on the formula:

$$L_{\infty} = L_t\,(1 - e^{\{-k(t - t0)\}})$$

where t is age in years, L_t is TL at age t, L_{∞} is the theoretical maximum TL, k is the growth coefficient, and t_0 is hypothetical age where TL is zero. The resultant models fitting parameters for both males and females were then combined into one full six-parameter model and compared to a reduced model on the pooled data in which sex was not considered. Each of these models also included 14 unsexed age-0 fish to provide points at the lower end of the curve. These individuals ranged in size from 36 mm to 94 mm TL. A likelihood ratio test of the six-parameter and the pooled data models was used to test for differences between sexes. Plots of residuals were used to test for normality of the data. A significance level of 0.05 was used for all statistical analysis.

RESULTS

Our personnel collected morphometric data, otoliths, and determined sexes for 374 gray snapper (202 males, 156 females, 14 juveniles, 2 unknown sex). A Komolgorov - Smirnov two-sample test indicated no significant difference between male and female TL frequencies in 25 mm increments (D = 5.38). Males ranged from 308 mm TL to 732 mm TL while females ranged from 298 mm TL to 756 mm TL (Figure 1). Both males and females showed mutimodal distributions of. A Komolgorov - Smirnov two sample test comparing distributions of TW (in 0.2 kg increments) did not indicate a significant difference between sexes (D = 5.9). Both male and female TW distributions are very similar with males ranging from 0.28 kg TW to 5.67 kg TW and females from 0.34 kg TW to a maximum of 5.62 kg TW.

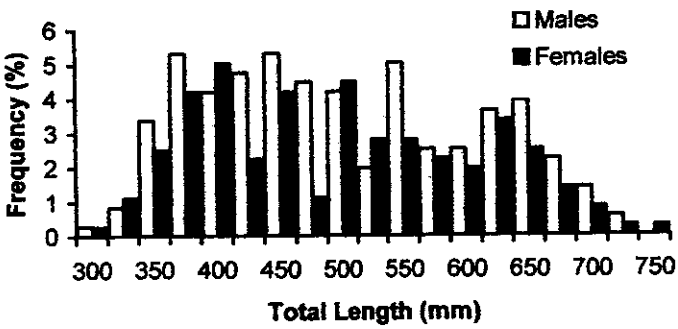

Figure 1. Total length frequency of male (n = 202) and female (n = 156) gray snapper, *Lutjanus griseus*, in 25 mm increments sampled from the Louisiana recreational fishery from July 2001 to August 2002.

No significant differences were detected when plotting TL-TW relationships between sexes (ANCOVA test of homogeneity of slopes, $F_{3,352} = 0.34$; $p = 0.56$; ANCOVA test for equal intercepts, $F_{3,352}=0.31$; $p = 0.58$). Therefore, one TL–TW regression was fit for males and females as follows:

$$\text{LogTW (kg)} = 1.15 \times 10^{-8}(\text{LogTL}^{2.96})$$

Examination of the percentage of otoliths with opaque and translucent margins by month of capture suggests that opaque increments are formed during the winter months. Preliminary data suggests that a translucent increment is accreted on the otolith from April to October (Figure 2).

Ages were obtained from transverse otolith sections of 342 gray snapper (184 males, 142 females, 14 juveniles, 2 unknown sex). Opaque rings are easily distinguishable on the ventral side of the sulcul groove (Manooch and Matheson 1981, Shipp 1991, Johnson et. al. 1994) (Figure 3). Readers disagreed on ages for only four individuals, so the ages of the more experienced reader (AJF) were used in all analyses. Both readers agreed on all other counts (N = 338) or 98.8 % of age estimates after the second reading. The average percent error was 0.5 %, the coefficient of variation was 0.001 and the index of precision was 0.0009.

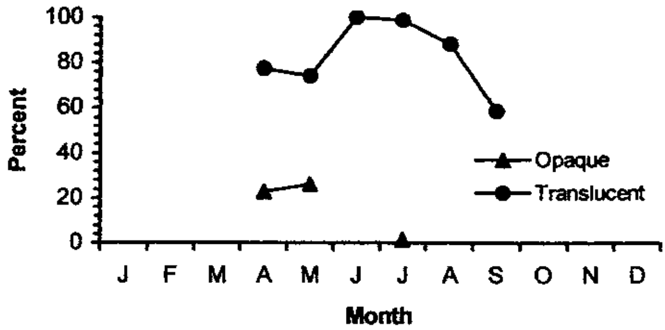

Figure 2. Marginal increment analysis of gray snapper, *Lutjanus griseus*, otoliths sampled from July 2001 to August 2002. Percentages of opaque margin edges are plotted against month of capture.

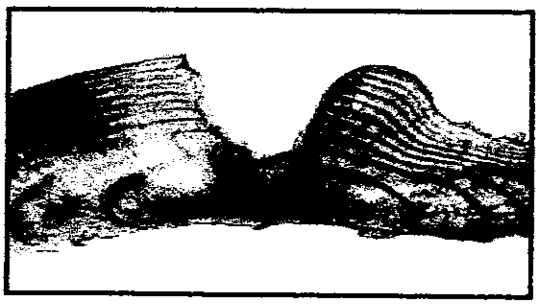

Figure 3. Photomicrograph of gray snapper, *Lutjanus griseus*, sagittal otolith transverse cross section under transmitted light.

A Komolgorov-Smirnov two-sample test revealed no significant difference in age distributions between sexes (D = 8.82). Males ranged in age from 3 to 28 years while females ranged from 2 to 25 years. Males were found in the greatest numbers at age 4 while females were most abundant at 8 years. The fishery is dominated by younger fish with 72 % of males and females aged at 10 years or less.

Data were fit to von Bertalanffy growth models and compared between sexes. A likelihood ratio test indicated a significant difference between a full six-parameter growth model and the pooled data growth model (χ^2 = 35.93; df = 3,341;p < 0.0001). Therefore, separate growth models were fit for each sex (Figure 4). The von Bertalanffy growth models derived from TLs are:

Male $L_t = 654.4\{1 - e^{[-0.22(age+0.18)]}\}$

Female $L_t = 670.2\{1 - e^{[-0.19(age+0.28)]}\}$

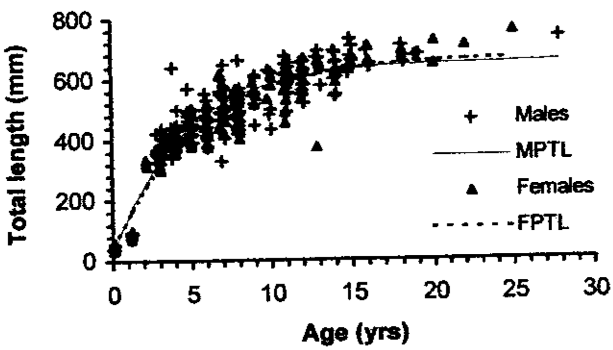

Figure 4. Von Bertalanffy growth models fitting total length at age for male and female gray snapper, *Lutjanus griseus*, sampled from July 2001 to August 2002. Each model includes 14 unsexed juveniles ranging from 36mm to 94mm.

DISCUSSION

Gray snapper otoliths are very similar in morphology, although much smaller in actual size, to those of red snapper. Although the opaque increments are distinct, the small size of the otoliths and apparent longevity of the species pose some challenges in age estimation. Considerable variability is displayed in the position of the first annulus in gray snapper. A similar pattern, also exhibited in red snapper otoliths, finds the first annulus variously located from somewhat distant from the core to close to and continuous with the otolith core (Wilson and Nieland 2001). Additional problems in otolith interpretation include counting the closely spaced annuli in older individuals and accurate interpretation of the otolith margin condition among these older specimens.

The lack of data from the months of November through March precludes our making a definitive statement of timing of opaque annulus formation based on marginal increment analysis. However, our data suggest that a translucent increment is accreted at the otolith edge from April to October. Burton (2001) used marginal increment analysis to validate the periodicity of gray snapper annulus formation in Florida waters stating that as opaque annulus is deposited on the otolith edge during June and July. Burton measured the distance between the distal edge of the last opaque zone and the otolith edge and then plotted measurement means against month of capture. He stated that the mean minimum distances, or minima, would indicate the month of opaque increment formation. However, measurement of the minimum distance from the distal edge of the last opaque zone may actually represent the beginning of the translucent zone and therefore estimate a late period of opaque zone formation.

Our maximum ages are greater then those found in previous studies. Johnson et. al (1994) reported maximum ages of 23 and 25 years for males and females, respectively, and Burton (2001) reported a non-sex-specific maximum age of 24 years.

The von Bertalanffy growth models estimated a slightly larger maximum theoretical size (L_∞) for females than males at 670.2 mm TL and 654.4 mm TL, respectively. The presence of more large, older fish in our sample population resulted in the model forming an asymptote at a smaller maximum theoretical size compared with Johnson et al. (1994) who predicted greater maximum theoretical lengths for both males and females with the regression method of Manooch and Matheson (1981) to back calculate lengths at age. Johnson et al. also had smaller estimated growth coefficients (k) than this study. Knight (1968) noted the close inverse correlation of L_∞ and k and that caution should be taken in interpretation of these parameters. It should be noted that Johnson et al. (1994) had no individuals below 200 mm TL. Burton (2001) also estimated growth parameters by fitting back-calculated lengths at age to predict larger maximum theoretical lengths. Burton (2001) had a number of fish below 200 mm TL allowing for more accurate estimates of k and t_0.

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