Age, Growth, and Mortality of Lane Snapper from the Northern Gulf of Mexico

Allyn G. Johnson, *National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, 3500 Delwood Beach Road, Panama City, FL 32408*

L. Alan Collins, *National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, 3500 Delwood Beach Road, Panama City, FL 32408*

John Dahl, *National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, 3500 Delwood Beach Road, Panama City, FL 32408*

M. Scott Baker, Jr., *National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, 3500 Delwood Beach Road, Panama City, FL 32408*

Abstract: Age, growth and mortality of lane snapper (*Lutjanus synagris*) from the northern Gulf of Mexico (Port Aransas, Texas, to Panama City, Fla.) were examined. Otolith sections from 694 fish collected from January 1991 to December 1994 were used to develop growth information using 2 methods (direct proportion and regression) of back-calculation. Fish ranged in age from 2 to 17 years and their size ranged from 210 to 673 mm total length. Males grew slightly faster and were larger at age than females; however, the oldest (age 17 at 500 mm) and largest (673 mm at age 11) were females. Full recruitment to the recreational fishery was at age 4–5. Estimated instantaneous total mortality (Z) ranged from 0.3750 to 0.5767. Natural mortality (M) ranged from 0.1125 to 0.2388.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 49:178–186

Lane snapper is a member of the reef fish complex that supports important recreational and commercial fisheries in the northern Gulf of Mexico. Little information is available from the northern Gulf of Mexico; Shipp (1991) reported on observed size at age of 107 fish using otolith sections. There are several reports on age and growth of this species from outside this area (Alegria C. and Menezes 1970; Reshetnikov and Claro 1976*a,b;* Cruz 1978; Manooch and Mason 1984; Rubio et al. 1985; Torres and Chavez 1987; Acosta and Appeldoorn 1992). The present report provides information on age, growth, and mortality of lane snapper from the northern Gulf of Mexico.

Methods

Lane snapper were obtained from recreational hook-and-line fisheries from the northern Gulf of Mexico. Collection areas were Port Aransas, Texas; Leeville, Louisiana; and Panama City, Florida. Sagittal otoliths were collected from each fish along with lengths (total [TL] and fork [FL]) in millimeters and sex when possible (some fish were cleaned at sea, thus no gonads). Whole body weight to the nearest 0.1 kg for Florida fish was recorded.

Otoliths were first examined whole and then again after being transversely sectioned. Two or 3 otolith sections (0.15 mm thick) were cut from the core of each otolith on a low-speed saw and mounted on glass slides using Pro-texx[1] mounting medium. Otolith examination followed the method of Manooch and Mason (1984) with the exception that sections were examined at 40X using transmitted light. Manooch and Mason (1984) examined sections at 20X using reflected light. Annuli (opaque marks) were counted and distances from the core to the distal edges of marks were measured. The margin of each otolith section was examined to determine if an annulus (opaque mark) was being formed at the time of capture. Otolith section age estimates were made by 2 readers and only fish where both readers agreed on the age were used.

Back-calculated lengths (mm TL) at ages were determined following the direct proportion (DP) method of Lea (1910) and the regression (REG) method of Manooch and Mason (1984). The REG method used TL vs. otolith radius relationships which were developed for all fish and for females and males separated and applied to their respective back-calculations. Data were analyzed with SAS software (SAS 1988) computer programs using standard statistical procedures (general linear and non-linear models and Student's t-test). Student's t-tests were used to test the significance ($P < 0.05$) of differences in length-at-age distributions between back-calculation methods and in length-at-age distributions between sexes. Von Bertalanffy growth equations were developed with both DP and REG back-calculated lengths using SAS NLIN procedure (option DuD). Total mortality (Z) estimates were made using catch curves (Nelson and Manooch 1982, Goodwin and Johnson 1986) assuming our collection represented the actual age distribution of the population. These estimates were made using the regression method of plotting the $\log_e$ of the age frequency on age. The slope of the linear descending right limb of the curve after full recruitment estimates Z. Natural mortality (M) was computed using the method of Pauly (1980) following the procedure of Nelson and Manooch (1982) assuming a mean annual water temperature of 22 C.

[1] Reference to trade names does not constitute endorsement by the National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA).

Results and Discussion

Eight-hundred twenty-six lane snapper (Texas $N = 45$, Louisiana $N = 471$, Florida $N = 310$) were collected from January 1991 to December 1994. Annuli formed on otoliths, based on the seasonal distribution of the percentage of opaque margins, during April to September peaking in June for the northern Gulf of Mexico ($N = 705$, Fig. 1). This distribution supports the hypothesis that opaque otolith marks are formed once a year in the northern Gulf of Mexico. Our distribution agrees with the finding of opaque mark formation in May to August for Trinidad (Manickchand-Dass 1987) and May and June for Cuba (Reshetnikov and Claro 1976*b*).

Agreement between surface and section age estimates was 69% (97% for ±1 mark). Agreement between 2 readers was 79% (96% for ±1 mark) using whole otoliths and 84% (96% for ±1 mark) using sections. Manooch and Mason (1984) could identify marks on 76% of their otolith sections and could measure the marks on 61%. Ages, determined from otolith sections, were agreed upon by both readers for 694 lane snapper.

Various regression equations (length-length, length-weight, and total length-otolith radius) were developed from the information collected (Table 1).

Considerable variation in empirical lengths at ages was observed in the lane snapper collection from the northern Gulf of Mexico (Fig. 2). This was not unexpected, as Manooch and Mason (1984) reported a broad empirical length-at-age range for fish from the east coast of Florida. The back-calculated mean

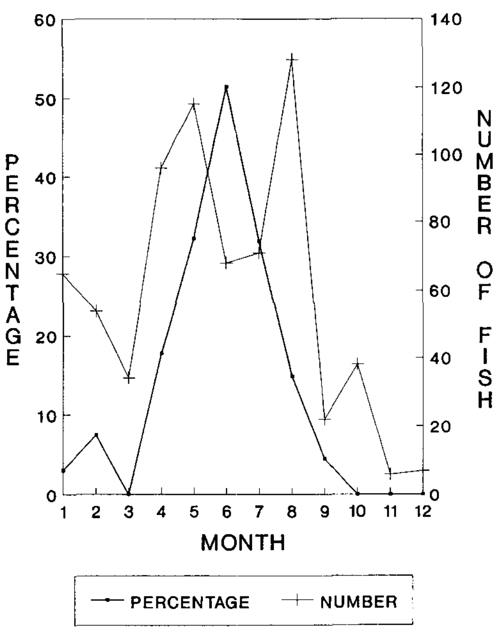

Figure 1. Percentage of lane snapper otoliths with opaque margins by month from the northern Gulf of Mexico.

Table 1. Lane snapper regression equations developed from the northern Gulf of Mexico.

Item[a]	Equation	SE of a[b]	SE of b[c]	r	N
TL vs. OR					
Female	$TL = 14.1173\ OR^{0.6263}$	0.1374	0.0270	0.7967	312
Male	$TL = 12.6253\ OR^{0.6528}$	1.1952	0.0348	0.7682	324
All fish	$TL = 13.6331\ OR^{0.6353}$	1.1049	0.0206	0.7682	691
TL vs. FL	$TL = 14.6753 + 1.0189\ FL$	2.8998	0.0086	0.9920	226
FL vs. TL	$FL = -8.9097 + 0.9659\ TL$	2.9204	0.0082	0.9920	226
WT vs. TL	$Log_{10}\ WT = 8.1023 + 3.1055\ Log_{10}\ TL$	0.1957	0.0774	0.9380	222

[a]TL is total length in mm, FL is fork length in mm, OR is otolith radius in mm from magnified image at 40X, WT is whole body weight in kg.
[b]a is the intercept of the equation.
[c]b is the slope of the equation.

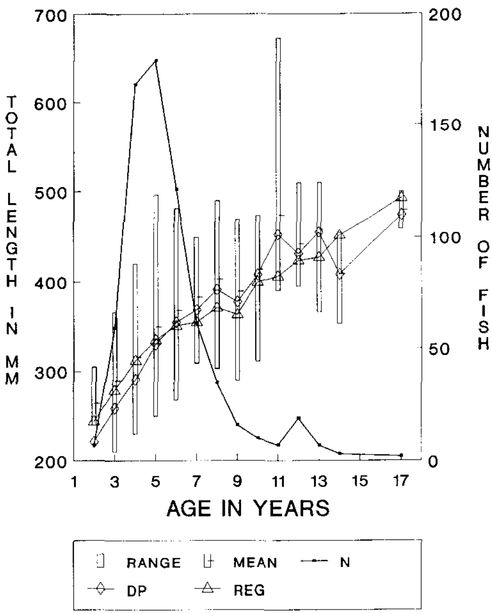

Figure 2. Distribution of empirical length and number (N) of lane snapper along with back-calculated mean length at age. DP and REG are back-calculated lengths at age (at mark completion) using direct proportion and regression methods, respectively.

length at age for the most recent (last) annulus formed before capture is also plotted (Fig. 2) for both the DP and REG methods. The 2 methods are presented for correspondence to the literature (e.g., Alegria C. and Menezes 1970 used DP, and Manooch and Mason 1984 used REG). The 95% confidence intervals (C.I.) of DP and REG from von Bertalanffy equations developed for all fish overlapped, but weighted mean lengths at ages were significantly different for ages 1–5 (Table 2, Fig. 3). Back-calculated lengths at ages between sexes were significantly different for ages 2–8 using the DP method and ages 2–7 using the REG method (Fig. 4). Males grew slightly faster and were larger at age than females; however, the oldest and largest fish in the collection were females at

Table 2. Parameters of von Bertalanffy growth equation for lane snapper from northern Gulf of Mexico, 1991–1994.

Type[a]	L_∞	SE	95% C.I.		K	SE	95% C.I.		t_0	SE	95% C.I.	
All fish												
DP	469.5256	13.4772	443.0639	495.9873	0.1944	0.0221	0.1511	0.2378	−1.0988	0.3642	−1.8149	−0.3847
REG	479.3384	21.0720	437.9647	520.7120	0.1259	0.0213	0.0841	0.1677	−4.2548	0.8115	−5.8481	−2.6614
Female												
DP	455.5567	16.8559	422.3897	488.7237	0.2021	0.0306	0.1420	0.2623	−1.0995	0.4873	−2.0583	−0.1406
REG	500.4294	28.3239	444.6972	556.1616	0.1060	0.1109	−0.1122	0.3241	−4.9258	21.7630	−47.7484	37.8967
Male												
DP	489.5847	23.9262	442.5121	536.6573	0.1796	0.0332	0.1144	0.2449	−1.2185	0.5985	−2.3960	−0.0411
REG	479.9387	30.1253	420.6699	539.2076	0.1364	0.0345	0.0685	0.2042	−3.7627	1.1701	−6.0647	−1.4607

[a]Method of back-calculation of total length in mm at age; direct proportion (DP) after Lea (1910), regression (REG) after Manooch and Mason (1984).
[b]L_∞ is asymptotic total length in mm, K is growth coefficient, t_0 is time when total length would theoretically be zero, C.I. is confidence interval.

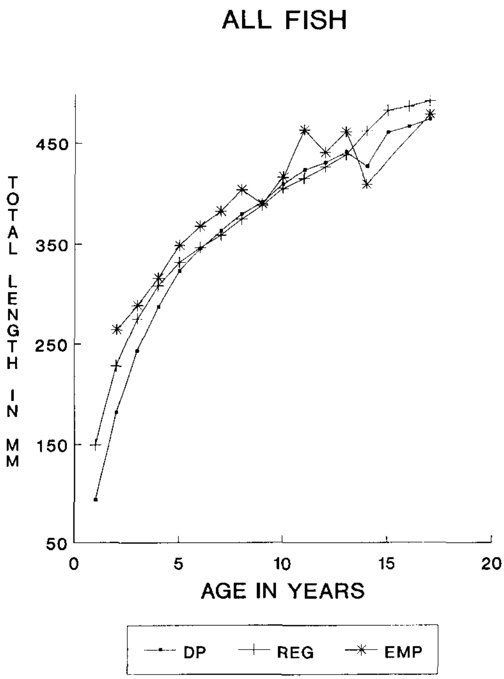

Figure 3. Lane snapper back-calculated weighted mean length at age for all fish using 2 methods of calculation. DP is the direct proportion method and REG is the regression method. EMP is empirical data.

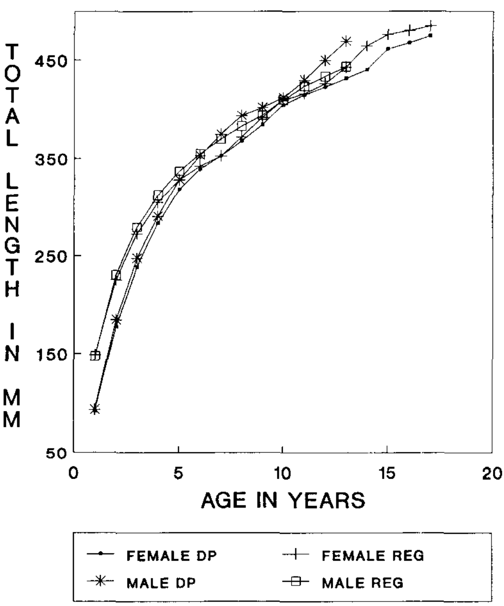

Figure 4. Lane snapper back-calculated weighted mean length at age for males and females using 2 methods of calculation. DP is the direct proportion method and REG is the regression method.

age 17 (500 mm TL) and 673 mm TL (age 11). This phenomenon has also been reported for lane snapper from Trinidad (Manickchand-Dass 1987). The oldest and largest males in our study were age 13 and 510 mm TL.

The von Bertalanffy-predicted lengths at ages in our study, using either the comparative DP or REG method, were greater than those reported from Florida (east coast), Cuba, and Yucatan, Mexico (Cruz 1978, Manooch and Mason 1984, Rubio et al. 1985, Torres and Chavez 1987). Alegria C. and Menezes (1970) values for Brazil were greater than our values. However, growth in all of these studies except in Cuba (Rubio et al. 1985) was within the 95% C.I. of our study. Values from Rubio et al. (1985) were lower than our equation's lower limit. Von Bertalanffy-predicted lengths at ages from Trinidad (Manickchand-Dass 1987) were greater than our equation's 95% C.I. upper limit (Fig. 5).

Our empirical lengths at ages were greater than those reported from southwest Florida by Shipp (1991), but smaller than his values for the northern Gulf of Mexico. It is difficult to compare the various studies of lane snapper because factors such as age determination structures, size of largest fish, separation or lack of separation of sexes, and methods of back-calculation differed among studies. For example, Manooch and Mason (1984) used REG, otolith sections, and fish up to age 10; Alegria C. and Menezes (1970) used DP, whole otoliths, and fish up to age 6; and Manickchand-Dass (1987) used whole otoliths and fish up to age 4. The maximum age and length in a study strongly influences the resultant von Bertalanffy growth equation. Knight (1968) pointed out the close inverse correlation of maximum length (L_∞) and growth coefficient (K) and expressed that caution should be taken in interpretation. Vaughan and Kanciruk

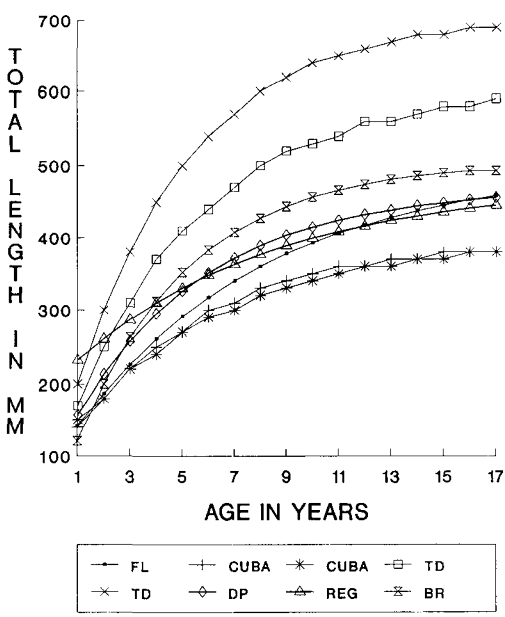

Figure 5. Lane snapper mean length-at-age estimates from von Bertalanffy growth equations. DP and REG represent direct proportion and regression calculations from this study. Other estimates are from the literature (FL is Florida east coast, Cuba is Cuba, TD is Trinidad, and BR is Brazil).

Table 3. Mortality estimates for lane snapper collected from northern Gulf of Mexico, 1991–1994.

	Item[a]					
	Z	SE of *Z*	*A*	*FR*	*T*	*M*
All fish	0.3750	0.0429	0.31	5	17	0.2280 (0.1441)
Female	0.4529	0.0658	0.36	4	13	0.2388 (0.1125)
Male	0.5767	0.0178	0.44	5	11	0.2080 (0.1773)

[a]*Z* is instantaneous (total) mortality, *A* is annual mortality, *FR* is age of full recruitment, *T* is age at which curve is truncated, and *M* is natural mortality using direct proportion back-calculation (in parenthesis is *M* using regression back-calculation).

(1982) provide more evidence reinforcing the need for cautious interpretation of growth equations.

We estimated *Z* to be 0.3750–0.5767, and full recruitment to be at age 4 or 5. These estimates of *Z* are lower than those reported by Cruz (1978) ($Z = 1.80$–1.81) and Acosta and Appeldoorn (1992) ($Z = 1.645$–1.81) for the Caribbean area, but similar to the estimate by Manooch and Mason (1984) ($Z = 0.678$) for the east coast of Florida. Our *M* estimates ranged from 0.1125 (based on REG) to 0.2388 (based on DP) depending on growth models (Table 3). The *M* estimates are dependent on *K*. Since the REG method of back-calculation averages individual variation in length at a given otolith radius and the DP method retains the variation, we have more confidence in the DP-derived values. Lane snapper is a relatively long-lived reef fish that could be over-exploited if a large, intensive fishery for it were developed in the northern Gulf of Mexico. At present, this species is not subject to an intensive harvest (as is evident by the low *Z* values compared to other locations). A low-intensity fishery could take most of the yield without endangering future production.

Literature Cited

Acosta, A. and R. S. Appeldoorn. 1992. Estimation of growth, mortality and yield per recruit for *Lutjanus synagris* (Linnaeus) in Puerto Rico. Bull. Mar. Sci. 50:282–291.

Alegria, C., J. R. and M. F. Menezes. 1970. Edad y crecimiento del ariaco, *Lutjanus synagris* (Linnaeus), en el nordeste del Brasil. Arquivos de Ciencias do Mar 10:65–68.

Cruz, R. 1978. Algunas consideraciones sobre la pesqueria de biajaiba (*Lutjanus synagris,* Linne 1758) en la plataforma suroccidental de Cuba. Revista Cubana de Investigaciones Pesqueras 3(3):51–82.

Goodwin, J. M. IV and A. G. Johnson. 1986. Age, growth, and mortality of blue runner, *Caranx crysos,* from the northern Gulf of Mexico. Northeast Gulf Sci. 8:107–114.

Knight, W. 1968. Asymptotic growth: an example of nonsense disguised as mathematics. J. Fish. Res. Board Can. 25:1303–1307.

Lea, E. 1910. On the methods used in herring investigations. Publications de Circonstance, Conseil Permanent International pour l'Exploration de la Mer. 53:7–25.

Manickchand-Dass, S. 1987. Reproduction, age and growth of the lane snapper, *Lutjanus synagris* (Linnaeus) in Trinidad, West Indies. Bull. Mar. Sci. 40:22–28.

Manooch, C. S. III and D. L. Mason. 1984. Age, growth, and mortality of lane snapper from southern Florida. Northeast Gulf Sci. 7:109–115.

Nelson, R. S. and C. S. Manooch III. 1982. Growth and mortality of red snappers in the west-central Atlantic Ocean and northern Gulf of Mexico. Trans. Am. Fish. Soc. 111:465–475.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. Journal du Conseil, Conseil International pour l'Exploration de la Mer 39:175–192.

Reshetnikov, Y. S. and R. M. Claro. 1976*a*. Cycles of biological processes in tropical fishes with reference to *Lutjanus synagris*. J. Ichthyol. 16:711–723.

——— and ———. 1976*b*. Time of formation of the annual ring in the Lutjanidae. Hydrobiol. J. 12(3):30–35.

Rubio, R., P. Salahange, and M. Betancourt. 1985. Relaciones de la edad con el largo, el peso y la fecundidad de la biajaiba (*Lutjanus synagris*) de la plataforma suroccidental de Cuba. Revista Cubana de Investigaciones Pesqueras 10(3–4):78–90.

SAS Institute, Inc. 1988. SAS guide for personal computers version 6.03 SAS Inst., Inc., Cary, N.C. 558 pp.

Shipp, R. L. 1991. Investigation of life history parameters of species of secondarily targeted reef fish and dolphin in the northern Gulf of Mexico. Marine fisheries initiative. Proc. 4th Annu. MARFIN Conf., San Antonio, Texas. pp. 80–85.

Torres, R. and E. Chavez. 1987. Evaluation and diagnosis of the lane snapper (*Lutjanus synagris* |L|) fishery in the state of Yucatan. Ciencias Marinas (Universidad Autonoma de Baja California). 13(1):7–29.

Vaughan, D. S. and P. Kanciruk. 1982. An empirical comparison of estimation procedures for von Bertalanffy growth equation. Journal du Conseil, Conseil International pour l'Exploration de la Mer 40:211–219.