Annual survival rates (S) and total instantaneous mortality coefficients (Z) were calculated for fully recruited snook by using the age distribution of harvested fish (Robson and Chapman, 1961). Natural mortality coefficients (M) were estimated utilizing Pauly's (1980) equation. Fishing mortality coefficients were obtained by subtracting natural mortality coefficients from total mortality coefficients. Conditional fishing and natural mortality rates and exploitation ratios were then calculated from these mortality coefficients (Ricker, 1975).

RESULTS

Three hundred and twenty five snook were collected from North Florida Bay and the inland waters of the park (Areas 1, 3, 4, and 5) (Fig. 1). No fish from South Florida Bay (Area 2) or the Ten Thousand Islands (Area 6) were sampled. Fish ranged in length from 284-940 mm (F.L.) and in weight from 0.7-11.6 kg. Two hundred ninety four snook were examined for age and growth information, 269 of which the sex was determined.

Length Frequency

The mean length of all fish was 643 $\pm$ 11 mm F.L. (Fig. 2). The mean length of females ($\bar{x}$ = 680 $\pm$ 25 mm, n = 71) was not significantly different from the mean length of males ($\bar{x}$ = 632 $\pm$ 14 mm, n = 222) (Fig. 3). Mean lengths and length distributions of males, females and combined sexes were not significantly different among areas of capture.

Length distributions of all fish (combined sexes and unsexed fish) differed significantly (x^2 = 22.739; $p < .01$) by season. Small fish (< 500 mm) occurred proportionately more often in winter (December, January and February) than in any other season. Mean fish length was smallest in winter and greatest in spring (March, April and May). There were no significant seasonal differences in length distributions of males or females when they were considered separately.

Verification of Aging Technique

Scales from 294 snook were analyzed for annular marks. Figure 4 shows a ctenoid scale from a 3-year-old male snook with annuli, circuli, radii, and focus labeled. Annular zones are distinguished primarily by complete circuli surrounded by discontinuous or broken circuli. The last few circuli laid down before the annulus are often incomplete in that they do not continue all the way around to the ctenii. Annular circuli are complete and cut across the ends of the incomplete circuli inside of them. New radii often originate in the immediate vicinity of annuli and provide especially useful clues to the location of annular marks in large scales of older fish.

The validity of aging snook by scale annuli was established by meeting all criteria listed in the methods section. Fish body length was regressed on total scale radius for each sex in each area of capture to determine if a relationship existed between fish growth and scale growth. Fish body length was significantly ($p < .001$) correlated with scale radius for each sex and area of capture. Two significantly ($.025 < p < .05$) different fish length-scale length relationships were determined by analysis of covariance: 1) males in north Florida Bay and Cape Sable (y intercept = 161.76) and; 2) females in north Florida Bay and Cape Sable together with males and females in Whitewater Bay and Shark River (y intercept = 241.41) (Fig. 5). The y intercept of each group was used as the correction factor "a" to back calculate lengths at age for that particular group.

To determine time of annulus formation, scale-margin increments were plotted by season for the dominant age class (IV) in the catch (Fig. 6). Most minimal scale-margin increments occurred in spring (March-May) and summer (June-August). The mean marginal increment was lowest in spring and rose steadily to reach a peak in winter (December-February), indicating that annulus formation occurs in spring.

A comparison of mean back-calculated lengths and mean observed lengths at capture for 294 scale-aged snook is shown in Figure 7 and Appendices I-III. Mean lengths at capture are similar to, but larger than, back-calculated lengths at each annulus because of growth since annulus formation.

The Petersen length-frequency method substantiated the age analysis of snook using scale annuli. Mean lengths at capture of scale-aged fish agreed with modal lengths determined by Cassie's (1954) method for length-frequency distributions of snook collected in 1976 (Table 1).

<u>Age Distribution</u>

The age distribution determined from scale annuli of snook in Everglades National Park consisted mainly of four- (32%) and five- (27%) year-old fish (Fig. 8). Recruitment to the fishery began at age two and was complete by age four for females and by age six for males. The number of fish caught dropped sharply after age six; only three eight-year-old fish were examined. No fish older than eight years were sampled. One-year-old fish were not sampled due to a legal size limit of 18 inches (457 mm F.L.).

The mean age for all fish was 4.4 ± 0.1 yrs. The mean age of females ($\bar{x} = 4.8 \pm 0.3$ yrs) was significantly older than the mean age of males ($\bar{x} = 4.3 \pm 0.2$ yrs). There were no differences in age distribution or mean age of snook among areas of capture.

<u>Sex Ratio</u>

The overall sex ratio favored males by 3/1. The ratio remained constant during the year. This ratio decreased significantly ($x^2 = 13.747$; $p < .01$) with age from favoring males (11/1) at age two to favoring females (2/1) at age eight (Table 2). The sex ratio varied significantly ($x^2 = 11.084$; $p < .01$) among areas of capture. Proportionately more females were taken from the Coot Bay-Whitewater Bay area (Area 4) than from other areas.

<u>Growth</u>

Back calculations based on scale annuli indicate that snook achieve their greatest growth (465 mm) in the first two years (Fig. 9). Thereafter, yearly growth of all fish (males, females, and combined sexes) ranged from 58-75 mm through age seven. The negative growth increment of males and the great increase in growth of females in the eighth year are probably artifacts of the small sample sizes of fish from which they were calculated.

Significant ($p < .025$) differences in calculated growth were found for snook from various areas. Fish taken from the Whitewater Bay-Coot Bay area were consistently largest and fish taken from the north Florida Bay and Cape Sable areas were consistently smallest at ages one through four (Fig. 10). Fish taken from north Florida Bay and Cape Sable grew significantly ($p < .025$) faster than fish taken from other areas at ages two and three. No differences in length at capture were found among areas. Differences in calculated growth existed between males and females at ages one through four (Fig. 11). Females were significantly ($p < .05$) longer than males at every age. No sexual differences in observed length at capture were found.

The relationship of G, the instantaneous growth coefficient, to the reciprocal of mean calculated length at age was significant ($.025 < p < .05$) and provided estimates of the von Bertalanffy parameters K, L_∞ and t_o according to Bayley's (1977) method (Fig. 12). Lengths predicted by the von Bertalanffy equations approximated calculated lengths closely (Fig. 13). The von Bertalanffy equations derived for park snook were:

males: $L_t = 987\ (1-e^{-.16(t + 1.95)})$

females: $L_t = 1173\ (1-e^{-.12(t + 2.72)})$

combined sexes: $L_t = 1615\ (1-e^{-.07(t + 2.68)})$

Growth parameters for combined sexes were different than for each sex considered separately because growth varied between the sexes. The maximum theoretical length (L_∞) provided by these equations, when converted to weight by our length-weight regression, approximates the size of the largest snook on record, a 23 Kg (50.5 lb) fish (Marshall, 1958).

Confidence intervals (95%) for K, $1/L_\infty$ and t_o are listed in Appendix IV. $1/L_\infty$ confidence intervals for all snook were wide because of the poor fit, and subsequent high variance of the length-weight regression to small (age 2) and large (age 8) fish. The high variance created wide confidence intervals around $1/L_\infty$, and thus L_∞. Confidence intervals around K and t_o were smaller.

Length-Weight Relationship

Length-weight relationships for Everglades National Park snook were determined from 303 fish ranging in size from 430-950 mm (Fig. 14). The most accurate predictions of weight based on length were obtained when using log 10 transformation (males $r = .95$, females $r = .95$ combined sexes $r = .93$). The length-weight relationship calculated for males was different than for females; the regression slopes differed but intercepts did not, indicating females grew significantly ($.01 < p < .02$) more in body weight at a given length than males.

There were no differences in the length-weight relationship of fish among areas of capture.

Food Habits

Twenty-one snook stomachs were examined for food items. All of these stomachs were found to be empty, therefore no information on food habits could be obtained.

Mortality

Annual mortality rates were calculated for fully recruited snook. Female snook were fully recruited by age four, male snook and combined sexes were fully recruited by age six.

Annual mortality rate of all fish was $A = 0.78 \pm .10$. Annual mortality rate of males ($0.86 \pm .12$) was higher than that of females ($0.46 \pm .09$). Conditional natural mortality of males ($n = 0.32$) was higher than for females ($n = 0.25$).

Conditional fishing mortality was twice as high as conditional natural mortality for males but equal to conditional natural mortality for females. Exploitation ratios were also higher for males ($E = 0.81$) than for females ($E = 0.53$) (Table 3).

DISCUSSION

This study represents the first investigation of adult snook age and growth since Volpe's study in 1959, and only the second reported in the literature. The lack of biological information on snook is surprising considering its popularity among sport fishermen and drastic decline in catch in park waters (National Park Service Fishery Assessment, 1979). As a result of this study, age and growth information essential for sound management of snook can now be obtained without having to kill the fish to obtain otoliths.

Calculated lengths determined for snook in the park were similar at ages four through eight to lengths reported for the southwest Florida snook population aged by otoliths (Volpe, 1959) (Fig. 15). At ages one through three, lengths of park snook were greater than in Volpe's study because of the back calculation formula used. Volpe back calculated snook lengths directly, without a correction factor, according to the formula:

$$L_n = \frac{Sn}{St} Lt$$

where:

L_n = length at age; L_t = length at capture; S_n = scale radius to annulus n; S_t = total scale radius.

The correction factor used in the present study elevated the fish lengths at ages one through three. A larger sample size of small snook would have probably decreased the correction factor, making our estimated lengths of snook at ages one through three smaller. When lengths of park snook were calculated using Volpe's