Reproductive Cycle and Maturation Size of Silk Snapper (*Lutjanus vivanus*)

By

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Abstract

Gonads and otoliths were collected from a total of 300 silk snapper sampled from January 8, 2005 to December 30, 2005 to determine the size of 50% maturation, reproductive season and age and growth. Samples were collected from deep water fishers from Rincón. The catch method was buoying a main line with several hooks tied up to a buoy and left to drift with the current. In any given fishing trip up to three buoys are set to drift at determined fishing ground simultaneously for an hour.

Of the total individuals sampled a total of 235 histological cuts were prepared, of which 108 (46.0%) were males and 127 were females (54.0%). The obtained males to females ratio was 1M:1.18F, roughly one to one. Males sizes ranged from 211 to 515 mm fork length. Mean size of males was 321.30 mm ± 60.54. Sampled females sizes ranged from 224 to 603 mm of fork length. The obtained mean size of females was 333.43 mm ± 73.19. Of total sampled females 78.0% were mature, meanwhile 61.1% of males were mature. From the gonadosomatic index (GSI) of females shown in Figure 8 it can be seen that silk snapper reproduce in all sampled months with a peak during November to December. It was not possible to plot the age growth curve for sampled silk snappers. Results for the number of otoliths ring versus fork length yielded a non-linear relationship.

Acknowledgements

We wish to express our sincere gratitude to all who, in one way or another, contributed to the project and to the completion of the report.

Special thanks are due to Mr. Eugenio Piñeiro, Guelo for their dedication to their work, as fisher and their interest in the conservation of those resources. To Ms. Janneth Rojas for her patience with us and all the processing of all samples, without her this study would not have been finished in time. Also to Mr. Miguel Figuerola, Wilfredo Torres and Noemi Peña that provided help and guidance to Ms. Rojas and prepare all the figures of this report. And last but not least to Mr. Miguel Rolón and the Caribbean Fishery Management Council for providing the funding to undertake this study.

All mistake and misinterpretation of the results are my own.

Table of Content

Introduction

The Lutjanidae family, commonly known as snappers has a circumtropical and subtropical distribution. The family comprises 17 genera and approximately 185 species; eleven of these are represented in the Western Atlantic (Rivas, 1970). Most of these species are substrate oriented, are carnivores and are found at depths that range from shallow water to depths of the magnitude of 340 fathoms (640 m's or 2,100 feet) (Anderson, 1967). Snappers are a group of high commercial importance along their wide distribution.

Deepwater snappers constitute the most important commercial species of finfish in Puerto Rico fisheries. Among the deep water snapper complex the silk snapper and the blackfin snappers (*Lutjanus vivanus* and *L. buccanella*) represented the most important species in the commercial landings until the 1990's. Commercial landings collected by the Fisheries Research Laboratory (FRL) showed that 8.1% of total catch was comprised mostly by these two species. Of these two species the silk snapper was the most seek snapper. Over the last five years data collected at the FRL have shown an increase reporting of the queens' snapper (*Etelis oculatus*), while silk snappers' landings decreased. Matos (2002) reported that deep water snappers comprised 9% (mainly *L. vivanus* and *Etelis oculatus*) of total landed finfishes. Although the exact composition of the landed deep water snappers is not known, the fact that there is a change in the two main species comprising this fish group is a signal of problems with this fishery. Besides a change in the species composition of the group, there is also a change in the fishing method involved and the depths targeted. These two factors are indication of over exploitation of the deep water snapper's group.

It's important to remark that the deep water snapper group usually consisted of the following species: the silk snapper (*L. vivanus*), blackfin snapper (*L. bucannella*), vermillion snapper (*Rhomboplites aurorubens*), queen snapper (*E. oculatus*), and wenchman (*Pristipomoides macrophthalmus*) (Erdman, 1983). Another species that is usually caught but seldom reported is the black snapper (*Apsilus dentatus*). The percentage of any of this species to the fisheries depends on the depth at which are caught since there is an apparent stratification by depth. Another factor that influenced the composition is the gear used. The traditional deep water snapper group landed in Puerto Rico until mid 1990's was composed mainly of the silk and blackfin snappers, mainly caught with fish traps and those captured with hook and line involved snappers' reels. Vermillion snappers were also part of this group. This fishery was mainly at depths that ranged from 40 fm. to 175 fm. (80 m to 350 m) (Boardman and Weiler, 1979b; Silvester *et al*., 1980). These species caught at 40 fm. (80 m) are usually juveniles. The present deep water snappers are mainly composed of the queens' snapper and the wenchman that are caught mainly 100 fm. to 200 fm. (200 m to 400 m) depths. The blackfin snapper are also caught at these depths toward shallower depths and might overlap with the silk snapper. Allen (1985) reported the depth ranges for these species to be 100 m to 450 m. The most common used gear to catch these species is hook and line, either with snapper's reels or buoying.

Regardless of the importance of this resource there is very little knowledge of the reproductive biology of the deep water snappers. This fact is alarming considering the decreasing trend on some of these species in our landings. There are a few studies done on the reproduction of the silk snapper, blackfin snapper and vermillion snapper in Puerto Rico. Since late 1970's Boardman and Weiler, (1979b) reported that 90% of the silk snapper landed in Puerto Rico are juvenile. Matos (2000) reported that 97% of landed silk snapper during 1994-97 were under the minimum maturity size of 410 mm FL reported by Figuerola (1991).

On the other hand, of the deeper species such as the queen and black snapper and the wenchman there is very few data or knowledge from Puerto Rico since their importance in our fisheries is very recent, due to the decreasing population of the silk snapper.

The distribution of all the species mentioned before in the western Atlantic is from North Carolina Gulf of Mexico southward through the Caribbean to Brazil, particularly abundant in the Bahamas and the Antilles. Their vertical distribution varies according to the geographical area (Grimes *et al*., 1977).

It's important to understand the life history of these species in order to determine the best management strategy for these species. All the mentioned species are included in the Caribbean Fishery Management Council's (CFMC) Reef Fish Management Plan and lack stock assessment data. In November 2005 the CFMC implemented the Sustainable Fisheries Act which amends all FMP's in place. Among the approved management measures it was established a close season from October 1 to December 31 every year to protect the silk snapper population. The present study was undertaken to provide information on the reproductive cycle of this species, which is much needed to evaluate the status of the species.

Objective:

This study was undertaken to describe, through the use of histology, the annual reproductive cycle and minimum size and age of sexual maturation of the silk snapper. The other aim of this project to determine the age and growth of this species.

Approach:

The methodology used consisted in collect 25 samples per month of gonads and otoliths covering a wide size range for a period of 12 months. Samples were collected from deep water fishers from Rincón. The catch method was buoying a main line with several hooks tied up to a buoy and left to drift with the current. In any given fishing trip up to three buoys are set to drift at determined fishing ground simultaneously for an hour. Every line consists of a buoy, monofilament (200 to a 300-lb. test); weight (10 to 15 lbs.), with forty hooks (size 10 to 12 tuna hooks) baited with squid and/or little tunny. For each individual size, weight, date, gear used and location of capture were recorded. Upon collection gonads were weighed, fixed in Davidson's fixative (Yevixch and Barszcz, 1981), embedded in Paraplast, sectioned at eight µ and stained with hematoxylin and eosin. Gonads are classified according to their maturity stage (Table 1). Analysis and classification of gonads histology maturation will follow Sadovy *et al*.,(1994); Moe (1969) and Hunter and Macewicz (1985). The annual reproductive cycle is described by the percentage of each maturity class/month and the average gonadosomatic index (GSI=100[ovary weight + somatic weight]) plotted against month of collection. To determine size of maturity (defined as the smallest size class in which 50% of the individuals are sexually mature) a maturity curve is developed. GSI was calculated using the relationship described by de Vlaming et al (1982) GSI = GW x 100/FW – GW,

where GW = gonad weight (g), and
FW = fish weight (g)

To determine the smallest size class in which 50% of individuals were sexually mature (size-at-maturity), a maturity curve of the percent of fish of maturity classes ≥ 2 was developed.

Otoliths were measured, weighed, mounted with silicone glue, sectioned to .5 mm or 500µ and read. Generally, the left sagitta is used for age determination. If the left otolith is lost or broken, the right otolith is sectioned. For sectioning, otoliths were mounted on a small card with glue, using a hot glue gun, and sectioned through the core with a 7.2 cm diameter low concentration diamond blade on a Buehler Isomet low speed saw. From each otolith, three sections of 0.5 mm were mounted on glass slides using Protocol mounting medium. Sections are read under a dissecting microscope (10-70X) with transmitted light. Only sexed fish were used for age determination. Terminology follows that of Wilson et al (1983).

Otoliths were sectioned and opaque bands counted by two readers under transmitted light. Marginal increment analysis will be performed to determine if opaque zones are annual and when they are formed. Growth curves will be fitted to the length-at-age data by using the von Bertalanffy growth model: $L_t = L_\infty(1-e^{-K[t-t0]})$, where L_t = the expected length at age t years; L_∞ = the asymptotic maximum length; K = the von Bertalanffy growth constant; and t_0 = the theoretical age at zero length.

Results

Gonads and otoliths were collected from a total of 300 silk snapper were sampled from January 8, 2005 to December 30, 2005. Although a total of 300 silk snappers were provided, samples could not be collected due to the bad conditions of the individuals. Table 2 summarizes by month the number of samples recorded and processed. During January 2005 only one size measurement was recorded, fork length. From February till the end of the study two size measurements were recorded. All gonads were embedded, sectioned and mounted in slides. Gonad reading was started by two independent readers. Otoliths were processed and mounted, and read was done by two independent researchers.

Table 3 shows descriptive statistics of total sampled individuals. The mean fork length of total collected silk snappers was 325.86 mm ± 66.53. Meanwhile mean total length was 355.43 mm ± 76.02 and mean weight of 640.18 g ± 468.49. Of the total individuals sampled a total of 235 histological cuts were prepared, of which 108 (46.0%) and 127 were females (54.0%). The obtained males to females ratio was 1M:1.18F, roughly one to one. Figure 1 shows the obtained size frequency distribution for total sampled silk snappers.

Modal class for the fork length was 310 mm for both sexes. Figure 2 displays obtained size frequency by sex of sampled silk snappers. Males sizes ranged from 211 to 515 mm fork length. Mean size of males was 321.30 mm ± 60.54. Sampled females sizes ranged from 224 to 603 mm of fork length. The obtained mean size of females was 333.43 mm ± 73.19 (Table 4). The observed difference between the size frequency distribution of males and females yielded a statistically significant results (Kolmogorov-Smirnov, $d \ll D_{.05}$, $0.023 \ll 0.052$) (Sokal and Rohlf, 1981). Length-weight frequency relationship for both sexes is shown in Figure 3.

Sexual Maturation Size

The observed minimum size of sexual maturation for females corresponded to 239 mm and 231 mm FL for males. Of total sampled females 78.0% were mature, meanwhile 61.1% of males were mature. Figures 4 and 5 display the obtained percent maturation size for females and males, respectively. The 50% maturation size for females exhibit a relatively ample distribution that goes from 250 to 290 mm class size. This posed a degree of uncertainty in point out an accurate 50% size of maturation. For males the size class that have the 50% mature individuals corresponds to 300 mm, 50% size is 302 mm. All females were mature at 390 mm FL size class and males at 350 mm FL.

A total of 767 silk snapper were sampled by port agents around PR during 2005 thru the biostatistical project. Figure 6 shows the obtained size frequency distribution of this sample. Due to constraints in the sampling these individuals were only measured, there is little information on weight and no sex data. The minimum size reported was 129 mm FL and a maximum of 740 mm with a mean size of 344.79 mm ± 92.95. The modal class of this distribution is 330 mm size class (Table 5).

The distribution of the percent sexual stages by months for females is shown in Figure 7. It can be observed that ripe individuals were caught in all sampled months (F2 to F5 stages). From the gonadosomatic index (GSI) of females shown in Figure 8 it can be seen that silk snapper reproduce in all sampled month with a peak during November to December. With a decrease in reproductive activity from May to August.

Age and Growth

Of the 300 sampled silk snapper 95 otoliths were prepared for examination. Opaque and translucent zones were detectable in most otoliths sections. When zones lacked sufficient definition for focus-to-opaque zone measurements, the otoliths were not use for age determination. Otolith radius does not showed a linear relationship with FL (N = 95; r = 0.27) (Figure 9).

It was not possible to plot the age growth curve for sampled silk snappers. In Figure 10 it can be observed the variation in size of otoliths versus the fork length.

Discussion

The size frequency distribution found in this study of silk snapper is similar to that reported by Boardman and Weiler (1979b) and Figuerola (1991). The major difference in this study is the low number of smaller individuals. The lowest recorded individual was 211 mm FL. Figuerola (1991) mentioned a scarcity in the number of individuals over the 360-390 mm size class was the difference between his study and Boardman and Weiler. This study also have a scarcity of individuals over the 390 mm size class, therefore we can concluded as Figuerola that the obtained tendency is representative of the commercial fisheries. The biggest size reported was 603 mm and 3,746 g, was below the biggest one reported by Figuerola in 1991 and well below to the size reported for the area that can reach around 25 lbs. The biggest sampled individual by the port agents was 740 mm.

It was noted a tendency of females to be of higher size than males. A similar result was obtained by Figuerola (1991). He cautioned that this might be due to difficulty in obtaining enough individuals for the bigger size classes. In his work there was no statistically significant results between the size distribution of males and females, unlike the present study. This might suggest a real tendency of females be bigger than males.

Boardman and Weiler (1979b) reported that female silk snappers mature at 500 mm FL and males at 380 mm. More recently Figuerola (1991) reported that the 50% size of sexual maturity for females snapper was 410 mm of FL and 265 mm FL for males. In this study the 50% of sexual maturity for females was very difficult to determine and the smaller size class at which 50% of the sample was 250 mm, while for males it was 300 mm. The percentage of immature females was 21.2% and 10.1% immature males for the present study. If we were to fit the distribution of the sampled silk snapper by port agents with the obtained the sexual maturation data from this study assuming that those corresponding to 290 mm size class and lower were all females it will yield 31% of immature individuals. Likewise assuming that those corresponding to the 310 mm size class were all males it will yielded 40.5% of immature sampled individual. This is a great difference to those reported by Figuerola (1991) were 45% of total males and 75% of sampled females were immature. If this a reflection of the actual fisheries it will showed an improvement of the population. A tendency to capture bigger and mature individuals will definitively will help the silk snapper population. But smaller size at maturity of females suggests an increase in fishing pressure, so females are maturing at smaller sizes (Zhao and Mc Govern, 1997).

On the other hand by the time that both this study and the port agents sampling the Puerto Rico Fishing Regulations were being enforced and it was illegal to capture and landed individual below the minimum size of 305 mm. Of the total sampled individuals 41.0% were under the legal size. This was necessary in order to have representation of immature individuals. Of those sampled by port agents 35.6% were under the minimum legal size. Therefore a word of caution in interpreting these results. The tendency to capture bigger individuals might be a reflection of a degree of compliance with the fishing regulations. Nonetheless, we still are seeing a great deal of immature individuals in our fisheries.

If the size of sexual maturation is related to the exploited populations (Garrat, 1985) is evident that *L. vivanus* is being exploited by the fisheries before reaching the sexual maturity to some extent we have recruitment overfishing.

Regarding the obtained size of maturation of females it shows a decline in size between that reported by Figuerola (1991) and the one obtained in this study. On the other hand males showed an increase in size. This might be a little confusing at to where the population is moving. But there is no doubt that the obtained results are a far cry to those reported by Boardman and Weiler.

The reported spawning season for silk snappers have been reported to be year round in Puerto Rico and Jamaica (Erdman, 1976; Boardman and Weiler, 1979b; Munro, *et al*, 1973). The obtained results are consistent with those reported. Although they reproduce year round there are an isolated peak in March (GSI = 50.5%) and another definite peak in reproduction in November-December (GSI > 60%). The proposed management measure of a close season during October-December will protect the population when a large percentage of the individuals might be reproducing.

The obtained results in this study for the age and growth are consistent with unpublished data for *L. vivanus* collected by Boardman and Weiler, 1979a, Collazo, 1982. Although these researchers were able to identify rings, they were not able to fit a growth curve. A most discouraging result those and this, but it's clear that traditional methods of using otoliths is not the way to calculate the age and growth of this species.

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Tables

Table 1. Microscopic description of sexual maturation of male and females gonads.	
Stage of Maturation	Microscopic description
Ovaries	
F1 (Inmature)	Early stages of oogenesis predominate (oocytes in stages 1 and 2) Stage 3 oocytes absent or very few. Compact gonad. Thin muscular tunica. No evidence of previous spawning (thick tunica, ovary with empty areas, post ovulatory follicles and atretic bodies present.
F2 (Inactive mature)	Oocytes in stages 1, 2 and 3 present, but stages 3 do not predominate. Oocytes in stage 4 absent or very few. Thin tunica, except in spent individuals.
F3 (Active mature)	Oocytes in stages 2, 3, 4 present. Advanced stages of 4 oocytes absent. Thin tunica, except in spent individuals.
F4 (Ripe)	Oocytes in stages 2, 3, 4 and rarely 5 present. Advanced stages predominate. Thin tunica, except in spent individuals.
F5 (Spent)	Post-ovulatory follicles and atretic bodies present. Thick tunica. Ovary with empty areas.
Testes	
M1 (Inmature)	Early stages of spermatogenesis, gonad small and compact with gonia and seminiferous tubules.
M2 (Mature)	All stages of spermatogenesis present, or later stages dominate. Post-spawning testes are disorganized with empty lumina.

Table 2. Catch summary by month of sampled silk snapper, *Lutjanus vivanus* in 2005.

Month	Samples collected
January	24
February	12
March	40
April	25
May	25
June	25
July	25
August	25
September	25
October	25
November	25
December	25

Table 3. Descriptive statistics of total sampled silk snapper during January to December 2005.

Fork length (mm)	***Total***	***Weight (g)***	***Total***
Mean	325.86	Mean	633.48
Standard Error	4.16	Standard Error	28.71
Median	312	Median	497
Mode	320	Mode	189
Standard Deviation	66.53	Standard Deviation	459.37
Variance	4,426.68	Variance	211,018.20
Kurtosis	1.14	Kurtosis	10.09
Skewness	0.98	Skewness	2.48
Range	392	Range	3,618
Minimum	211	Minimum	0
Maximum	603	Maximum	3,746
Sum	83,420	Sum	162,172
Count	256	Count	256
Confidence Level(0.95)	8.15	Confidence Level(0.95)	56.27

Table 4. Descriptive statistics of sampled silk snapper by sex during January to December 2005.

Fork length (mm)	***Males***	***Females***	***Weight (g)***	***Males***	***Females***
Mean	321.30	333.43	Mean	602.45	684.41
Standard Error	5.83	6.49	Standard Error	35.34	48.11
Median	311	315	Median	496	499.5
Mode	305	295	Mode	285	302
Standard Deviation	60.54	73.19	Standard Deviation	367.22	542.18
Variance	3,664.83	5,357.14	Variance	134,852.72	293,958.93
Kurtosis	0.46	1.00	Kurtosis	2.81	8.97
Skewness	0.78	0.97	Skewness	1.62	2.43
Range	403	379	Range	1,849	3,618
Minimum	211	224	Minimum	148	0
Maximum	515	603	Maximum	1,997	3,746
Sum	34,700	42,346	Sum	65,065	86,920
Count	108	127	Count	108	127
Confidence Level(0.95)	11.42	12.73	Confidence Level(0.95)	69.26	94.30

Table 5. Descriptive statistics of sampled silk snapper by port samplers during January to December 2005).

Fork Length (mm)	
Mean	344.79
Standard Error	0.09
Median	330
Mode	310
Standard Deviation	92.55
Variance	8,564.70
Kurtosis	1.10
Skewness	0.79
Range	611
Minimum	129
Maximum	740
Sum	264,451.00
Count	767
Confidence Level(0.95)	6.55

Figures

Figure 1.Size frequency distribution of sampled silk snapper from January 2005 to December 2005.

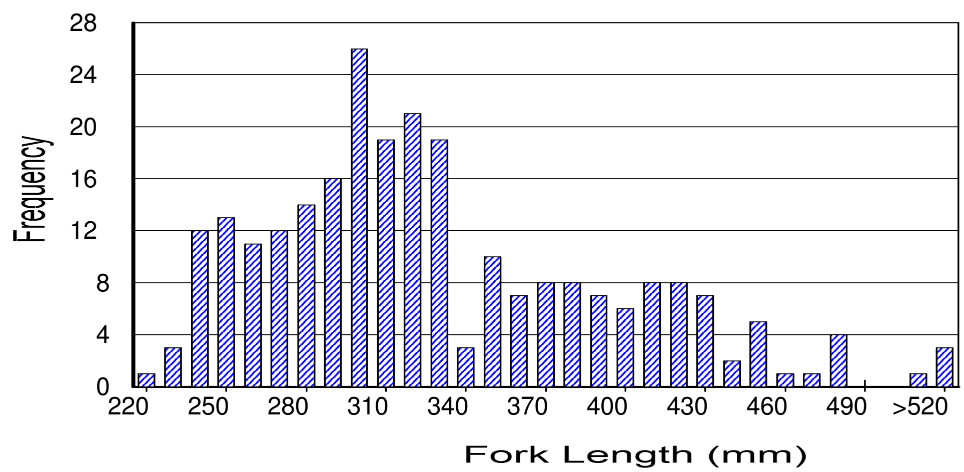


Figure 2. Size frequency distribution by sex of sampled silk snapper.

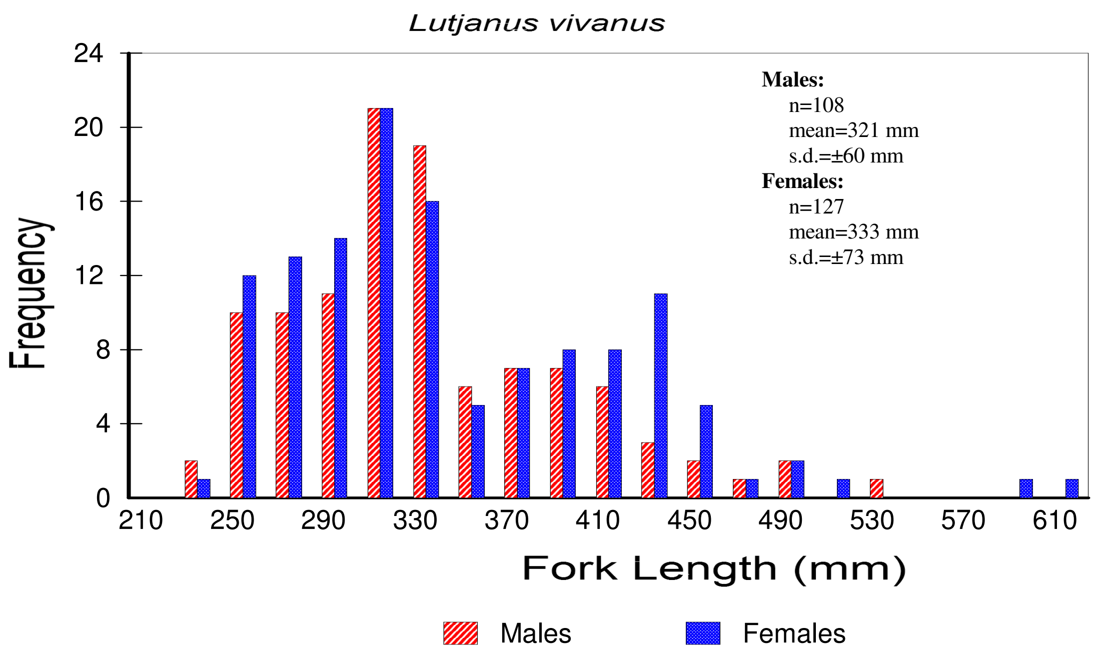


Figure 3. Length-weight relationship of sampled silkd snapper. Log W = -4.44 + 2.86 Log FL (N = 233; r = 0.96).

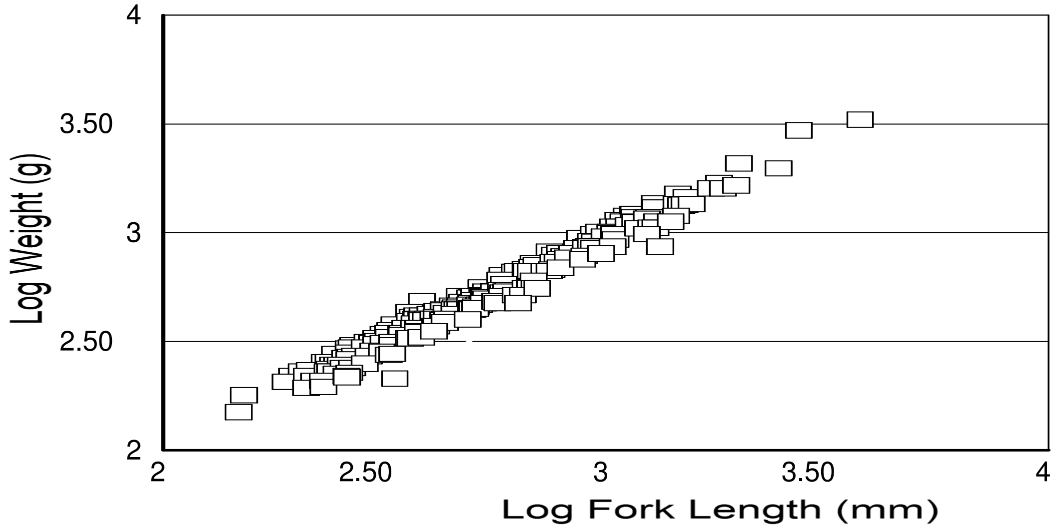


Figure 4. Percent of mature females silk snappers.

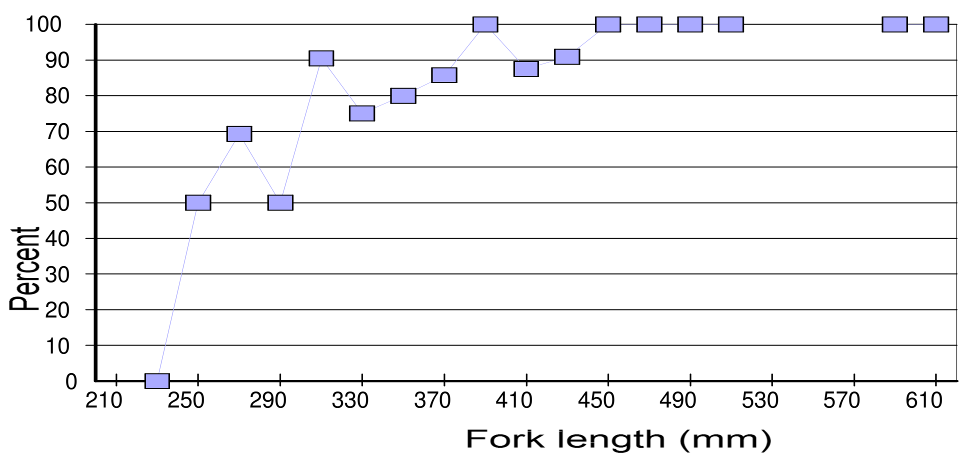


Figure 5. Percent of sampled mature males.

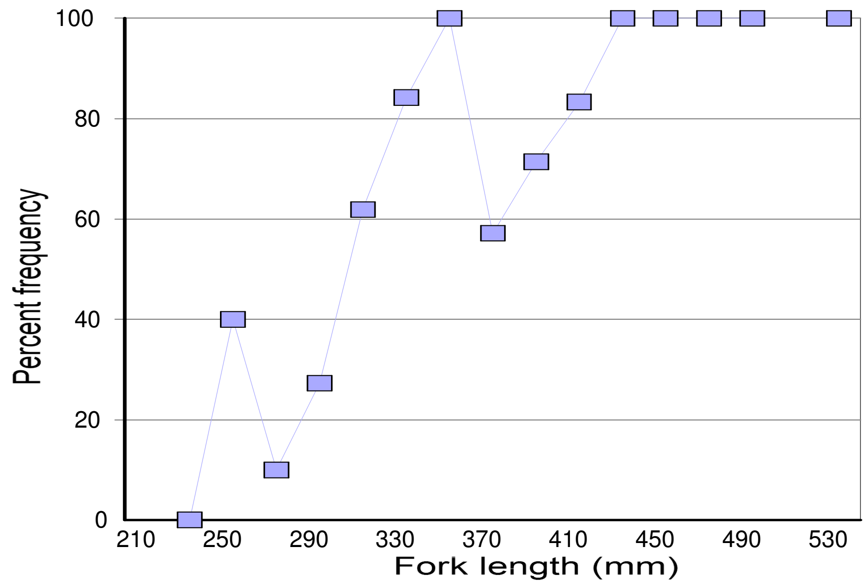


Figure 6. Size frequency distribution of sampled silk snapper by port samplers during January to December 2005 around Puerto Rico.

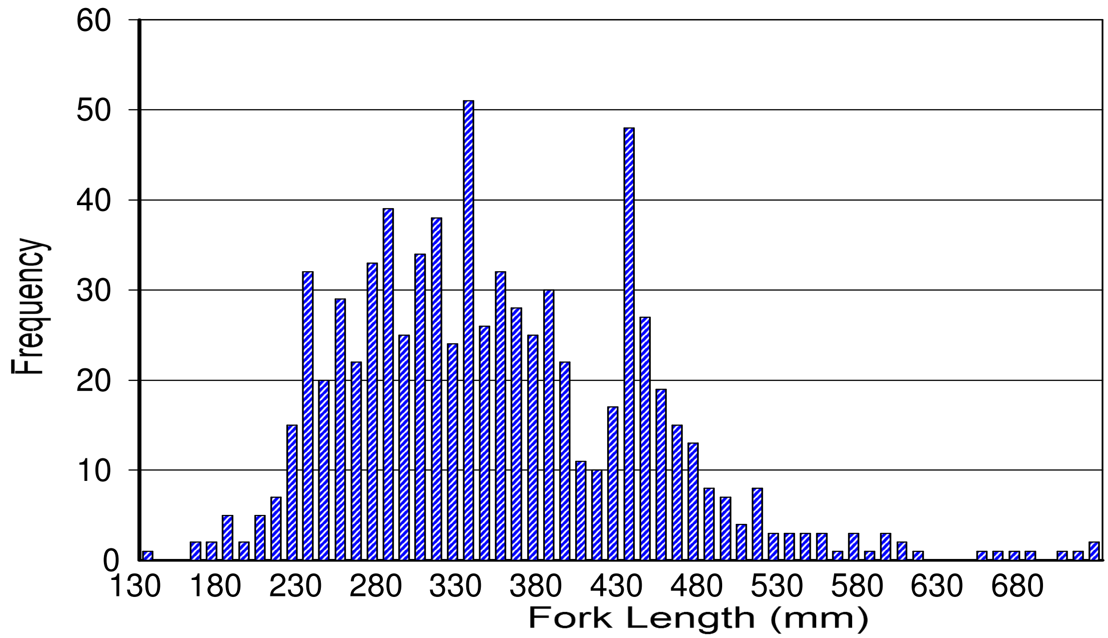


Figure 7. Percent sexual stage by months.

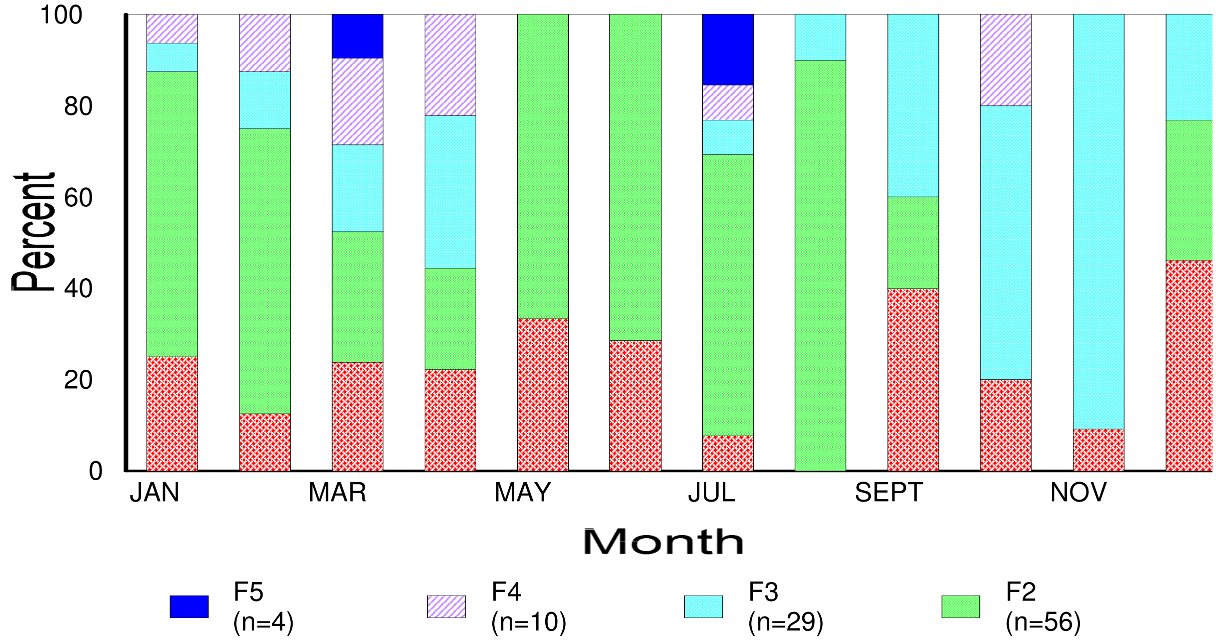


Figure 8. Calculated gonadosomatic index by months.

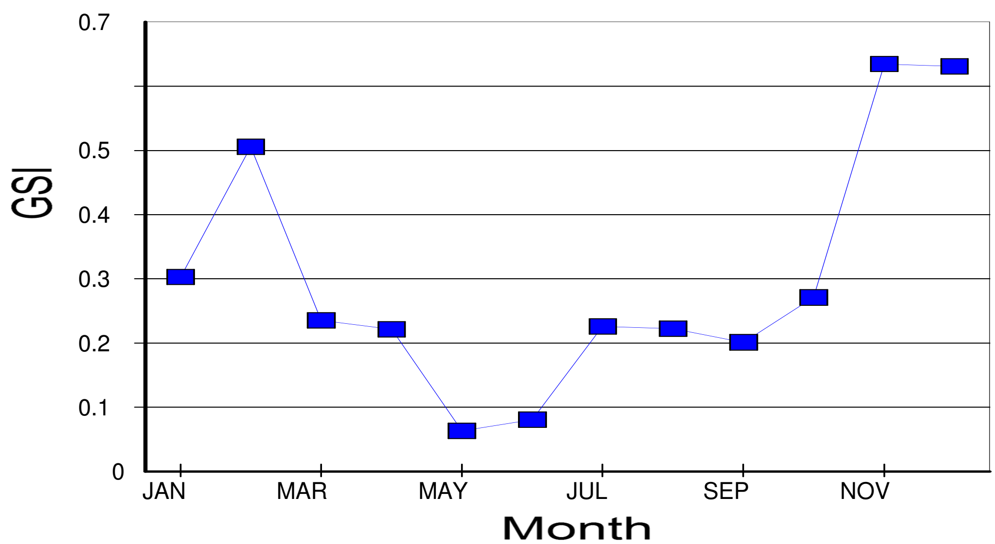


Figure 9. Size of otolith vs fork length (mm).

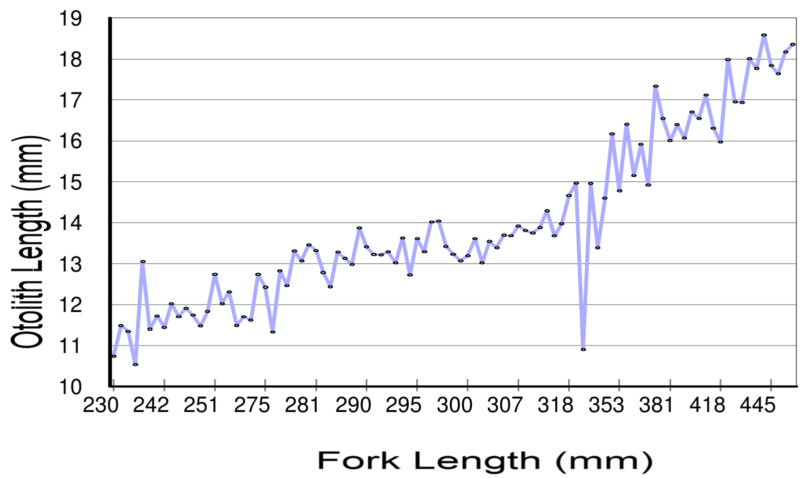
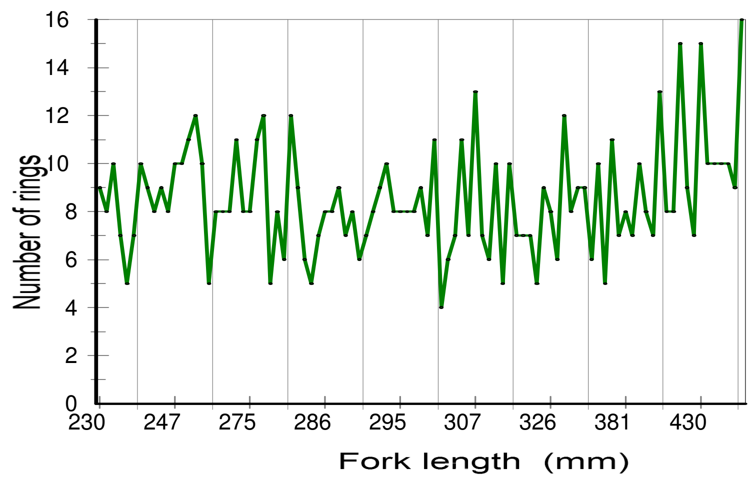
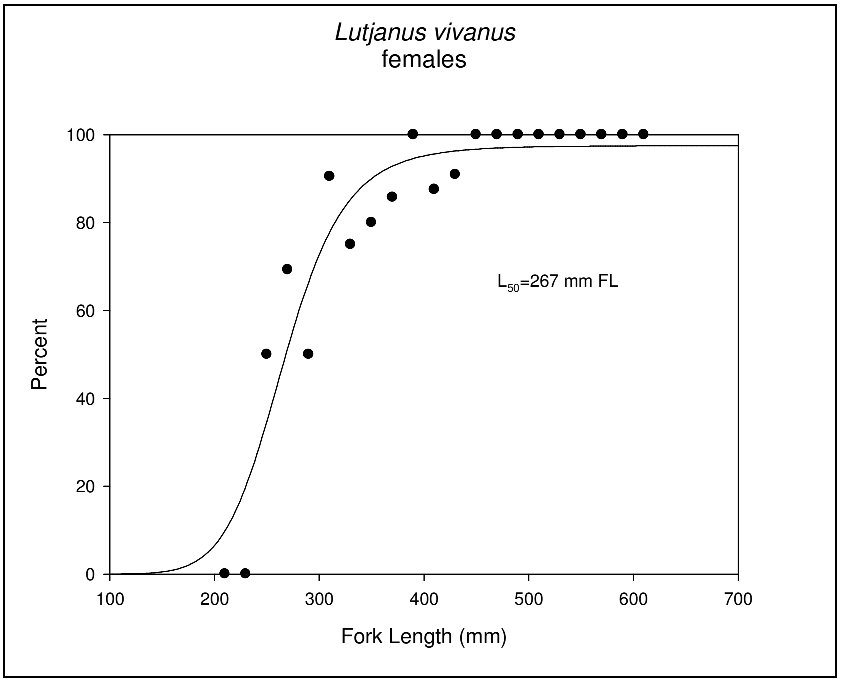


Figure 10. Relationship between the number of rings in otolith with size.
(N = 93; r = 0.26).



Maturation curve of sample females silk snappers.



Maturation curve of sample males silk snappers.