Reproductive parameters for the Gulf of Mexico gray snapper, *Lutjanus griseus,* 1991-2015

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Data:

- This document was prepared as a contribution to SEDAR 51 and summarizes reproductive data collected at the Panama City Laboratory from gray snapper sampled from research surveys or harvested in the Gulf of Mexico between 1991-2015.
- Linear regressions and logistic functions (Logit model fit to binary data) were fit in EXCEL using XLSTAT software.

Results:

- Macroscopic data characteristics by year and region: Macroscopic observations of sex were made from 6789 individuals collected during routine sampling for age composition. These observations were well distributed across years 1991-2015 ranging from 61 to 602 (low year/ high year; mean of 272 per year). However, these records were predominately based on samples from Florida Gulf waters (91%) versus other Gulf states.
- Sex ratio based upon collection mode ranged from 0.43 to 0.52 proportion females. Males slightly dominated (0.48 proportion females) when collections were combined (Table 1).
- Female histological data characteristics by year and region: 997 females were histologically assessed with subsets available for age, size, and seasonal based maturity assessments (below). These samples were primarily obtained (67%) between years 1994-1999 when port agents were actively obtaining gonads from cooperative fishers. Only 3% of these samples were from more recent years (2009 – 2015) obtained by observers and research survey biologists who are able to sample fish in the round. As with macroscopic observations, histological records are mostly from gray snapper sampled in Florida Gulf waters (97%).
- Reproductive seasonality was determined from female gonadosomatic indices and from female histological assessments by month (Figures 1 & 2). Reproductive development was evident in April with spawning beginning in May, peaking in July and lasting through September (estimate of 137 d; see also Table 4). There is no evidence for female skipped spawning. This is based upon seasonal synchrony in ovarian development as viewed by gonad weight (Figure 1) and by oocyte stage (Figure 2).
- Female maturity by age (A50) estimated at 2.3 years; 90 % mature at age 5.2 years (Figure 3, Table 2).
- Female maturity by size (L50) estimated at 253 mm FL (Figure 4, Table 2). However we found onset of maturity based on histology to occur over a broad range of size (10% at 144 mm FL, 90 % at 362 mm FL; Figure 4).
- Comparative maturity study: Domeier et al. 1996 studied aspects of gray snapper reproduction including maturity. They sampled gray snapper at two shallow inshore reefs

and two offshore reef sites near Key West, Florida. Female maturity was estimated to occur between 198 mm SL (minimum maturity for n< 80) and 240 mm SL (estimate of 100% maturity for both males and females n=80). These standard lengths convert to 239 – 288 mm FL using the regression in Table 2, which brackets our estimate of 50% female maturity at 253 mm FL.

- Comparison based on gonad weight: Gonad weight (expressed as gonadosomatic idex GSI), plotted by female length indicates that females less than 280 mm FL allocate little to reproduction (Figure 5). This suggests the maturity fit (50% maturity at 253 mm FL) based on histology may somewhat overestimate the reproductive contribution of females under 300 mm FL.
- Batch fecundity: A total of six samples were available for batch fecundity of gray snapper (Table 3). Average batch fecundity equaled 616 thousand ova (Table 3). Relative fecundity was estimated at 4546 ova per gram of female body weight (Table 3).
- Number of batches: Season duration is the fraction of a year wherein spawning markers are detected (day 134 to 271 = 137 d); approximately May to September. Expected number of batches equals the daily probability * season duration (0.26 * 137 d = 37) (Table 4).
- Spawning fraction by size: Larger females (e.g. ≥ 450 mm FL) tend to be captured bearing spawning markers in greater proportion than smaller females as reflected by spawning fraction (Table 5). This suggests that larger females are spawning more often with the caveat that sampled females were not distributed evenly by size or time throughout the spawning period. Computed by length, spawning fraction ranges from 0.25-0.75 (Table 5) compared to an overall seasonal average spawning fraction (all sizes) of 0.36 (Table 4). Generally higher values of spawning fraction observed in Table 5 are due to the fact that most females were captured near the peak of the spawning period (Table 4). A full model of egg production, if undertaken, would need to statistically account for female size and time captured.

Table 1. Macroscopic sex ratio. Number of gray snappers sexed macroscopically in the field or in the laboratory as male (M) or female (F) by sampling mode. These results are based on observations obtained during collection of hard parts for aging.

Mode	Male	Female	Total	F proportion
Commercial	1212	1233	2445	0.50429
Charter Party	1034	771	1805	0.42715
Headboat	643	651	1294	0.50309
Private	406	450	856	0.52570
Scientific survey	106	80	186	0.43011
Tournament	83	82	165	0.49697
Unknown	20	18	38	0.47368
Total	3504	3285	6789	0.48387

Table 2. Equations for size conversion and maturity. Fork (FL) and standard length (SL) data pairs provided by Florida Fishery Independent Monitoring Program. Logistic maturity equations (M) are shown in Excel format by age and fork length. Corresponding maturity fits and data are shown in Figs 3 & 4.

Equation	N	Data Range	Mean (sd)
FL = 7.707+1.169*SL, R^2=0.997	2457	96-605 mm FL	265 mm FL (73)
M = 1 / (1 + exp(-(1. 767+0.756*Age))), AIC= 295	572	1-27 years	7 years (3.8)
M = 1 / (1 + exp(-(5.086+0.020*FL))), AIC = 347	719	180-689 mm FL	417 mm FL (90.4)

Table 3. Fecundity. After Hunter et al (1985) batch fecundity (BF) is the estimate of the spawning batch of fully hydrated oocytes within a female. Relative fecundity (RF) is the number of hydrated oocytes per gram of female body weight (less gonad weight).

	N	Data Range	Mean	SD	FL Range
BF	6	222642-1405892	615714.87	622910.16	335-655
RF	6	3667-5721	4546.12	664.4	335-655

Table 4. Expected number of batches. Numbers of females, all years, by 15 day time bins (see Figure 1), with spawning markers (hydrated oocytes and postovulatory follicles) either present or absent, spawning fraction (proportion of females with spawning markers) and daily probability of spawning (spawning fraction adjusted to 24 hours) estimated following Porch et al. 2015. Season duration is the fraction of a year wherein spawning markers are detected (day 134 to 271 = 137 d); approximately May through September. Expected number of batches equals the daily probability * season duration (0.26 * 137 d = 37).

Time bin (days of year)	Spawning markers absent	Spawning markers present	Total	Spawning fraction	Daily Probability of spawning
0-15	2		2		
15-30	2		2		
30-45	7		7		
45-60	5		5		
60-75	13		13		
75-90	21		21		
90-105	39		39		
105-120	42		42		
120-135	40	2	42	0.05	0.03
135-150	62	5	67	0.07	0.05
150-165	45	56	101	0.55	0.39
165-180	36	44	80	0.55	0.39
180-195	25	90	115	0.78	0.55
195-210	41	107	148	0.72	0.51
210-225	29	53	82	0.65	0.46
225-240	46	21	67	0.31	0.22
240-255	30	8	38	0.21	0.15
255-270	32	2	34	0.06	0.04
270-285	29	1	30	0.03	0.02
285-300	32		32		
300-315	11		11		
315-330	9		9		
330-345	2		2		
345-360	7		7		
Average across time bins with spawning markers present				0.36	0.26

Table 5. Spawning fraction by size. Numbers of females by size group with spawning markers (hydrated oocytes and postovulatory follicles) either present or absent, and spawning fraction (proportion of females with spawning markers) for the period wherein spawning markers were detected (Table 4: time bin 120-135 days to time bin 270-285 days).

Size bin (mm FL)	Spawning markers absent	Spawning markers present	Total	Spawning fraction
150-199	1		1	
200-249	3	1	4	0.25
250-299	32	20	52	0.38
300-349	81	48	129	0.37
350-399	84	74	158	0.47
400-449	89	73	162	0.45
450-499	49	68	117	0.58
500-549	35	51	86	0.59
550-599	18	26	44	0.59
600-649	10	12	22	0.55
650-699	1	3	4	0.75
Grand Total	403	376	779	

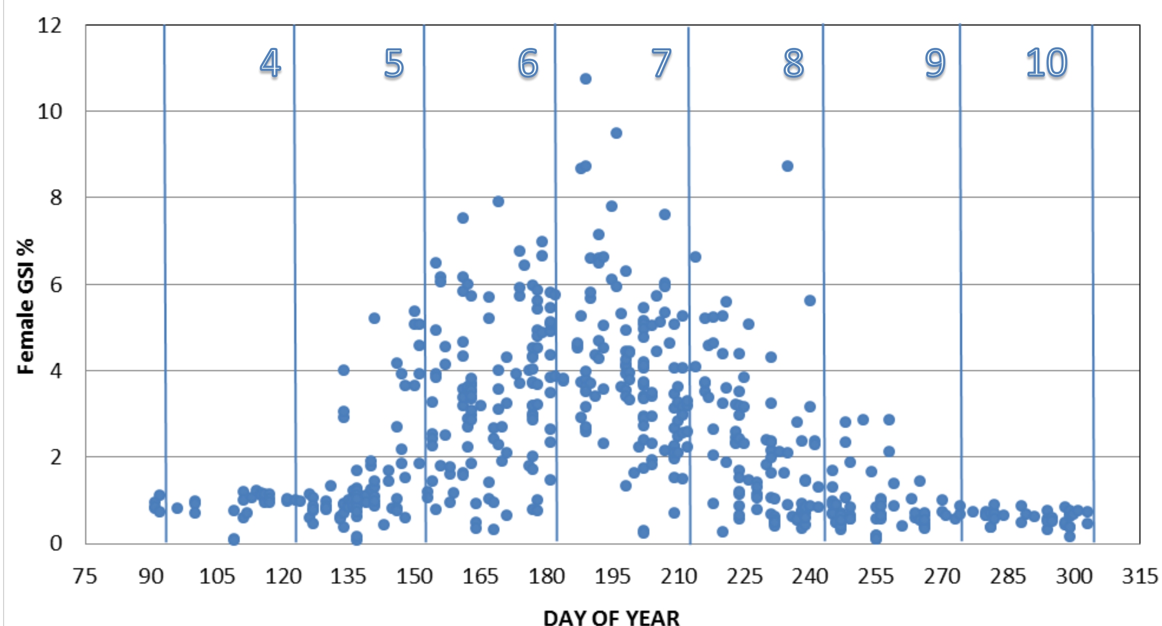

Figure 1. Female gonadosomatic index (GSI) by day of the year and numeric month (n=539). GSI is the percentage of gonad weight relative to body weight (total weight minus gonad weight). One outlier not shown (GSI = 27%).

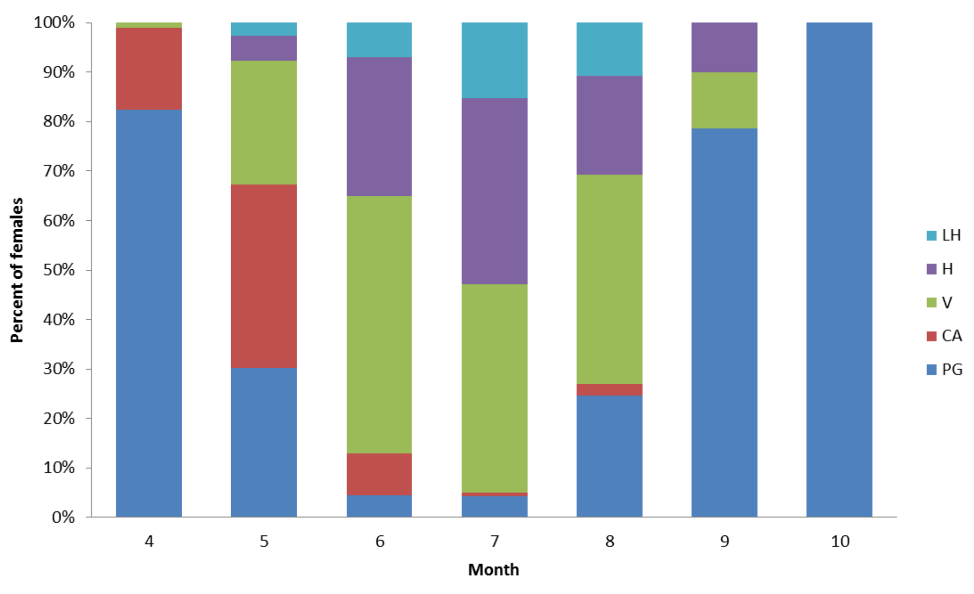

Figure 2. Percent of females observed histologically each month denoted by stage of oocyte development; primary growth (PG), cortical alveolus (CA), vitellogenic (V), oocyte maturation (hydration, H), and fully hydrated (late hydration, LH). Stages H and LH are indicators of spawning as ovulation is imminent (n=862).

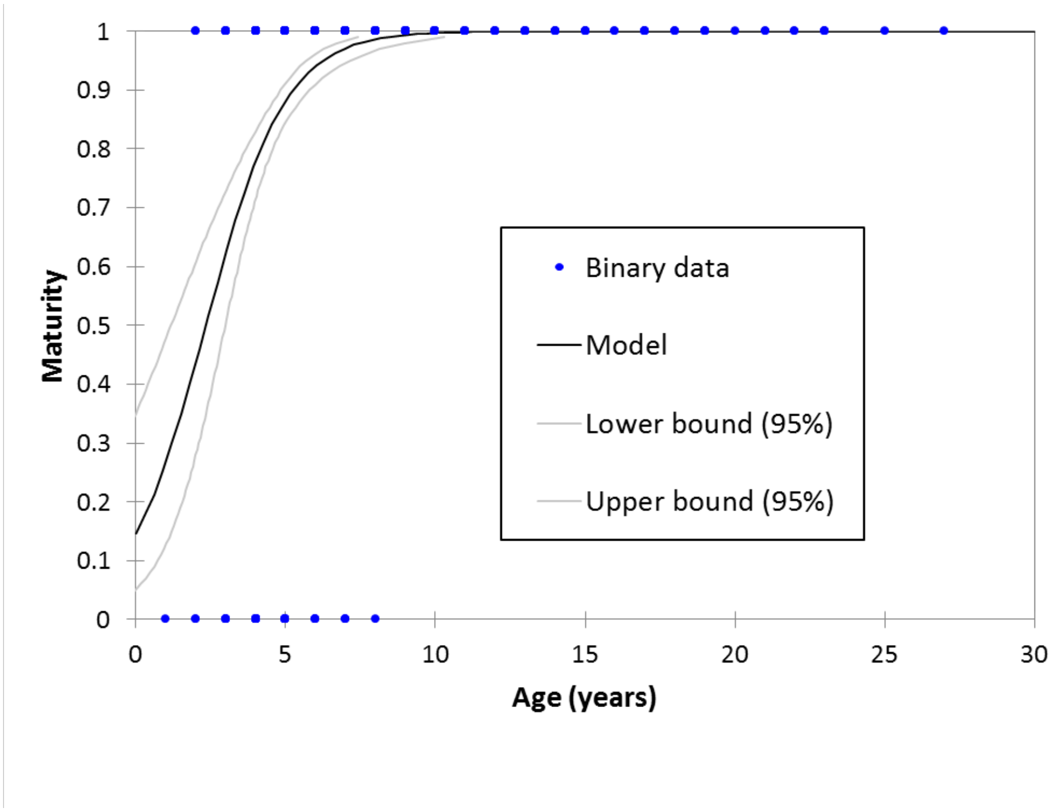

Figure 3. Logistic regression of female gray snapper maturity by age. The blue circles denote the binary data wherein an individual should be spawning (1) or not (0) during the reproductive season. The dark line is the predicted maturity, light lines are 95% confidence intervals. A total of 572 histology slides for female gray snapper captured during the months of April–October (spanning the reproductive season) and aged, were assessed for a maturity ogive. Females with cortical alveolar or more advanced oocytes and/or postovulatory follicles were denoted as mature. Females with primary growth oocytes and no indicators of prior spawning were categorized as immature. Females with primary growth oocytes as leading stage but displaying potential atretic yolked oocytes observed outside the lamella (potential contaminants from storage) are of uncertain maturity and maturity was not assigned

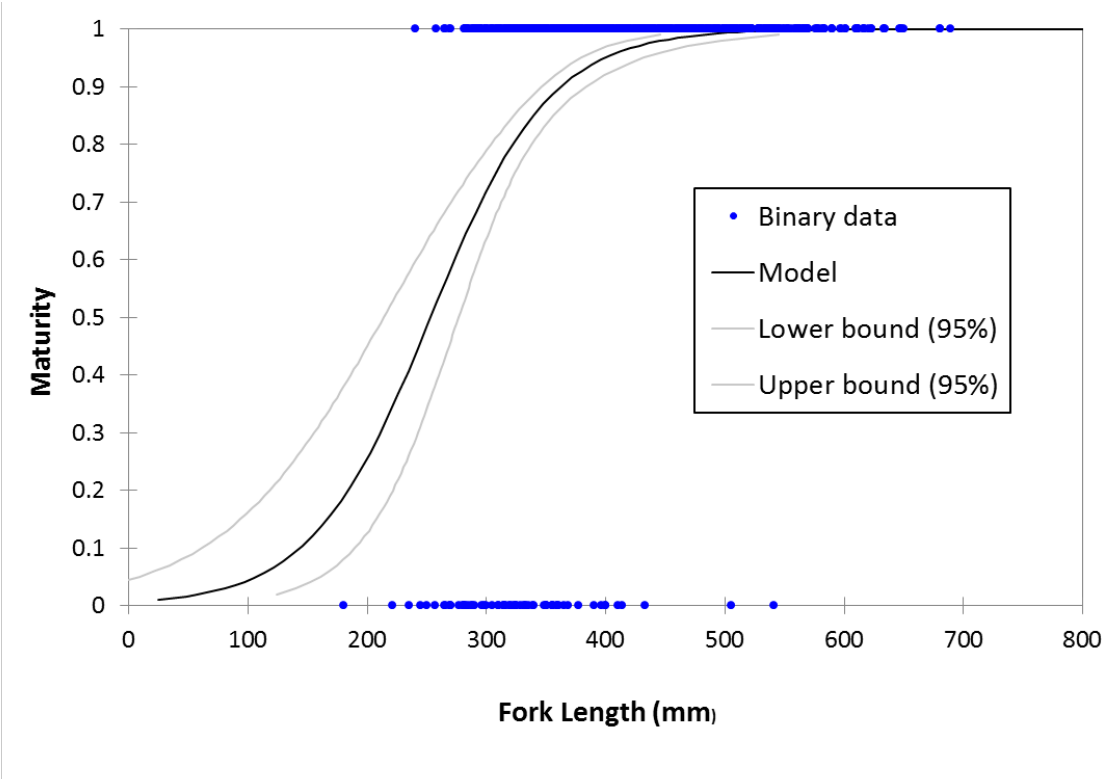

Figure 4. Logistic regression of female gray snapper maturity by fork length. The blue circles denote the binary data wherein an individual should be spawning (1) or not (0) during the reproductive season. The dark line is the predicted maturity, light lines are 95% confidence intervals. A total of 719 histology slides for female gray snapper captured during the months of April–October (spanning the reproductive season) with length recorded, were assessed for a maturity ogive. Females with cortical alveolar or more advanced oocytes and/or postovulatory follicles were denoted as mature. Females with primary growth oocytes and no indicators of prior spawning were categorized as immature. Females with primary growth oocytes as leading stage but displaying potential atretic yolked oocytes observed outside the lamella (potential contaminants from storage) are of uncertain maturity and maturity was not assigned.

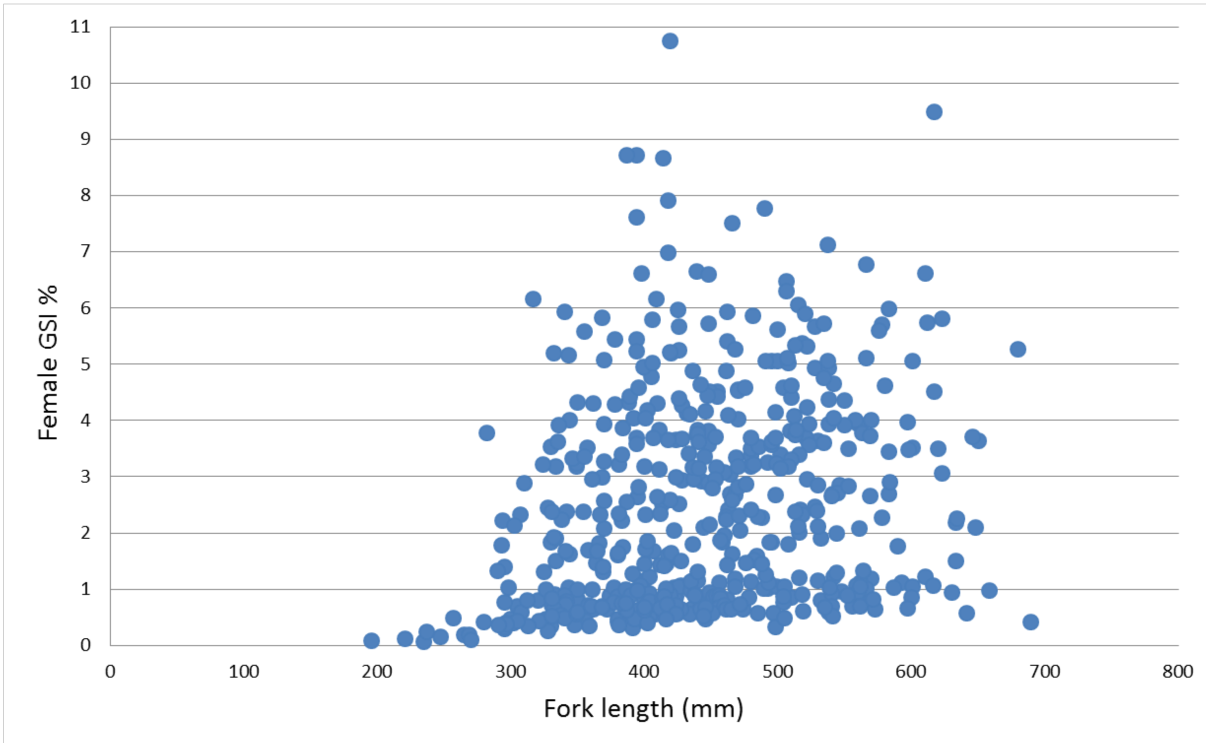

Figure 5. Female gonadosomatic index (GSI) by fork length. GSI is the percentage of gonad weight relative to body weight (total weight minus gonad weight). One outlier not shown (GSI = 27%).

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