# A Comparison of Sampling Methods and Continuation of Red Snapper Life History Metrics

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# A Comparison of Sampling Methods and Continuation of Red Snapper Life History Metrics

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**Summary**
Although red snapper (*Lutjanus campechanus*) is the most thoroughly assessed fish in the Gulf of Mexico, biological data on older specimens (i.e. ages >8) are sparse compared to younger mature individuals (i.e. ages<7). Data collected from tournament caught fish provides information on older red snapper, but is inherently biased because tournament anglers target larger fish. Data collected during tournament sampling proved to be significantly different than data collected during standard recreational angler surveys according to a likelihood ratio test ($\chi^2$ = 39.393, P < 0.0001; Ogle 2015). Despite that bias, the collection of larger and older fish from fishing tournaments allow for fecundity metrics that can be inserted into a fecundity at age curve for egg production estimates. Red snapper batch fecundity increased with age as observed in the past (Collins et al. 1996, Porch et al. 2015). Red snapper greater than age 15 show a sharp increase in fecundity.

## Introduction

The status of the red snapper (*Lutjanus campechanus*) stock has been assessed more than any other federally managed fish in the Gulf of Mexico (SEDAR 2013). Biological data is sparsely represented among older age classes (i.e. ages >8). Directed sampling at fishing tournaments may provide a cost-effective method for collecting reproductive samples from older age classes of red snapper. Improved fecundity estimates would contribute to improved stock assessment recommendations.

The Louisiana Department of Wildlife and Fisheries (LDWF) obtained an exempted fishing permit from the federal government to hold fishing tournaments outside of the recreational fishing season for the year 2012. Data and samples were collected from these recreational fishing tournaments along the northern Gulf of Mexico (nGOM) coast. The objectives of this study were:

1.) Collect otoliths for age and growth analysis from red snapper not normally sampled in standard recreational angler surveys
2.) Collect ovaries for fecundity estimates from red snapper not normally sampled in recreational angler surveys
3.) Compare age and growth of tournament and non-tournament caught red snapper from the recreational sector
4.) Better document the age structure and biology of red snapper normally associated with offshore platforms and artificial reefs in the nGOM

## Methods

Red snapper were sampled at eight fishing tournaments with reef fish categories along the nGOM coast from June to October in 2012. Five tournaments were sampled in Louisiana with one each sampled in Mississippi, Alabama and Florida. As per the exempted fishing permit issued for these fishing tournaments, each angler was told to keep the first two red snapper caught. When the angler returned, he or she was asked if the fish was caught on standing platforms (portion above the surface of the water), artificial reefs (entirely underwater), or natural reef. For the purpose of analysis, data from standing platforms and artificial reefs were combined.

All fish sampled were weighed to the nearest gram (g) and fork length (FL) measured to the nearest millimeter (mm). Otoliths and ovaries were removed and all ovaries were subsequently fixed in 10% neutral buffered formalin (NBF).

Every left otolith was transversely sectioned and aged by the enumeration of annuli and assignment of an edge code by two readers following VanderKooy (2009). If there was disagreement, the two readers would attempt to come to a consensus; and if a consensus could not be achieved, then a third reader would determine the age. A hatching date of July 1$^{st}$ was assigned to all fish for calculation of a final age (Patterson et al. 2001, Wilson and Nieland 2001, Wells et al. 2008). Age data derived from tournament samples was compared to that of non-tournament recreational fishing samples to determine any differences in age structure and size. Age data derived from standard Louisiana recreational sampling (in June and July 2012) was compared with that of fishing tournaments (excluding the tournament sampled in Florida). Red snapper 2012 federal recreational season lasted from June 1$^{st}$ through July 16$^{th}$, which did not allow for standard recreational sampling outside of that season. All tournament sampling fell under an exempted fishing permit that allowed the harvest of red snapper in federal waters out of season. A likelihood ratio test was used to compare the von Bertalanffy growth curve parameters between the two sampling methods using methods from Ogle (2015) in the R statistical program.

A gonadosomatic index (GSI), a ratio of gonad weight to body weight, was calculated for every sampled female. Batch fecundity was estimated for all ovaries with hydrated oocytes. Three subsamples of approximately 75 milligrams (mg) were removed from randomly selected regions of each hydrated ovary. The number of hydrated oocytes within each subsample and the diameter (mm) of each oocyte were recorded. Gravimetric methods were employed to calculate batch fecundity. The quotient of the count of oocytes and the subsample mass yielded an eggs/gram ovary weight metric called oocyte density. The oocyte density was then multiplied by the ovarian mass, yielding batch fecundity.

**Results**

A total of 513 red snapper were sampled from eight tournaments out of several nGOM ports spanning from Port Fourchon, Louisiana to Dauphin Island, Alabama in June, July, and August 2012 (Table 1). Both age and length data from the Destin, Florida tournament were excluded due to problems in merging two databases. Among the 281 males and 232 females for which FL could be measured ranged from 221 mm to 975 mm FL. (Figure 1). Red snapper ages were determined for specimens from tournaments in Louisiana, Mississippi, and Alabama (Table 1). Ages ranged from 1 to 25 years. Standard LDWF recreational fishery sampling in June and July 2012 yielded FL and age data for 658 non-tournament specimens. All tournament red snapper were caught in federal waters due to the exempted fishing permit.

Tournament sampling provided larger and older red snapper than non-tournament sampling. Because there were more fish sampled during standard recreational angler surveys, histograms were constructed based upon percent of total catch for the allotted time periods (Figures 1 and 2). Anglers were instructed to 'keep the first fish caught' during the tournaments, which may explain why there are a greater number of fish between 300 and 400 mm FL than expected. However, there were proportionally more fish over 700 mm collected from tournaments (average [±SE]; 594 mm FL [±3.23]) than non-tournament fish (609 mm FL [±4.97]; Figure 1). Despite the oldest red snapper sampled during tournament and non-tournament fishing being similar in age (25 and 23 years respectively), tournament sampling yielded a larger number of fish >8 years (183) than non-tournament sampling (73; Figure 2).

A comparison of tournament and non-tournament growth model parameters indicates that tournament red snapper showed a larger theoretical maximum length ($L_\infty$) while the non-tournament fish have a higher growth coefficient (K; Table 2, Figure 3). Von Bertalanffy growth parameters for tournament and non-tournament red snapper were significantly different according to a likelihood ratio test ($\chi^2$ = 39.393, P < 0.0001; Ogle 2015). Individual growth parameters were compared statistically with a sum-of-squares test (Ogle 2015). The hypothetical age at zero length ($t_0$) was not different between tournament and non-tournament fish (F = 0.5587, *P* = 0.45493), but $L_\infty$ ( F = 6.5149, *P* = 0.01083) and K (F = 5.0629, *P* = 0.02463) were different between the two sampling methods.

The sample size of tournament caught fish on natural reefs was too low to perform a meaningful statistical comparison. A standardized sampling approach is recommended to compare age and growth of fish from these two habitat types.

Both GSI and batch fecundity data were examined against corresponding age data. Fecundity and GSI data were compiled into 1 year age brackets. Data were combined into 5 year brackets beyond age 15 due to small sample sizes per age class. A plot of average GSI at age exhibits a linear trend of higher reproductive potential with increasing age (Figure 4). Larger variation in red snapper GSI among ages >15 years can be attributed to smaller sample sizes. There are no error bars for ages 1 and 2 due to an n=1 for both ages. Batch fecundity estimates mirror the positive trend of GSI with age and size (Table 2; Figures 5 & 6). Although average batch fecundity values drop in the 20-25 age bracket, that age bracket is comprised of only 2 fish. In contrast, GSI increases slightly within 20-25 age bracket. Additionally, GSI follows a linear trend whereas fecundity follows an exponential trend. There is a noticeable batch fecundity increase from age six to seven, but the fit is tighter and less variable when correlated with size (FL). When the older age groups are combined together within 100mm FL bins, it is evident that red snapper over 800mm produce the most ova (Figure 6). The batch fecundity at age relationship indicated that red snapper above the age of 15 produce the most eggs.

Diameters (mm) of hydrated red snapper oocytes were plotted by age from samples with the most advanced stage of hydration as determined through histological analysis (Figure 7). No trend was evident in hydrated ova size with increasing age, though a larger sample size would increase confidence.

**Discussion**

Red snapper collected from fishing tournaments tended to be older and larger than individuals sampled from the standard recreational angler surveys. However, the recreational non-tournament fish did exhibit a similar size range to tournament data. Patterson et al. (2001) also sampled larger and older fish from tournament fishing compared to random recreational dockside sampling.

The von Bertalanffy growth models estimated a larger $L_\infty$ for tournament fish and a lower $L_\infty$ for non-tournament red snapper when compared to the stock assessment growth model (SEDAR 2013). The $L_\infty$ of tournament fish is not only larger than that estimated for non-tournament fish, but it additionally exceeds several other $L_\infty$ estimates (Wilson and Nieland 2001, Fischer et al. 2004, SEDAR 2013). Patterson et al. (2001) indicated a different trend with an inflated $L_\infty$ value when excluding the tournament fish, but almost all of the older fish in his model were obtained from tournament sampling. Without the older fish to level the asymptote, the model predicted an unrealistic $L_\infty$. Based on our data and those of Patterson et al. (2001), tournament sampling yields a significantly higher proportion of fish >age 7.

The exponential relationship of batch fecundity estimates with increasing age and size is present in this study as it is in previous documentation (Collins et al. 1996, Porch 2007, Fitzhugh et al. 2012, Kulaw 2012, Porch et al. 2015). The data within this report indicate that 15-20 year-old red snapper contribute the most ova per fish. However, the most frequently caught age classes in tournament and non-tournament fishing were 7 and 6 respectively. In comparison, a relatively small amount of fish older than 10 years were caught in the recreational fishery in 2012. A larger proportion of red snapper greater than age 10 will lead to greater egg production and a more sustainable fishery.

There has also been a question among some researchers whether there is a correlation of egg quality with age (pers. comm. Gary Fitzhugh and Dave Nieland). The results of measuring the most advanced hydrated oocyte stage from ripe ovaries did not indicate there was a trend of larger egg size among older fish, but low sample size of fish with advanced hydrated oocytes stages could have affected the results. Papanikos et al. (2008) used spawned eggs to show an effect of reduced egg viability with lack of nutrition, but a similar investigation is needed to determine effect of maternal age/size. While fishing tournaments are a poor indicator of over-all catch-at-age, the targeting of older, larger fish is a valuable resource for reproductive information.

Fish collected from tournaments provided valuable reproductive and length data for older red snapper. Data from fish within older age classes is necessary to prepare a meaningful stock assessment. The specific goal of red snapper management is to achieve a spawning potential ratio (SPR) of 26% (SEDAR 2013). Greater data resolution on older red snapper would better inform stock assessment and more accurately forecast when the goal of 26% SPR will be reached.

**Acknowledgements**

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Table 1. Each fishing tournament name, location, number of fish sampled within that tournament, and number of red snapper (*Lutjanus campechanus*) aged from each tournament (Destin tournament data were excluded because of a common numbering error).

| Tournament | Location | # Fish Sampled | # Fish Aged |
|---|---|---|---|
| 13th Louisiana Legislators' Invitational Fishing Rodeo | Grand Isle, LA | 74 | 74 |
| 14th Annual Faux Pas Lodge Invitational Fishing Rodeo | Venice, LA | 132 | 123 |
| Grand Isle Tarpon Rodeo | Grand Isle, LA | 114 | 113 |
| Oilman's Rodeo | Port Fourchon, LA | 50 | 50 |
| 1st Only Mochael Memorial Fishing Tournament | Venice, LA | 8 | 8 |
| 64th Annual Mississippi Deep Sea Fishing Rodeo | Gulfport, MS | 6 | 6 |
| Alabama Deep Sea Fishing Rodeo | Dauphin Island, AL | 130 | 130 |

Table 2. Von Bertalanffy growth parameters for tournament and non-tournament caught red snapper (*Lutjanus campechanus*).

| Recreational Fishing Method | Theoretical Maximum Size ($L_\infty$±SE) | Growth Rate Coefficient (K±SE) | Hypothetical Age at Zero Length ($t_0$±SE) |
|---|---|---|---|
| Tournament | 871.12 ± 19.79 | 0.18 ± 0.01 | -0.87 ± 0.18 |
| Non-Tournament | 783.25 ± 24.69 | 0.24 ± 0.03 | -0.62 ± 0.28 |

Table 3. Tournament caught red snapper (*Lutjanus campechanus*) fecundity within age with relative metrics, location and date information.

| Age (yrs) | Date | State | Total Length (mm) | Fork Length (mm) | Batch Fecundity | Relative Fecundity | Annual Fecundity |
|---|---|---|---|---|---|---|---|
| 2.06 | 22-Jul-12 | AL | 369 | 342 | 36229.26 | 45.87 | 352510.72 |
| 3.03 | 13-Jul-12 | LA | 545 | 510 | 43771.47 | 20.10 | 783946.99 |
| 3.06 | 22-Jul-12 | AL | 404 | 378 | 45773.80 | 45.83 | 819808.83 |
| 3.07 | 26-Jul-12 | LA | 466 | 433 | 30397.06 | 18.39 | 544411.32 |
| 3.07 | 27-Jul-12 | LA | 545 | 506 | 68983.39 | 30.09 | 1235492.49 |
| 3.07 | 28-Jul-12 | LA | 476 | 443 | 65608.83 | 39.49 | 1175054.22 |
| 4.06 | 22-Jul-12 | AL | 477 | 436 | 122236.13 | 89.99 | 4278264.56 |
| 5.05 | 21-Jul-12 | AL | 564 | 525 | 30719.41 | 12.36 | 1167337.45 |
| 5.05 | 21-Jul-12 | AL | 567 | 528 | 75327.40 | 29.96 | 2862441.07 |
| 5.05 | 21-Jul-12 | AL | 582 | 540 | 103219.02 | 40.81 | 3922322.71 |
| 5.06 | 22-Jul-12 | AL | 509 | 470 | 114091.30 | 71.37 | 4335469.35 |
| 5.06 | 22-Jul-12 | AL | 596 | 557 | 141560.84 | 51.91 | 5379311.99 |
| 5.07 | 28-Jul-12 | LA | 602 | 555 | 135566.33 | 42.00 | 5151520.41 |
| 5.07 | 27-Jul-12 | LA | 559 | 515 | 83331.33 | 36.70 | 3166590.36 |
| 5.07 | 28-Jul-12 | LA | 626 | 578 | 417104.50 | 140.26 | 15849970.97 |
| 5.09 | 4-Aug-12 | LA | 580 | 535 | 137772.62 | 51.94 | 5235359.59 |
| 5.09 | 4-Aug-12 | LA | 580 | 540 | 30612.15 | 11.63 | 1163261.84 |
| 6.03 | 13-Jul-12 | LA | 696 | 650 | 100764.93 | 25.16 | 4131362.30 |
| 6.04 | 14-Jul-12 | MS | 713 | 693 | 253368.86 | 50.47 | 10388123.33 |
| 6.05 | 20-Jul-12 | AL | 718 | 667 | 55749.23 | 11.37 | 2285718.46 |
| 6.05 | 21-Jul-12 | AL | 764 | 701 | 331272.00 | 61.29 | 13582152.20 |
| 6.06 | 22-Jul-12 | AL | 620 | 585 | 100639.94 | 29.63 | 4126237.37 |
| 6.06 | 22-Jul-12 | AL | 706 | 653 | 129311.09 | 30.48 | 5301754.73 |
| 6.06 | 22-Jul-12 | AL | 705 | 651 | 394551.46 | 83.56 | 16176609.66 |
| 6.06 | 22-Jul-12 | AL | 738 | 687 | 343441.70 | 69.33 | 14081109.59 |
| 6.06 | 22-Jul-12 | AL | 732 | 681 | 258593.73 | 46.97 | 10602342.75 |
| 6.07 | 26-Jul-12 | LA | 571 | 529 | 149111.69 | 61.60 | 6113579.46 |
| 6.07 | 27-Jul-12 | LA | 684 | 636 | 432313.55 | 103.31 | 17724855.38 |
| 6.07 | 28-Jul-12 | LA | 571 | 528 | 101509.36 | 37.91 | 4161883.74 |
| 6.07 | 28-Jul-12 | LA | 694 | 635 | 398830.86 | 94.18 | 16352065.14 |
| 6.09 | 4-Aug-12 | LA | 662 | 623 | 172942.06 | 45.68 | 7090624.53 |
| 7.05 | 21-Jul-12 | AL | 622 | 580 | 256417.72 | 73.08 | 16923569.62 |
| 7.06 | 22-Jul-12 | AL | 752 | 688 | 4761.68 | 0.87 | 314270.66 |
| 7.06 | 22-Jul-12 | AL | 756 | 697 | 426985.75 | 76.99 | 28181059.68 |
| 7.06 | 22-Jul-12 | AL | 744 | 688 | 405356.63 | 69.71 | 26753537.28 |
| 7.07 | 27-Jul-12 | LA | 796 | 736 | 900426.25 | 131.56 | 59428132.22 |
| 7.07 | 27-Jul-12 | LA | 778 | 720 | 548489.55 | 75.25 | 36200310.45 |
| 7.07 | 27-Jul-12 | LA | 724 | 673 | 59707.47 | 11.56 | 3940692.95 |
| 7.07 | 28-Jul-12 | LA | 668 | 615 | 50135.68 | 12.68 | 3308954.64 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7.07 | 28-Jul-12 | LA | 675 | 603 | 192552.00 | 48.48 | 12708432.00 |
| 7.09 | 4-Aug-12 | LA | 760 | 707 | 588251.12 | 110.75 | 38824573.75 |
| 8.03 | 13-Jul-12 | LA | 804 | 759 | 377999.52 | 47.11 | 23084430.95 |
| 8.07 | 26-Jul-12 | LA | 683 | 635 | 180413.52 | 43.21 | 11017853.84 |
| 8.07 | 27-Jul-12 | LA | 815 | 760 | 48134.11 | 7.27 | 2939549.93 |
| 8.07 | 27-Jul-12 | LA | 821 | 765 | 528176.45 | 72.30 | 32255735.54 |
| 8.07 | 27-Jul-12 | LA | 747 | 697 | 562429.22 | 102.12 | 34347552.69 |
| 8.07 | 28-Jul-12 | LA | 760 | 714 | 211672.25 | 36.65 | 12926824.60 |
| 16.04 | 14-Jul-12 | LA | 881 | 825 | 788165.37 | 84.59 | 43349095.10 |
| 18.04 | 14-Jul-12 | LA | 862 | 810 | 2248000.00 | 248.89 | 123640000.00 |
| 20.07 | 26-Jul-12 | LA | 896 | 832 | 538885.16 | 56.48 | 29638683.78 |
| 24.04 | 14-Jul-12 | LA | 911 | 856 | 1440649.47 | 127.56 | 79235720.64 |

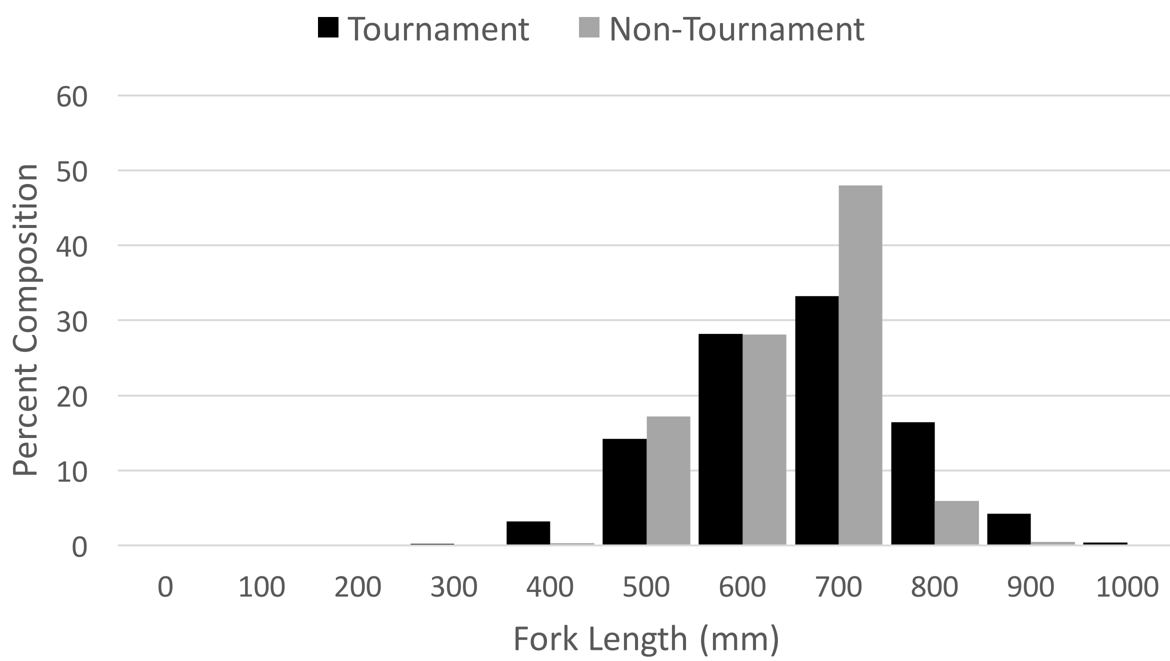


Figure 1. Percent composition of tournament and non-tournament catch of red snapper (*Lutjanus campechanus*) by 100mm length bins. Tournament fish comprised of fish caught in Louisiana, Mississippi, and Alabama fishing tournaments from June-October 2012. Non-tournament fish comprised of all recreational catch in Louisiana in June and July of 2012.

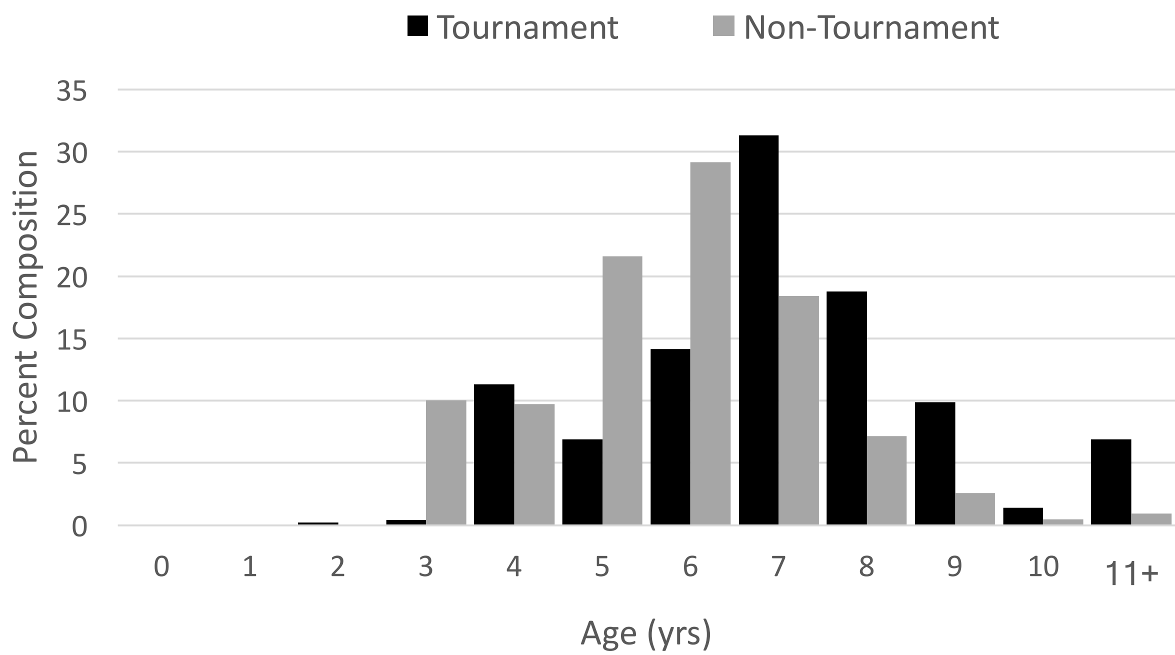


Figure 2. Percent composition of tournament and non-tournament catch of red snapper (*Lutjanus campechanus*) by age in years. Tournament fish comprised of fish caught in Louisiana, Mississippi, and Alabama fishing tournaments from June-October 2012. Non-tournament fish comprised of all recreational catch in Louisiana in June and July of 2012.

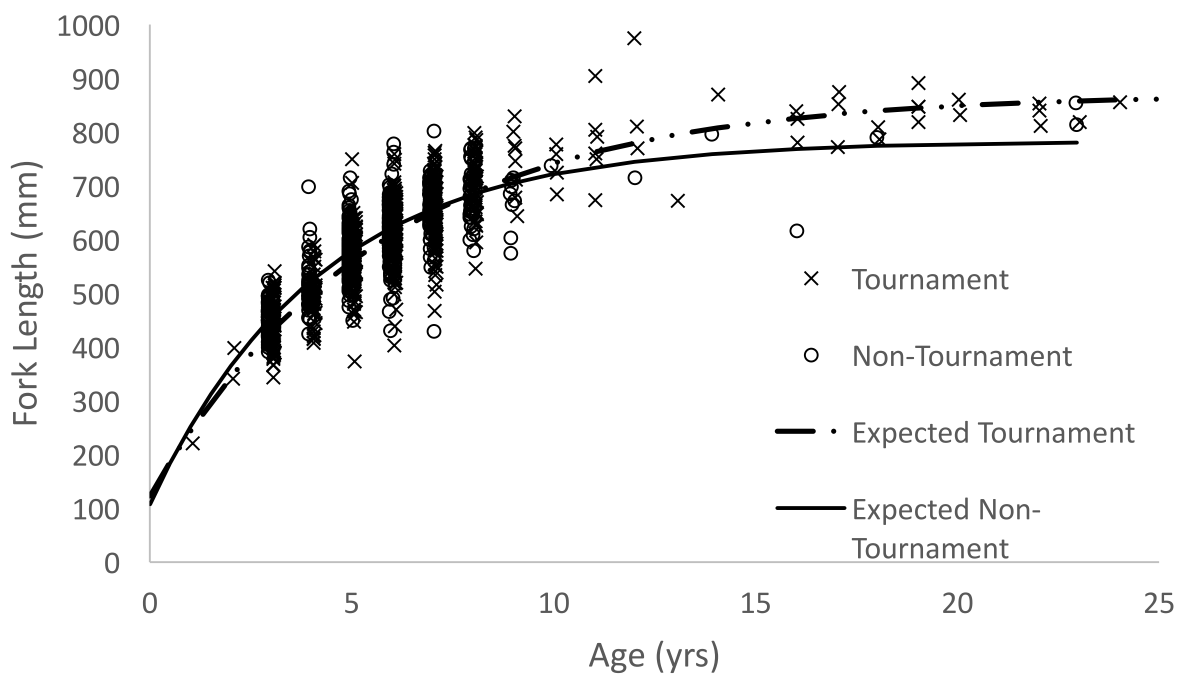


Figure 3. Fork length in millimeters plotted for each red snapper (*Lutjanus campechanus*) aged in years. von Bertalanffy equation generated for tournament (FL=871.12(1-e^(-0.17508[t+0.87255]) and Non-Tournament (FL=783.25(1-e^(-0.23942[t+0.61941]) fish.

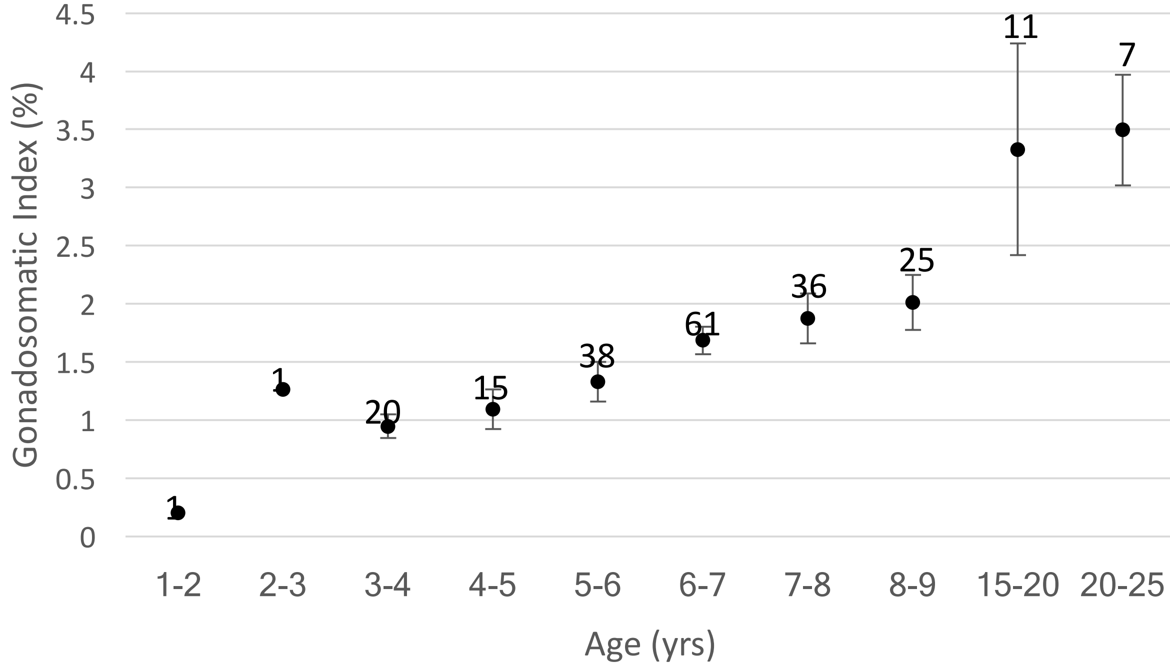


Figure 4. Red Snapper (*Lutjanus campechanus*) mean (±SE) gonadosomatic index (a ratio of gonad weight to body weight) within age (yrs). Number above each data point represents the number of specimens in that age group.

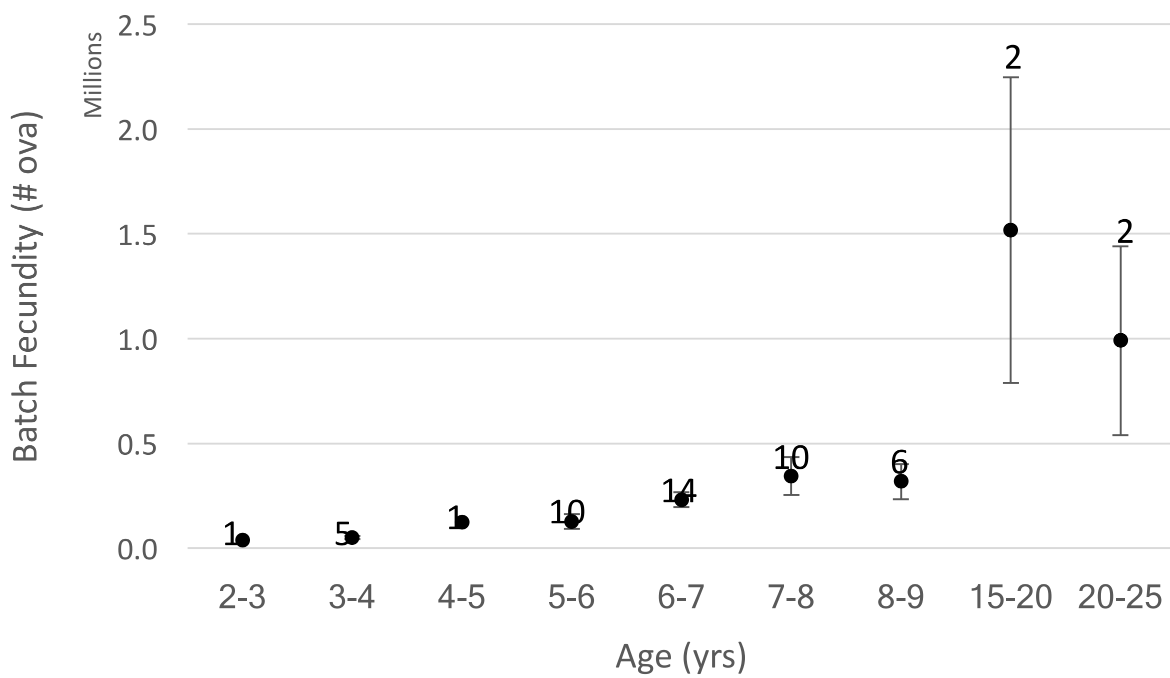


Figure 5. Tournament caught red snapper (*Lutjanus campechanus*) mean (±SE) batch fecundity (# of ova produced in one spawning event) within age (yrs). Number above each data point represents the number of specimens in that age group.

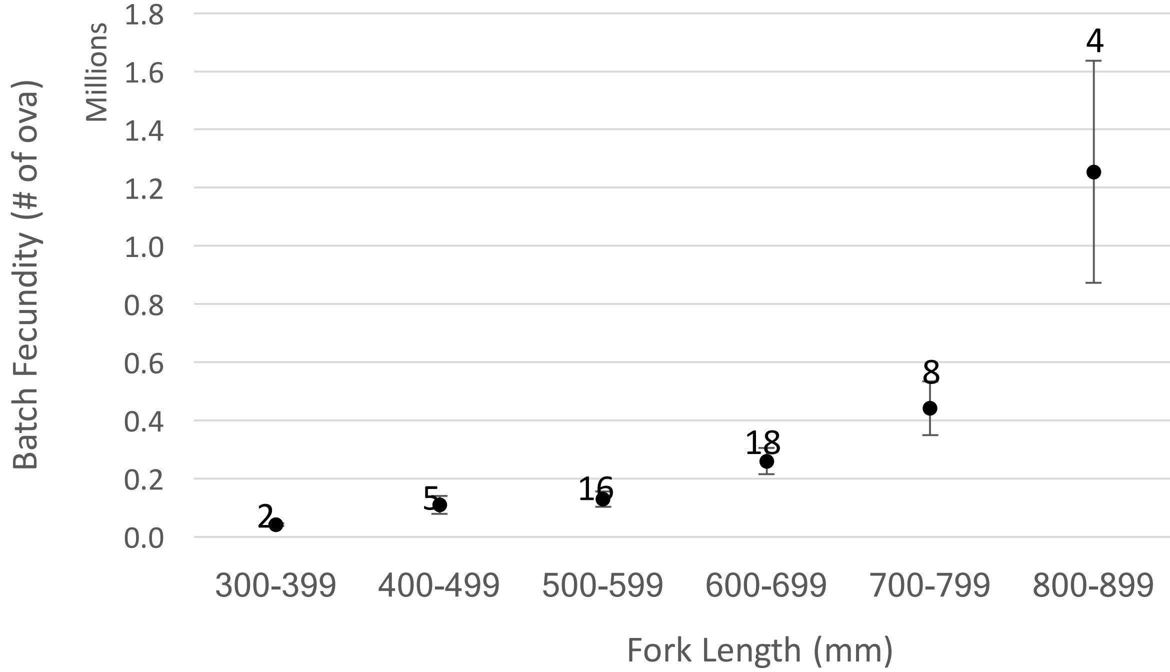


Figure 6. Tournament caught red snapper (*Lutjanus campechanus*) mean (±SE) batch fecundity (# of ova produced in one spawning event) within fork length bins (mm). Number above each data point represents the number of specimens in that length bin.

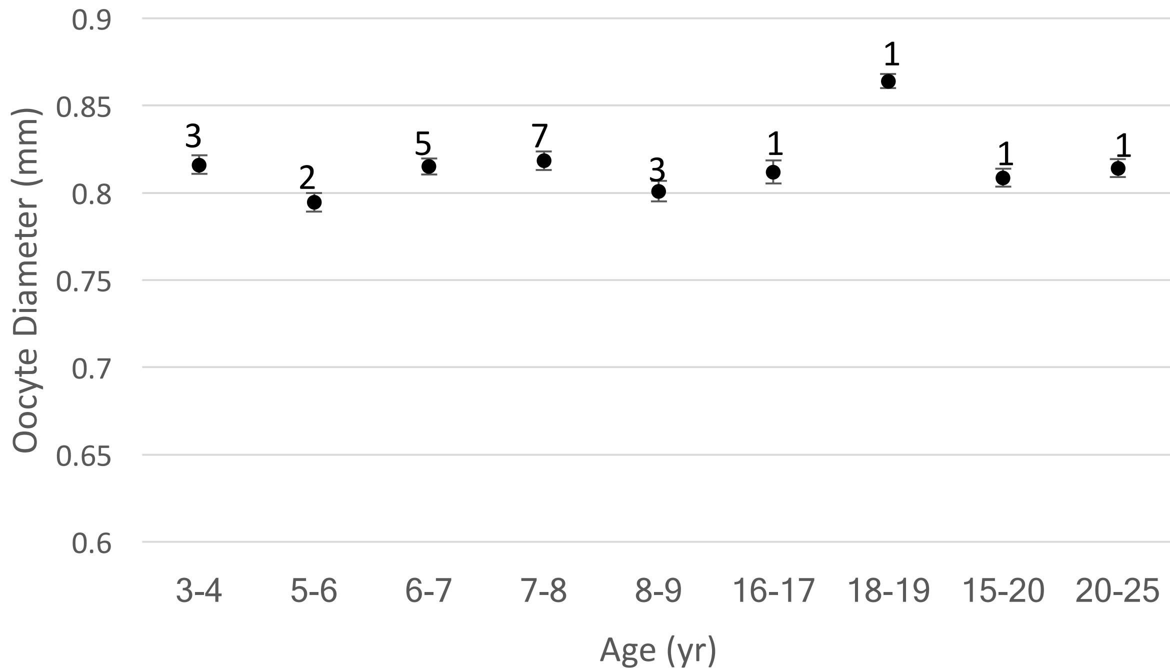


Figure 7. Average oocyte diameter (mm; ±SE) of hydrated red snapper (*Lutjanus campechanus*) oocytes with standard error bars within age (yrs). Number above each data point represents the number of specimens in that age group, but there were three fecundity subsamples per fish ovary.