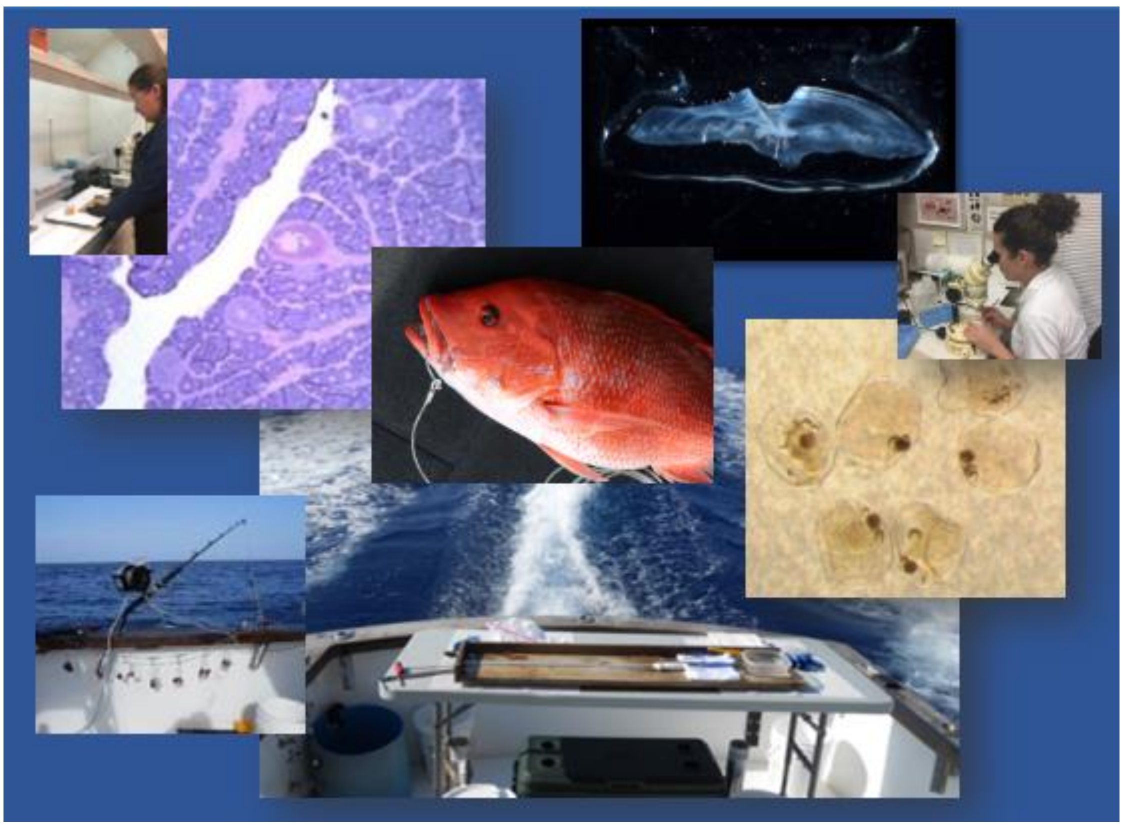
NOAA Technical Memorandum NMFS-SEFSC-737
doi:10.25923/kwcm-nn81

DEMOGRAPHICS AND LIFE HISTORY TRAITS OF RED SNAPPER FROM SOUTH TEXAS, A HISTORICALLY UNDER-SAMPLED REGION

BY

JAMES C. PATTERSON, VERONICA D. BEECH, GARY R. FITZHUGH, PAMELA M. COLSON, BRANDI T. NOBLE AND NAEEM A. WILLETT



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive,
Miami, FL 33149

May 2019

NOAA Technical Memorandum NMFS-SEFSC-737
doi:org/10.25923/kwcm-nn81

DEMOGRAPHICS AND LIFE HISTORY TRAITS OF RED SNAPPER FROM SOUTH TEXAS, A HISTORICALLY UNDER-SAMPLED REGION

BY

JAMES C. PATTERSON, VERONICA D. BEECH, GARY R. FITZHUGH, PAMELA M. COLSON, BRANDI T. NOBLE AND NAEEM A. WILLETT.

National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149

U.S. DEPARTMENT OF COMMERCE
Wilber Ross, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Neil Jacobs, Under Secretary of Commerce for Oceans and Atmosphere
(Acting)

NATIONAL MARINE FISHERIES SERVICE
Christopher Oliver, Assistant Administrator for NOAA Fisheries

May 2019

This Technical Memorandum series is used for documentation and timely communication of preliminary results, interim reports, or special-purpose information. Although the memoranda are not subject to complete formal review, editorial control, or detailed editing, they are expected to reflect sound professional work.

NOTICE

The National Marine Fisheries Service (NMFS) does not approve, recommend or endorse any proprietary product or material mentioned in this publication. No reference shall be made to NMFS or to this publication furnished by NMFS, in any advertising or sales promotion which would imply that NMFS approves, recommends, or endorses any proprietary product or proprietary material mentioned herein which has as its purpose any intent to cause directly or indirectly the advertised product to be used or purchased because of this NMFS publication.

This report should be cited as follows:
Patterson, J.C, V.D. Beech, G.R. Fitzhugh, P.M Colson, B.T. Noble and N. Willett. 2019. Demographics and life history traits of red snapper from south Texas, a historically under-sampled region. NOAA Technical Memorandum NMFS-SEFSC-737, 27p.
https://doi.org/10.25923/kwcm-nn81

Authors' Addresses:
J.C.P. - NMFS; SEFSC; Fisheries Statistics Division; 2401 Village Drive, Suite B; Brownsville, TX 78521
V.D.B., P.M.C., and N.A.W. - Riverside Technology (contracting for NMFS); SEFSC Panama City Laboratory; 3500 Delwood Beach Rd.; Panama City, FL 32408
G.R.F. - NMFS; SEFSC; Panama City Laboratory; 3500 Delwood Beach Rd.; Panama City, FL 32408
B.T.N. – NMFS; SEFSC; Mississippi Laboratories; 3209 Frederic St.; Pascagoula, MS 39567

Copies of this report may be obtained from:

James C. Patterson
National Marine Fisheries Service
Fisheries Statistic Division
2401 Village Drive Suite B
Brownsville, TX 78521
Tel: (956) 982-6917
James.patterson@noaa.gov

Or

Veronica D. Beech
National Marine Fisheries Service
Panama City Laboratory
3500 Delwood Beach Rd.
Panama City, FL 32408
Tel: (850) 234-6541
Veronica.beech@noaa.gov

Abstract

This project was conducted to augment biological data and stock demographics of red snapper (*Lutjanus campechanus*) from south Texas and U.S. waters in the U.S./Mexico maritime boundary. Fish were sampled from a contracted fishing vessel from June through September of 2017, using a vertical line rigged with 30 hooks. Sampling stations were selected from industry-supplied red snapper fishing locations or located via exploratory fishing within statistical reporting grid 21. The sampled red snappers were processed to obtain length , weight, internal temperature, both sagittal otoliths, and gonadal tissue. The highest proportion of captured red snapper measured between 400 and 500 millimeters FL. Ages were determined from traverse sections of otoliths for 1871 individuals, with the highest proportion of ages at age 5 years, and the oldest fish at 19 years. Trends for ages increased with both weight and length. Weights were collected for 1904 gonads, and the trends for both male and female increased with length. Macro staging of the gonads revealed the highest proportion of running ripe females occurred in late July, and running ripe males in early July. Maturity assignations for 705 female red snapper yielded 18 immature, 670 mature, 13 of uncertain maturity and four were discarded. A maturity ogive was not estimated due to the lack of contrast between smaller and younger individuals, and larger and older ones. Batch fecundity estimations of 58 female red snapper averaged 39459 eggs per individual. Batch fecundity trend increased with age and size; however the relative batch fecundity for grid 21 was lower if compared with the relative batch fecundity for other published estimates. The results of spawning fraction also support lower reproductive outputs for grid 21 females when compared with publications of other areas in the Gulf of Mexico. The reproductive outputs estimated for this project were lower than previous estimations that assessed the western Gulf of Mexico, potentially due to the diversity in the age composition and demographics of the stock of grid 21. Overall, this project provided biological parameters for the red snapper fisheries in the western Gulf of Mexico that will aid in the understanding of the stock in this under-sampled area.

Introduction

This project sought to augment biological sampling and provide exploratory fishing in south Texas and U.S. waters adjacent to the U.S./Mexico maritime boundary (Figure 3), with a focus on red snapper (*Lutjanus campechanus*). This region has been historically under-sampled and a lack of information regarding habitat has inhibited agency surveys in the past. This project was conducted to provide background information on stock demographics to help managers better understand the potential effects of this harvest. Eight particular areas of interest within statistical reporting grid 21 (Figure 3) were identified based upon prior surveys and from (aggregated) plots of US and Mexican fishing vessel GPS coordinates (U.S. fishery landings are reported by statistical reporting grid; see 13494 Federal Register Vol. 49, No. 85, May 1, 1984). Commercial and recreational fishermen's knowledge, and exploration of unknown areas within the grid, was applied for final site selection within selected blocks following previous agency-industry approaches. Objectives were to: 1) sample a minimum of 1600 red snapper (minimum goal of 800 females) distributed in time across the spawning season, 2) provide reproduction and age information to enhance stock assessment models for the south Texas area of the Gulf of Mexico, and 3) compare reproductive information on increased temporal and spatial scales to potentially identify regions or habitats of vital importance in spawning.

Methodology

Trips and stations

There were 14 single day trips conducted aboard a contract fishing vessel (*F/V Miss Directed*) between June 27 and September 13 of 2017, during the spawning season of red snapper in the western Gulf of Mexico (day 15 canceled due to deteriorating weather/sea conditions). The goal was to complete 5 stations (separation between stations of a minimum of 1/10 mile) per trip within selected blocks in grid 21, with a catch goal of 30 red snapper per station, for a total of 150 red snapper caught and sampled per trip.

Fishing Gear

F/V Miss Directed was outfitted with a Kristal XL 75 electric reel mounted on a Penn Ally 6 foot bent butt swivel tip 250 pound rod (Figure 1). The reel was spooled with 1000 meters of 100 pound Daiwa Spectra metered line, with color changes every 10 meters, and hash marks every meter. The gangion was composed of 800 pound mainline containing 15 three way swivels at intervals of approximately 15 cm, with 2 Mustad 10/0 non-offset hooks per swivel on approximately 10 cm 300 pound monofilament line, for a total of 30 hooks. The gangion was weighted with a 4 pound lead weight on the bottom end. Hooks were baited with Bonita cut into cube chunks of approximately 20 to 30 grams (approximately 3 cubic centimeters). Fish, natural hard bottom, and areas of live bottom with strong acoustic echos were located using a Lowrance Hook 9 sonar with a Raymarine 2 kilowatt transducer.

Fishing Methodology

Stations were mainly selected by utilizing known areas frequently fished for red snapper during the federal red snapper season. Some stations (unknown to the commercial and/or recreational entities of the area) were located using the sonar during transit between known fishing areas, and through exploration of unknown areas. Drops were conducted after locating the natural hard bottom areas/large sea life signals, and establishing the current/drift direction of the vessel. The vessel was then situated to drift through the target area, and the drops commenced. Each drop had a maximum soak time of 2 minutes, with the maximum fishing time of 2 hours per station. In most cases, the gear was dropped until hitting bottom then raised off the bottom 2 to 5 meters in an attempt to target red snapper and minimize bycatch of other species, as red snapper are typically found higher in the water column above the natural hard bottom. Sea surface temperature (°C) was recorded at each station. In three of the stations, where the fish were located by sonar higher in the water column/mid-water depths (trip 4-station 1 (all drops), trip 11-station 2 (all drops), and trip 14-station 4 (one drop): Table 1, Figure 4), the gear was lowered to the desired depth utilizing the metered color indicators on the line, effectively hanging the baited gear at the depth the fish were marking on the sonar.

Sample methodology

Captured fish were weighed using a 10 kg Pesola spring scale, and an internal temperature was taken immediately after landing utilizing a ThermoWorks RT600C digital temperature probe. Fish internal temperature often differs from sea surface temperature and may be used to draw inference about fish depth distribution and temperature preference. The probe was inserted into the anus/urogenital opening of the largest red snapper on the gangion on the first, middle, and last sets to calculate a mean internal fish temperature (MIT) for that station (probe inserted to various areas/depths of the body cavity with lowest stable temperature recorded). The fish were then euthanized in an ice slurry and sampling began while fishing continued. The fish were measured for fork length (FL) and maximum total length (TL) on a manual metric fish board in millimeters. Both sagittal otoliths were removed, cleaned, and stored dry. One red snapper otolith per fish was sectioned and aged at the Panama City Laboratory (PCLAB) using methodologies consistent with previous red snapper studies (Allman and Fitzhugh 2007, Allman et al., 2012).

Gonads were removed, weighed using a Pesola 100 g spring scale, and macro staged. Gonads that weighed over 100 grams were cut in half at the bifurcation, with total weight being the sum weight of both halves. Samples of the female gonad (approximately 10 g) were cut from the area of the bifurcation and fixed in 10% buffered formalin solution as quickly as possible. Male gonads were weighed, macro staged, and discarded. The preserved red snapper female gonads were trimmed and sliced at the PCLAB and histologically prepared using hematoxylin and eosin (H&E) staining. The histology slides were examined at magnifications between 40x and 100x using Wallace and Selman (1981) techniques, with modification including dividing vitellogenesis (Vtg1-Vtg3) and assigning reproductive phases (Brown-Peterson et al., 2011 and Lowerre-Barbieri at al., 2011). Characteristics that were used to determine prior spawning activity included the appearance and presence of the ovarian wall, muscle bundles, brown bodies and post ovulatory follicles. Maturity was assigned to females captured between June through the end of August, and only the individuals with vitellogenic oocytes and oocytes at more advance stages were considered mature. This criterion is consistent with previous reporting (Fitzhugh et al. 2012, Fitzhugh et al. 2017). Individuals exhibiting a few sparse cortical alveolar with undetermined indicators of prior spawning were of uncertain maturity, and therefor maturity was not scored. Spawning markers, including hydrated oocytes and post ovulatory follicles, were used to calculate spawning fractions (SF), which were compared with previous studies.

Gonads selected to estimate batch fecundity exhibited fully hydrated oocytes and were in the late stages of hydration which is consistent with Hunter et al. (1985) hydrated oocyte method (Figure 2). Each batch fecundity estimate (BFE) was calculated from two sub-samples per fish, each weighing approximately 0.075 grams. Before removing the sub-samples, the gonads were removed from the formalin solution and blotted dry. Each of the subsamples was placed in their own vial, and the tissue submerged in 33% glycerin solution for a minimum of 48 hours to help separate the hydrated oocytes from the rest of the gonadal tissue. Hydrated oocytes of sub-samples A and B, were counted in a gridded petri-dish and BFE was calculated:

$$BFE = \frac{\text{Total \# of Hydrated oocytes in subsample } A+B \times \text{Whole ovary weight (g)}}{\text{Total weight of subsample } A+B \text{ (g)}}$$

Results

A total of 1923 red snapper were caught and sampled, 839 (43.6%) of which were female (Table 1). The numbers of females caught were often lower than number of males (in 11 out of 14 trips) with a ratio as low as 36% female by trip (Table 1).

Red snapper was targeted through the specific use of the gear, resulting in a minimal amount of bycatch. Additional species caught and sampled included three lane snapper (*Lutjanus synagris*), five vermilion snapper (*Rhomboplites aurorubens*), and one scamp (*Mycteroperca phenax*) (Table 2). Other bycatch that was captured and released without sampling included two almaco jack (*Seriola rivoliana*), one white grunt (*Haemulon plumierii*), two sandbar shark (*Carcharhinus plumbeus*) , and two Atlantic sharpnose (*Rhizoprionodon terraenovae*).

All stations were located over natural bottom/natural hard bottom areas and structures. No artificial bottom structures (i.e. rigs, wrecks, artificial reefs, etc.) were fished for this project. Most of the stations fished were either on expansive hard bottom areas, e.g. East Banks, Seabree Banks, Mysterious Banks, or over sporadic hard bottom areas previously known or located via sonar during area exploration (Table 1, Figure 4). Four stations were fished over natural sand/mud bottom (no hard bottom located in the area). Fishing at these stations resulted in low catch totals with a proportionally high number of drops (trip1-station 2, trip 11-station 3, trip 12-station 1, and trip 14-station 3: Table 1, Figure 4). Sea surface temperature was fairly consistent over the duration of the study (28 – 30° C); however, fish internal temperature declined with increasing depth of the station fished ranging between 20 – 28° C (Table 1).

Red snapper female FL ranged from 256 to 737 millimeters, and male FL ranged from 215 to 730 millimeters. The highest proportion of red snapper captured measured between 400 and 500 millimeters FL (female average 465 mm, male average 473 mm; Figure 5). Whole weights of the fish ranged from 0.1 to 6.3 kilograms, with the highest proportion weighing between 1 to 2 kilograms (Figure 6). Female weights ranged from 0.3 and 5.7 kilograms and males from 0.1 to 6.3 kilograms.

Age composition

Of the total number of red snapper, 1871 (Females= 817, Males=1054) were assigned ages, with the highest proportion being age 5 (average age = 5 for either sex). Fish over the age of 10 were scarce, and the oldest was 19 years of age. The oldest caught female was 17 years with a FL of 644 millimeter and weight of 4.3 kilograms. The oldest male was 19 years with a FL of 671 millimeters and weight of 5.8 kilograms (Figures 7 and 8). Ages for male and female individuals increased with size and weight; the greatest rate of change occurring during the first five years.

Reproduction

A total of 1904 red snapper gonads were removed and weighed, with weights ranging from 0.9 to 121 grams for females and 1 to 207 grams for males (Figure 10), and both trends increased with size. However clusters of individuals exhibited low gonad weights even with their large body sizes. The gonadosomatic index (GSI) was also calculated for both male and female red snapper (Figure 11), with the GSI increasing from late June to early July, and decreasing from late July to early September for both sexes. Macro staging revealed the highest proportion of red snapper running ripe for females occurring in late July (Figure 12), and for males occurring in early July (Figure 13). Maturity was assessed for females collected from June through the end of August; 18 individuals were scored immature, 670 mature, 13 had uncertain maturity and 4 were discarded due to anomalies in preparation or sampling. Mature individuals were found in all size bins (Table 3) and in all age classes (Table 4), there were no immature individuals after FL 450-499 millimeters and age 5.

Spawning individuals were observed throughout the duration of the survey, with the highest fraction recorded during the first 10 days of the survey, June 27-July 6 (Table 5). Spawning was also observed in all size bins, with the highest fraction being fish with FL between 600 and 649 millimeters (Table 6). In respect to age, spawning fraction was generally equivalent between ages 4 and 8 (0.32 – 0.39), lower for ages 2 & 3 (0.2-0.3) and higher for age 9 (0.42). After age 9 there were limited number of samples from which to draw inference (Table7).

A total of 58 red snapper females were selected for batch fecundity estimation. The average batch fecundity was 39459 eggs (Table 8) and the estimates varied from 1375 to 263024 eggs (Figure 15 and 16). Values for relative batch fecundity ranged from 0.8 to 72.6 eggs/g with an average of 18.1 eggs/g ovary-free body weight.

Discussion

The red snappers sampled during this study helped augment the number of biological samples and data necessary to develop parameters for the western Gulf of Mexico and to better understand the status of the red snapper fisheries of this under-sampled area. In addition, the study helped provide reproductive parameters that are area-specific. This survey returned somewhat larger and older red snapper on average than did a large scale synoptic survey conducted from the western Gulf in 2011 using similar vertical line gear (c.f. Campbell et al., 2012). In 2011 western red snapper caught on vertical lines with all hook sizes (8/0 to 15/0) averaged 457 mm TL and age 4.7 years compared to this study with females averaging 465 mm FL and age 5 years caught using 10/0 hook size. Relatively high frequencies of large and old red snapper have been sampled from south Texas (grids 20 and 21) compared to elsewhere within the U.S. Gulf (SEDAR 31 stock assessment report). However, the predominance of larger and older age red snapper was detected from long-line gear captures as opposed to vertical hook and line gear (Campbell et al., 2012 and Figure 9). Thus while grid 21 may return higher proportions of larger and older ages than areas elsewhere surveyed, this survey generally returned young adults (averaging 5 years of age) as a result of the gear and hook size used. This may have implications for the interpretation of reproductive output which we explore further below.

The sampled individuals were predominantly male, with female spawning thoughout the duration of the survey (June through September) coinciding with months of peak spawning (June-August) well established in U.S waters of the Gulf of Mexico (Brown-Peterson et al., 2018). However, we were not able to begin sampling during the time just preceding and during the onset of spawning; likely April and/or May based on gonadosomatic and spawning fraction results. Sampling during these months could have allowed us to intercept more fish still experiencing recrudescence and development.

Some immature females were encountered, but most showed indicators of maturity. There were difficulties estimating maturity benchmarks due to the lack of contrast between smaller and younger individuals, and larger and older ones. The scarcity of females deemed immature made it impractical to generate a maturity ogive via logistic model fit. This has been noted in other studies wherein red snapper were targeted from gears such as trawls in order to more certainly obtain small sized immature individuals (Cook et al., 2009).

Batch fecundity increased with age and size as a function of increasing body volume (as evidenced by GSI) (Figure 15 and 16). However, relative batch fecundity (average = 18 eggs/g) was lower than estimates observed elsewhere. Relative batch fecundity in the eastern Gulf, while decreasing over time, ranged from 70.7 eggs/g in 1991 to 51.4 eggs/g in 2017 (Brown-Peterson et al., 2018). Our grid 21 fecundity result was even lower than estimates of relative batch fecundity from other studies of the western Gulf (33 eggs/g in 1994 to 32.2 eggs/g in 2017; Brown-Peterson et al 2018). Based on our knowledge of prior studies, compiled fecundity results in Brown-Peterson 2018 from the western Gulf likely were from grids north and east of grid 21.

Spawning fraction results also indicate lower reproductive output for grid 21 females. For example spawning fractions of 0.32 to 0.42 were observed for ages 4 to 9. However from a previous study, western Gulf spawning fraction ranged from 0.31 to 0.75 for ages 4 to 9 and eastern Gulf spawning fraction ranged 0.6 to 0.75 for ages 4 to 9 (Fitzhugh et al., 2017). Similar regional differences are seen with spawning fraction by size (Figure 14). As with fecundity, we are fairly certain that previous spawning fraction results from the western Gulf were primarily obtained from areas north and east of grid 21.

As indicated earlier, the results of a large scale synoptic survey (Campbell et al., 2012) and results of long-line surveys (SEDAR 31 and 52 stock assessment reports) have indicated that the western Gulf (in particular, south Texas grid 21), is a locale within the Gulf of Mexico with perhaps the largest and oldest components of the red snapper stock. As with other reproductive studies however, we did not sample larger and older components of the stock but rather obtained more young adults (average 5 years; cf Brown-Peterson et al., 2018) potentially as a result of vertical line gear selection. Our finding of overall low reproductive output at size and age for young females from grid 21, lower than even other areas of the western Gulf, may be indicative of the age diversity of the stock in grid 21. That is, the reduced egg production of young females may reflect a shift in reproductive success and production by larger and older females, albeit difficult to sample in numbers. Further exploration of these data may be fruitful as demographic and reproductive traits were collected together with infrequently collected covariates including precise location, depth and body temperature.

As Gulf red snapper continues to respond to stock rebuilding, sampling for reproductive traits, timed to the several months-long spawning season, will be needed for assessment models to provide meaningful updates of spawning stock biomass. Because management is becoming more regionally tuned within U.S. Gulf waters, there is an increased need for more spatially explicit sampling as well. Under sampling has occurred in some areas such as south Texas because fishing intensity may be lower, or habitat and survey grounds may be less known, but these areas nonetheless provide important contrast. Additionally, because we suspect that reproductive potential at age may be increasing among older ages within a recovering population (Porch et al., 2013, Brown-Peterson et al., 2018) our sampling must be capable of detecting such a change. We recommend periodic synoptic sampling as was conducted during the 2011 congressional supplemental sampling program (Campbell et al., 2012), particularly using gears capable of sampling oldest and largest components of the Gulf red snapper population.

Acknowledgments

We thank the Captain and Crew of the *F/V Miss Directed*, Daniel Cole (Captain), Jordan Beck, D. J. Lerma and Kyle Grayson.

Literature Cited

Allman, R.J. and G.R. Fitzhugh. 2007. Temporal age progressions and relative year-class strength of Gulf of Mexico red snapper. Pages 311-328 in: W.F. Patterson, III, J. H. Cowan, Jr., G.R. Fitzhugh, and D.L. Nieland, editors. Red snapper ecology and fisheries in the in the U.S. Gulf of Mexico. American Fisheries Society, Symposium 60, Bethesda Maryland.

Allman,R., B. Barnett, H. Trowbridge, L. Goetz, and N. Evou. 2012. Red snapper (Lutjanus Campechanus) otolith ageing summary for collection years 2009-2011. Panama City Laboratory Contribution Series 12-03.

Brown-Peterson, N. J., D. M. Wyanski, F. Saborido-Rey, B. J. Macewicz, and S. K. Lowerre-Barbieri. 2011. A standardized terminology for describing reproductive development in fishes. Mar. Coast. Fish. 3:52–70.

Brown-Peterson, N.J., C.R. Peterson and G.R. Fitzhugh. 2018. Multi-decadal meta-analysis of the reproductive parameters of female red snapper (*Lutjanus compechanus*) in the northern Gulf of Mexico. Fishery Bulletin, U.S. 117:37-49.

Campbell, M., A. Pollock, T. Henwood, J. Provaznik, and M. Cook. 2012. Summary report of the red snapper (*Lutjanus campechanus*) catch during the 2011 congressional supplemental sampling program. SEDAR31-DW17. 26 p.

Cook, M., B. K. Barnett, M. S. Duncan, R. J. Allman, C. E. Porch, and G. R. Fitzhugh. 2009. Characterization of red snapper (Lutjanus campechanus) size and age at sexual maturity for the 2009 Gulf of Mexico SEDAR update. Panama City Laboratory Contribution Series 09-16, Panama City, FL, USA.

Hunter J.R., N.C.H. Lo, and R.J.H. Leong. 1985. Batch fecundity in multiple spawning fishes. Pp 67-78 in R. Lasker (ed), An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. NOAA Technical Report NMFS 36.

Fitzhugh, G.R., E.T. Lang and H. Lyon. 2012. Expanded annual stock assessment survey 2011: Red snapper reproduction. SEDAR 31. SEDAR31-DW-07. North Charleston, S.C. 31 pp.

Fitzhugh, G.R., H.M. Lyon, V.C. Beech, and P.M. Colson. 2017. Reproductive data compiled for the Gulf of Mexico Red Snapper, Lutjanus campechanus, SEDAR 52. SEDAR52-WP-15. SEDAR, North Charleston, SC. 5 pp.

Lowerre-Barbieri, S. K., N. J. Brown-Peterson, H. Murua, J. Tomkiewicz, D. Wyanski, and F. Saborido-Rey. 2011. Emerging issues and methodological advances in fisheries reproductive biology. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 3: 32–51.

Porch, C.E., G.R. Fitzhugh, and B.C. Linton. 2013. Modeling the dependence of batch fecundity and spawning frequency on size and age for use in stock assessments of red snapper in U.S. Gulf of Mexico waters. SEDAR31-AW03.

Wallace, R., & Selman, K.. 1981. Cellular and Dynamic Aspects of Oocyte Growth in Teleosts. *American Zoologist*, *21*(2), 325-343.

Table 1. Catch summary for red snapper. Recordings were made at each station for sea surface temperature (SST) and mean internal fish temperature (MIT). Fish count is red snapper only.

Date	Trip	Station	No. of sets	Time	Depth (m)	SST(°C)	MIT(°C)	Latitude	Longitude	Fish Count	% Female
6/27/2017	1	1	15	7:40	69.0	28.7	25.0	26.04933	96.44231	24	47.7
		2	18	10:38	63.0	28.7	25.0	26.05122	96.47824	11	
		3	4	12:45	60.4	28.8	26.7	26.06537	96.49361	32	
		4	6	16:07	40.2	29.0	27.2	26.04497	96.81453	32	
		5	11	17:35	37.5	29.0	27.3	26.08328	96.87488	31	
6/28/2017	2	1	11	11:35	67.8	28.5	25.3	26.16113	96.44106	30	39.0
		2	12	15:00	48.5	28.5	25.9	26.15088	96.57753	30	
		3	11	16:33	46.8	29.0	25.6	26.15552	96.63285	30	
		4	9	18:35	40.3	29.0	27.5	26.11605	96.81727	15	
		5	8	19:27	39.5	29.1	27.7	26.11422	96.83604	13	
7/11/2017	3	1	13	7:53	73.7	29.0	22.5	26.21067	96.40190	28	38.5
		2	12	10:30	96.9	29.0	20.2	26.26695	96.34097	28	
		3	5	13:03	86.3	29.1	20.8	26.33257	96.35147	28	
		4	15	15:33	81.9	29.1	20.8	26.38085	96.36680	26	
		5	6	17:45	76.1	29.2	21.5	26.35231	96.39596	33	
7/13/2017	4	1	5	7:00	63.4	28.1	22.3	26.19378	96.45582	30	38.9
		2	9	8:30	63.8	28.3	23.5	26.22321	96.43124	29	
		3	8	11:45	73.1	29.0	22.6	26.36189	96.43688	30	
		4	15	14:15	81.4	29.0	20.9	26.46603	96.44313	21	
		5	4	16:30	79.7	29.1	21.9	26.47254	96.45866	34	
7/18/2017	5	1	10	7:45	42.1	29.4	26.4	26.47240	96.72153	30	51.1
		2	9	9:15	46.1	29.5	26.5	26.46981	96.96125	32	
		3	22	13:00	34.6	29.2	26.4	26.40761	96.95681	26	
		4	12	15:10	31.7	29.2	26.7	26.41026	96.98356	15	
		5	8	17:02	29.7	29.2	27.0	26.43582	97.00904	30	

Date	Trip	Station	No. of sets	Time	Depth (m)	SST (°C)	MIT (°C)	Latitude	Longitude	Fish Count	% Female
7/20/2017	6	1	6	7:49	43.0	29.6	27.0	26.40124	96.74402	32	39.5
		2	19	10:53	36.4	29.4	26.8	26.35624	96.90262	23	
		3	5	13:23	33.7	29.6	27.5	26.37193	96.95918	30	
		4	13	14:43	34.5	29.7	27.5	26.39904	96.94878	37	
		5	16	16:35	29.6	29.4	27.5	26.39382	96.99849	30	
7/20/2017	7	1	4	7:27	79.7	29.2	23.2	26.49050	96.49293	34	44.4
		2	11	9:20	103.0	29.4	20.7	26.54908	96.42823	9	
		3	7	14:25	46.3	29.8	24.9	26.53479	96.42524	33	
		4	4	16:05	44.8	29.7	25.6	26.52203	96.74520	32	
7/29/2017	8	1	7	9:20	96.4	29.6	21.8	26.65302	96.55505	32	45.3
		2	7	11:48	84.1	29.7	22.3	26.63760	96.58598	30	
		3	11	13:30	86.5	29.9	21.9	26.65014	96.59795	31	
		4	9	15:45	83.5	30.0	21.6	26.65852	96.61919	28	
		5	5	17:50	83.9	29.8	21.6	26.65606	96.62885	29	
7/31/2017	9	1	5	8:20	76.2	29.6	23.7	26.72564	96.67740	30	44.7
		2	5	9:20	73.0	29.8	23.1	26.73882	96.69132	31	
		3	6	10:37	73.5	30.0	22.8	26.76426	96.70067	34	
		4	3	11:45	71.4	30.0	22.8	26.77329	96.73296	31	
		5	3	13:15	70.6	30.0	22.9	26.78127	96.75542	33	
8/21/2017	10	1	5	8:22	70.0	29.8	22.8	26.87202	96.75923	31	40.9
		2	13	9:34	63.1	29.8	25.2	26.88082	96.77106	30	
		3	15	13:15	62.1	30.0	22.5	26.95372	96.81734	28	
		4	3	15:20	60.7	30.0	24.7	26.95961	96.81615	30	
		5	10	16:05	64.2	30.0	24.2	26.95799	96.80793	30	

Date	Trip	Station	No. of sets	Time	Depth (m)	SST (°C)	MIT (°C)	Latitude	Longitude	Fish Count	% Female
8/23/2017	11	1	4	9:25	61.3	29.9	24.4	26.21599	96.49653	32	36.4
		2	4	10:35	53.1	30.0	25.4	26.23351	96.55906	30	
		3	12	12:17	53.8	30.1	24.9	26.34494	96.56473	6	
		4	4	16:13	53.7	30.3	26.8	26.44281	96.60471	34	
		5	5	18:20	58.1	30.2	25.6	26.24714	96.52542	30	
8/31/2017	12	1	5	8:10	48.1	29.3	25.2	26.22473	96.61923	1	50.4
		2	4	9:58	46.2	29.0	26.5	26.26980	96.66457	36	
		3	6	12:25	46.7	31.0	27.0	26.39894	96.62829	31	
		4	5	13:45	53.2	30.3	26.4	26.46538	96.62238	33	
		5	4	17:05	46.3	29.7	25.7	26.15903	96.63838	32	
9/1/2017	13	1	6	8:53	39.5	28.0	27.8	26.33322	96.81460	32	44.9
		2	4	10:45	45.3	28.6	27.2	26.31564	96.68235	33	
		3	4	12:03	46.2	28.7	26.7	26.22889	96.67108	34	
		4	5	13:22	43.7	28.8	26.8	26.17567	96.72964	37	
		5	6	15:23	41.4	28.8	27.5	26.20434	96.76817	31	
9/13/2017	14	1	5	7:25	33.6	27.5	28.6	26.15134	96.92055	30	51.4
		2	3	9:17	38.6	27.4	28.0	26.21838	96.85549	33	
		3	8	10:33	37.3	27.5	28.1	26.24432	96.87826	10	
		4	6	12:15	37.5	27.9	27.7	26.27926	96.88202	32	

Table 2: Catch summary of other sampled species (LS-Lane Snapper, SCA-Scamp, VS-Vermilion Snapper)

Date	Trip	Station	No. of sets	Time	Depth (m)	SST (°C)	MIT (°C)	Latitude	Longitude	Fish Count
6/27/2017	1	2	18	10:38	63.0	28.7	25.0	26.05122	96.47824	3 VS
7/18/2017	5	3	22	13:00	34.6	29.2	26.4	26.40761	96.95681	2 LS
		4	12	15:10	31.7	29.2	26.7	26.41026	96.98356	1 LS, 1 VS
7/27/2017	7	2	11	9:20	103.0	29.4	20.7	26.54908	96.42823	1 SCA, 1 VS

Table 3. Female maturity assignment by size (mm)

Fork Length (mm)	**Immature**	**Mature**	**Total**	**% Maturity (Observed)**
250-299	2	8	10	80%
300-349	2	52	54	96%
350-399	6	103	109	94%
400-449	7	140	147	95%
450-499	1	124	125	99%
500-549		114	114	100%
550-599		78	78	100%
600-649		39	39	100%
650-699		8	8	100%
700-749		4	4	100%
Total	18	670	688	-

Table 4. Female maturity assignment by age (years)

Age (Years)	**Immature**	**Mature**	**Total**	**% Maturity (Observed)**
1		2	2	100%
2	6	49	55	89%
3	8	85	93	91%
4	2	82	84	98%
5	2	156	158	99%
6		104	104	100%
7		76	76	100%
8		54	54	100%
9		23	23	100%
10		16	16	100%
11		5	5	100%
12		3	3	100%
13		3	3	100%
14		1	1	100%
15		1	1	100%
16		2	2	100%
17		1	1	100%
Total	18	663	681	-

Table 5. Spawning fraction of female red snapper analyzed in days of the year during the period of the survey.

Time Bin (days of year)	Spawning markers absent	Spawning markers present	Total	Spawning fraction
170-179	56	48	104	0.462
190-199	136	40	176	0.227
200-209	65	42	107	0.393
210-219	85	51	136	0.375
230-239	69	40	109	0.367
240-249	102	39	141	0.277
250-259	46	7	53	0.132
Total	559	267	826	-
Average across time with spawning markers present				0.32

Table 6. Spawning fraction of female red snapper analyzed by fork length.

FL (mm)	Spawning markers absent	Spawning markers present	Total	Spawning Fraction
250-299	13	3	16	0.19
300-349	42	24	66	0.36
350-399	82	44	126	0.35
400-449	139	35	174	0.20
450-499	103	48	151	0.32
500-549	90	46	136	0.34
550-599	56	40	96	0.42
600-649	24	23	47	0.49
650-699	7	3	10	0.30
700-749	3	1	4	0.25
Total	559	267	826	-
Average across time bins with spawning markers present				0.32

Table 7. Spawning fraction of female red snapper analyzed by Age (n=804). A total of 22 fish could not be aged.

Final Age	Spawning markers absent	Spawning markers present	Total	Spawning fraction
1	6	1	7	0.14
2	52	22	74	0.30
3	104	26	130	0.20
4	66	34	100	0.34
5	120	71	191	0.37
6	69	44	113	0.39
7	50	27	77	0.35
8	38	18	56	0.32
9	14	10	24	0.42
10	12	4	16	0.25
11	5		5	
12	1	2	3	0.67
13	2	1	3	0.33
14	1		1	
15		1	1	1.00
16	2		2	0.00
17	1		1	0.00
Grand Total	543	261	804	-
Average across ages with spawning markers present				0.34

Table 8: Batch Fecundity summary for red snapper (n=58).

	Egg count	Batch Fecundity Estimate	Relative batch fecundity
Average	183	39459	18.1
Minimum	15	1375	0.8
Maximum	500	263024	72.6
Standard dev.	124	50940	18.4

Figure 1. Vertical line fishing gear deployed using rod and electric reel.

Figure 2. Example of maturing hydrated oocytes enumerated for estimates of batch fecundity.

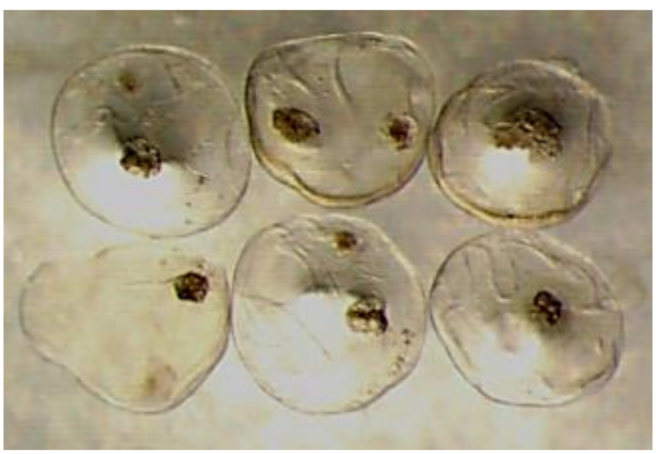


Figure 3: Bathymetry and habitat within Statistical Reporting Grids 19, 20 and 21 with eight focus areas identified or could say areas of interest.

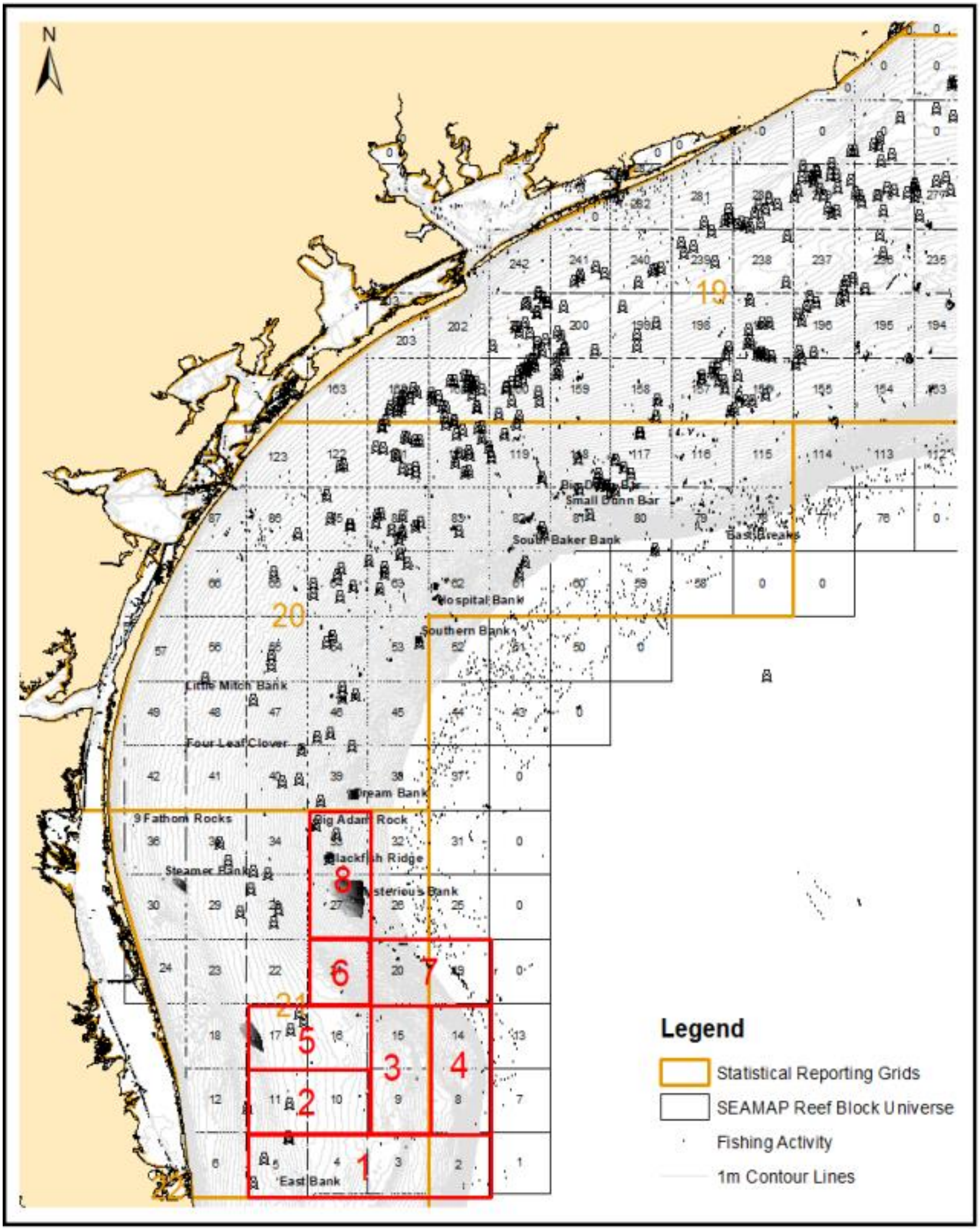


Figure 4: Station locations for the F/V Miss Directed. Station locations and counts for red snapper only.

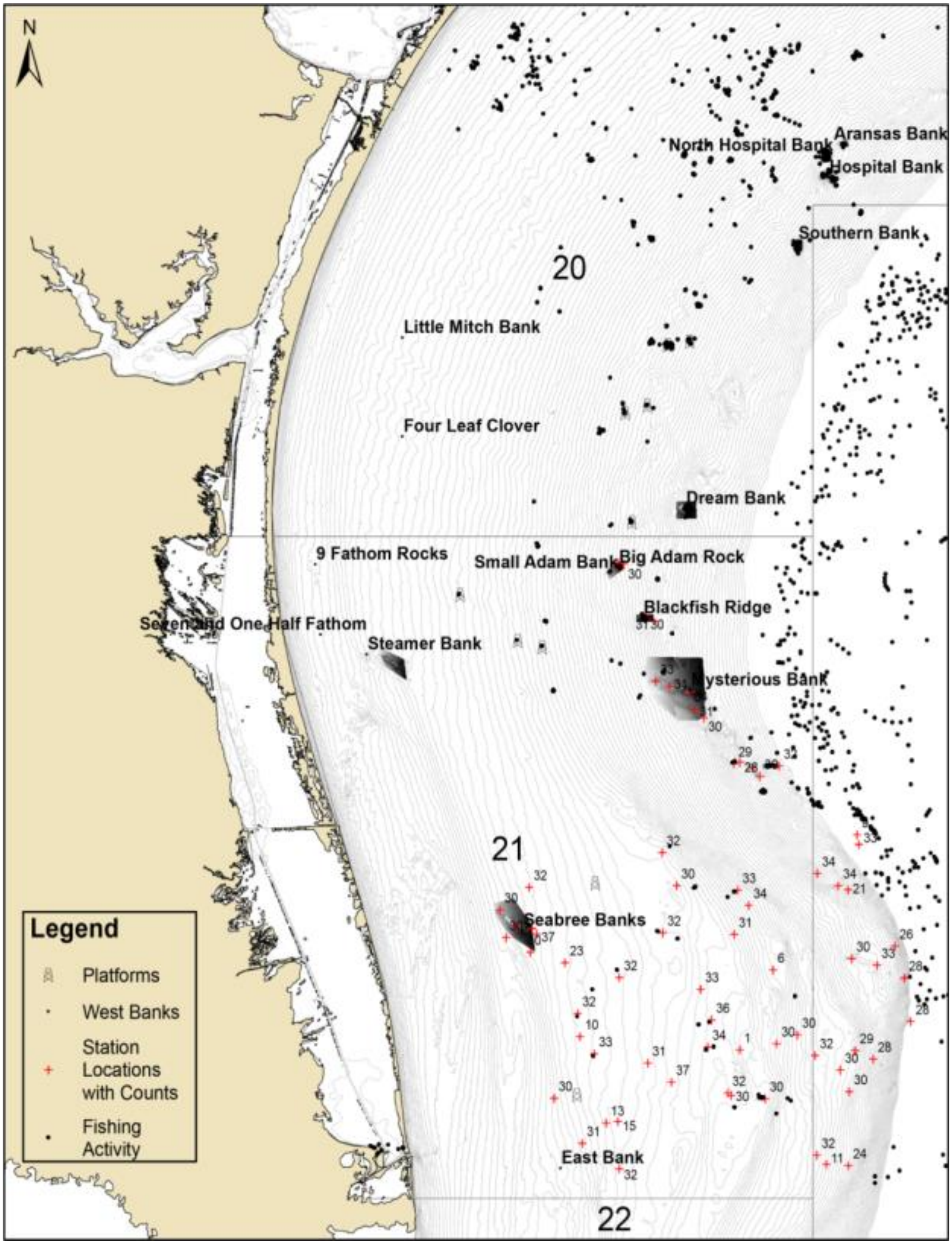


Figure 5: Distribution of red snapper by fork length (n=1923).

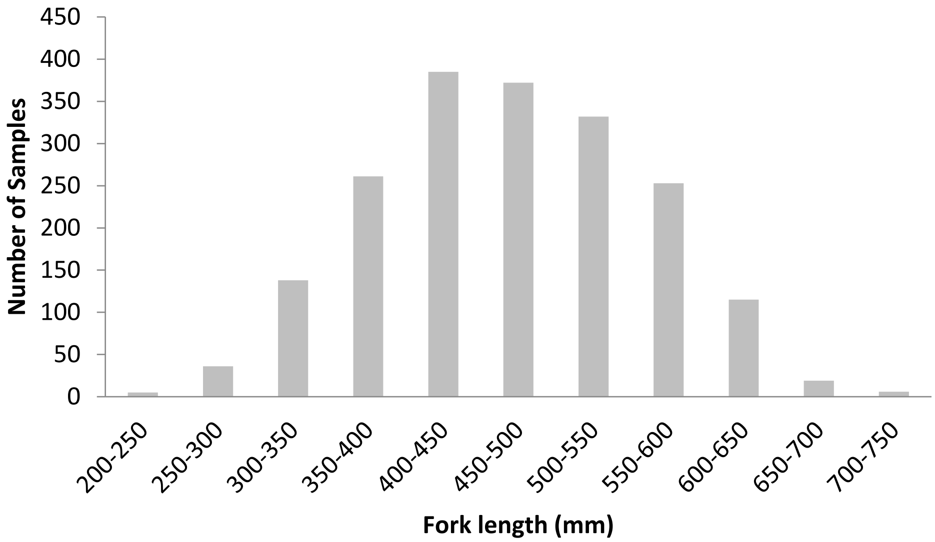


Figure 6. Distribution of red snapper by weight (n=1923).

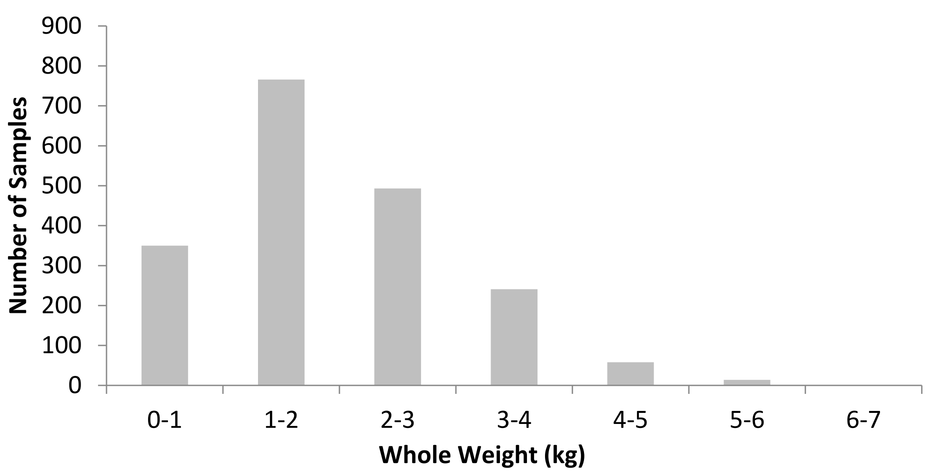


Figure 7: Fork Length at age for red snapper (n=1871).

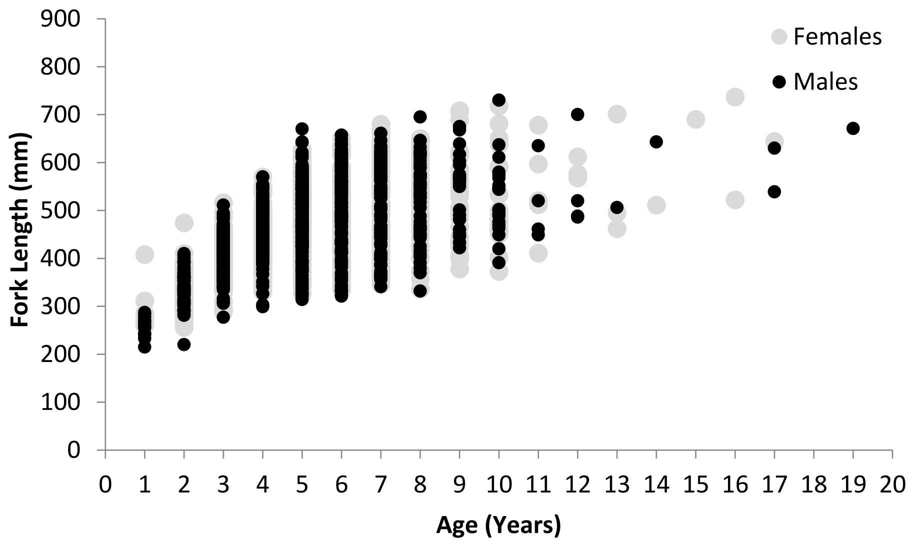


Figure 8: Whole Weight (kg) at age for red snapper (n=1871).

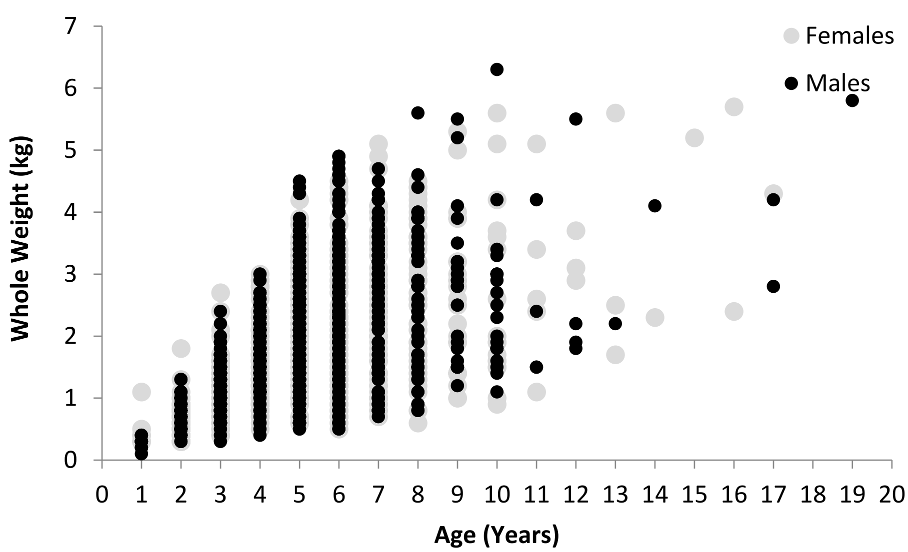


Figure 9: Frequency of red snapper by age intercepted during this study (n=1871) and the 2000-2017 bottom long-line SEAMAP survey (Mississippi Laboratories) (n=116) in Grid 21.

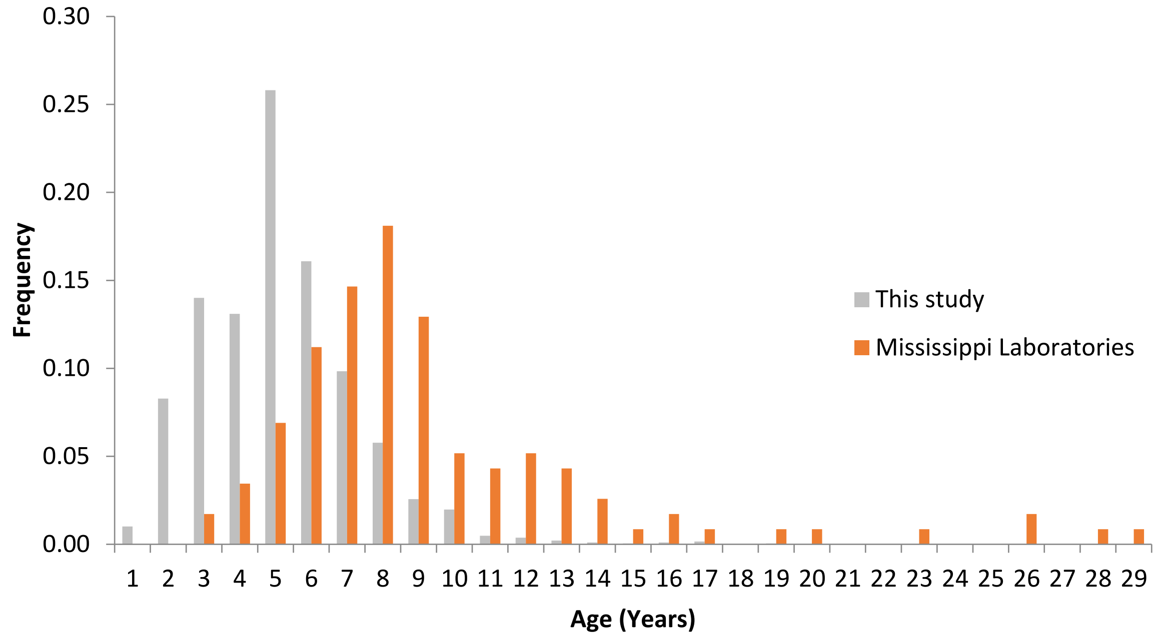


Figure 10: Gonad weight (g) at size

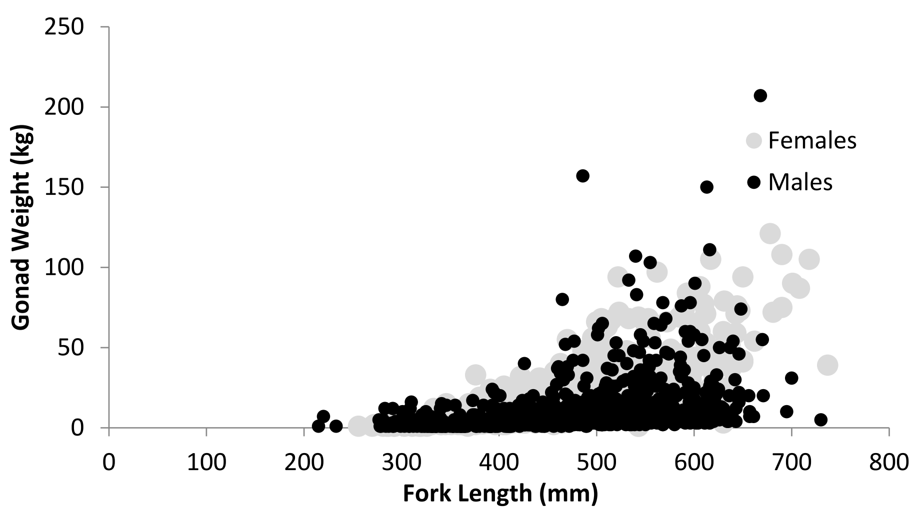


Figure 11: Red snapper gonadosomatic index by date. Two males not shown (GSI = 5.6 &7.7).

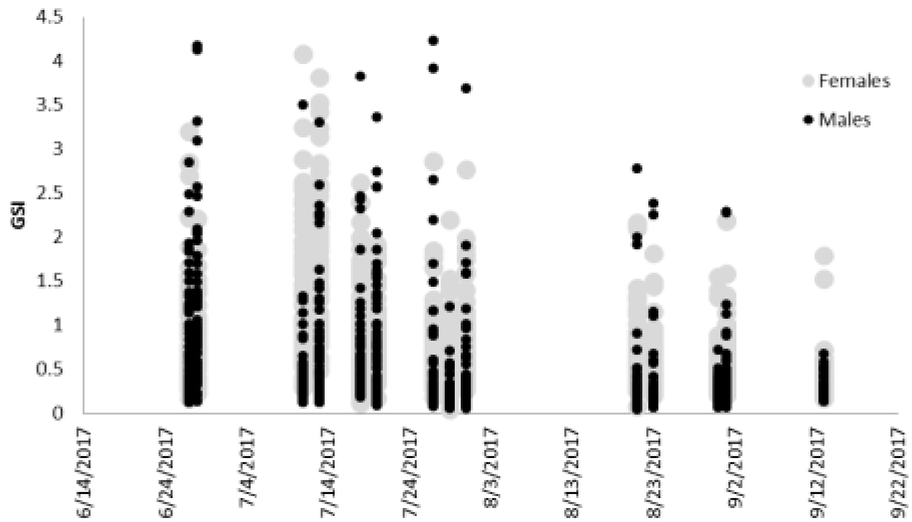


Figure 12: Proportion of females running ripe by date.

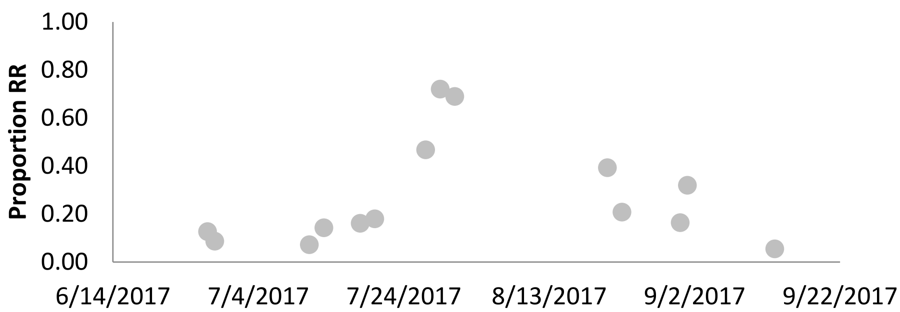


Figure 13: Proportion of males running ripe by date.

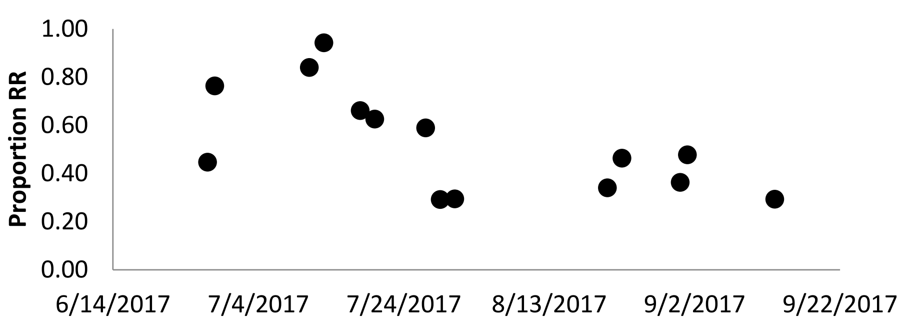


Figure 14: Female spawning fractions by size contrasting results from this study and a previous report for the eastern and western regions of the U.S. Gulf of Mexico (Fitzhugh et al., 2017)

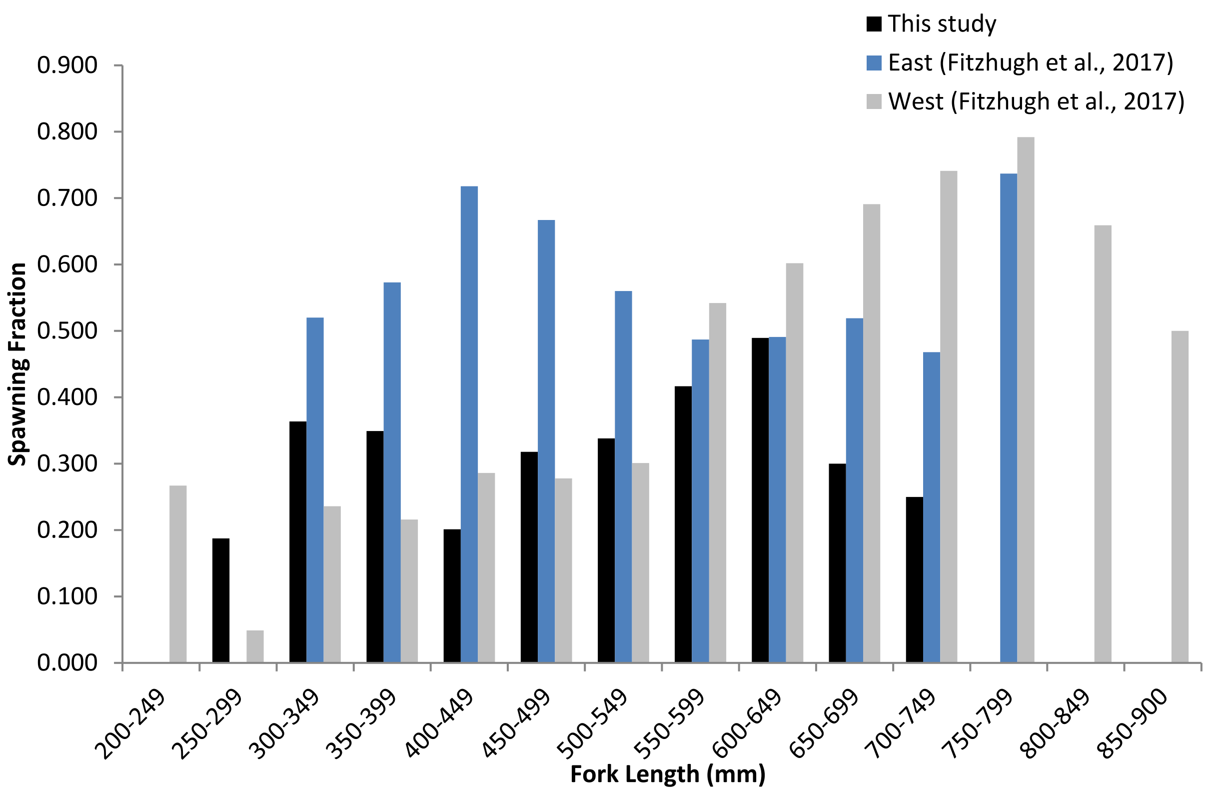


Figure 15. Batch fecundity as a function of fork length (n=58).

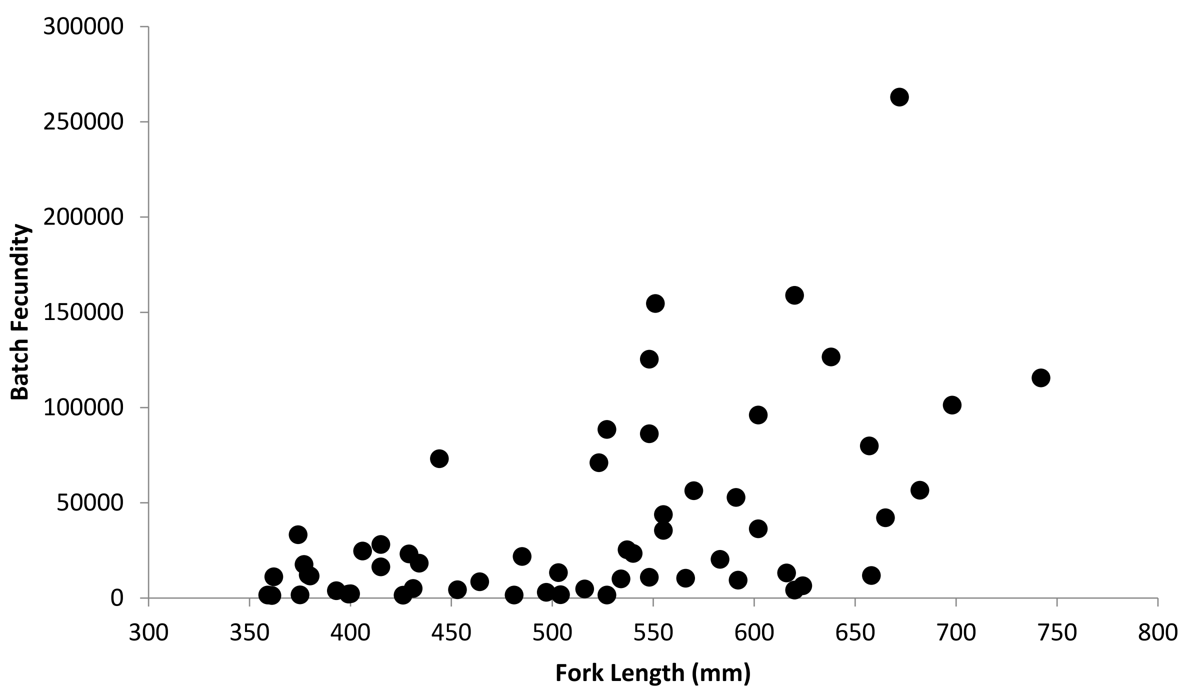


Figure 16. Batch Fecundity as a function of age (n=56).