Mississippi Red Snapper Data Summary

Trevor Moncrief

SEDAR74-SID-04

12 March 2021

Please cite this document as:

Moncrief, Trevor. 2021. Mississippi Red Snapper Data Summary. SEDAR74-SID-04. SEDAR, North Charleston, SC. 16 pp.

Mississippi Red Snapper Data Summary

Submitted by: Trevor Moncrief, Mississippi Department of Marine Resources

Study Background and Motivation

NFWF Reef Fish related activities (the Survey) began in 2016 after the recognition of information-gaps in Mississippi's offshore areas. A primary focus of this work is to perform extensive fishery independent (FI) monitoring using vertical long line (VLL) sampling gear.

Survey area domain is 7,095 km^2 in the Mississippi Bight (Figure 1). Monthly stations (March through October; n = 23) were randomly allocated into three depth strata and habitat strata. In the shallow strata (< 20m) and mid strata (20-49m) we sampled, 3 Fish Havens, 3 Oil/Gas platforms, and 2 non-structure stations. In the 50-100m depth stratum we sampled, 2 Rigs to Reef, 3 Oil/Gas Platforms, and 2 non-structure sites. Vertical longline procedures follow NMFS' Southeast Area Monitoring and Assessment Program (SEAMAP) protocols. Sampling gear consisted of three bandit reels rigged with a 24-foot back bone that was outfitted with ten 18-inch gangions spaced two feet apart and a ten-pound weight at the terminal end. All gangions of a backbone were rigged with one hook size (8/0, 11/0, or 15/0 circle hooks of zero offset) and baited with Atlantic Mackerel, *Scomber scombrus*. All rigs were fished on the bottom simultaneously for five minutes prior to retrieval. Table 1 presents the meta data characteristics of fish sampling pertinent to this report.

The programmatic scope of the Survey work involved seven separate but inter-related tasks (vertical line sampling, age and growth, reproduction, trophic ecology, water quality, fishery dependent monitoring). This report will focus on the age and growth and reproduction aspects only.

Table 1. Meta data characteristics of fish sampling relevant to this report.

Feature.Name	Units	Method
Species	alpha	
Month	categorical	
Year		
Date		
Reef Type		
Structure Type	categorical	1=platform, 2=artificial reef, 3=rigs-to-reef, 4=control
Actual Depth (FT)	feet	
Depth	categorical	1=shallow, 2=mid, 3=deep
Depth Strata	nominal	
SL	mm	
FL	mm	
TL	mm	

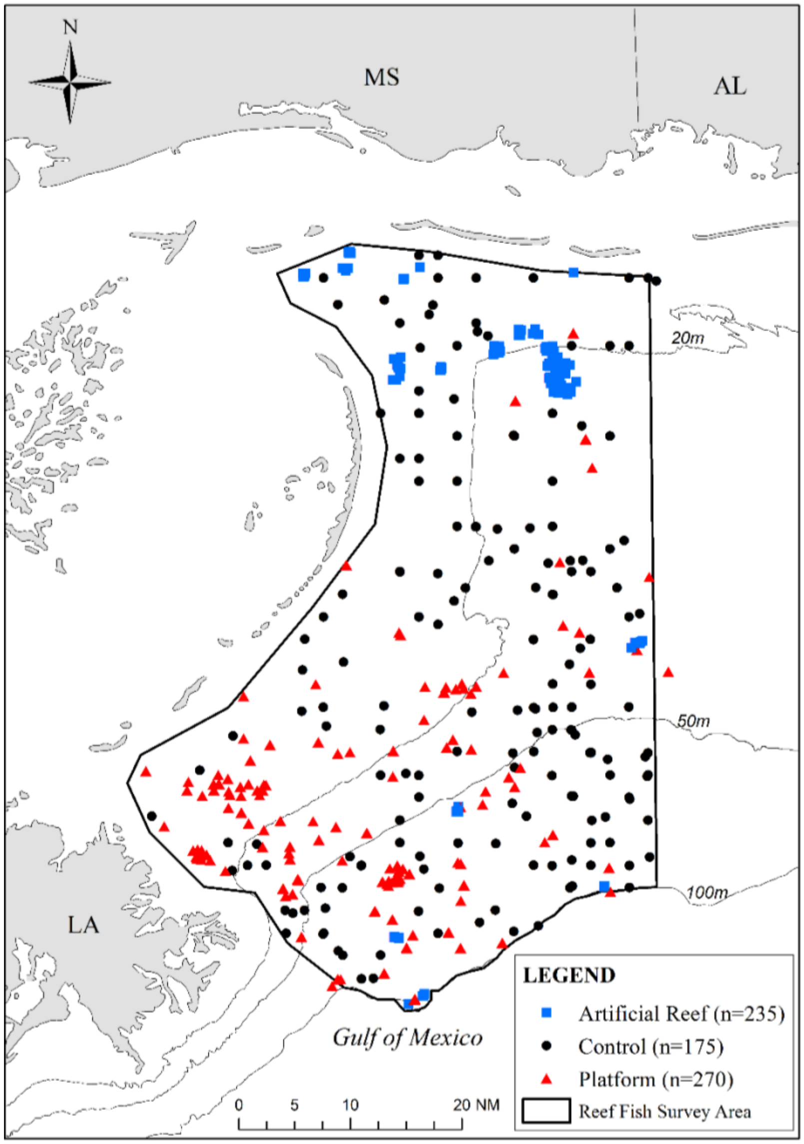

Figure 1. Sampling domain for the Survey and representative sampling from 2016 to 2018.

Age and Growth

The purpose of this task was to assess biological metrics of age and growth of Red Snapper. In this task, sagittal otoliths were removed from fishes collected during field sampling cruises for purposes of species age determination, assessment of species age composition, and description of species age-length relationships by sex. This report summarizes the age and growth research conducted on Red Snapper from 2016 through 2019.

Sampling Characteristics

Table 2. Meta data characteristics of the age and growth data.

Feature.Name	Units	Method
TL.MM	Millimeters (mm)	Total length measured to nearest millimeter
WGT.KG	Kilograms (Kg)	Fish weighed on a digital scale (kg)
SEX	Categorical (M,F,U)	Visually determined male, female, or unknown
ANNULI.COUNT	Years	Annuli read by 3 readers from core to margin
MARGIN.CODE	Categorical (1-4)	Stage of outer edge ring formation (1-4), visually determined
MONTH	Months	
mE	Fractional age assigned to an individual fish based on the fraction of a year calculated between date of birth and collection date	Number of months from July 1 divided by 12
BIO.AGE	Time from birthdate to capture (decimal years)	Adding or subtracting mE from (annuli, annuli count -1, respectively) based on margin code
COHORT	Years	If capture month less than 7, subtracting the mE from biological age +1; if capture month 7 and above, biological age – mE

Age Determination

The following figures use the "Biological Age" as the reported age. This age estimate incorporates the annuli-determined age and is the marginal increment. This approach follows otolith processing and ageing methodologies in the Age and Growth Task SOP established for the NFWF project and the Gulf States Marine Fisheries Commission's *A Practical Handbook for Determining the Ages of Gulf of Mexico Fishes, Second Edition: GSMFC Publication No. 167* (VanderKooy 2009). Sagitta were cleaned of tissue, embedded in epoxy resin, and sectioned through the core region, typically to obtain sections 0.4 - 0.5 mm in thickness. Sections from each sagitta were polished, as needed, and mounted on glass microscope slides for viewing and assessment. Assessments included enumeration of visible rings (marks) considered annuli and the assignment of one of four otolith margin codes. Margin codes assigned to sections viewed under transmitted light were: 1 (Opaque), 2 (1/3 Translucent), 3 (1/2 Translucent), and 4 (2/3 Translucent).

Data Characteristics and Summary Results

A total of 1,202 Red Snapper were aged from the 2016 – 2019 collections. Table 3 presents summary data for aged specimens by collection year and month. The length (TL) of Red Snapper ranged from 180 mm (July 2017) to 792 mm (October. 2017), and their estimated age (y; biological age) ranged from 0.83 to 13.08 years (Table 3). Table 4 presents the summary of Red Snapper age(y) and length (TL) data by sex. Females exhibited the widest range of length and estimated age in the collection.

Table 3. Summary of age (y) and length (TL, mm) of Red Snapper processed in the Survey from 2016 to 2019.

Year	Month	Number Aged	Min Age Estimate (y)	Max Age Estimate (y)	Min TL (mm)	Max TL (mm)
2016	4	41	1.75	2.75	264	478
	5	106	1.83	10.83	272	740
	6	8	1.92	2.92	305	427
	7	16	1	2	223	751
	8	15	1.08	2.08	284	525
	9	23	1.17	10.17	264	718
	11	55	1.33	2.33	236	520
2017	4	34	1.75	2.75	296	533
	5	72	0.83	2.83	200	526
	6	39	0.92	2.92	205	525
	7	51	1	2	180	515
	8	52	1.08	2.08	239	423
	9	39	1.17	2.17	286	488
	10	41	1.25	11.25	228	792
2018	3	38	1.67	2.67	270	567
	4	76	1.75	2.75	261	647
	5	76	1.83	2.83	253	508
	6	40	1.92	2.92	260	455
	7	30	1	2	253	430
	8	13	2.08	13.08	333	779
	9	29	1.17	2.17	284	431
	10	73	1.25	2.25	211	486
2019	3	18	1.67	2.67	240	476
	4	71	1.75	2.75	245	562
	5	46	0.83	2.83	208	533
	6	43	0.92	2.92	267	453
	7	12	2	2	346	454
	8	21	1.08	2.08	183	426
	9	13	1.17	2.17	243	461
	10	24	1.25	2.25	297	444
	11	7	1.33	2.33	277	372

Table 4. Sex-specific summary of age (y) and length (TL, mm) of Red Snapper processed in the Survey from 2016 to 2019.

SEX	Number Aged	Min Age Estimate (y)	Max Age Estimate (y)	Min TL (mm)	Max TL (mm)
F	647	0.83	13.08	180	792
M	575	0.92	10.17	205	751

The number of Red Snapper collected from the mid-depth strata dominated the collections overall and represented the widest range of size (TL) (Table 5). The youngest specimen (y) was collected from the shallow depth strata, while the oldest fish (y) was caught in the deep strata (Table 5). The number of Red Snapper caught on hook sizes 8/0 and 11/0 each far outnumbered those fish caught on the 15/0 hook size (Table 6). The 8/0 hook size produced the youngest specimen in the collection and, interestingly, a maximum age estimate of only 2.92 y (Table 6).

Table 5. Habitat-specific summary of age (y) and length (TL, mm) of Red Snapper processed in the Survey from 2016 to 2019.

DEPTH.STRATA	Number Aged	Min Age Estimate (y)	Max Age Estimate (y)	Min TL (mm)	Max TL (mm)
Shallow	406	0.83	2.92	200	567
Mid	712	0.92	11.25	180	792
Deep	104	1.17	13.08	243	779

Table 6. Hook size-specific summary of age (y) and length (TL, mm) of Red Snapper processed in the Survey from 2016 to 2019.

HOOK.SIZE	Number Aged	Min Age Estimate (y)	Max Age Estimate (y)	Min TL (mm)	Max TL (mm)
11/0	512	1	10.83	183	751
15/0	98	1.17	13.08	245	792
8/0	612	0.83	2.92	180	525

The sex and year-specific distribution of age estimates (y) for Red Snapper in the collections varied little among the depth strata (Figures 2 and 3). Obvious outliers (much older fish) are noted for years 2016, 2017 and 2018. Habitat-specific distribution of length (TL) of Red Snapper in overall collections are presented in Figure 4. Hook size size-specific distribution of age estimates (y) of Red Snapper collected from the three depth strata varied little, with the exceptions of the single older fish caught on the 11/0 (deep strata) and 15/0 (mid strata) hooks, along with the notable wide range in age (y) of fish caught on the 15/0 hook from the deep strata (Figure 5). Year and habitat-specific distributions of length (TL, mm) and weight (kg) estimates of Red Snapper collected from 2016 through 2019 are shown in Figures and 6 and 7.

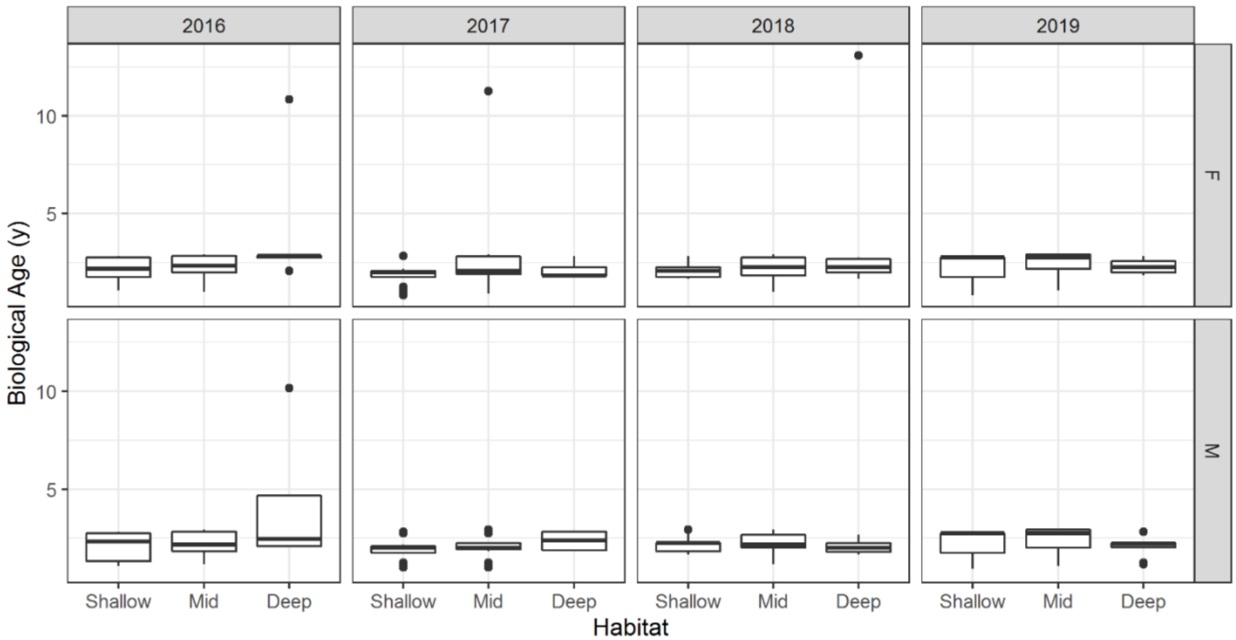

Figure 2. Sex- and year-specific distribution of age estimates of Red Snapper collected from 2016 to 2019.

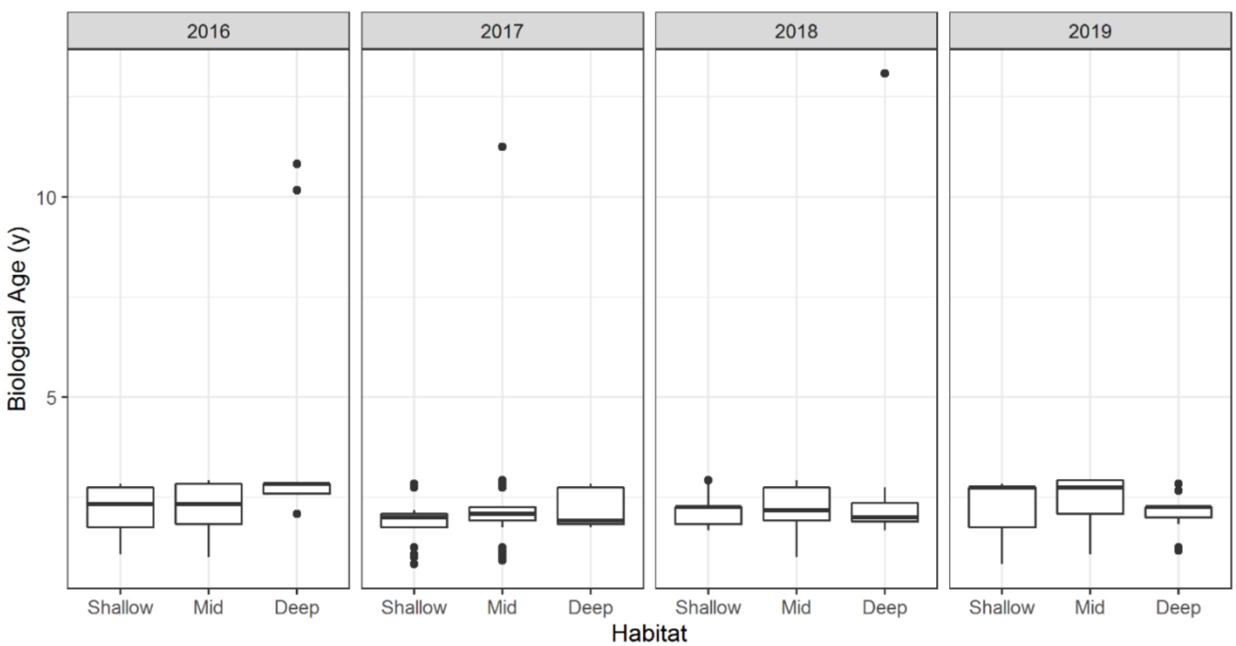

Figure 3. Year-specific distribution of age estimates of Red Snapper collected from 2016 to 2019.

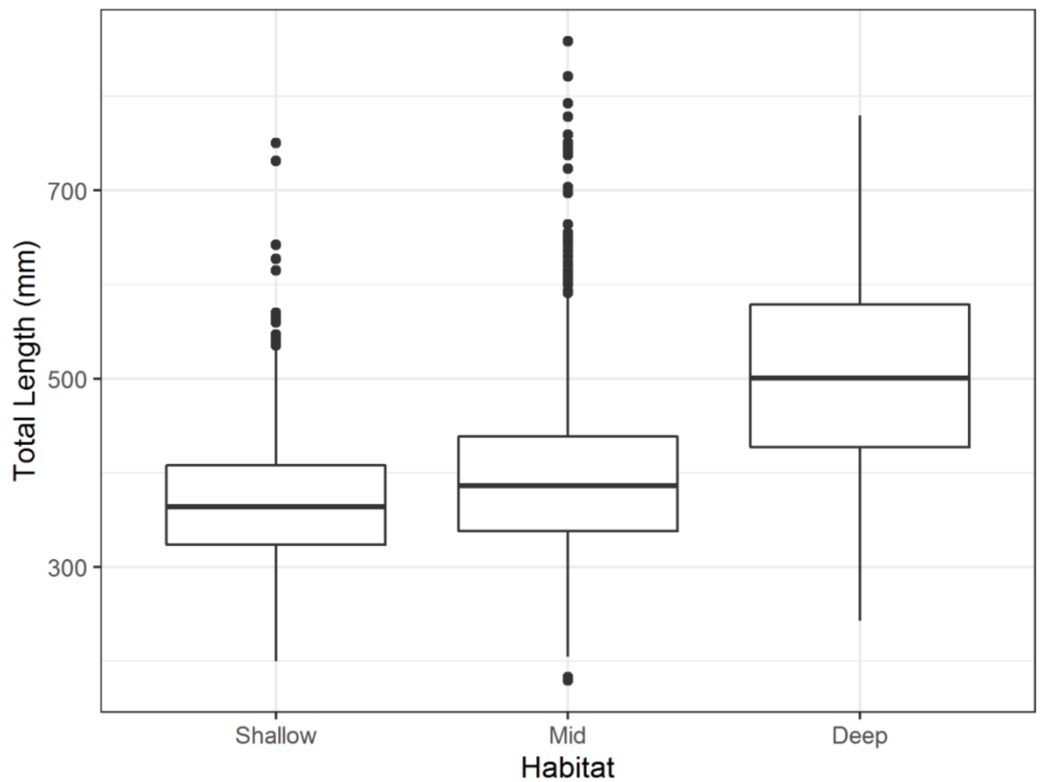

Figure 4. Habitat-specific distribution of age estimates of Red Snapper collected from 2016 to 2019.

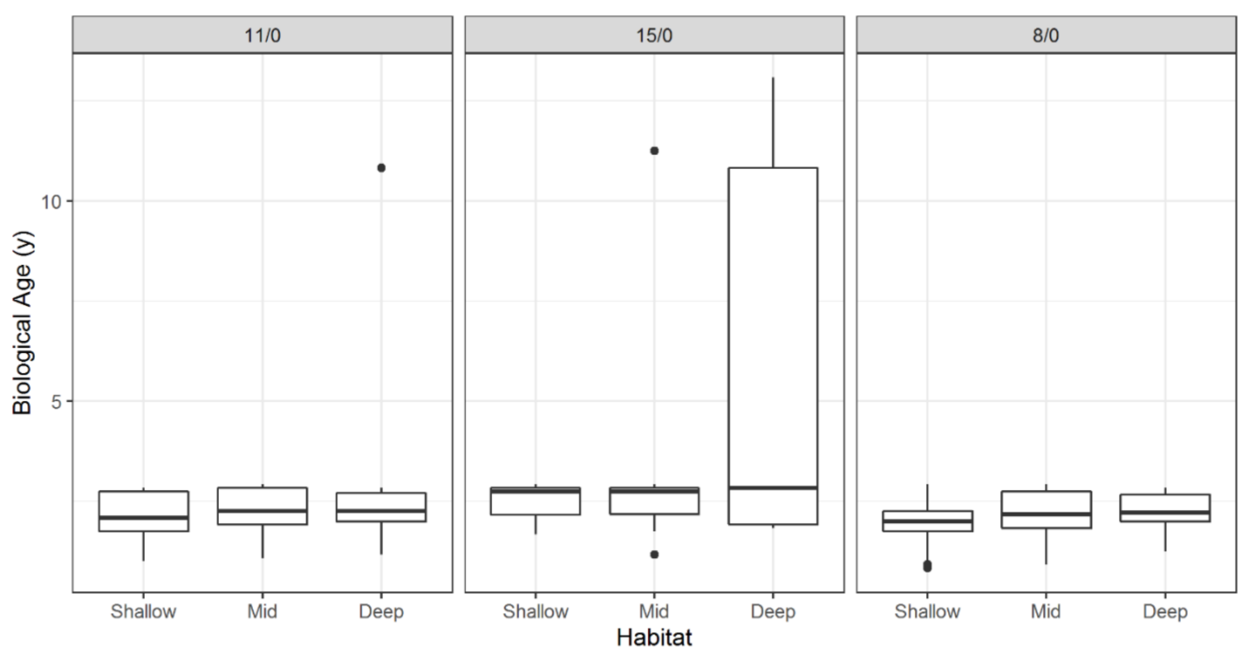

Figure 5. Hook size-specific distribution of age estimates of Red Snapper collected from 2016 to 2019.

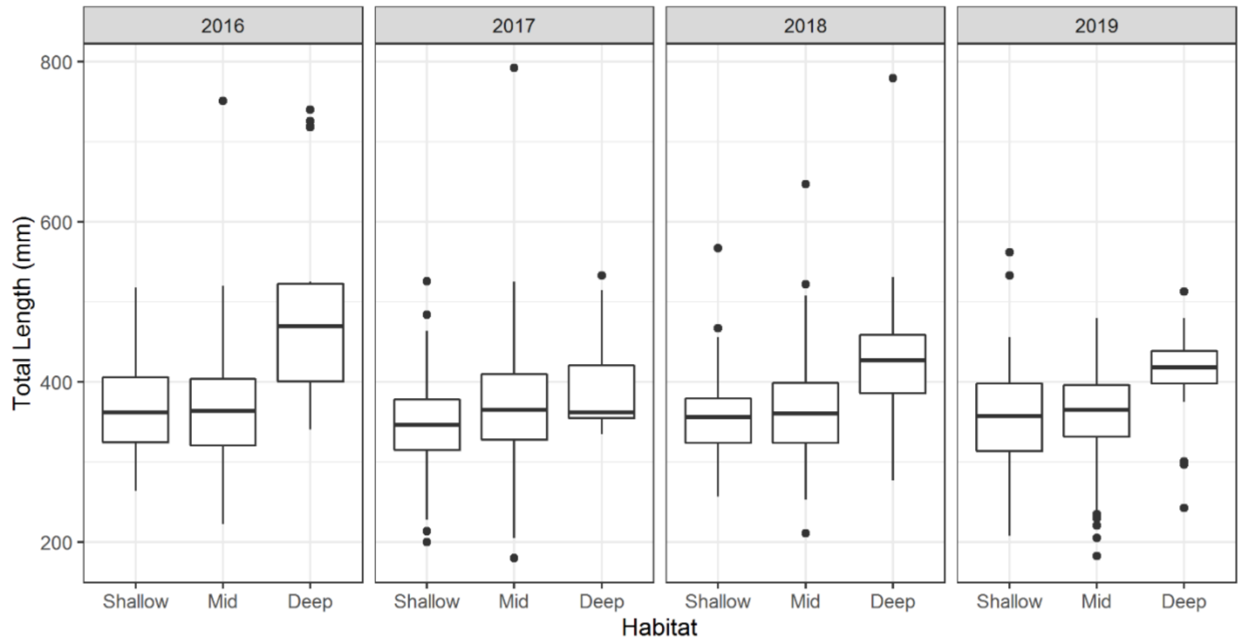

Figure 6. Year and habitat-specific distribution of length (TL, mm) estimates of Red Snapper collected from 2016 to 2019.

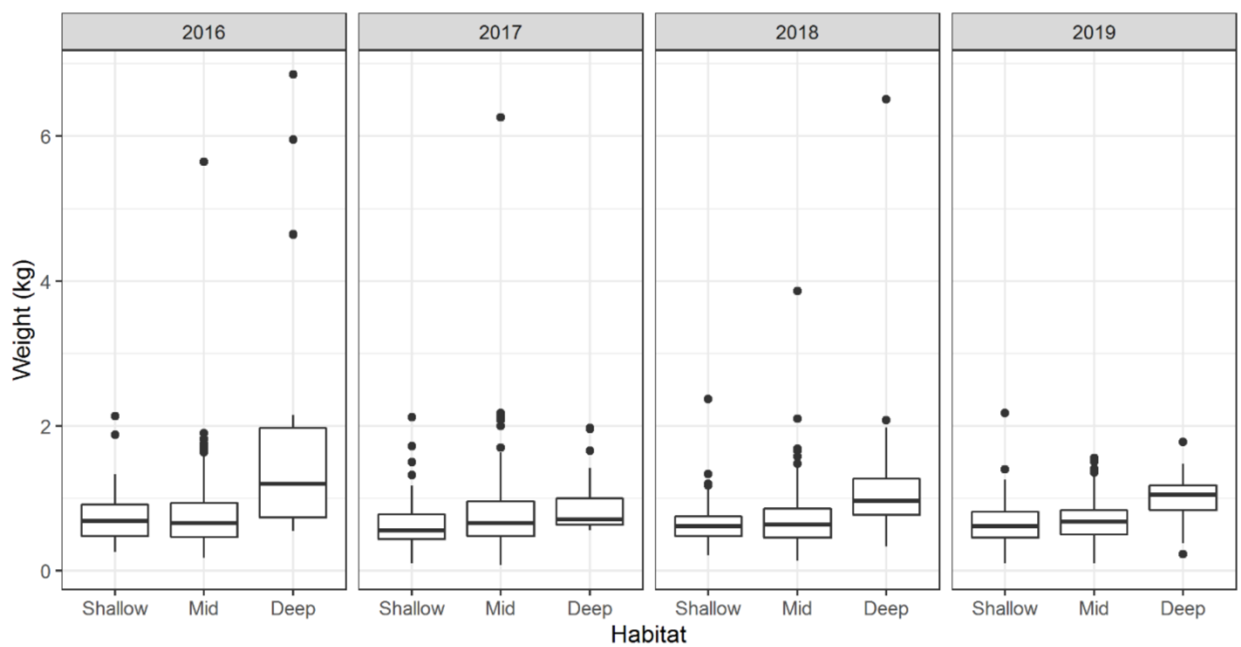

Figure 7. Year and habitat-specific distribution of weight (kg) estimates of Red Snapper collected from 2016 to 2019.

Literature Cited

VanderKooy, S.J. 2009. A Practical Handbook for Determining the Ages of Gulf of Mexico Fishes, Second Edition: Gulf States Marine Fisheries Commission Publication No.167.

Reproductive Characteristics

The purpose of this task is to investigate the reproductive biology of Red Snapper (*Lutjanus campechanus*). Specifically, we document size- and age-at-maturity, spawning seasonality, spawning frequency, and fecundity of Red Snapper. While the reproductive biology of Red Snapper has been studied in the northern Gulf of Mexico (GOM; Collins *et al*. 2001, Jackson *et al*. 2006, 2007, Fitzhugh *et al*. 2012a, Lowerre-Barbieri *et al*. 2012, Glenn *et al*. 2017, Kulaw *et al*. 2017, Downey *et al*. 2018), none of these studies included fish from Mississippi waters, and few address all aspects of Red Snapper reproductive biology. This report provides a summary of reproductive characteristics conducted on female Red Snapper from 2016 to 2019.

Sampling Characteristics

Table 7. Meta data characteristics of Red Snapper reproductive characteristics.

Feature.Name	Units	Method
Sex	alpha	
GW	g	gonad weight to nearest 0.01 g
GSI	percent	GSI = (gonad weight/ovary-free body weight) * 100
Macro Phase	alphanumeric	from Brown-Peterson et al. 2011. 1=regenerating, 2-developing, 3=spawning capable, 3A=actively spawning, 4=regressing, 5=immature
Macro Sex	categorical	1=male, 2=female, 3=unknown
Histo Sexual Maturity	binomial	physiological maturity from Brown-Peterson et al. 2011. 0=immature, 1=mature
Histo Sex	categorical	1=male, 2=female, 3=unknown
Histo Maturity Phase	categorical	from Brown-Peterson et al. 2011. 1=immature, 2=early developing, 3=developing, 4=spawning capable, 5=actively spawning, 6=regressing, 7=regenerating
Male SC Subphase	ordinal	from Brown-Peterson et al 2011 41=early GE, 42=mid GE, 43=late GE
24 Hour POF	binomial	from Brown-Peterson et al 2011. 0=absent, 1=present. Only recorded for females in histo phases 4 and 5
SMI	percent	Spermatogenic Maturity Index from Tomciewicz et al. 2011. ranges from 0 to 1. Only for males
Fecundity Subsample Weight (G)	g	small amount of ovarian tissue from actively spawning females used for batch fecundity calculations
Mean	# eggs	mean number of eggs counted in subsample for batch fecundity
V1	ml	total dilution volume
V2	ml	volume of egg subsample
BF	# eggs	Batch fecundity: volumetric method calculated following Bagenal and Braum 1971
RBF	#eggs/g ovary-free bodyweight	Relative bath fecundity from Brown-Peterson et al. 2019. calculated as BF/ovary-free body weight

Determination of Reproductive Characteristics

Fish were measured (standard length (SL); fork length (FL); and total length (TL); all to the nearest mm) and weighed (W, 0.01 kg). An incision was made across the body from the anus to the gills, taking care not to damage any stomach, intestine, or gonadal tissue. The sex of the fish was determined macroscopically, and the gonad was removed and weighed

(GW, 0.01g). The Gonadosomatic Index (GSI [GSI = (GW/W-GW)*100]) was calculated for each fish to assess spawning seasonality. Immature fish were not included in monthly GSI calculations since GSI is a measure of reproductive readiness. The reproductive phase of each gonad was assessed macroscopically following modifications of Brown-Peterson et al. (2011). For histological assessment, a small (1 cm^3) portion of tissue was removed from the middle of the right gonad, placed in a labeled cassette within 24 h of capture, and fixed in 10% neutral buffered formalin for seven days.

Females macroscopically assessed to be in the actively spawning sub-phase were also sampled for fecundity analysis. A small (1-4 g) portion of the ovary of actively spawning fish was weighed (0.01 g) and placed into ~50 ml of Gilson's solution for a minimum of three months prior to fecundity analysis.

Formalin-fixed gonadal tissues were sent to either Crowder Histology Consulting or to Texas A&M Veterinary Histology for histological processing. Tissues were sectioned at 4µm and stained with Hemotoxylin and Eosin. Slides were microscopically analyzed and assigned to reproductive phases following Brown-Peterson et al. (2011).).

Fish were considered sexually mature if ovarian tissue contained cortical alveolar (CA) oocytes and/or markers of previous spawning (Brown-Peterson et al. 2011), corresponding to physiological maturity. The spawning interval (estimated days between spawns) for female Red Snapper was calculated using the reciprocal of the total number of females with postovulatory follicles (POF) < 24 h in the ovary divided by the total number of spawning capable females (Brown-Peterson et al. 2019). Fish were classified as daily spawners if the ovary contained histological evidence of oocytes undergoing OM as well as POF < 24 h.

Batch fecundity (BF) was estimated using the volumetric method (Bagenal and Braum 1971) from fish histologically confirmed to be in the actively spawning sub-phase. Oocytes were suspended in 50-200 ml of water and all oocytes > 500 µm were counted in six 1-ml subsamples with replacement; the mean of these counts was used to calculate BF. Relative batch fecundity (RBF) was calculated as RBF = BF/(W-BW).

Table 9. Summary table of gonadosomatic Index (GSI) values from female Red Snapper collected by depths and habitat type.

DEPTH.STRATA	Month	Mean GSI	Min GSI	Max GSI
Shallow	3	0.196	0.050	0.342
	4	0.360	0.016	2.547
	5	1.327	0.010	6.602
	6	1.338	0.108	5.630
	7	0.371	0.031	1.665
	8	0.739	0.052	3.073
	9	0.650	0.061	3.771
	10	1.258	0.010	60.194
	11	0.227	0.014	0.541
Mid	3	0.188	0.005	3.408
	4	0.407	0.026	3.461
	5	1.003	0.015	9.980
	6	0.744	0.025	4.803
	7	0.678	0.050	5.854
	8	0.460	0.017	3.734
	9	0.416	0.023	2.845
	10	0.179	0.010	0.844
	11	0.178	0.011	0.467
Deep	3	0.212	0.028	0.703
	4	0.696	0.053	4.506
	5	1.258	0.046	5.072
	6	1.175	0.038	3.823
	7	0.788	0.046	7.952
	8	0.971	0.049	3.340
	9	0.427	0.053	1.646
	10	0.231	0.008	0.966
	11	0.143	0.052	0.200

Table 10. Monthly percentages of female Red Snapper in various reproductive phases collected from 2016 to 2019. All years, depths, and habitat types combined. Phase assignment based on histological evaluation of the ovaries. n—number of fish; Imm—immature; EDev—early developing; Dev—developing; SC—spawning capable; AS—actively spawning; Rgs—regressing; Rgn—regenerating.

Month	Imm	EDev	Dev	SC	AS	Rgs	Rgn
3	23.3%	18.9%	20.0%	10.0%	0.0%	1.1%	17.8%
4	15.7%	17.5%	19.9%	31.0%	3.6%	0.3%	8.1%
5	7.0%	6.5%	11.4%	57.6%	11.4%	0.0%	1.6%
6	6.2%	6.2%	6.2%	58.8%	14.1%	0.6%	4.5%
7	4.9%	8.0%	5.3%	53.1%	13.3%	8.8%	2.2%
8	11.2%	7.6%	5.9%	60.6%	7.6%	1.8%	1.2%
9	1.6%	3.8%	1.6%	63.6%	10.9%	10.9%	3.3%
10	12.1%	4.7%	7.5%	25.7%	0.5%	21.0%	25.2%
11	17.9%	2.7%	2.7%	17.0%	0.0%	17.9%	37.5%

Table 11. Monthly percentages of female Red Snapper in various reproductive phases collected by year from 2016 to 2019. All depths and habitat types combined. Phase assignment based on histological evaluation of the ovaries. n—number of fish; Imm—immature; EDev—early developing; Dev—developing; SC—spawning capable; AS—actively spawning; Rgs—regressing; Rgn—regenerating.

Year	Month	Imm	EDev	Dev	SC	AS	Rgs	Rgn
2016	4	7.9%	19.0%	22.2%	42.9%	4.8%	0.0%	1.6%
	5	1.4%	1.4%	9.8%	72.0%	13.3%	0.0%	0.0%
	6	0.0%	0.0%	16.7%	66.7%	16.7%	0.0%	0.0%
	7	10.5%	5.3%	1.8%	61.4%	19.3%	1.8%	0.0%
	8	4.0%	4.0%	4.0%	76.0%	6.0%	4.0%	0.0%
	9	1.6%	8.2%	0.0%	63.9%	6.6%	6.6%	9.8%
	10	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	33.3%
	11	8.6%	3.7%	2.5%	19.8%	0.0%	18.5%	42.0%
2017	4	3.8%	5.7%	11.3%	69.8%	7.5%	0.0%	0.0%
	5	3.2%	5.4%	3.2%	65.6%	15.1%	0.0%	0.0%
	6	4.1%	4.1%	4.1%	63.3%	16.3%	0.0%	2.0%
	7	3.1%	12.5%	10.9%	48.4%	14.1%	7.8%	0.0%
	8	16.7%	7.6%	6.1%	50.0%	15.2%	1.5%	1.5%
	9	0.0%	4.3%	4.3%	63.8%	23.4%	4.3%	0.0%
	10	26.0%	2.0%	6.0%	16.0%	0.0%	18.0%	32.0%
2018	3	23.0%	19.7%	21.3%	13.1%	0.0%	1.6%	18.0%
	4	16.9%	18.5%	27.4%	17.7%	4.0%	0.0%	11.3%
	5	23.6%	11.2%	14.6%	32.6%	3.4%	0.0%	6.7%
	6	8.9%	11.1%	11.1%	48.9%	8.9%	0.0%	4.4%
	7	3.2%	7.9%	1.6%	54.0%	7.9%	11.1%	4.8%
	8	0.0%	23.5%	11.8%	52.9%	0.0%	0.0%	5.9%
	9	0.0%	0.0%	2.7%	56.8%	0.0%	35.1%	0.0%
	10	10.0%	4.6%	4.6%	26.2%	0.0%	23.8%	26.9%
2019	3	24.1%	17.2%	17.2%	3.4%	0.0%	0.0%	17.2%
	4	26.1%	21.7%	13.0%	18.5%	0.0%	1.1%	13.0%
	5	1.6%	12.9%	22.6%	48.4%	12.9%	0.0%	0.0%
	6	7.0%	5.6%	2.8%	60.6%	15.5%	1.4%	7.0%
	7	2.4%	4.8%	7.1%	47.6%	11.9%	16.7%	4.8%
	8	16.2%	5.4%	5.4%	62.2%	0.0%	0.0%	0.0%
	9	5.1%	0.0%	0.0%	69.2%	12.8%	2.6%	0.0%
	10	0.0%	9.7%	22.6%	38.7%	3.2%	12.9%	6.5%
	11	41.9%	0.0%	3.2%	9.7%	0.0%	16.1%	25.8%

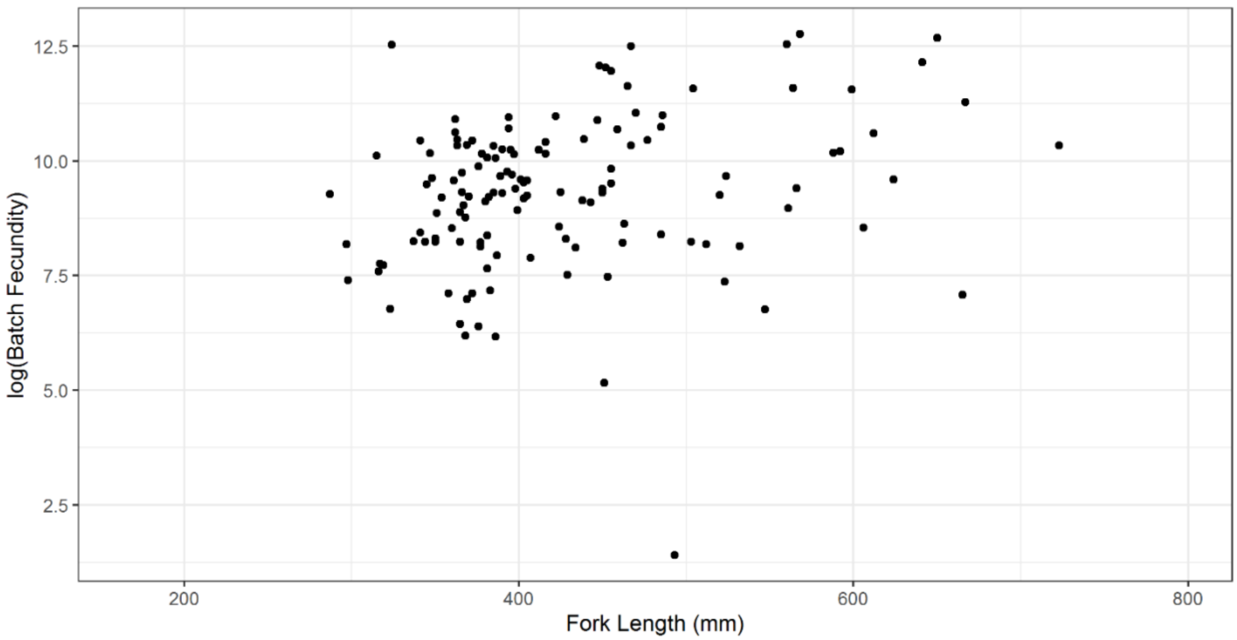

Figure 8. Log-transformed Batch Fecundity as a function of fish length (FL, mm) for Red Snapper collected by the survey, all fish combined.

Table 12. Monthly spawning interval for female Red Snapper in the spawning capable and actively spawning phases, 2016-2019 combined.

Month	N spawning capable or actively spawning	N with POF	% with POF	Spawning Interval (days)
April	40	6	15	6.7
May	115	45	39.1	2.6
June	54	15	27.8	3.6
July	52	9	17.3	5.8
August	37	12	32.4	3.1
September	37	14	37.8	2.6
October	9	1	11.1	9.1