Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida

Kevin J. Kolmos, Shelly Falk, David M. Wyanski, Michael A. Schmidtke

SEDAR50-DW19

Submitted: 9 January 2017
Updated: 10 January 2017
Updated: 26 January 2017

This information is distributed solely for the purpose of pre-dissemination peer review. It does not represent and should not be construed to represent any agency determination or policy.

Please cite this document as:

Kolmos, K. J., S. Falk, D. M. Wyanski, and M.A. Schmidtke. 2017. Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida. SEDAR50-DW19. SEDAR, North Charleston, SC. 12 pp.

Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida

SEDAR50 – DW19
January 2017

Prepared by [1]Kevin J. Kolmos, [1]Shelly Falk, [1]David M. Wyanski, [2]Michael A. Schmidtke

[1]Marine Resources Research Institute

South Carolina Department of Natural Resources

P. O. Box 12559

Charleston, SC 29422

[2]Center for Quantitative Fisheries Ecology

Old Dominion University

Norfolk, VA 23529

NOT TO BE CITED WITHOUT PRIOR WRITTEN PERMISSION FROM AUTHORS

Please cite this document as:

Kolmos, K. J., S. Falk, D. M. Wyanski, and M. A. Schmidtke. 2017. Reproductive Paramenters for Blueline Tilefish in Atlantic Waters from Virginia and Florida. SEDAR50-DW19. SEDAR, North Charleston, SC. 12pp.

Executive summary, methods, sex ratio results, maturity results, literature cited, table 3, 4, 5, and 6 were updated on 1/26/2017.

Executive Summary

Blueline Tilefish analyzed for life history were collected from Virginia to Florida (approximately between 37.5°N and 24.3°N), by fishery-independent and fishery-dependent sources throughout 1979 – 2015 (n= 2,548 to date). If necessary, total length (mm) was converted to fork length (mm) using a meristic conversion from Ballew and Potts (2017; Table 1), producing a range from 307 – 910 mm FL. The reproductive phase of 2,437 samples from males and females was assessed using criteria listed in Brown-Peterson et al. (2011). Observed sex ratio was 1.19:1 (Female:Male). Females reached sexual maturity as small as 312 mm FL and are considered 100% mature by 365 mm FL. Estimates of female length at 50% maturity ranged from 299 - 312 mm FL, with the logit model providing the best fit (305 mm; CV = 0.447). Females with spawning indicators were collected from February – November. Spawning females, with available location data (n=950), were collected largely from South Carolina, North Carolina, and Virginia; however, spawning individuals were found in all states throughout this study. Spawning fraction was calculated based on size, and found to range between 0.24 - 0.40, with an overall fraction of 0.31. The number of spawning events during the spawning season ranged from 57 – 102, with an overall average of 94 events.

Introduction

Blueline Tilefish (*Caulolatilus microps*) is a commercially and recreationally important fish that is a long-lived, slow-growing, deepwater, demersal species that historically has been described as occurring along the outer continental shelf from Nova Scotia to Venezuela, Guyana, and Suriname, including the Gulf of Mexico and continental Caribbean (FAO 2002). Harris et al. (2004) reported a spawning season from February – October, with spawning occurring at night.

Blueline tilefish is an iteroparous, gonochorist species that releases eggs in batches for a prolonged period, February through October (Harris et al. 2004); the spawning season may extend beyond October, as no specimens were collected in November and December. Juveniles settle into a more structured habitat within the rocks (Carmichael et al. 2016), where they grow to feed primarily on benthic invertebrates and fishes (Dooley 1978).

Samples were collected from New Jersey to Florida (largely from South Carolina and Virginia), including fishery-independent and fishery-dependent data, in order to assess reproductive parameters in the Blueline Tilefish population(s) along the entirety of their range off the Atlantic coast of the U.S. Sampling gear consisted of hook and line efforts, chevron traps, short bottom longlines and long bottom longlines. In 2015, a large fishery-dependent sampling effort was made by NMFS using longlines, contributing 820 samples to the dataset. Datasets from the Marine Resources Monitoring Assessment and Prediction (MARMAP) program, the Southeast Reef Fish Survey (SERFS), and Old Dominion University (ODU) were combined into one dataset to evaluate age, sex, reproductive phase, length, and reproductive parameters. Note that the current collaborative fishery-independent snapper grouper monitoring in the South Atlantic is conducted by the MARMAP program, the South East Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) (both housed at SC-DNR's Marine Resources Research Institute), and the South East Fishery Independent Survey (SEFIS) (NMFS project housed at SEFSC, Beaufort, NC), now collectively referred to as SERFS. MARMAP/SEAMAP-SA reproductive histology samples include specimens collected from 1979 to the present with ODU and NMFS samples contributing since 2009 and 2015, respectively (n=2,478).

Methods

This study contains samples of Blueline Tilefish that were collected along the east coast of the U.S., from New Jersey to Florida, between 1979 and 2015 (n=2,548) utilizing pre-existing MARMAP protocols (see details in Harris et al. 2004, MARMAP 2009, Smart et al. 2015). These samples were largely collected in the South Atlantic Bight by the MARMAP program. MARMAP gear types primarily included snapper/bandit reels, short bottom longlines (SBLL; 20-hook), long bottom longlines (LBLL; 100-hook), and hook and line (H&L), depending on known bottom type (i.e. Hard, rocky, mud, sand). Fishery-independent samples were weighed to the nearest gram (g) and measured in millimeters (mm) for a pinched, maximum total length (TL), in addition to fork length (FL), and standard length (SL). Otoliths were then removed and stored dry prior to processing, while reproductive tissue was fixed in an 11% seawater-buffered formalin solution to prepare for processing. For fishery-dependent samples, whole weights (g) were taken, TL and sometimes FL (mm), as well as otoliths and reproductive tissue for later processing.

Reproduction

SERFS (n=1,456) fishery-independent sampling (53%) and fishery-dependent sampling (47%)

Following specimen capture and dissection, the posterior portion of the gonads was fixed for 14 days in an 11% seawater–formalin solution and later transferred to 50% isopropanol for an additional 7–14 days. Reproductive tissue was processed in an automated and self-enclosed tissue processor and blocked in paraffin. Three transverse sections (6–8 µm thick) were cut from each sample with a rotary microtome, mounted on glass slides, stained with double-strength Gill hematoxylin, and counterstained with eosin-y. Sections were viewed under a compound microscope at 20-400X magnification, and sex and reproductive phase were determined without knowledge of capture date, specimen length, or specimen age. Independently, two readers used histological criteria from Brown-Peterson et al. (2011) to assign one of the following reproductive phases: immature, developing, spawning capable, regressing, and regenerating. When assignments differed, the readers re-examined the section simultaneously to reach agreement on the reproductive phase. Females were considered to be in spawning condition if they possessed oocytes undergoing maturation (i.e. fusing of yolk globules, germinal vesicle migration and breakdown, and/or hydration) or postovulatory follicle complexes (POCs).

NMFS (n = 820) 2015 fishery-dependent sampling (100%)

In a collaborative effort, sampling was conducted using generally standardized protocols by cooperating fishermen on industry vessels, with data and biological samples being collected by a trained NMFS-Southeast Fisheries Science Center (SEFSC) fishery observer (Kellison 2016). Sampling largely took place offshore of Virginia, South Carolina, and North Carolina, using SBLL, LBLL, and vertical H&L. Site selection was done during daylight hours, over a relatively broad area within each latitude/depth cell to avoid "clustering" of sampling. Sampling protocol involved species identification, measurement of FL (cm, later converted to mm), and removal of otolith and reproductive tissue.

Reproductive samples were sent to MARMAP/SCDNR for processing and analysis.

ODU sampling (n=272)

Blueline tilefish were collected from the Norfolk Canyon off of Virginia during 2009-2014. Specimens were collected from commercial and recreational fisheries, as well as from special charters conducted by the Center for Quantitative Fisheries Ecology and Virginia Marine Resources Commission (VMRC) scientists aboard recreational charter vessels. Recreational samples were primarily collected through the Virginia Marine Sportfish Collection Project, a freezer program conducted by VMRC through which anglers donated carcasses to scientific research after filleting them at local cleaning stations. Length measurements, sagittal otoliths, and macroscopic determinations of sex and reproductive phase were taken for all fish collected. Total weight was measured for all whole fish, and gonads were extracted from fresh specimens, weighed, and placed in 10% formalin for later histological processing.

One reader examined histological sections and used criteria from Brown-Peterson et al. (2011) to determine sex and reproductive phase. Only histological data were analyzed for the current working paper.

Analyses

All analyses were done using R Statistics software.

Age: No age-based analyses were included in this working paper because the method of determining age for Blueline Tilefish hasn't yet been finalized.

Length: Fork length (mm) was used in analyses when available, or was generated from TL for 469 fish using the meristic conversion from Ballew and Potts (2017; Table 1).

Histological Criteria: Immature, Developing, Spawning Capable, Regressing, Regenerating phases used were based on Brown Peterson et al. 2011.

Sex Ratio: Data were analyzed using a Chi-square goodness of fit test to determine if observed ratios differed among geographic areas (states) from an expected 1:1 female:male (F:M) ratio (Zar 1984).

Maturity: Logistic regression models were used to estimate fork length (L_{50}) at which 50% of the population has reached sexual maturity.

Location: A "State" category was derived from available latitudinal data: Virginia (VA) north of 36.3^0N; North Carolina (NC) 36.3≥Lat>33.5; South Carolina (SC) 33.5≥Lat>32.0; Georgia (GA) 32.0≥Lat>30.4; and Florida (FL) 30.4≥Lat. Latitude values for ODU samples were generated from the NMFS Statistical Area of Capture midpoints for respective sample locations.

Results

Sex ratio

Table 1 presents a summary of sex ratio by sampling area. Sampling areas were defined by state latitudinal boundaries. The total sample size (n=2,524) was comprised of 1,374 females and 1,150 males collected from Virginia through Florida, with most samples collected off South Carolina. The overall female:male sex ratio favored females, but this statistical significance was likely due to sample size, and thus not biologically significant. Although the sample sizes for Virginia (n=486) and North Carolina

(n=441) were similar, the presence of a female skewed sex ratio in Virginia could reflect the selective removal of males, which attain larger sizes than females, by the recently developed fishery off Virginia.

Spawning season and location

Spawning females, with available location data (n=950), were collected largely from South Carolina (55%), followed by Virginia (23%), and North Carolina (13%); However, spawning individuals were found in all states throughout this study (Tables 2 and 3). An overall monthly count of reproductive phases is provided in Table 4.

From 1979 – 2015, spawning females (n=1,030) were observed February – November (Table 3). Immature fish (n=4) were caught in the months of March, April, June and September.

Maturity

Female samples (n=1,350) were histologically examined to estimate size at maturity. There were four immature females in the entire dataset. Females reached sexual maturity as small as 312 mm FL and are considered 100% mature by 365 mm FL. Estimates for female length at 50% maturity ranged from 299-312 mm FL (Table 5).

Spawning fraction

Spawning fraction measures the proportion of mature females spawning daily. Spawning indicators for this deep water species were estimated to last 60 hours based on the temperature (mean $\pm$ 1 sd = 14.9 $\pm$ 2.1^{o}C) at which Blueline Tilefish spawn (Sedberry et al. 2006) and the duration of oocyte maturation and POC degeneration in Northern Anchovy (Hunter and Macewicz 1985a, b), a species that spawns at a similar temperature range (13 - 19^{o}C). Therefore, spawning fraction was proportionally reduced to indicate a 24-hour period (Figure 1). The results of size-based analyses revealed an overall spawning fraction ranging from 0.24 - 0.40. In addition, there was no evidence for latitudinal variation in spawning fraction. The size-based results did not reveal an increasing trend, but rather a sustained moderate spawning fraction (Table 6, Figure 1). This species has a very long spawning season resulting in a high number of spawning events ranging from 57 - 102 for females 300 to 700 mm FL (Figure 2); the size bins with sufficient sample size revealed an increasing trend between 400 and 600 mm FL. Female Blueline tilefish spawn about every 3 days.

Literature Cited

Ballew, N. and J. C. Potts. 2017. Summary of the Blueline Tilefish meristic conversions using data from the entire US Atlantic and Gulf of Mexico. SEDAR50-DW21. SEDAR, North Charleston, SC. 6pp.

Brown-Peterson, N., Wyanski, D., Saborido-Rey, F., Macewicz, B. J., Lowerre-Bardieri, S. K. 2011. A Standardized Terminology for Describing Reproductive Development in Fishes. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 3:52-70.

Carmichael, J, M Duval, Reichert, M., Bacheler N., and Kellison, T. 2016. Workshop to determine optimal approaches for surveying the deep-water species complex off the southeastern U.S. Atlantic coast. NOAA Technical Memorandum NMFS-SEFSC-685.
http://docs.lib.noaa.gov/noaa_documents/NMFS/SEFSC/TM_NMFS_SEFSC/NMFS_SEFSC_TM_685.pdf

Dooley, J. K. 1978. Systematic revision and comparative biology of the tilefishes (Perciformes: Branchiostegidae and Malacanthidae). Doctoral dissertation. University of North Carolina, Chapel Hill

FAO. 2002. The living marine resources of the Western Central Atlantic. Volume 2: Bony fishes part 2 (Opistognathidae to Molidae), sea turtles and marine mammals. Carpenter, K.E. FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologist and Herpetologist Special Publication No. 5. Pg 1395-1411

Harris, P., Wyanski, D.M., Mikell, P.T.P. 2004. Age, Growth, and Reproductive Biology of Blueline Tilefish along the Southeastern Coast of the United States, 1982-1999. Transactions of the American Fisheries Society, 133:1190-1204.

Hunter, J. R., N. C. H. Lo, and R. J. H. Leong. 1985a. Batch fecundity in multiple spawning fishes. In R. Lasker editors, An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*, p. 67–77. NOAA Technical Report NMFS 36.

Hunter, J. R., and B. J. Macewicz. 1985b. Measurement of spawning frequency in multiple spawning fishes. Pages 79–94 in R. Lasker, editor. An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. National Oceanic and Atmospheric Administration, NOAA Technical Report NMFS 36, Seattle.

Kellison, T. 2016. Summary of the 2015 blueline tilefish cooperatice-with-industry data collection project. SEDAR50-DW02. SEDAR, North Charleston, SC. 11pp.

MARMAP. 2009. Overview of sampling gear and vessels used by MARMAP. Charleston, SC.

Smart, T. I., M. J. Reichert, J. C. Ballenger, W. J. Bubley, and D. Wyanski. 2015. Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners. Charleston, SC. 15 pp.

Sedberry, G.R., O. Pashuk, D.M. Wyanski, J.A. Stephen, and P. Weinbach. 2006. Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S. Proceedings of the Gulf and Caribbean Fisheries Institute 57:463-514.

Zar, J.H. 1984. Biostatistical analysis, 2nd edition. Prentice Hall, New Jersey. 719 p.

Tables and Figures

Table 1. Sex ratio for Blueline Tilefish, by sampling area, with corresponding p-value denoting level of significance. Sampling areas were defined by state latitudinal boundaries. Data for specimens captured off Georgia were not analyzed due to small sample size. Data included 4 immature specimens.

	Overall	State				
		VA	NC	SC	GA	FL
Females	1374	274	224	739	7	39
Males	1150	212	217	598	8	25
F/M	**1.19**	**1.29**	**1.03**	**1.24**	**0.875**	**1.56**
% Female	**54%**	**56%**	**51%**	**55%**	**47%**	**61%**
Chi Sq	**19.88**	**7.91**	**0.11**	**14.87**		**3.063**
P-Value	**<0.001**	**0.005**	**0.739**	**<0.001**		**0.08**

Table 2 A & B. Frequency and proportion of reproductive phases of female Blueline Tilefish by state. Note: Only 2 of the 4 immature females had associated catch location data available.

A.

	State						
Repro. Phase	**FL**	**GA**	**NC**	**SC**	**VA**	**None**	**Total**
Developing	10	2	18	101	16	7	154
Immature				1	1	2	4
Regenerating	10		21	15	5	1	52
Regressing	2	2	30	30	15	1	80
Spawning	12	3	132	568	235	80	1030
Total	**34**	**7**	**201**	**715**	**272**	**91**	**1320**

B.

	State						
Repro. Phase	**FL**	**GA**	**NC**	**SC**	**VA**	**None**	**Total**
Developing	29%	29%	9%	14%	6%	8%	12%
Immature	0%	0%	0%	0%	0%	2%	0%
Regenerating	29%	0%	10%	2%	2%	1%	4%
Regressing	6%	29%	15%	4%	6%	1%	6%
Spawning	35%	43%	66%	79%	86%	88%	78%
Total	100%	100%	100%	100%	100%	100%	100%

Table 3. Maturity by state and month for female Blueline Tilefish.

Maturity by State	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
FL								**1**		**33**			**34**
Developing										10			10
Regenerating										10			10
Regressing										2			2
Spawning								1		11			12
GA						**2**	**1**	**1**	**3**				**7**
Developing							1		1				2
Regressing								1	1				2
Spawning						2			1				3
NC						**2**	**2**	**8**		**137**	**52**		**201**
Developing								1		13	4		18
Regenerating								1		20			21
Regressing						1	1	3		20	5		30
Spawning						1	1	3		84	43		132
SC	**10**		**14**	**53**	**155**	**99**	**22**	**159**	**146**	**57**			**715**
Developing	5		4	20	14	6	3	17	8	24			101
Immature				1									1
Regenerating	5							2	1	7			15
Regressing				1	1	10		11	3	4			30
Spawning			10	31	140	83	19	129	134	22			568
VA	**11**			**4**	**4**	**12**	**45**	**26**	**5**	**145**	**12**	**8**	**272**
Developing	5			4	2	4				1			16
Immature						1							1
Regenerating	3											2	5
Regressing	3										6	6	15
Spawning					2	7	45	26	5	144	6		235
None		**2**	**2**	**23**		**2**	**35**		**5**	**22**			**91**
Developing				1			2		1	3			7
Immature			1						1				2
Regenerating			1										1
Regressing							1						1
Spawning		2		22		2	32		3	19			80
Grand Total	**21**	**2**	**16**	**80**	**159**	**117**	**105**	**195**	**159**	**394**	**64**	**8**	**1320**

Table 4 A & B. Frequency and proportion of reproductive phases for female Blueline Tilefish by month.

A.

Reproductive Phase	Month 1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
Developing	10		4	25	16	10	6	18	10	51	4		154
Immature			1	1		1			1				4
Regenerating	8		1					3	1	37		2	52
Regressing	3			1	1	11	2	15	4	26	11	6	80
Spawning		2	10	53	142	95	97	159	143	280	49		1030
Grand Total	**21**	**2**	**16**	**80**	**159**	**117**	**105**	**195**	**159**	**394**	**64**	**8**	**1320**

B.

Reproductive Phase	Month 1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
Developing	48%	0%	25%	31%	10%	9%	6%	9%	6%	13%	6%	0%	12%
Immature	0%	0%	6%	1%	0%	1%	0%	0%	1%	0%	0%	0%	0%
Regenerating	38%	0%	6%	0%	0%	0%	0%	2%	1%	9%	0%	25%	4%
Regressing	14%	0%	0%	1%	1%	9%	2%	8%	3%	7%	17%	75%	6%
Spawning	0%	100%	63%	66%	89%	81%	92%	82%	90%	71%	77%	0%	78%
Grand Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5. Logistic regression analysis of fork length (FL; in mm) at maturity for female Blueline tilefish at maturity. Note: Data includes 4 immature females with FL of: 307, 312, 320, and 365 mm.

Model	n	AICc	L_{50}	CV
Logit Logistic	1350	28.47	305	0.447
Probit Logistic	1350	29.00	299	
cloglog Logistic	1350	29.53	301	
Cauchy Logistic	1350	31.29	312	

Table 6. Female Blueline Tilefish spawning fraction by fork length (FL), with bins center rounded to the nearest 100 mm. Spawning fraction and resulting spawning events were proportionally reduced from a 60 to a 24-hour period based on longevity of spawning indicators from Harris et al. 2004.

FL mm	Spawners	1st date spawn (Month/Day)	Last Date Spawn (Month/Day)	Spawning Season (days)	# Mature	Spawning Fraction	Spawning Events
300	16	4/22	11/26	218	18	0.36	78
400	138	3/26	11/20	239	231	0.24	57
500	489	2/5	11/30	298	613	0.32	95
600	352	2/3	11/30	300	415	0.34	102
700	29	5/22	11/26	188	33	0.35	66
800	2	9/3	10/22	49	2	0.40	20
Total	**1030**	**2/3**	**11/30**	**300**	**1316**	**0.31**	**94**

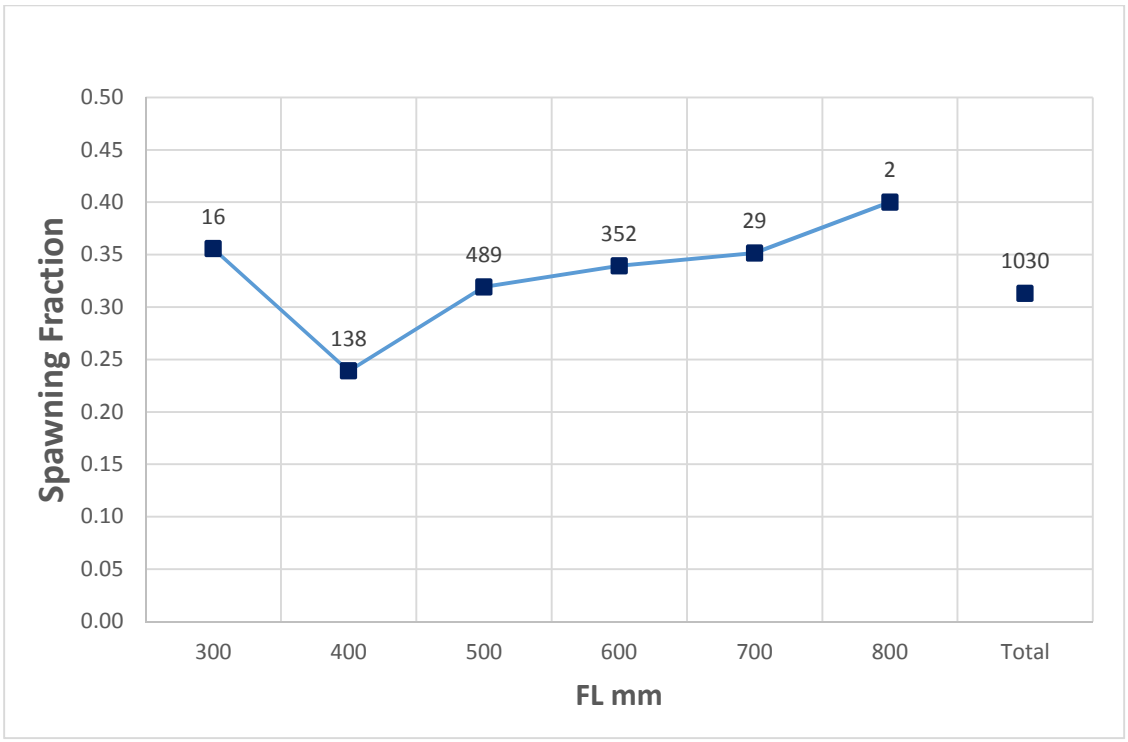

Figure 1. Spawning fraction by binned FL (mm) of female Blueline Tilefish. Data labels above points represent the number of individuals examined. Bins were center rounded to the nearest 100 mm.

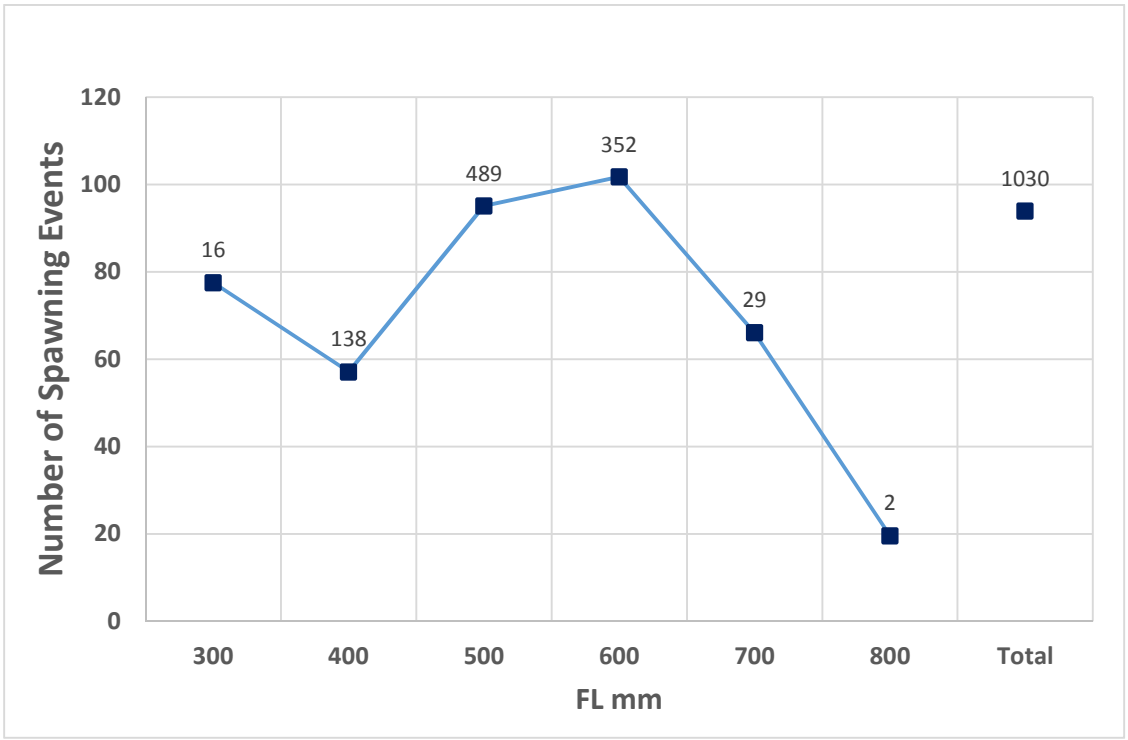

Figure 2. Number of spawning events by binned FL (mm) of female Blueline Tilefish. Data labels above points represent the number of individuals examined. Bins were center rounded to the nearest 100 mm.