SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2018

Project **Page**

Marine Fisheries Habitat Enhancement and Management

Program PI\Participants: Robert M. Martore, Ryan Yaden, Brent Merritt

Program Period: July 2, 2017 - July 1, 2018

Program Objectives:

Construction and maintenance of marine artificial reefs

- Continue artificial reef development on new and existing permitted reef sites along the South Carolina coast through the completion of reef construction activities in accordance with the State's Marine Artificial Reef Management Plan.
- Maintain a system of private aids to navigation on reef sites by following a schedule of routine inspection, maintenance and replacement on all applicable artificial reef sites.
- Continue performance and compliance monitoring, as required by reef permits, by following a schedule of routine and special underwater inspections to document the stability, structural integrity, and biological effectiveness of the materials in place on each of the State's artificial reef sites.

Summary of Activities:

Seventeen reef construction projects were carried out during this fiscal year on 15 separate artificial reef sites, adding over 300,000 cubic feet of hard bottom habitat to our offshore reefs. These projects are summarized below:

Date	Material	Reef Site
22 Aug 17	22 pieces concrete culvert & boxes	Cape Romain Reef
21 Sept 17	1500 tons of concrete rubble	Charleston Nearshore Reef
11 Oct 17	2 steel corrals and 6 steel trees	Edisto 60' Reef
12 Oct 17	1680 tons of concrete rubble	Charleston Nearshore Reef
26 Oct 17	3 concrete pyramids	Charleston 60' Reef
10 Oct 17	168' swing bridge & 130' barge	Charleston Deep Reef
27 Nov 17	1578 tons of concrete rubble	Charleston Nearshore Reef
02 Dec 17	58 pieces concrete culvert	McClellanville Reef
07 Dec 17	6 concrete pilings	Parris Island Reef
21 Jan 18	30 pieces concrete culvert	Ron McManus Memorial Reef
20 Feb 18	30 pieces concrete culvert	Pop Nash Reef
13 Apr 18	30 pieces concrete culvert	Paradise Reef
26 Apr 18	6 Eternal Reef Balls	Jim Caudle Reef
02 May 18	106-ft tugboat	Comanche Reef
12 May 18	30 pieces concrete culvert	Capers Reef
25 May 18	26 concrete junction boxes	Ten Mile Reef
31 May 18	9 pieces concrete culvert	Area 53 research reef

- Thirty-four days of offshore reef monitoring were completed, including monitoring of reef materials and fish populations, and side-scan sonar surveys of reef sites.
- Eighty scuba dives were made to conduct video surveys, document colonization of reef structures, and service acoustic receivers.
- Two aerial flights were made to determine where reef buoys were missing.
- Thirteen missing reef buoys were replaced.
- Acoustic radio receivers on offshore artificial reefs continue to be monitored every quarter. They continue to show the seasonal presence of highly migratory species from as far away as Massachusetts and Florida, as well as local migrants (inshore to offshore) like sturgeon and sea turtles.
- Updates of reef construction activities continue to be presented to fishing and diving clubs around the state.

The 168-foot truss of the Highway 41 swing bridge, welded to the deck of a barge, is deployed on the Charleston Deep Reef MPA.

The 106-foot tug, General Oglethorpe, is deployed on the Comanche Reef.

Concrete pyramids, built in-house at MRD, have been placed on several reef sites around the state.

Inshore Fisheries Monitoring and Research

Project PI: Joseph C. Ballenger

Reporting Period: July 1, 2017 – June 30, 2018.

(Data compiled with assistance from John Archambault, Ashley Shaw & Katie Anweiler)

Summary of Activities / Accomplishments to Date:

The Inshore Fisheries Section conducts long-term monitoring and research on the inshore fish species in South Carolina. SRFAC funding supports four long-term, fishery-independent surveys, including: (i) a trammel net survey of lower estuarine shoreline habitats, (ii) an electrofishing survey of upper estuarine shoreline habitats, (iii) a coastal bottom long-line survey, and (iv) a trawl survey of estuarine benthic habitats. We also take biological samples from angler-caught fish via a freezer drop-off program and a fishing tournament sampling program. SCDNR and other management agencies (e.g., ASMFC and NOAA Fisheries Service) use the data to make scientifically-based fishery management decisions aimed at sustaining healthy fish stocks.

Trammel net survey

The trammel net survey operates in lower estuary (high salinity) habitats targeting species such as Red Drum, Black Drum, Spotted Seatrout, Southern Flounder and Sheepshead. The survey, which began in November 1990, uses 600 ft x 8 ft nets that are set along marsh-front and oyster reef habitat. Scientists and managers use data from the survey for stock assessments, management, compliance reports to regional agencies, and other scientific publications. Researchers use biological samples from the survey for various purposes such as genetic studies, assessing SCDNR's fish stocking programs, mercury monitoring and student projects.

During the reporting period (July 1, 2017 – June 30, 2018), Inshore Fisheries staff made 899 trammel sets in nine survey areas ('strata') along the South Carolina coast (**Table 1**). The survey caught 16,030 specimens belonging to 69 taxa (**Appendix 1**). We enumerated and measured all fish, and we released the majority of them alive at the site of capture. From the 16,030 specimens, we collected 4,019 biological samples from some of the specimens caught (**Table 2**), mostly using non-lethal methods (e.g. fin clips for genetic investigations into population structure and stocking contributions). We present long-term population trends for a sub-set of species in **Figure 1** (Atlantic Croaker, Black Drum, Red Drum, Sheepshead, Spotted Seatrout, and Southern Flounder).

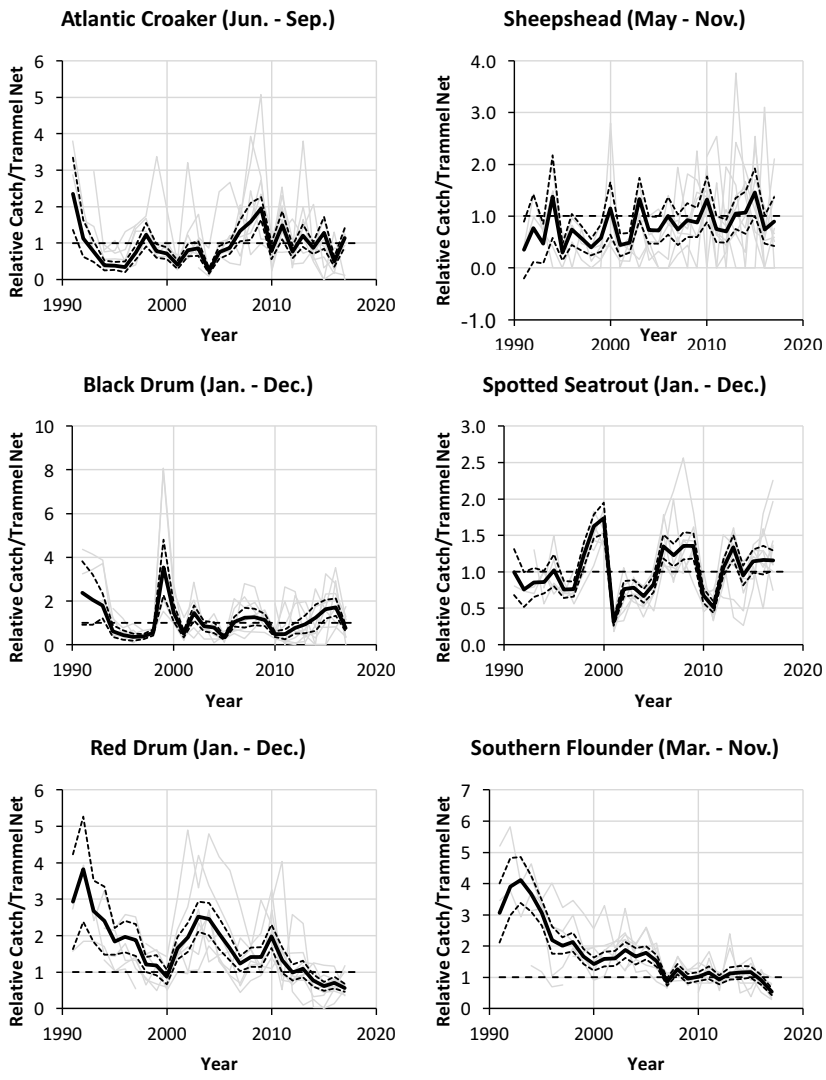
Table 1: Number of trammel sets in each sampling stratum during July 1, 2017 – June 30, 2018.

	2017						2018						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Winyah Bay	6	10	7	11	12	12	12	9	12	12	12	10	**125**
Cape Romain	12	8	8	12	13	11	10	12	12	10	11	11	**130**
Muddy & Bulls Bays	10	8		10	12	12	12	12	12	12	10	8	**118**
Lower Wando River	10	8	7	8	10	10	6	10	10	11	10	10	**110**
Charleston Harbor	8	9		10	10	10	8	10	11	10	7	7	**100**
Ashley River	10	11	8	8	11	12	12	13	10	11	12	10	**128**
ACE Basin	10	7		6	12	11	12	11	12	10	10	10	**111**
Broad River			6		10		6				11		**33**
Colleton River			8		12		12				12		**44**
Total	**66**	**61**	**44**	**65**	**102**	**78**	**90**	**77**	**79**	**76**	**95**	**66**	**899**

Table 2: Number of biological samples collected during July 1, 2017 – June 30, 2018.

		Gear				
Sample	**Purpose**	**Electrofishing**	**Hook and Line**	**Longline**	**Trammel**	**Total**
Fillet	SC DHEC mercury analysis				33	**33**
Fin Clip	Genetics	854	446	511	2,565	**4,376**
Gonad	Sex, maturity, fecundity	111	141	87	333	**672**
Otoliths	Aging	114	472	90	674	**1,350**
Scales	Aging	15			91	**106**
Stomach	Graduate student study on environmental microplastics	253			91	**344**
Whole Specimen	Education programs	6			150	**156**
Whole Specimen	Invasive American Eel parasite study	90				**90**
Whole Specimen	Parasite study	120			14	**134**
Whole Specimen	SCDNR black gill-shrimp predation experiment				23	**23**
Whole Specimen	SCDNR study of invasive *Penaeus monodon*	3				**3**
Whole Specimen	SCDNR terrapin head start project				6	**6**
Whole Specimen	Southern Flounder tracking study				39	**39**
Total		**1,566**	**1,059**	**688**	**4,019**	**7,332**

Figure 1: Examples of long-term population trends for selected species, as assessed by the SCDNR trammel net survey. The vertical axis is a relative index of fish abundance (annual average catch/2010-2017 average catch). Gray lines show data from individual strata; black lines shows the statewide average across all strata. Dashed black lines represent 95% CI about statewide annual CPUE.



Electrofishing survey

The electrofishing survey's main purpose is to monitor upper estuary (low salinity) waters, which are important habitat for juvenile stages of fish (e.g. Red Drum, Spotted Seatrout, Southern Flounder, Spot, Atlantic Menhaden). The Atlantic States Marine Fisheries Commission also use catch rates of American Eel as an index of abundance in their US stock assessment models. The survey, which began in May 2001, uses a specially designed electrofishing boat that temporarily stuns fish, enabling staff to collect, measure, and enumerate individual fish before releasing them alive.

During the reporting period, Inshore Fisheries staff made 332 electrofishing sets in five strata along the South Carolina coastline (**Table 3**). The survey caught 25,878 specimens belonging to over 74 taxa (**Appendix 2**). From those 25,878 specimens, staff took 1,566 biological samples (e.g. otoliths, scales, fin clips; **Table 2**). We present long-term population trends for a sub-set of species as observed in the electrofishing survey in **Figure 2** (American Eel, Atlantic Croaker, Red Drum, Spot, Spotted Seatrout, and Southern Flounder).

Longline survey

The longline survey is SCDNR's primary source of information on adult (up to 40-year old) Red Drum. These older fish live in deeper waters than the sub-adults (< 5 years old) which we sample through the trammel net and electrofishing surveys. The survey also provides information on several regionally managed coastal shark species.

Although the longline survey began during the 1990s, SCDNR Inshore Fisheries Research section staff redesigned the longline survey during 2007 to expand spatial coverage and improve the accuracy and precision of fish abundance estimates. We use data on both Red Drum and sharks for stock assessments, compliance reports to federal agencies, and other projects such as genetic and diet studies. We retain alive and transfer a small number of adult red drum to the SCDNR Mariculture Section for their use as brood stock.

During the reporting period we made 357 longline sets (each longline is one-third of a mile long) in four survey strata along the South Carolina coast (**Table 4**). These sets caught 2,078 specimens belonging to 26 taxa, of which Atlantic Sharpnose Shark was the most abundant (**Appendix 3**). Project staff took length measurements from all specimens before releasing most of them alive at the site of capture. Staff sacrificed 84 Red Drum for otolith aging and reproductive analysis (**Table 2**), as requested by the Atlantic States Marine Fisheries Commission, and all Red Drum were fin clipped for genetic analysis.

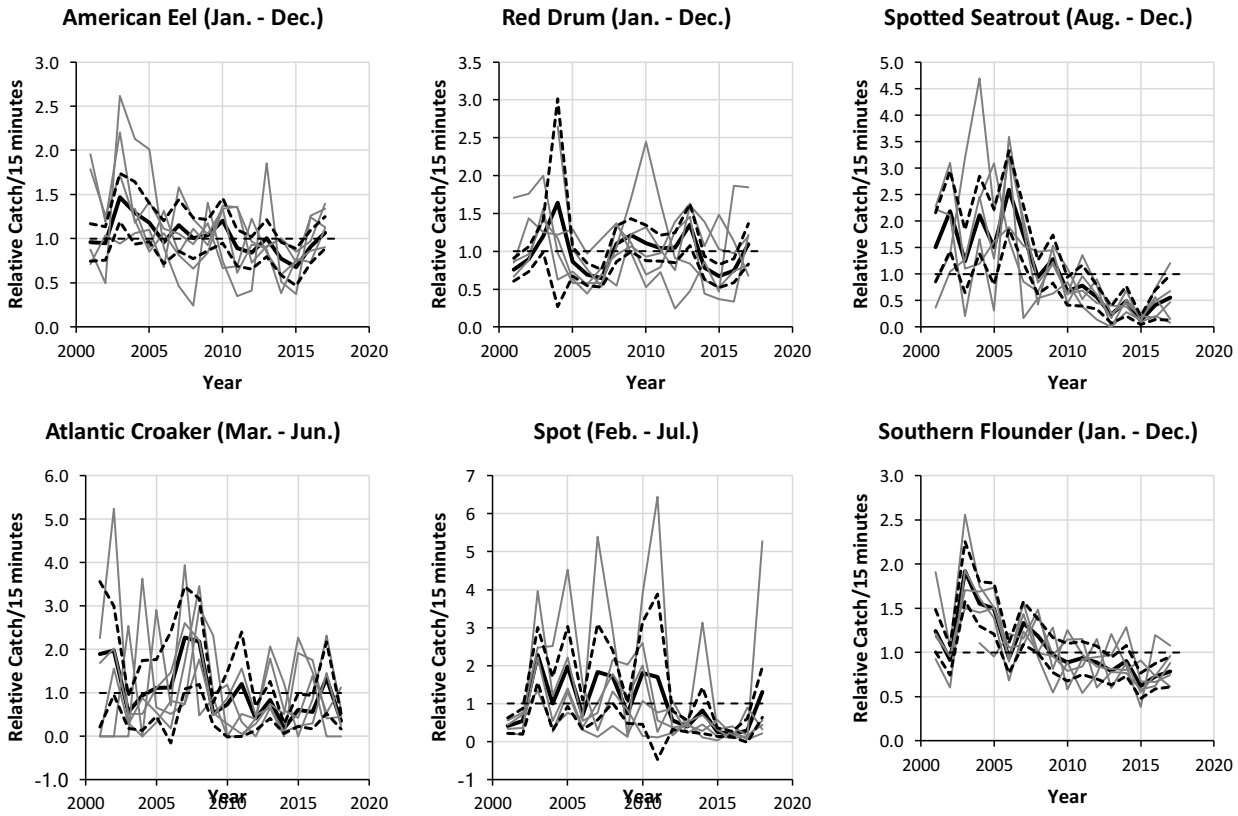
Table 3: Number of electrofishing sets made in each stratum during July 1, 2018 – June 30, 2018.

	2017						2018						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Combahee River	6	6		6	6	6	5	6	5	6	6	5	**63**
Winyah Bay	5	5	6	5	5	5	5		6	6	5	6	**59**
Edisto River	4	3	6	6	6	5	6	4	5	5	5	5	**60**
Ashley River	5	5	6	5	5	6	5	6	5	10	10	8	**76**
Cooper River	6	5	5	5	5	6	6	6	4	10	8	8	**74**
Total	**26**	**24**	**23**	**27**	**27**	**28**	**27**	**22**	**25**	**37**	**34**	**32**	**332**

Table 4: Number of one-third mile longline sets made during July 1, 2017 – June 30, 2018.

Stratum		**Month**				
Area	**Depth**	**August**	**September**	**October**	**November**	**Total**
Winyah Bay	Inner	0	9	10	10	**29**
Winyah Bay	Outer	0	21	20	20	**61**
Charleston Harbor	Inner	8	1	11	7	**27**
Charleston Harbor	Outer	7	11	19	23	**60**
Saint Helena Sound	Inner	15	0	11	10	**36**
Saint Helena Sound	Outer	7	8	19	20	**54**
Port Royal Sound	Inner	6	0	12	10	**28**
Port Royal Sound	Outer	24	0	18	20	**62**
Total		**67**	**50**	**120**	**120**	**357**

Figure 2: Examples of long-term population trends for selected species, as assessed by the SCDNR electrofishing survey. The vertical axis is a relative index of fish abundance (annual average catch per 15 minutes/2010-2017 average catch per 15 minutes). Gray lines show data from individual strata; black lines shows the statewide average across all strata. Dashed black lines represent 95% CI about statewide annual CPUE.



Finfish Bycatch in the Crustacean Management Trawl Survey

Staff assessed the finfish catch in 92 trawls performed by the Crustacean Trawl Survey. Forty-eight of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). Staff performed the remaining 44 trawls in the southern part of the state (August 2017, December 2017, February 2018, and April 2018; **Table 5**).

The 92 trawls yielded 47,984 fish belonging to 66 species (**Appendix 4**), of which 14 fall under federal/regional management plans. Inshore Fisheries staff collected fin clips from the first 50 specimens of each species encountered within a calendar year. The SCDNR Genetics Laboratory archived these fin clips as part of a continuing effort to collect historical DNA samples, which will form a valuable resource for generating future funding proposals and research. We also archive voucher specimens for each species encountered by the survey.

Finfish monitoring of the Crustacean Management Trawl Survey began in 2010. However, a historical survey (now discontinued) by the Bears Bluff Laboratory also surveyed many of the sites we visit. As we accumulate more data, we will eventually be able to compare our contemporary data with historical Bears Bluff information from the 1950s and 1960s. This will create the longest time frame fish survey available from anywhere in South Carolina coastal waters.

As we continue to accumulate data they will also become increasingly useful for stock assessments for managed species. In the past year, Weakfish were the 5th most numerous species captured in the trawl survey, with 1,183 individuals captured. Most of these specimens represent young-of-year Weakfish. The 2016 ASMFC Weakfish Stock Assessment incorporates data from seven young-of-year fisheries-independent surveys, representing areas from Rhode Island through North Carolina. Data from the Crustacean Management Trawl Survey may be used in future stock assessments to supplement data from the current young-of-year surveys and will provide representation of the stock south of what is currently included. Additionally, the 50 genetic samples that we take and catalogue every year may also be used in the future to aid in identifying potential sub-stocks of the species, one of the research needs named in the 2016 stock assessment.

Freezer program

The freezer program collects filleted fish carcasses donated to SCDNR by recreational anglers at conveniently located drop-off freezers. It enables scientists to collect information needed for population assessments, such as the size, age, and sex composition of harvested fish.

Table 5: Number of Crustacean Management trawls that we monitored for finfish from July 1, 2017 – June 30, 2018.

	2017						2018						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Charleston Harbor	2	2	2	2	2	2	2	2	2	2	2	2	**24**
Ashley River	2	2	2	2	2	2	2	2	2	2	2	2	**24**
Stono River/Kiawah River		3				3		3		3			**12**
ACE Basin		4				4		4		4			**16**
Port Royal Sound		1				1		1		1			**4**
Calibogue Sound		3				3		3		3			**12**
Total	**4**	**15**	**4**	**4**	**4**	**15**	**4**	**15**	**4**	**15**	**4**	**4**	**92**

We acquired 243 fish carcasses belonging to five species through the freezer program during the reporting period, with the largest number coming from Sheepshead (**Table 6**). Length, sex, and maturity (where possible) were determined from each specimen, and otoliths were extracted for ageing. We also preserved a fin clip from each specimen for genetic investigations.

Fish tournament program

Like the freezer program, the tournament program enables us to gather information on the size, age, and sex composition of harvested fish. SCDNR staff members attend weekend tournaments and collect measurements and biological samples from certain species of interest. To minimize bias in the sizes of fish sampled, we examine all of a cooperating angler's harvested fish, rather than just trophy fish.

During the reporting period, the SCDNR Inshore Fisheries Section took measurements and biological samples from 206 fish belonging to six species, of which Sheepshead was the most numerous, followed by Spotted Seatrout (**Table 6**).

Tagging program

During Inshore Fishery surveys, SCDNR Inshore Fisheries staff tag certain species of fish before releasing them so that we gather information on recapture frequency, movement patterns and fate of re-captured fish.

The trammel and electrofishing surveys tagged 1,790 fish belonging to five species between July 1, 2017 and June 30, 2018, with the majority being Red Drum (**Table 7**). Over the same period, individuals recaptured 456 tagged fish, of which recreational anglers caught 380 and SCDNR survey staff caught 79 (**Table 8**). Anglers released alive approximately 79% (300/380) of the angler-caught fish (mostly Red Drum), while they harvested the remaining 21% (80/380).

Table 6: Number of fish acquired from the freezer and tournament monitoring programs during July 1, 2017 – June 30, 2018.

Species	Freezer	Tournament	Total
Black Drum	19	8	27
Bluefish		16	16
Red Drum	27	15	42
Sheepshead	177	105	282
Southern Flounder	7	22	29
Spotted Seatrout	13	40	53
Total	**243**	**206**	**449**

Table 7: Number of fish tagged by the trammel net and electrofishing surveys during July 1, 2017 – June 30, 2018.

Species	Electrofishing	Trammel	Total
Atlantic Tripletail		30	30
Black Drum	2	111	113
Red Drum	453	868	1,321
Sheepshead	1	87	88
Southern Flounder	75	163	238
Total	**531**	**1,259**	**1,790**

Inshore Fisheries Section Peer-Reviewed Publications (https://goo.gl/wXsZVY)

Comment [JB1]: All, please review and add any information that you have!

Recent publications (2015-present) in international, peer-reviewed journals that were co-authored by staff members (bold) of the Inshore Fisheries Section:

2018

Adams, G. D., R. T. Leaf, **J. C. Ballenger**, **S. A. Arnott** and **C. J. McDonough** (2018). Spatial variability in the individual growth of Sheepshead (*Archosargus probatocephalus*) in the Southeast US: Implications for assessment and management. Fisheries Research 206: 35-43.

Bacheler, N.M. and **J. C. Ballenger** (2018). Decadal-scale decline of Scamp (*Mycteroperca phenax*) abundance along the southeast United States Atlantic coast. Fisheries Research 208: 74-87.

Frazier, B.S., W.B. Driggers III, D.M. Bethea, R. E. Hueter, C. T. McCandles, and J.P. Tyminski (2018) Growth rates of Bonnetheads (*Sphyrna tiburo*) estimated from tag-recapture data. Fishery Bulletin (*in revision*).

2017

Arnott S. A., I. Dyková, **W. A. Roumillat**, and I. de Buron (2017). Pathogenic endoparasites of the Spotted Seatrout, *Cynoscion nebulosus*: patterns of infection in estuaries of South Carolina, USA. Parasitology Research 116(6): 1729–1743.

Barker A. M., **B. S. Frazier**, D. M. Bethea, J. R. Gold, and D. S. Portnoy (2017). Identification of young-of-the-year Great Hammerhead Shark *Sphyrna mokarran* in northern Florida and South Carolina. Journal of Fish Biology 91(2): 664-668.

de Buron, I., K. M. Hill-Spanik, L. Haselden, S. D. Atkinson, S. L. Hallett, and **S. A. Arnott** (2017). Infection dynamics of *Kudoa inornata* (Cnidaria: Myxosporea) in Spotted Seatrout *Cynoscion nebulosus* (Teleostei: Scaienidae). Diseases of Aquatic Organisms 127: 29-40.

Farmer, N. A., W. D. Heyman, M. Karnauskas, S. Kobara, T. I. Smart, **J. C. Ballenger**, M. J. M. Reichert, D. M. Wyanski, M. S. Tishler, K. C. Lindeman, S. K. Lowerre-Barbieri, T. S. Switzer, J. J. Solomon, K. McCain, M. Marhefka, G. R. Sedberry (2017). Timing and locations of reef fish spawning off the southeastern United States. PloS One 12(3): e0172968.

Peterson C. D., C. N. Belcher, D. M. Bethea, W. B. Driggers III, **B. S. Frazier**, and R. J. Latour (2017). Preliminary recovery of coastal sharks in the south-east United States. Fish & Fisheries 18(5): 845-859.

Sinkus, W., V. Shervette, **J. Ballenger**, L. A. Reed, C. Plante, and B. White (2017). Mercury bioaccumulation in offshore reef fishes from waters of the Southeastern USA. Environmental Pollution 228: 222-233.

2016

Bowden J. A., C.M. Cantu, R. W. Chapman, S.E. Somerville, M. P. Guillette, H. Botha, A. Hoffman, W. J. Luus-Powell, W. J. Smit, J. Lebepe, J. Myburgh, D. Govender, **J. Tucker**, A. S. P. Boggs, and L. J. Guillette (2016). Predictive blood chemistry parameters for Pansteatitis-affected Mozambique Tilapia (*Oreochromis mossambicus*). PloS One 11 (4): e0153874.

Hart M., **H. DaVega**, **S. A. Arnott**, A. S. Harold, and **A. M. Grosse** (2016) *Regina regida regida* (glossy crayfish snake) predation. Journal of Herpetology.

Hein J. L., I. de Buron, **W. A. Roumillat**, W. C. Post, A. P .Hazel and **S. A. Arnott** (2016) Infection of newly recruited American eels (*Anguilla rostrata*) by the invasive swimbladder parasite *Anguillicoloides crassus* in a US Atlantic tidal creek. ICES Journal of Marine Science 73: 14-21.

Lytton, A. R., **J. C. Ballenger**, M. J. M. Reichert, and T. I. Smart (2016). Age validation of the North Atlantic stock of Wreckfish (*Polyprion americanus*), based on bomb radiocarbon (^{14}C), and new estimates of life history parameters. Fishery Bulletin 114(1): 77-88.

O'Donnell, T.P. , **S. A. Arnott**, M. R. Denson, T. L. Darden (2016). Effects of cold winters on the genetic diversity of an estuarine fish, the Spotted Seatrout (*Cynoscion nebulosus*). Marine & Coastal Fisheries: Dynamics, Management, and Ecosystem Science 8: 263-276.

Paller, M. H., B. A. Prusha, D. E. Fletcher, E. Kosnicki, S. A. Sefick, M. S. Jarrell, S. C. Sterrett, **A. M. Grosse**, T. D. Tuberville, and J. W. Feminella (2016). Factors influencing stream fish species composition and functional properties at multiple spatial scales in the sand hills of the southeastern United States. Transactions of the American Fisheries Society 145(3): 545-562

Portnoy D. S. , C. M. Hollenbeck, D. M. Bethea, **B. S. Frazier**, and J. Gelsleichter (2016). Population structure, gene flow, and historical demography of a small coastal shark (*Carcharhinus isodon*) in US waters of the Western Atlantic Ocean. ICES Journal of Marine Science 73(9): 2322-2332.

Shaw, A. L., **B. S. Frazier**, J. R. Kucklick, and G. Sancho (2016). Trophic ecology of a predatory community in a shallow-water, high-salinity estuary assessed by stable isotope analysis. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science 8(1): 46-61.

Taliercio, M., T. Darden, V. Connors, **W. Roumillat**, and I. de Buron (2016). Striped Bass, *Morone saxatilis*: a new intermediate host for the Heterphyid *Asocotyle nana*. Comparative Parasitology 83: 29-35.

2015

Bacheler, N. M. and **J. C. Ballenger** (2015). Spatial and temporal patterns of Black Sea Bass sizes and catches in the southeastern United States from spatially explicit nonlinear models. Marine and Coastal Fisheries 7(1): 523-536.

Leidig, J. M., V. R. Shervette, **C. J. McDonough**, and T. L. Darden (2015). Genetic population structure of Black Drum in US waters. North American Journal of Fisheries Management 35(3): 464-477.

Li, W. X., **S. A. Arnott**, K. M. M. Jones, P. E. Braicovich, I. de Buron, G. T. Wang, and D. J. Marcogliese (2015). First record of paratenic hosts of the swimbladder nematode *Anguillicola crassus* in North America. Journal of Parasitology 101: 529-535.

Midway S. R., T. Wagner, **S. A. Arnott, P. Biondo** and F. Martinez-Andrade (2015). Spatial and temporal variability in growth of Southern Flounder (*Paralichthys lethostigma*). Fisheries Research 167: 323-332.

Mortensen R. A., **S. A. Arnott**, W. J. Jones and D. I. Greenfield (2015). Development of a sandwich hybridization assay for the identification and quantification of red drum (*Sciaenops ocellatus*) eggs: a novel tool for fishery research and management. Canadian Journal of Fisheries and Aquatic Sciences 72: 1-11.

Table 8: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2017 – June 30, 2018.

Capture Method	Disposition	Black Drum	Red Drum	Sheepshead	Southern Flounder	Striped Bass	Atlantic Tripletail	Total
Anglers	Harvested	17	53	3	3		4	80
	Released	10	284	3	1	1	1	300
	Anglers: sub-total	**27**	**337**	**6**	**4**	**1**	**5**	**380**
SCDNR Surveys	Harvested		1		1			2
	Released	3	68	2	1			74
	Survey: sub-total	**3**	**69**	**2**	**2**			**76**
Total		**30**	**406**	**8**	**6**	**1**	**5**	**456**

Appendix 1 Total catch of each species encountered by the trammel net survey during July 1, 2017 – June 30, 2018.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Striped Mullet	*Mugil cephalus*	3,412	36	Butterfish	*Peprilus triacanthus*	9
2	Spotted Seatrout	*Cynoscion nebulosus*	2,428	37	Weakfish	*Cynoscion regalis*	8
3	Blue Crab	*Callinectes sapidus*	2,094	38	Lemon Shark	*Negaprion brevirostris*	6
4	Red Drum	*Sciaenops ocellatus*	1,515	39	Gulf of Mexico Ocellated Flounder	*Ancylopsetta ommata*	5
5	Spot	*Leiostomus xanthurus*	1,174	40	Gray Snapper	*Lutjanus griseus*	5
6	Atlantic Menhaden	*Brevoortia tyrannus*	812	41	White Catfish	*Ameiurus catus*	5
7	Diamondback Terrapin	*Malaclemys terrapin centrata*	634	42	Summer Flounder	*Paralichthys dentatus*	4
8	Atlantic Croaker	*Micropogonias undulates*	553	43	Bull Shark	*Carcharhinus leucas*	4
9	Gizzard Shad	*Dorosoma cepedianum*	480	44	Blacktip Shark	*Carcharhinus limbatus*	3
10	Southern Flounder	*Paralichthys lethostigma*	361	45	Blueback Herring	*Alosa aestivalis*	3
11	Longnose Gar	*Lepisosteus osseus*	301	46	Bighead Searobin	*Prionotus Tribulus*	3
12	Pinfish	*Lagodon rhomboids*	294	47	Lookdown	*Selene vomer*	3
13	Ladyfish	*Elops saurus*	223	48	Naked Goby	*Gobiosoma bosc*	3
14	Atlantic Stingray	*Dasyatis sabina*	218	49	Roughtail Stingray	*Dasyatis centroura*	3
15	Southern Kingfish	*Menticirrhus americanus*	202	50	Atlantic Ridley Turtle	*Lepidochelys kempii*	3
16	Black Drum	*Pogonias cromis*	172	51	Atlantic Bumper	*Chloroscombrus chrysurus*	3
17	Bonnethead	*Sphyrna tiburo*	138	52	American Shad	*Alosa sapidissima*	3
18	Horseshoe Crab	*Limulus Polyphemus*	105	53	Tarpon	*Megalops atlanticus*	3
19	Sheepshead	*Archosargus probatocephalus*	105	54	Loggerhead Turtle	*Caretta caretta*	3
20	Hogchoker	*Trinectes maculatus*	74	55	Bay Whiff	*Citharichthys spilopterus*	2
21	Finetooth Shark	*Carcharhinus isodon*	72	56	Hickory Shad	*Alosa mediocris*	2
22	Bluntnose Stingray	*Dasyatis say*	70	57	Shrimp Eel	*Ophichthus gomesii*	2
23	Silver Perch	*Bairdiella chrysoura*	67	58	Smooth Butterfly Ray	*Gymnura micrura*	2
24	Cownose Ray	*Rhinoptera bonasus*	62	59	Spanish Mackerel	*Scomberomorus maculatus*	2

25	Bluefish	*Pomatomus saltatrix*	56	60	White Perch	*Morone americana*	1
26	Striped Burrfish	*Chilomycterus schoepfii*	50	61	Atlantic Thread Herring	*Opisthonema oglinum*	1
27	Atlantic Sharpnose Shark	*Rhizoprionodon terranovae*	42	62	Atlantic Sturgeon	*Acipenser oxyrinchus*	1
28	Atlantic Spadefish	*Chaetodipterus faber*	40	63	Irish Pompano	*Diapterus auratus*	1
29	American Harvestfish	*Peprilus paru*	38	64	Leatherjack	*Oligoplites saurus*	1
30	Atlantic Tripletail	*Lobotes surinamensis*	36	65	Seatrout spp.	*Cynoscion spp.*	1
31	Pigfish	*Orhtopristis chrysoptera*	32	66	Atlantic Needlefish	*Strongylura marina*	1
32	Northern Puffer	*Sphoeroides maculatus*	26	67	Southern Stingray	*Dasyatis Americana*	1
33	Green Sea Turtle	*Chelonia mydas*	25	68	Spotted Eagle Ray	*Aetobatus narinari*	1
34	White Mullet	*Mugil curema*	10	69	Hardhead Catfish	*Ariopsis felis*	1
35	Crevalle Jack	*Caranx hippos*	10				
						Total	**16,030**

Appendix 2 Total catch of each species encountered by the electrofishing survey during July 1, 2017 – June 30, 2018.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Striped Mullet	*Mugil cephalus*	10,157	38	Flathead Catfish	*Pylodictis olivaris*	18
2	Spot	*Leiostomus xanthurus*	4,088	39	Naked Goby	*Gobiosoma bosc*	17
3	Atlantic Menhaden	*Brevoortia tyrannus*	2,891	40	Spotted Sunfish	*Lepomis punctatus*	16
4	Bay Anchovy	*Anchoa mitchilli*	1,491	41	White Perch	*Morone americana*	12
5	Inland Silverside	*Menidia beryllina*	1,465	42	Golden Shiner	*Notemigonus crysoleucas*	11
6	Red Drum	*Sciaenops ocellatus*	670	43	Atlantic Needlefish	*Strongylura marina*	10
7	Longnose Gar	*Lepisosteus osseus*	612	44	Hogchoker	*Trinectes maculatus*	9
8	Largemouth Bass	*Micropterus salmoides*	572	45	Black Drum	*Pogonias cromis*	8
9	American Eel	*Anguilla rostrate*	437	46	Highfin Goby	*Govionellus oceanicus*	8
10	Bluegill	*Lepomis macrhchirus*	327	47	Warmouth	*Lepomis gulosus*	8
11	Silver Perch	*Bairdiella chrysoura*	321	48	Fat Sleeper	*Dormitator maculatus*	7
12	Blue Catfish	*Ictalurus furcatus*	298	49	Channel Catfish	*Ictalurus punctatus*	5
13	Southern Flounder	*Paralichthys lethostigma*	292	50	Bay Whiff	*Citharichthys spilopterus*	5
14	Tidewater Mojarra	*Eucinostomus harengulus*	286	51	Brook Silverside	*Labidesthes sicculus*	4
15	White Catfish	*Ameiurus catus*	235	52	Blueback Herring	*Alosa aestivalis*	4
16	Threadfin Shad	*Dorosoma petenense*	170	53	Tarpon	*Megalops atlanticus*	4
17	Redbreast Sunfish	*Lepomis auratus*	153	54	Common Snook	*Centropomus undecimalis*	4
18	Pinfish	*Lagodon rhomboids*	133	55	Sailfin Molly	*Poecilia latipinna*	4
19	Mummichog	*Fundulus heteroclitus*	128	56	Grass Carp	*Ctenopharyngodon idella*	4
20	Gizzard Shad	*Dorosoma cepedianum*	120	57	Chain Pickerel	*Esox niger*	3
21	Atlantic Croaker	*Micropogonias undulates*	108	58	Sheepshead	*Archosargus probatocephalus*	3
22	Redear Sunfish	*Lepomis microlophus*	97	59	Tiger Shrimp	*Penaeus monodon*	3
23	Bowfin	*Amia calva*	73	60	Lepomis species	*Lepomis sp.*	3
24	Spotted Seatrout	*Cynoscion nebulosus*	73	61	Tilapia species	*Lepomis sp.*	2

25	White Mullet	*Mugil curema*	69	62	Rainwater Killifish	*Lucania parva*	2
26	Minnow – Species TBI	*Minnow – Species TBI*	57	63	Note: Family (Gobies)	*Gobiidae*	2
27	American Shad	*Alosa sapidissima*	55	64	Crevalle Jack	*Caranx hippos*	2
28	Striped Bass	*Morone saxatilus*	52	65	Violet Goby	*Gobioides broussonetii*	1
29	Black Crappie	*Pomoxis migromaculatus*	47	66	Atlantic Stingray	*Dasyatis sabina*	1
30	Freshwater Goby	*Ctenogobius shufeldti*	44	67	Blue Crab	*Callinectes sapidus*	1
31	Irish Pompano	*Diapterus auratus*	36	68	Bluefish	*Pomatomus saltatrix*	1
32	Speckled Worm Eel	*Myrophis punctatus*	26	69	Spotted Sucker	*Minytrema melanops*	1
33	Common Carp	*Cyprinus carpio*	24	70	Silver Seatrout	*Cynoscion nothus*	1
34	Gray Snapper	*Lutjanus griseus*	22	71	Leatherjack	*Oligoplites saurus*	1
35	Western Mosquitofish	*Gambusia holbrooki*	22	72	Chain Pipefish	*Syngnathus louisianae*	1
36	Ladyfish	*Elops saurus*	21	73	Sheepshead Minnow	*Cyprinodon variegatus*	1
37	Pumpkinseed	*Lepomis gibbosus*	18	74	Brown Bullhead	*Ameiurus nebulosus*	1
						Total	**25,878**

Appendix 3: Total catch of each species encountered by the SCDNR longline survey during July 1, 2017 – June 30, 2018.

Rank	Common name	Scientific name	# Caught
1	Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	1,051
2	Red drum	*Sciaenops ocellatus*	519
3	Sandbar shark	*Carcharhinus plumbeus*	123
4	Blacknose shark	*Carcharhinus acronotus*	89
5	Southern stingray	*Hypanus americanus*	74
6	Blacktip shark	*Carcharhinus limbatus*	55
7	Finetooth shark	*Carcharhinus isodon*	52
8	Spinner shark	*Carcharhinus brevipinna*	21
9	Black sea bass	*Centropristis striata*	18
10	Oyster toadfish	*Opsanus tau*	13
11	Nurse shark	*Ginglymostoma cirratum*	8
12	Bonnethead	*Sphyrna tiburo*	8
13	Bull shark	*Carcharhinus leucas*	7
14	Atlantic stingray	*Hypanus sabinus*	6
15	Southern kingfish/whiting	*Menticirrhus americanus*	6
16	Lemon shark	*Negaprion brevirostris*	4
17	Carolina/scalloped hammerhead	*Sphyrna gilberti/S.lewini*	4
18	Smooth butterfly ray	*Gymnura micrura*	4
19	Tiger shark	*Galeocerdo cuvier*	3
20	Gafftopsail catfish	*Bagre marinus*	3
21	Atlantic croaker	*Micropogonias undulatus*	3
22	Clearnose skate	*Raja eglanteria*	2

23	Great hammerhead	*Sphyrna mokarran*		1
24	Gag grouper	*Mycteroperca microlepis*		1
25	Cobia	*Rachycentron canadum*		1
26	Horseshoe crab	*Limulus polyphemus*		1
			Total	**2,077**

Appendix 4: Total number of fish caught in the Crustacean Management Trawl Survey between July 1, 2017 and June 30, 2018, by species.

	Common Name	Scientific Name	# Caught
1	Star Drum	*Stellifer lanceolatus*	16,793
2	Bay Anchovy	*Anchoa mitchilli*	14,743
3	Atlantic Croaker	*Micropogonias undulatus*	6,676
4	Spot	*Leiostomus xanthurus*	2,703
5	Weakfish	*Cynoscion regalis*	1,183
6	Spotted Hake	*Urophycis regia*	988
7	Blackcheek Tonguefish	*Symphurus plagiusa*	800
8	Silver Perch	*Bairdiella chrysoura*	777
9	Hogchoker	*Trinectes maculatus*	534
10	Atlantic Menhaden	*Brevoortia tyrannus*	481
11	Southern Kingfish	*Menticirrhus americanus*	424
12	Seatrout spp.	*Cynoscion spp.*	406
13	Silver Seatrout	*Cynoscion nothus*	248
14	Bighead Searobin	*Prionotus tribulus*	130
15	Butterfish	*Peprilus triacanthus*	117
16	Inland Silverside	*Menidia beryllina*	110
17	Atlantic Cutlassfish	*Trichiurus lepturus*	109
18	Threadfin Shad	*Dorosoma petenense*	90
19	Atlantic Spadefish	*Chaetodipterus faber*	82
20	Fringed Flounder	*Etropus crossotus*	76
21	Banded Drum	*Larimus fasciatus*	66
22	Gulf of Mexico Ocellated Flounder	*Ancylopsetta ommata*	54
23	Atlantic Bumper	*Chloroscombrus chrysurus*	45
24	Southern Hake	*Urophycis floridana*	39
25	White Catfish	*Ameiurus catus*	38
26	Summer Flounder	*Paralichthys dentatus*	37
27	Rock Sea Bass	*Centropristis philadelphica*	35
28	Striped Searobin	*Prionotus evolans*	35
29	Tidewater Mojarra	*Eucinostomus harengulus*	35
40	American Harvestfish	*Peprilus paru*	34
41	Highfin Goby	*Gobionellus oceanicus*	33
42	Hardhead Catfish	*Ariopsis felis*	33
43	White Mullet	*Mugil curema*	33
44	Atlantic Moonfish	*Selene setapinnis*	33
45	Bluefish	*Pomatomus saltatrix*	33
46	Oyster Toadfish	*Opsanus tau*	32
47	Skilletfish	*Gobiesox strumosus*	32
48	Striped Killifish	*Fundulus majalis*	32
49	Striped Mullet	*Mugil cephalus*	32
50	Red Drum	*Sciaenops ocellatus*	32
51	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	31
52	Black Sea Bass	*Centropristis striata*	31
53	Bluntnose Stingray	*Dasyatis say*	31
54	Chain Pipefish	*Syngnathus louisianae*	31
55	Darter Goby	*Ctenogobius boleosoma*	31
56	Gafftopsail Catfish	*Bagre marinus*	31

24				57		*Dorosoma cepedianum*	1
42	Atlantic Stingray	*Dasyatis sabina*	29	75	Gizzard Shad		
25	Southern Flounder	*Paralichthys lethostigma*	27	58	Gray Snapper	*Lutjanus griseus*	1
25	Striped Anchovy	*Anchoa hepsetus*	26	59	Leopard Searobin	*Prionotus scitulus*	1
27	Spotted Seatrout	*Cynoscion nebulosus*	16	60	Mummichog	*Fundulus heteroclitus*	1
28	Feather Blenny	*Hypsoblennius hentz*	15	61	Naked Goby	*Gobiosoma bosc*	1
29	Blueback Herring	*Alosa aestivalis*	14	62	Northern Pipefish	*Syngnathus fuscus*	1
30	Atlantic Thread Herring	*Opisthonema oglinum*	11	63	Pinfish	*Lagodon rhomboides*	1
31	Lookdown	*Selene vomer*	11	64	Shrimp Eel	*Ophichthus gomesii*	1
32	Smooth Butterfly Ray	*Gymnura micrura*	11	65	Striped Cusk-Eel	*Ophidion marginatum*	1
33	Bay Whiff	*Citharichthys spilopterus*	10	66	Inshore Lizardfish	*Synodus foetens*	1
						Total	**47,894**

Fish Stock Enhancement Research: Evaluating A Responsible Approach To Marine Finfish Stock Enhancement of Spotted Seatrout, Red Drum, Cobia and Striped Bass

Project PI/ Participants**: M. Denson (PI)**, **T. Darden (PI)**

Project Duration: July 1, 2017 through June 30, 2018

INTRODUCTION:

The South Carolina Department of Natural Resources has a long history of state-of-the-art aquaculture, stock enhancement, genetics, and applied fisheries research. The mariculture and genetics sections have received funding from SRFAC for a number of years and has, coupled with other funding sources, been able to develop one of the most technically-sophisticated stocking and genetics research programs in the country. Funds have been used in the past to develop genetic microsatellite markers for red drum, spotted sea trout, cobia, and striped bass. In addition, with the technological infrastructure and the professional staff in place, SCDNR has been able to apply this technology to red drum, spotted seatrout, striped bass, and cobia stock enhancement and fisheries research. The use of stocked animals as a proxy for wild fish to answer challenging biological and ecological questions, referred to as "Applied Fisheries Research," is also a product of our research program.

During this fiscal year, stocking occurred in several estuaries in SC from Winyah Bay to Port Royal Sound with several species to meet grant obligations. All of the stocking research followed "Responsible Approach" guidelines and adhered to a strict internal policy that ensures the health and well-being of the resource. These guidelines require us to evaluate the impacts and be capable of identifying stocked fish from their wild cohorts to determine contribution, for which we use DNA genotyping. We annually evaluate the contribution to stocking for all species from staff and angler collections 1-2 years after release.

Project Objectives:

- Genetic management of broodstock to verify genetic uniqueness of stocked families.
- Produce and stock small juveniles (~1-2 inch total length) in targeted estuaries to evaluate the contribution of stocked fish to the wild populations.
- Use genetic tags to determine the contribution of stocked fish to wild populations from stockings in previous years.
- Evaluate the success of the approach for each species and adapt stocking strategies to improve success.

SUMMARY OF ACCOMPLISHMENTS/ACTIVITIES:

Red Drum:

2017 Production: During the fall of 2017, SRFAC funds were used to produce and stock 1,346,024 into three estuaries throughout South Carolina. A total of 972,973 juvenile red drum were released into two stocking locations within Winyah Bay by SCDNR staff: small juveniles stocked in the brackish water (<8 g/L) and small juveniles stocked in saltwater (>25 g/L). Small

juveniles (13,081) were also released by SCDNR staff into the ACE Basin. An additional stocking of small juveniles (359,970) into the North Edisto (Bohicket and Leadenwah Creek) was conducted by Bears Bluff National Fish Hatchery utilizing larvae spawned at MRRI. Approximately 8,000 fish have been overwintered at the Waddell Mariculture Center of which 1,000 fish will be stocked into Colonial Lake for a kids fishing tournament that will be held in late September 2018. Any residual fish will be stocked into the Ashley River and Port Royal Sound at a larger size-class. Production was impacted for the third year in a row by a major weather event, Hurricane Irma. Its potential influences on contribution of these stocked fish will be evaluated next year following collection of 2017 YC samples.

Table 1. 2017 year-class red drum stocking summary from SRFAC funding including number stocked, timing, location, and size at release.

Number Stocked	Timing	Stocking Location	Mean TL at Release (Inches)
566,755	Fall 2017	Winyah Bay (saltwater release)	1.4
406,218	Fall 2017	Winyah Bay (freshwater release)	1.4
13,081	Fall 2017	ACE Basin	3.0
359,970	Fall 2017	N. Edisto River	1.2

Evaluation of 2016 YC Stocking:

Three unique genetic families contributed to the 2016 YC stock enhancement releases. Six estuaries were stocked including the Ashley River, Port Royal Sound, North Edisto, Winyah Bay, Murrell's Inlet, and Cherry Grove (Table 2). Additional stockings in land-locked pond systems at the James Island County Park and Colonial Lake were conducted for youth fishing tournaments in cooperation with the Coastal Reserves and Outreach section at the Marine Resources Division (MRD). Three distinct size classes were produced: small (mean TL 1.3-1.7 inches), medium (mean TL 5.4-7.7 inches), and large (mean TL 12.1-14.4 inches) juveniles with stocking occurring from 9/9/2016 to 11/30/2017.

Table 2. Red drum genetic family, stocking locations, and treatments for the 2016 YC by genetic family.

Genetic Family	Stocking Location
NWL6	Winyah Bay (small, pre-hurricane)
	N. Edisto River (small)
HML118	N. Edisto River (small)
	Port Royal Sound (medium)
	May River (medium)
	Ashley River (medium)
	Cherry Grove (large)
	Murrell's Inlet (large)
	Outreach/education sites
HML119	Winyah Bay (small, post-hurricane)

	Port Royal Sound (small)
	N. Edisto River (small/medium

During the middle of the production season, 10/06/2016 – 10/09/2016, Hurricane Matthew paralleled the coast of the southeastern USA before making landfall near the Cape Romain National Wildlife Refuge in South Carolina as a Category 1 hurricane. The Hilton Head area including the Waddell Mariculture Center (WMC) had extensive tree damage and power outages, which delayed the second production run of red drum. Many South Carolina estuaries saw dramatic effects including the Waccamaw River and the Little Pee Dee River, both tributaries of Winyah Bay, which saw record river crests due to high rain totals. In addition, the Charleston Harbor experienced peak storm tides reaching 9.29 feet, accounting for the third highest levels on record.

Due to this meteorological event, the red drum stocking strategy for 2016 was revised to include a pre-hurricane stocking with one unique genetic family in Winyah Bay and a post-hurricane release utilizing an additional family in the same stocking location, similar to the stocking plan in 2015. This strategy was to evaluate the effects that increased precipitation and storm surge have on hatchery juvenile red drum survival and distribution in Winyah Bay and potential impacts to wild larval recruitment to the system. Additionally, two genetic families were grown to different sizes (small and medium) and released into the Colleton River (Port Royal Sound) to evaluate the effects of size at release on hatchery success. The final five stocking locations (Ashley River, North Edisto, May River (PRS), Murrell's Inlet and Cherry Grove) did not have a study design and fish were released for stock enhancement purposes only.

A single family of medium juvenile red drum was released directly from the trailer (1,432 fish at ~7.4 inches TL) at Leeds Avenue boat ramp on the Ashley River. Six 2016 YC cultured fish were recaptured in the Ashley River, resulting in an overall contribution of 13.6%. All but one cultured fish travelled upstream into the electrofishing strata from the initial stocking location, with the one exception staying within the trammel net strata and moving towards the Cosgrove Bridge. Comparisons of sampling gear showed that more of the 2016YC hatchery recaptures came from electrofishing gear (n=5, 83%) than trammel netting gear (n=1, 17%). Hatchery contribution for the 2016YC was also higher in the electrofishing sites than in the trammel netting sites (50% vs. 3%). This movement into the less saline portions of the Ashley River is consistent with hatchery recapture results from previous years.

In Cherry Grove, a total of 567 large yearling red drum (mean TL 12.1 inches) from a single genetic family were released by trailer at Cherry Grove Park and Boat Ramp on 6/6/2016. These fish were remaining individuals from a feeding trail conducted at the Hollings Marine Laboratory. As no sampling was conducted in Murrell's Inlet in 2017, contribution from this location is not known.

Two families were released into the Port Royal Sound of two distinct size classes: small juveniles from one family and medium juveniles from a second family. Fish in both treatments were released by trailer at Trask Landing which is located on the Colleton River next to the Waddell Mariculture Center. A total of 105,037 small juvenile red drum (mean TL 1.7 inches) were released on 3/22/2017 (76,966) and 3/23/17 (28,071). A total of 6,942 medium juvenile red

drum (mean TL 7.7 inches) were released on 5/11/2017. Genetic analyses of 2016 YC one-year old red drum captured in the trammel net results showed an overall 23.1% contribution to the system and all stocked fish were from the medium release treatment (n=6). The absence of the small juvenile releases is likely due to the size and time of year these fish were released. Limited movement was seen with the medium sized fish only traveling a maximum of 3.5 miles from the release location.

In James Island County Park, a single family totaling 1,267 medium-sized juveniles (mean TL 7.7 inches) were released as part of an outreach event to increase fishing access for kids and determine the feasibility of using this location for future fishing tournaments. Stocking occurred on 5/02/2017 at the front pond in James Island County Park. The education and outreach section at MRD and children from the community assisted staff with measurements and with externally tagging and releasing of the fish. In addition, two separate releases utilizing the same genetic family occurred at Colonial Lake in downtown Charleston. A total of 1,200 medium juveniles (mean TL 6.9 inches) were initially released on 4/19/2017 to verify fish could survive and grow in the enclosure. A second release of 942 large fish (mean TL 13.5 inches) was completed on 9/07/2017 with assistance from the education and outreach section. These fish were stocked for the Huck Finn kid's fishing tournament which took place in September. Based on feedback from the event coordinator and DNR staff (Robert Wiggers), catches exceed the previous year with approximately 50 fish, mostly red drum, being caught.

In the May River, medium juvenile red drum where released by trailer at Alljoy Boat Landing near Bluffton, SC on 5/11/2017. A total of 2,339 medium-sized juveniles (mean TL 7.7 inches) were released as part of our stock enhancement program. As no sampling was conducted in the May River in 2017, contribution from this location is not known.

In Murrell's Inlet, a total of 839 large juvenile red drum (mean TL 14.4 inches) from a single genetic family were released by trailer at Morse Park Landing on 11/30/2017. As no sampling was conducted in Murrell's Inlet in 2017, contribution from this location is not known.

Three genetic families were released into the North Edisto River from the 2016 YC. The WMC produced 148,241 small juveniles (mean TL 2.0 inches) from two families which were released at Cherry Point Boat ramp on 10/20/2016 and 10/24/2016. In addition, the WMC produced 4,417 medium-sized juveniles (mean TL 5.4 inches) which were stocked at Cherry Point Boat Ramp on 3/24/17. Bears Bluff National Fish Hatchery received larvae from MRD which were extensively cultured at their facility and 409,133 small juveniles (mean TL 1.3 inches) were released by boat into Leadenwah and Bohicket Creeks. A total of 98,408 fish were released on 9/22/2016 and 10/20/2016 into Leadenwah Creek. The remaining 310,725 fish were released into Bohicket Creek and Wee Creek on 9/26/2016 and 10/05/2016. Our genetic analyses shows an overall contribution of 23.2% to the North Edisto. Hatchery contribution to the North Edisto for the 2016 YC was higher than any of the previous years-classes stocked into this estuary except 2005 (39.4%). Hatchery fish from the 2016 YC made a higher contribution to Leadenwah Creek (38.5%) than to Bohicket Creek (20.7%), which was similar to what was found for the 2013 YC. As the sampling in this estuary is fishery-dependent from limited sources and locations, it is likely that our contribution numbers are an overestimate of contribution to the entire system.

In Winyah Bay, two families were assigned one of two treatment groups: a pre-hurricane treatment or a post-hurricane treatment. Fish in both treatments were released by boat near the Thousand Acre Bridge as a single batch release occurring over multiple days. A total of 277,328 small juvenile red drum (mean TL 1.3 inches) from the pre-hurricane treatment were released on 9/09/16 (72,849), 9/13/16 (28,667) and 9/26/16 (175,812) approximately two weeks to a month prior to Hurricane Matthew's landfall. A total of 241,079 small juvenile red drum (mean TL 1.4 inches) from the post-hurricane treatment were released on 10/21/16 (34,238), 11/07/16 (159,585) and 11/09/16 (47,256) two weeks to a month after the event. This experimental design was opportunistic as knowledge of the hurricane was not previously known. However, we were able to adjust our stocking plan in order to examine the effect major weather events have on hatchery contribution/movement, and the potential impacts to wild recruitment. A similar experimental design was also opportunistically employed with the 2015 YC in the Ashley River. Due to the large geographic distance between stocking locations (North Edisto River and Colleton River) and past experience, it is improbable that there would be movement from the other stocked estuaries into Winyah Bay. Genetic analysis of age one red drum revealed the post-hurricane release juveniles had a contribution (n=35, 17.2%) and recapture rate (0.015) higher than the pre-hurricane release juvenile's contribution (n=21, 10.3%) and recapture rate (0.008). The recapture rate (number recaptured / number stocked) of the pre-hurricane release juveniles was significantly less from the recapture rate of the post-hurricane release juveniles (0.008 vs. 0.015; p=0.006). This same pattern was seen with the 2015 YC in the Ashley River suggesting that natural disaster events, especially during important life history stages, can have a significant negative impact on early hatchery success and potentially reduce wild recruitment survival. Similar to previous years, comparisons of gear showed a higher return of the 2016 YC hatchery recaptures came from electrofishing gear (n=54; 96%) than from trammel netting gear (n=2; 4%) even though stocking occurred in closer proximity to the trammel net sites. This movement into brackish water is currently being evaluated with stocking efforts in 2017-2019.

Table 3. Red drum contribution summary of 2016 YC stockings.

Estuary	Samples (n)	Cultured Contribution (%)
Ashley River	44	13.6
Port Royal Sound	26	23.1
North Edisto	95	23.2
Winyah Bay	203	27.6

Spotted Seatrout:

2017 Production:

For the 2017 production year, a total of 782,562 spotted seatrout were produced at the WMC and stocked into the Charleston Harbor system (Table 3), replicating previous stocking experiments in 2015-2016 to evaluate the effects of size and season on contribution. Four genetically unique families were used for these releases. In May, 599,378 small juveniles were released at James Island Yacht Club representing the small juvenile/early season release. In July, an additional 121,322 small juveniles were released in the Ashley River at the Leeds Avenue boat ramp as small juveniles in order to assess movement patterns of spotted seatrout between the Ashley

River and Charleston Harbor. In September and October, 59,897 small juveniles were released at James Island Yacht Club as a small juvenile/late season treatment. Finally, in October an additional 1,965 large juveniles were released at James Island Yacht Club. The contribution of 2017 YC stocked fish will be evaluated following ongoing sampling efforts in 2018.

Table 4. Spotted seatrout produced at WMC and stocked in South Carolina estuaries in 2017.

Year Class	Number Stocked	Total Length (inches)	Release Location	Release Treatment
2017	599,378	~1.1	Charleston Harbor	Early season, small
2017	121,322	~1.4	Ashley River	Small
2017	59,897	~1.1	Charleston Harbor	Late season, small
2017	1,965	~5.2	Charleston Harbor	Late season, large

Evaluation of 2014 thru 2017 YC Stockings:
Genetic identification of hatchery raised spotted seatrout released into the Charleston Harbor system continued in 2017 resulting in 20 stocked individuals from four separate year-classes collected during September-December. No hatchery fish were collected in the Wando River for the third consecutive year, which was expected given that no stocking has occurred there since 2013 and observation of spotted seatrout movement from the stocking locations in the Ashley River and Charleston Harbor to the Wando River is rare.

There was a 16.7% stocking contribution to the 2014 YC, which is similar to what has been observed in previous years (5-20%). A higher contribution of stocked fish (24.4%) was observed for the 2015 YC, which represents the greatest contribution documented to date for spotted seatrout beyond age 1 and is similar to the previous year's contribution rate of 23.7%. Season of release likely influenced spotted seatrout survival given that only juveniles from the small/early season release where recaptured (n=11), whereas no small or large juveniles were captured from the late season releases. Low contribution from the 2016 YC (1.1%) was expected given that no hatchery spotted seatrout from that year-class were collected in the previous year as age 0 and the low numbers of fish released that year (106,071). Interestingly, the small and large late season releases were the only hatchery fish recaptured, but is likely due to lower stocking numbers during the early season and timing of stocking compared to the previous year. Results from the 2017 YC (22.7%) suggest that small/early season releases have higher contribution similar to the 2015 YC. The 2017 YC contribution number is likely to decrease once the wild year-class is fully recruited to Inshore Fisheries sampling gear.

Based on the results, it appears that releasing small/early season spotted seatrout increases the success rate of hatchery-raised fish in the wild. The extended growing time during the summer appears to allow fish to reach larger sizes than the late season-released fish prior to the onset of decreased water temperatures during the winter, which is likely increasing their survival through

the winter period. Production of juveniles is also more difficult during mid and late summer months due to the excessively high water temperatures in our pond systems. The overall low contribution but high return rate from the large juvenile sea trout (>5 inches) may not be worth the additional effort, time, and resources necessary for raising large juvenile spotted seatrout. Based on these results, hatchery protocols were adjusted in 2018 to maximize hatchery success by releasing fish earlier in the season.

Striped Bass:
The SCDNR stocked striped bass in the Ashley River from 2006–2014 as part of a project designed to explore the possibility of restoring the extirpated population of striped bass in this system. In past years, stocking efforts had been implemented using fish produced at both freshwater and brackish water hatcheries and stocked both small 1-2 inch phase I juveniles in the spring, as well as 6-8 inch phase II juveniles in the fall. The experimental stocking concluded in 2014 after modeling efforts suggested a sufficient number of genetically diverse striped bass across many year-classes had been stocked to theoretically establish a self-sustaining population. Our monitoring of striped bass in the Ashley River continues to date.

There were no striped bass captured in the Ashley River during routine sampling between July 2016 and June 2017. However, a total of 47 striped bass were captured in Winyah Bay and the Pee Dee River during this time. These samples were genotyped and analyzed to determine if fish originally released in the Ashley River moved into neighboring estuaries and river systems. Although 17 of these fish were determined to be cultured (5 from SC and 12 from NC), all of the fish stocked by SCDNR were originally released into Lake Marion or Lake Moultrie.

The lack of detection of striped bass within the Ashley River during our standardized sampling suggest that there is limited to no recruitment and that stocked fish either moved out of the system, were captured by recreational anglers, or environmental factors in the system were insufficient to support and sustain the population.

Cobia:
Mariculture staff have been collecting cobia carcasses from recreational anglers as well as from tournaments over the last 10 years. Because of cobia fishing closures in state and federal waters in 2017, collection of cobia in the Port Royal and St. Helena sounds as well as offshore to produce life history information did not occur. However, collection of undersized fish by SCDNR's SEAMAP section and fin clips from acoustically tagged fish utilizing funds from a Cooperative Research Program (CRP) grant did provide a small number of samples. The SEAMAP samples of undersized fish are particularly valuable in that they represent a life history stage not available from recreational anglers or tournaments. The data will be used in the SEDAR stock assessment being held later this year.

In 2017, a total of 28 undersized cobia were collected by SEAMAP and provided to the EFR section for processing. An additional 108 cobia fin clip samples were collected through the CRP acoustic tagging study. Of these, 17 samples were collected during the April-July spawning season within South Carolina estuaries (all CRP samples) and used to estimate contribution of stocked fish following genetic parentage analysis. Three fish completely matched to the 2012 broodstock for a 17.6% contribution to the whole inshore population. This contribution

percentage is consistent with 2015 and 2016 collection years (22.2% and 25.0% respectively) and is relatively high considering only 4,048 juveniles were released from this year-class suggesting the wild population abundance is low.

The federal government opened the fishery in 2018, however the inshore fishery remained closed during May which coincides with the peak of inshore intercepts in South Carolina. A total of 74 samples were collected from offshore and fish captured inshore outside of the May closure through a cooler program working cooperatively with local charter boat captains which includes fish racks, genetic samples, and catch information. In addition, staff attend all cobia tournaments in the state to collect similar life history and genetics data. Genetic samples of all cobia are utilized to evaluate population structure as well as identify the contribution of stocked fish to the population.

In addition to the collection of life history data, recreational license funds were used to make several trips from April - June 2018 to collect cobia broodstock from the Broad River annual inshore aggregation for hatchery production of fingerlings for stock enhancement research. Seven wild cobia including two females were collected by cooperating recreational anglers and SCNDR staff in the Broad River and transported back to MRRI for use as broodstock. Cobia were prophylactically treated for any external parasites and introduced to existing broodstock. Cobia broodstock injected with spawning hormones produced viable eggs which were hatched and stocked into ponds at the WMC. Unfortunately, spawning did not occur until late summer when water temperatures became too hot for successful juvenile production. Juvenile production was successful in July 2017 when a total of 8,924 cobia fingerlings were produced and subsequently released into the Colleton River. These fish are expected to begin showing up in the 2019 collection year when contribution to the wild population can be assessed.

The Stock Identification Workshop is the first step in the SEDAR Stock Assessment process and was conducted in May and June of 2018. SCDNR's genetic and movement/tagging data were analyzed and submitted to determine the stock ID boundaries for cobia. Our compiled genetic dataset represented 2,796 samples from 18 collections locations ranging from Virginia to Corpus Christi, Texas. STRUCTURE, F_{ST}, and AMOVA analyses supported genetically distinct Atlantic (South Carolina and northward) and Gulf of Mexico (Texas to Ft. Pierce, Florida) genetic groupings representing separate populations. The updated traditional tagging evaluation continued to support the presence of Gulf of Mexico and Atlantic stocks and our CRP-supported acoustic tagging data set provided a significant new data source for the assessment process and also provided support for Gulf of Mexico and Atlantic stocks. None of the analyses refuted the current placement of the prior assessment stock boundary at the Georgia-Florida line. Multiple MRD staff participated in the entire Stock Identification Workshop process and will be participating in the upcoming Assessment Data Workshop as well.

Management Implications:

The stocking results presented here build upon our comprehensive applied fisheries research programs to provide sound scientific data upon which appropriate and responsible natural resource management decisions are based. Red drum, spotted seatrout, striped bass, and cobia

are four of the most important recreational sportfish in SC. The Marine Resources Division is coordinating efforts to more efficiently and effectively evaluate the most pressing questions associated with these species using applied and conventional fishery research techniques. The information gained will enhance the effectiveness of the SCDNR in addressing natural resource issues by refining stocking strategies to improve survival and contribution, as well as address the impacts of population growth, habitat loss, environmental alterations, and other challenges faced in protecting, enhancing, and managing these valuable resources. Results from this research will also allow managers to utilize the most effective stocking strategies given local characteristics, improve enhancement efficiency, and increase post-stocking survival while providing data that will allow us to better understand ecosystem limitations to full recruitment. Our stock enhancement research programs not only increases our knowledge of the population dynamics that drive abundance of these recreationally-important species, but also lay the groundwork for long-term genetic monitoring and improve our understanding of both the individual species' life histories and the broader ecosystems they inhabit. Continued genetic evaluation provides critical population information for the proper management of these species in addition to determining cultured contributions from experimental stockings.

Table 7. Summary of genetic samples processed for each species during the past year.

Species	Number of Samples
Red drum	1428
Spotted seatrout	1198
Striped bass	47
Cobia	621
Total	3,294

Genetic Population Structure of Weakfish.

Project PI/ Participants**: T. Darden (PI)**, B. Cushman, T. O'Donnell, K. Kanapeckas, W. Sinkus

Project Duration: July 1, 2017 through June 30, 2018

INTRODUCTION:

A special project was included this year to evaluate the coast-wide genetic population structure of weakfish along the southeastern U.S. Atlantic coast. Under the ASMFC Interstate Fisheries Management Plan, weakfish are currently managed as one stock. However, a lack of congruence among studies using otolith chemistry (Thorrold et al. 2001), genetics (Crawford et al. 1988, Graves et al. 1992, Cordes & Graves 2003), and meristic and morphometric characteristics (Nesbit 1954, Shepherd & Grimes 1983, 1984, Scoles 1990) provide uncertainty in the understating of the stock structure. The ASMFC has determined that there is evidence of stock structure within the managed region, but data is inadequate provide the resolution necessary to define the management unit(s) along the U.S. Atlantic coast and continues to manage weakfish as a single unit throughout their coastal range (NEFSC 2009). Previous genetic work has established baseline information, but additional geographic resolution and a more informative marker suite are needed to resolve the issue of stock structure for weakfish.

Project Objectives:

- Select and optimize a suite of microsatellite markers for weakfish
- Coordinate and compile genetic samples collections for weakfish
- Determine stock structure of weakfish along the southeastern U.S. Atlantic coast

SUMMARY OF ACCOMPLISHMENTS/ACTIVITIES:

Microsatellite Marker Suite Selection and Optimization:
To develop a multiplexed microsatellite marker suite for weakfish, we tested 52 different microsatellite markers from five congeneric or closely related species. Our final multiplexed marker panel is comprised of 15 polymorphic microsatellites (15-40 alleles per locus) originally developed for weakfish (*Cynoscion regalis*), acoupa weakfish (*Cynoscion acoupa*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus;* Table 1). Markers were combined into three multiplexed polymerase chain reactions along with two genetic markers to detect possible misidentified individuals of the *Cynoscion* genus or hybrids between *Cynoscion* species.

Table 1. Fifteen microsatellite loci used to genotype weakfish from the Atlantic coast of the U.S. Multiplex group, number of alleles, fluorescent label (dye), final PCR concentration (μM), and reference are given for each locus.

Locus	Group	N_a	Dye	[Primer]	Reference
Soc1128	1	21	D2	0.09	Renshaw et al. 2012
Soc904	1	18	D3	0.03	Renshaw et al. 2012
Cneb07	1	17	D4	0.03	Seyoum unpublished
Cneb03	1	40	D3	0.06	Seyoum unpublished
Cyne12	1	23	D2	0.03	Piller & Cordes 2012
Cneb01	1	15	D4	0.03	Seyoum unpublished
Cneb35	2	27	D2	0.04	Seyoum unpublished
Cne612	2	30	D4	0.04	Chapman et al. 1999
Soc781	2	26	D3	0.09	Renshaw et al. 2012
Cneb09	2	19	D4	0.04	Seyoum unpublished
CacMic18	2	27	D4	0.09	Farias et al. 2006
Cneb36	3	29	D2	0.04	Seyoum unpublished
Soc029	3	28	D3	0.10	Chapman et al. 1999
Soc999	3	26	D4	0.03	Renshaw et al. 2012
CacMic19	3	20	D4	0.10	Farias et al. 2006

All processed samples were preserved in a 1% sarcosyl-urea solution and DNA was isolated using a metal beads isolation procedure. Weakfish samples were genotyped across the suite of 15 microsatellite primers in 11-μl polymerase chain reactions (PCR) which contained autoclaved Milli-Q water (Millipore; Burlington, MA), 1X HotMaster PCR Buffer (Quanta BioSciences Inc.; Gaithersburg, MD), 2.5 mM $MgCl_2$, 0.80 mM dNTPs (0.2 mM each), 0.30 μM each of forward and reverse primers (Table 3), 0.03 U/μl of HotMaster *Taq* (Quanta), and 1μl of DNA (10-50 ng/μl). Forward primers were labeled with a WellRED fluorescent dye (Sigma-Aldrich; St. Louis, MO). PCR amplifications were performed on a Bio-Rad iCycler (Bio-Rad Laboratories; Hercules, CA). Amplifications commenced with an initial denaturation step at 94°C for 2 mins; followed by 30 cycles at 94°C for 30 s, 58°C for 1 min, and 65°C for 1 min; and ending with a final extension at 65°C for 60 min. PCR reactions (1.5 μl) were mixed with 40 μl of sample loading solution (0.9% fluorescently labeled 400-bp size standard in formamide) and separated by capillary electrophoresis on a Beckman CEQ 8000 (Beckman Coulter Inc.; Brea, CA). Resulting chromatograms were scored using CEQ Fragment Analysis Software (Beckman Coulter Inc.). To maintain quality control, all data was scored independently by two readers and differences were resolved by conference or reprocessing of the samples.

Sample Collections:
Weakfish samples were collected from a variety of locations from nine different states along the Atlantic coast of the United States: Florida (FL), Georgia (GA), South Carolina (SC), North Carolina (NC), Virginia (VA), Delaware (DE), New Jersey (NJ), New York (NY), and Rhode Island (RI) (Figure 1). Weakfish samples were collected by several organizations including SCDNR's Inshore Fisheries group, SEAMAP, NEAMAP, and ChesMMAP using various gear

types including trammel nets, falcon trawl, and hook-and-line. Weakfish samples were collected from three different time points: 1990's (1994/1995), 2000's (2005), and 2010's (2011-2018). Most weakfish samples were from adult fish (>150 mm TL), with the exception of the Charleston Harbor area (i.e., Charleston Harbor, Ashley River) where many sampled fish were smaller (<100 mm TL); representing juvenile individuals. Samples from the 1990's included a mixture of heart and fin tissue, while samples from the 2000's and 2010's were all fin clips.

Our research objective was to target 400 samples each from southern (Florida to North Carolina) and northern (Virginia to Rhode Island) regions along the U.S. Atlantic coast. From the northern region, we genotyped 239 samples from five states. The northern region sample sizes were lower than planned due to a fire that occurred on the research vessel that NEAMAP chartered last year, delaying sampling until the spring 2018 with a reduced southern survey range. In the southern region, we genotyped a total of 588 samples from a range of localities. A total of 827 genotyped samples were included in the subsequent analyses (Table 2).

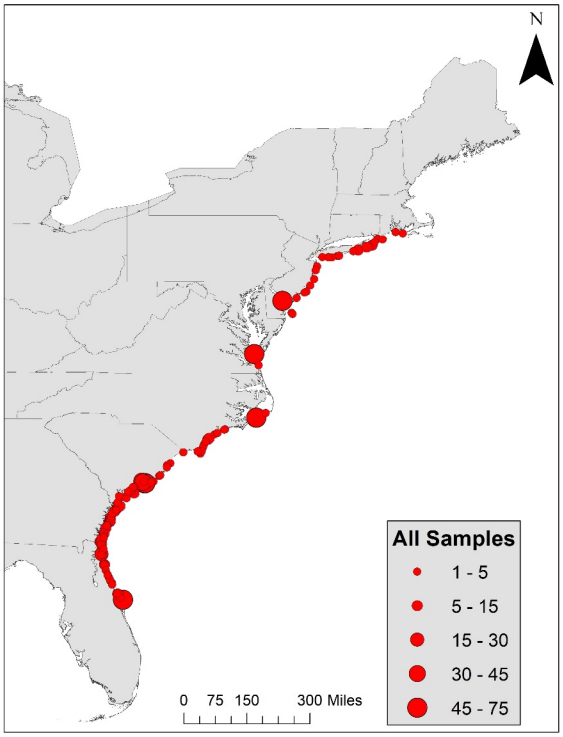


Figure 1. Collection locations for weakfish samples from nine different states along the Atlantic coast of the U.S.

Table 2. Sample size composition by collection location and year.

State of Collection	1994/1995	2005	2011-2018	Total
Florida (FL)	60	0	60	120
Georgia (GA)	17	0	103	120
South Carolina (SC)	4	0	228	232
North Carolina (NC)	60	0	56	116
Virginia (VA)	72	0	3	75
Delaware (DE)	0	73	7	80
New Jersey (NJ)	0	0	12	12
New York (NY)	0	0	57	57
Rhode Island (RI)	0	0	15	15
Total	**213**	**73**	**541**	**827**

Genetic Analysis Protocols:
Using the complete dataset (following duplicate sample removal, n=1), tests for Hardy-Weinberg equilibrium (HWE), linkage disequilibrium, and null alleles were performed for all loci for each state. Examinations for HWE were conducted with exact tests performed via Markov Chain randomization in ARLEQUIN 3.5.1.3 (Excoffier & Lischer 2010) using chains with 1,000,000 steps and a 100,000 step burn-in. Tests for linkage equilibrium between all microsatellite pairs were executed in ARLEQUIN using 10,000 permutations. The frequency of any possible null alleles segregating at each locus was estimated in GENEPOP 4.2 (Rousset 2008). Significance levels for all analyses were adjusted using a sequential Bonferroni correction (Rice 1989).

After correction for multiple comparisons (Bonferroni), all loci adhered to HWE, except for CacMic18 and Cyne12, which were out of HWE for most locations. None of the inter-locus comparisons for disequilibrium were significant upon correction with one exception: Soc1128 X Soc781 in SC. The probability of null alleles was relatively low (null frequency < 0.05) for most loci, except for CacMic18, Cyne12, and Soc1128 which had a high probability of null alleles for most locations. Therefore, CacMic18, Cyne12, and Soc1128 were excluded from all further analyses and the final suite of microsatellite markers used for the analysis of population structure and genetic diversity contained 12 loci.

To determine if there was significant temporal genetic differentiation within the weakfish population, samples from the 1990's were compared to samples from the 2010's in Florida, Georgia, and North Carolina using pairwise F_{ST} values calculated in ARLEQUIN. After correction for multiple comparisons, no significant temporal differentiation was found in either Florida, Georgia, or North Carolina and samples from these locations were combined across years for the remainder of the data analysis.

The complete dataset was also subjected to sibship analyses as implemented in the software Colony 2.0.6.4 (Jones & Wang 2010) to identify any potential large family groups that could confound further genetic structure analyses. Empirical analyses were run using settings of polygamous breeding, weak prior, updating allele frequencies, no genotyping error, and FPLS likelihood method for a medium run length. No large family groups (>3) were present within the dataset and only four full sibling pairs were identified ($p>0.979$); therefore no confounding effects from family structure were anticipated in further analyses.

To assess the degree of genetic spatial differentiation between states, exact tests comparing allelic (genic) distributions were conducted in GENEPOP and pairwise F_{ST} values were calculated in ARLEQUIN and GenAlEx 6.5 (Peakall & Smouse 2006, 2012). Iterative AMOVA (R_{ST}-based) analyses were conducted to evaluate areas of genetic discontinuity in the dataset with potential location groupings under two-population scenarios in ARLEQUIN. Pairwise D_{EST} (Jost 2008), a measure of genetic differentiation that examines the fraction of allelic variation between locations, was calculated between states using 1,000 bootstrap replicates in the program DEMEtics (a package for R; Gerlach et al. 2010). Population structure was further examined using a Bayesian model based clustering algorithm employed in the program STRUCTURE 2.3.4 (Pritchard et al. 2000). A burn-in of 10,000 replicates, followed by 50,000 replicates of the Markov Chain Monte Carlo simulation was run under the admixture model with correlated allele frequencies (Falush et al. 2003) and sampling locations were used as priors (LOCPRIOR; Hubisz et al. 2009). All other parameters were set at default values. To estimate the most likely number of populations, five independent replicates were run for K (number of populations) with K set from 1 to 9. STRUCTURE HARVESTER (Earl & vonHoldt 2012) was used to compile the STRUCTURE output data. The most likely value of K was determined using ΔK (i.e., the second-order rate change between successive K values; Evanno et al. 2005). Finally, given the continuous collection pattern of weakfish along the U.S. Atlantic coast, Microsatellite Analyzer was used to generate a variety of genetic distance matrices between individuals to test for isolation-by-distance. Individual genetic distance metrics included absolute differences, average square, Nei's chord distance, Nei's Distance, delta mu squared, fuzzy set similarity, kinship coefficient, and proportion of shared alleles. To visualize the variability in genetic distance, a multidimensional scaling (MDS) plot was created using R for each genetic distance metric matrix with points colored according to latitude. In addition, Mantel tests were performed to test for a correlation between genetic and geographic distance between individuals using the 'ade4' package in R.

Due to potential complex migratory and reproductive patterns of weakfish along the U.S. Atlantic coast, the full dataset was also partitioned into spawning and non-spawning seasons for spatial genetic structure analyses. One dataset included all samples collected from April through August (Figure 2), with a total of 724 samples. An additional dataset included all samples collected from May through August (Figure 2), with a total of 474 samples. Non-spawning season datasets included those samples not meeting either the Apr-Aug or May-Aug inclusion criteria. All five datasets (including the full dataset) were subjected to the analyses described above.

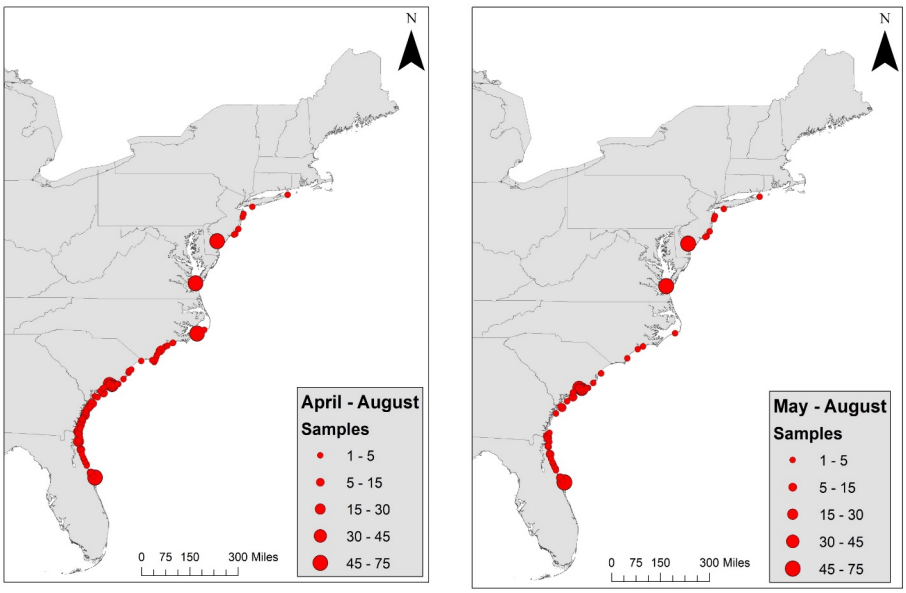


Figure 2. Collection locations for weakfish sample data sets defined by a spawning period of April through August (left, n=724) and May through August (right, n=474) along the Atlantic coast of the U.S.

Genetic Results:
Interestingly, results from all five of the data sets revealed similar patterns. However, the detection of genetic structure was inconsistent among different tests. After Bonferroni correction, no significant spatial genetic differentiation was detected for the pairwise comparisons of F_{ST} or D_{EST} between states. The AMOVA revealed that the among-population component of variation was low and not significant for any of the potential break points within the range of sample collection. Exact tests for allelic (genic) distributions were significant after correction only for a few isolated comparisons that were not consistent among datasets.

Additionally, no significant isolation by distance was detected by the Mantel tests with any of the genetic metrics and the MDS plots indicate no geographical pattern of variation by latitude (Figure 3). In contrast to the rest of the tests, the STRUCTURE analyses indicated that *K*=2 was the most likely number of genetically discernible groups for all datasets. However, the geographic relationships to the ancestral groups is difficult to interpret (Figure 4). Finally, the only test that resulted in inconsistencies among data sets was the pairwise comparisons when the data are grouped as southern and northern regions (which is not statically supported based on the state-based analyses). The southern and northern regions showed significant F_{ST} and D_{EST} values for the full and April-August datasets, but not for the May-Aug or either non-spawning season datasets. Resulting patterns also did not change when juveniles were removed from the datasets.

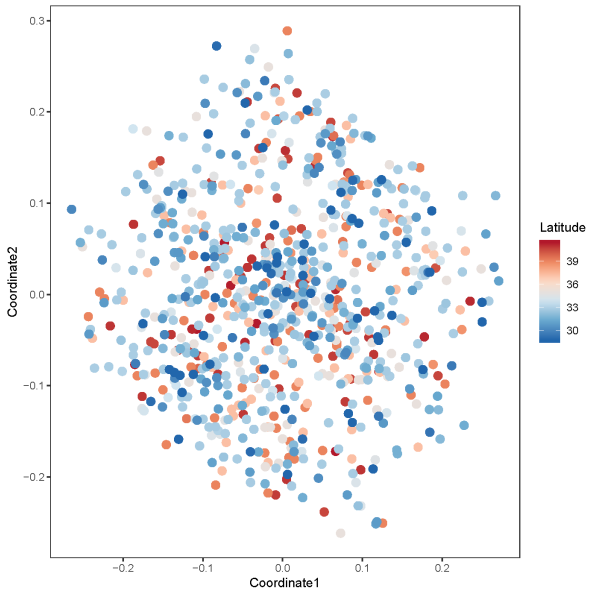


Figure 3. MDS plot of variation in individual sample pairwise comparisons of genetic distances using the complete dataset. Heat color-coding is indicative of latitude, with no resulting geographic patterns.

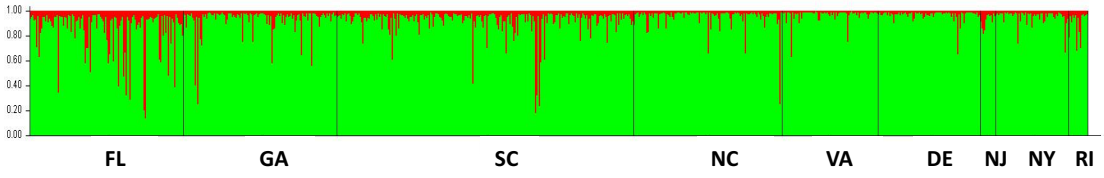


Figure 4. Population ancestry plot for the full data set based on STRUCTURE results of *K*=2. Each vertical bar represents a single individual in the plot with colors indicating percent ancestry to each genetic group. Collections are geographically oriented from Florida on the left to Rhode Island on the right.

Management Implications:

We have assembled a highly polymorphic suite of 12 microsatellite markers that can be used to assess weakfish population structure and genetic diversity. These markers amplify well, adhere to principles of Hardy-Weinberg equilibrium, are unlinked (i.e., independent of one another), and do not contain a high instance of null alleles (i.e., alleles which don't amplify). Therefore, the microsatellite panel will be beneficial for any future genetic work with weakfish.

The lack of any significant temporal genetic differentiation between the collections from the 1990's to the 2010's in the southern region provides evidence of temporal stability and a robust spawning pool for the weakfish population.

Weakfish has a broad distribution along the Atlantic coast of the U.S., extending from Massachusetts to Florida, and typically inhabit nearshore waters. Under the ASMFC Interstate Fisheries Management Plan, weakfish are currently managed as one stock. Meristic and morphometric characteristics (Nesbit 1954; Shepherd & Grimes 1983, 1984; Scoles 1990) suggest that there may be structure within the weakfish stock. Shepard and Grimes (1983) identified differences in growth rates between three regions in the area from Cape Hatteras, NC to Cape Cod, MA, while Scoles (1990) found differences in morphology between samples collected from northern and southern regions based on analysis of 22 measurements. Weakfish are believed to migrate seasonally with movement strongly correlated to the 16-24°C isotherm. During the fall and winter, weakfish migrate south and offshore, while in the spring and summer fish migrate northward and inshore. The inshore migration to bays and estuaries in the spring corresponds with spawning during the months of March through August, with the duration depending on water temperature. Using otolith microchemistry, Thorrold et al. (2001) found that between 60 – 80% of weakfish in NY, DE, VA, NC, and GA return to natal spawning estuaries. This natal homing behavior also suggests the possibility that structure may exist within the weakfish population. Previous genetic studies using allozymes (Crawford et al. 1989), RFLP analysis of mitochondrial DNA (Graves et al. 1992), and a suite of 4 nuclear microsatellite markers (Cordes & Graves 2003) did not detect significant genetic differentiation along mid-Atlantic coast of the U.S. (GA, NC, VA, DE, NY), but additional geographic resolution and higher power markers were needed to resolve the issue of stock structure for weakfish. In our study, we examined 827 weakfish collected from nine states (FL, GA, SC, NC, VA, DE, NJ, NY, RI) across a wide geographic range (Cape Canaveral, FL to Block Island Sound in RI) using an array of 12 nuclear microsatellite markers. Although some aspects of our results suggest the presence of two genetic groups, the geographic interpretation of those results is challenging at best. Therefore, our current findings are congruent with those of previous genetic studies,

logically cannot refute that weakfish are a single stock along the U.S. Atlantic coast, and provide justification for the current management scheme for weakfish. However, complex migration, spawning, and life history patterns can have substantial influences (masking) on patterns of genetic differentiation, and particularly so in the marine environment where species occur across large spatial scales, have long distance movement potential, and have very large population sizes. Therefore, an increased understanding of migration and reproductive patterns can allow for better partitioning of genetic samples for significant increases in clarity of gene flow patterns. The lack of differences between putative spawning and non-spawning season datasets in our analyses may be an indication of a need to revisit our understanding of weakfish movement patterns. Finally, it is important to remember that the amount of gene flow necessary to create genetic homogeneity between populations from different geographic areas may be as little as a few individuals per generation (Allendorf & Phelps 1981), so migration of weakfish between states on the U.S. Atlantic coast may be sufficient to prevent the accumulation of significant genetic divergence – as might be expected if 20-40% of weakfish are straying to non-natal estuaries as suggested by Thorrold et al (2001).

References:

Allendorf, F. W., and Phelps, S. R. 1981. Use of allelic frequencies to describe population structure. *Canadian Journal of Fisheries and Aquatic Sciences* 38(12): 1507-1514.

Chapman, R. W., Sedberry, G. R., McGovern, J. C., and Wiley, B. A. 1999. The genetic consequences of reproductive variance: studies of species with different longevities. *American Fisheries Society Syposium* 23: 169-181.

Crawford, M. K., Grimes, C. B., and Buroker, N. W. 1989. Stock identification of weakfish, *Cynoscion regalis,* in the middle Atlantic region. *Fishery Bulletin* 87(1): 205-211.

Cordes, J. F., and Graves, J. E. 2003. Investigation of congeneric hybridization in and stock structure of weakfish (*Cynoscion regalis*) inferred from analyses of nuclear and mitochondrial DNA loci. *Fishery Bulletin* 101(1): 443-450.

Earl, D. A., and vonHoldt, B. M. 2012. STRUCTURE HARVESTER: a website and program for visualizing STRUCTURE output and implementing the Evanno method. *Conservation Genetics Resources* 4(2): 359-361.

Evanno, G., Regnaut, S., and Goudet, J. 2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. *Molecular Ecology* 14(8): 2611-2620.

Excoffier, L., and Lischer, H. E. L. 2010. Arlequin suite ver 3.5: a new series of programs to perform population genetics analyses under Linux and Windows. *Molecular Ecology Resources* 10(3): 564-567.

Falush, D., Stephens, M., and Pritchard, J. K. 2003. Inference of population structure using multilocus genotype data: linked loci and correlated allele frequencies. *Genetics* 164(4): 1567-1587.

Farias, I. P., Muniz, L. B., Astolfi-Filho, S., and Sampaio, I. 2006. Isolation and characterization of DNA microsatellite primers for *Cynoscion acoupa*, the most exploited sciaenid fish along the coast of Brazil. *Molecular Ecology Notes* 6: 660-663.

Gerlach, G., Jueterbock, A., Kraemer, P., Deppermann, J., and Harmand, P. 2010. Calculations of population differentiation based on G_{ST} and D: forget G_{ST} but not all of statistics! *Molecular Ecology* 19(18): 3845-3852.

Graves, J. E., McDowell, J. R., and Jones, M. L. 1992. A genetic analysis of weakfish *Cynoscion regalis* stock structure along the mid-Atlantic coast. *Fishery Bulletin* 90(1): 469-475.

Jones, O. and J. Wang. 2010. COLONY: a program for parentage and sibship inference from multilocus genotype data. Molecular Ecology Resources 10:551–555.

Jost, L. 2008. G_{ST} and its relatives do not measure differentiation. *Molecular Ecology* 17(18): 4015-4026.

Nesbit, R. A. 1954. Weakfish migration in relation to its conservation. U.S. Fish and Wildlife Service. Species Scientific Report, Fish, 115(1): 1-81.

Northeast Fisheries Science Center (NEFSC). 2009. 48th Northeast Regional Stock Assessment Workshop (48th SAW) Assessment Summary Report. US Department of Commerce, Northeast Fisheries Science Center Reference Document. 09-10; 50 p. Available from: http://www.nefsc.noaa.gov/nefsc/publications/

Peakall, R. and P.E. Smouse. 2006. GENALEX 6: genetic analysis in Excel. Population genetic software for teaching and research. Molecular Ecology Notes 6:288-295.

Peakall, R. and P.E. Smouse. 2012. GenAlEx 6.5: genetic analysis in Excel. Population genetic software for teaching and research-an update. Bioinformatics 28:2537-2539.

Piller, K. R. and L. M. Cordes. 2011. Development and characterization of 12 polymoprhic microsatellite loci in the Spotted Seatrout, *Cynoscion nebulosus* (Teleostei: Sciaenidae). Molecular Ecology Resources.11:418-421.

Pritchard, J. K., Stephens, M., and Donnelly, P. 2000. Inference of population structure using multilocus genotype data. *Genetics* 155(2): 945-959.

Renshaw, M. A., Hollenbeck, C. M., and Gold, J. R. 2012. Isolation of microsatellite markers for red drum, *Sciaenops ocellatus*, and characterization in red drum and spotted seatrout, *Cynoscion nebulosus*. *Molecular Ecology Resources* 12: 570-572.

Rice, W. R. 1989. Analyzing tables of statistical tests. *Evolution* 43(1): 223-225.

Rousset, F. 2008. GENEPOP'007: a complete re-implementation of the GENEPOP software for Windows and Linux. *Molecular Ecology Resources* 8(1): 103-106.

Scoles, D. R. 1990. Stock identification of weakfish, *Cynoscion regalis*, by discriminant function analysis of morphometric characters [thesis].Virginia Institute of Marine Science, College of William and Mary.

Shepherd, G. R., and Grimes, C. B., 1983. Geographic and historic variations in growth of weakfish, *Cynoscion regalis*, in the Middle Atlantic Bight. *Fishery Bulletin*, 81: 803-813.

Shepherd, G. R., and Grimes, C. B. 1984. Reproduction of weakfish, *Cynoscion regalis*, in the New York Bight and evidence of geographically specific life history characteristics. *US National Marine Fisheries Service Fishery Bulletin* 82: 501-511.

Thorrold S. R, Latkoczy, C., Swart, P. K., and Jones, C. M. 2001. Natal homing of a marine fish metapopulation. *Science* 291(1): 297-299.

South Carolina Marine Recreational Fisheries Survey

Project Title: South Carolina Marine Recreational Fisheries Survey

Period Covered: July 1, 2017 – June 30, 2018

Principal Investigators: Amy Dukes & Brad Floyd

Project Objectives:

- Conduct creel surveys to obtain catch, effort, and biological data from saltwater recreational fishermen.
- Monitor participation, effort, and landings of charter boat fishermen through the Charter Boat Logbook Program.

Summary of Activities/Accomplishments:

Item 1: State Recreational Survey (SRS) and Marine Recreational Information Program (MRIP)
Recreational fisheries surveys allow MRD staff to monitor recreational catch and fishing effort as well as provide an opportunity for staff to interact with the angling public. These interactions provide an opportunity for DNR biologists to distribute rules & regulations booklets/fish rulers, inform anglers of changes to size/bag limits, and collect anecdotal data on fishing trends and angler opinions on a variety local fisheries. MRD staff interview recreational anglers at public and selected private access sites throughout SC's coastal counties. Data collected during interviews include: mode fished, body of water fished, angler's county of residence, species targeted, time spent fishing, angling trips taken previous year, catch/disposition by species, length/weight measurements for retained fish, and otoliths from selected species when permissible. The survey provides data to help determine the components of finfish stocks that are being targeted by recreational anglers as well as recreational fishing effort and behavior. This information is used for decision making by managers on a state level, to supplement and verify recreational fishing data collected by SCDNR's Charter Boat Logbook Program, and by National Marine Fisheries Service (NMFS) to produce estimates for stock assessments and management of species on a regional basis.
SRS – Starting December of 2017, the state recreational survey was expanded to cover shellfish harvest. During the reporting period from December 1, 2017 to March 31, 2018; 280 fishing parties were interviewed in private boat mode representing contact with 506 recreational fishermen. 96.4% of fishing parties interviewed fished in inshore waters, while 1.8% fished in nearshore state waters (0-3 miles offshore) and 1.8% fished in offshore federal waters (greater than 3 miles offshore). Interviews were conducted at public and selected private boat landings in all coastal counties throughout the reporting period (**Table 1**). The top species targeted by fishing parties was red drum. Fishing parties interviewed caught a total of 610 fish belonging to 31 species of which 21.8% were harvested by anglers and kept for consumption (**Table 2**). Of those fish harvested, a total of 84 finfish were measured by SCDNR staff belonging to 10 species. Southern Kingfish accounted for 33.3% of all finfish measured (**Table 3**).
MRIP - During the reporting period from July 1, 2017 to December 31, 2017 and March 1, 2018 to June 30, 2018 409 assignments were completed resulting in 4,896 angler interviews in all modes (**Table 4**). NMFS handles data from the MRIP survey and these data and the estimates generated are available on NMFS's website as they become finalized. NMFS data access site:
http://www.st.nmfs.noaa.gov/recreational-fisheries/access-data/run-a-data-query/queries/index

Table 1. Number of site visits and completed interviews by SFS staff in each coastal region during December 2017 – March 2018.

Region	Site Visits
	Total
Horry County	**9**
Georgetown County	**55**
Charleston County	**34**
Beaufort and Jasper Counties	**63**
Total	**161**
Region	**Interviews**
	Total
Horry County	**13**
Georgetown County	**177**
Charleston County	**39**
Beaufort and Jasper Counties	**51**
Total	**280**

Table 2. Disposition of fish caught by fishing parties interviewed by SFS staff during January 2018 – February 2018.

Disposition	Number of Fishes Caught	Percent Of Catch
Kept to eat	113	21.8%
Thrown Back (illegal, under)	282	46.2%
Thrown Back (illegal, over)	12	2.0%
Thrown Back (legal)	183	30.0%
Thrown Back (dead)	0	0.00%
Total	**610**	

Table 3. Mean total length (TL; mm), and size range (mm) of top nine finfish measured by SFS staff during January 2018 – February 2018.

Scientific Name	Species Name	Fish Measured	Mean TL (mm)	Size Range TL (mm)
Archosargus probatocephalus	Sheepshead	4	468.50	430 - 509
Centropristis striata	Seabass, Black	19	369.37	331 - 405
Haemulon plumieri	Grunt, White	4	311.25	288 - 358
Ictalurus furcatus	Catfish, Blue	2	521.00	452 - 590
Ictalurus punctatus	Catfish, Channel	1	414.00	414 - 414
Menticirrhus americanus	Kingfish, Southern	28	189.14	170 - 215
Pagrus pagrus	Porgy, Red	2	396.00	364 - 428
Pogonias cromis	Drum, Black	1	351.00	351 - 351
Rhomboplites aurorubens	Snapper, Vermilion	2	329.50	315 - 344
Sciaenops ocellatus	Drum, Red	21	459.76	375 - 616

Table 4. MRIP assignments and interviews obtained by mode in FY2018.

Wave 4 2017				
Mode	**July**		**August**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter	11	143	13	151
Head Boat	5	68	8	128
Private	20	225	20	155
Shore	7	154	8	124
Grand Total	**43**	**590**	**49**	**558**

Wave 5 2017				
Mode	**September**		**October**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter	7	85	9	184
Head Boat	2	23	1	9
Private	18	141	20	140
Shore	6	92	11	185
Grand Total	**33**	**341**	**41**	**518**

Wave 6 2017				
Mode	**November**		**December**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter	6	5	2	7
Head Boat	1	10		
Private	17	181	14	77
Shore	10	165	10	83
Grand Total	**34**	**361**	**26**	**167**

Wave 2 2018				
Mode	**March**		**April**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter	10	22	12	67
Head Boat	2	63	2	25
Private	17	82	17	235
Shore	8	99	8	208
Grand Total	**37**	**266**	**39**	**535**

Wave 3 2018				
Mode	**May**		**June**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter	16	47	12	170

Head Boat	4	61	5	71
Private	23	354	24	395
Shore	11	205	12	257
Grand Total	**54**	**667**	**53**	**893**

Job 2: Charter Boat Logbook Reporting Program

Since 1993, all fishermen with for-hire licenses have been required to submit monthly trip level logbook reports to MRD's Fisheries Statistics Section. These logbook reports allow staff to monitor catch and effort of for-hire vessels in the state. Charter boat trip logs are coded and entered into a database. If trip logs are incomplete, staff contacted charter vessel owners/captains to fill in data gaps to ensure accurate information. This program provides 100% reporting of catch and effort from licensed six passengers or fewer charter boat operators in South Carolina. It can be used to supplement and verify the National Marine Fisheries Service's Marine Recreational Information Program's charter vessel data and has been provided for potential use in fishery stock assessments and regional fisheries management.

During this reporting period (July 1, 2017 – June 30, 2018) there were 563 licensed six passenger or fewer charter boat vessels in South Carolina. Trip level data is submitted by licensed vessel owners/operators on a monthly basis. June's charter data was not required to be submitted to the agency until July 10th, 2018 and that data was not successfully edited, entered, and verified prior to this report submission deadline. Since the available data is not representative of a complete fiscal year and in order to assess the yearly trends in SC recreational charter fishing, the following tables summarize the 2017 calendar year charter boat data (**Tables 5 and 6**).

Table 5. "Top 10 Species" caught, landed, and released during reported charter vessel trips in 2017.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 82.58% of all species caught	Accounts for 75.05 % of all species landed	Accounts for 85.07% of all species released
Sea Bass, Black (30.84%)	Mackerel, Spanish (22.48%)	Sea Bass, Black (36.50%)
Drum, Red (15.43%)	Sea Bass, Black (11.08%)	Drum, Red (18.55%)
Seatrout, Spotted (10.87%)	Snapper, Vermilion (9.26%)	Seatrout, Spotted (11.71%)
Mackerel, Spanish (6.16%)	Seatrout, Spotted (7.95%)	Shark, Atlantic Sharpnose (4.97%)
Snapper, Vermilion (4.92%)	Whiting (Kingfish) (4.75%)	Snapper, Vermilion (3.67%)
Shark, Atlantic Sharpnose (4.65%)	Drum, Red (4.54%)	Drum, Black (3.39%)
Drum, Black (3.55%)	Drum, Black (4.13%)	Flounder, General (1.68%)
Flounder, General (2.11%)	Bluefish (3.68%)	Sheepshead (1.60%)
Whiting (Kingfish) (2.10%)	Flounder, General (3.61%)	Shark, Black Tip (1.52%)
Bluefish (1.95%)	Grunt, White (3.57%)	Mackerel, Spanish (1.48%)

Table 6. Overall comparisons of effort by charter vessels over the past six years with percentage of effort by area fished.

Year	2012	2013	2014	2015	2016	2017
Trips	12,231	12,975	13,702	15,609	14,361	15,595
Boat Hours	49,872	53,261	56,952	63,692	58,534	63,108
Anglers	41,292	45,320	48,305	55,773	50,732	54,283
Angler Hours	168,251	186,409	199,622	226,281	206,025	219,345
Estuarine Trips (%)	58.5	54.6	50.7	48.4	50.1	55.14
Nearshore Trips (%)	24.1	25.56	32.5	31.2	31.0	27.30
Offshore Trips (%)	17.5	19.85	16.9	20.4	18.9	17.56

Shell Recycling/Planting, Research and Reef Management

Project PI/Participants: Nancy Hadley, Ben Dyar, Peter Kingsley-Smith
Reporting Period: July 1, 2017 to June 30, 2018
Scope of Work:

1. Recycle oyster shells from caterers, restaurants and the general public. Maintain drop-off sites, dump trailers, and shell-moving equipment. Disseminate material to educate public on the necessity and benefits of recycling oyster shell with DNR. Recycling goal for FY2018 is 30,000 bushels of shell.
2. Build and maintain at least 2 new oyster shell recycling bins for public use. One in Beaufort County and one in Lexington County. Increase number of restaurants participating in oyster recycling program.
3. Increase public awareness and participation by use of different marketing strategies including attending events to discuss and disseminate educational information.
4. Plant oyster shell on public grounds to provide substrate for oyster attachment, thereby enhancing and creating habitat. Using DNR equipment we will plant 20,000 bushels of shell in Charleston County to create 1.5-2 acres of new or enhanced oyster habitat.
5. Using Water Rec or Game and Fish Funds, plant 20,000 bushels in other areas of the state using purchased shell and private contractors.
6. Monitor status of recently planted shellfish grounds to evaluate need for maintenance planting. Monitor status of beds planted over last three years to help constantly refine best management practices (BMP) for planting shell.
7. Maintain maps of public grounds available for recreational harvest and make these available on the internet and as hard copy by request.
8. Deploy signs to mark boundaries of public and state shellfish grounds.

Summary of Activities/Accomplishments

1. In FY 2018, a **record total of 31,466** bushels of shell were recycled (Figure 1). This puts DNR as one of the top two or three programs in the nation for quantity of shell and the largest state funded program. Thirty-two public drop-off sites were serviced in eleven counties. Recycled shell collected from these public drop-off facilities, individual oyster roasts, oyster roast caterers and local restaurants resulted in a savings of over **$95,000** by not having to purchase an equivalent quantity of out of state shell.

Sub-Category Totals for 2017-2018 Recycling (bushels)

Permanent Bins	Restaurants	Events	Caterers	Public Trailers	Grand Total
12117.00	11353.01	3836.50	2875.81	1283.31	31465.63
Percent Contribution to Total					
38.51	36.08	12.19	9.14	4.08	100

2. Two new oyster shell recycling drop-off locations were constructed. One at the Coastal Discovery Museum on Hilton Head Island in Beaufort County in partnership with The Outside Foundation and the Museum. A new bin in Murrells Inlet was constructed at the access road to Clambank Landing on the property and partnering with Huntington Beach State Park. This bin is a new and larger replacement for the original bin constructed in 1999.

   The program partnered with a total of 17 new restaurants to collect shell, 3 in the Charleston area, 1 in Greenville, 8 in Hilton Head and 5 in Murrels Inlet.

   The 3 new restaurants in the Charleston area that were added to the recycling route are Nico's, Hanks and Leons.

   The Sucking Shack in Greenville is now recycling shell on a weekly basis. The collection of the shells is made possible by a volunteer group form the SC Master Naturalist and will be stored at Renewable Water Resources facility who is partnering with DNR to store the shell. This is the first coordinated shell collection by DNR in Greenville.

   The program has partnered with The Outside Foundation to aquire shell from 8 new restaurants on Hilton Head Island. With grant funding from Patagonia the Outside Foundation set up a service to collect shell from the restaurants. The program initially payed i2 recycling company to pick up from 8 Hilton Head restaurants for a year. DNR is providing rolling cans to the restaurants to recycle the shells. The restaurants are now charged a fee by i2 to collect shells and they dump the shells at the newly constructed shell drop off site at Coastal Discovery Museum.

   An Oyster Shell Recycling Co-op headed by Dead dog saloon in Murrels Inlet has increased their partnerships with 5 new restaurants now to a total of 8 including Bovine's, Bubbas Dockside, Claw House, Creek Rats, Dead Dog Saloon, Jumping Jacks, Wicked Tuna, and Wahoo's Fish House. The Co-op is taking their shells to the Murrells Inlet drop off location.

   Due to employee persistance three restaurants, 167 Raw, Rappahanock and The Ordinary, have come back online after being gone a year or more. The program collects shell from 42 restaurants.

3. Staff conducted 5 interviews for print in Charleston and Greenville media as well as a live interview for Live 5 News in Charleston and radio interview with NPR. Ads to recycle shell were placed in several periodicals.

   The Oyster Shell Recycling Program has partnered with Good Catch based at the Aquarium

to spread the message of seafood sustainability within the restaurant industry in South Carolina. This symbiotic relationship with Good Catch will help create awareness to support local fisheries and consumption of responsibly harvested seafood. Restaurants benefit through marketing and advertisement as being a member of this program.

A survey of recreational oyster harvesting was conducted with the assistance of DNR creel clerks at public boat landings. The survey will be conducted annually in December and January. Surveyors will gather a range of information to aid in the estimation of recreational harvest totals. Creel clerks will also disseminate information and handouts on proper culling in place techniques and the importance of recycling oyster shells and locations to do so.

Consistent full loads for the restaurant can lift trailer prove that it is an asset to the recycling program and gives DNR the ability to recycle shell from restaurants and smaller venues with efficiency.

The new oyster shell drop-o
Georgetown County being c
and the final product.

4. & 5. A total of **32,450** bushels of oyster shells were planted on State and Public Shellfish Grounds between July 1, 2017 and June 30, 2018, creating **11,131 square meters (2.77 acres)** of shellfish habitat along approximately **1.5** miles of shoreline.

Charleston County – 1.4 acres

- Swinton Creek SSG (S251) – **1,610 bushels**
- Lower Hamlin Creek SSG (S255) - **2,100 bushels**
- Upper Hamlin Creek PSG (R252) - **1,610 bushels**
- Steamboat Creek SSG (S161) – **5,320 bushels**
- Robbins Creek/Cuttoff Reach SSG (S206W) – **3,605 bushels**
- Second Sisters Creek SSG (S206E) - **1,575 bushels**

Georgetown County – 0.56 acres

- Oaks Creek PSG (R351) – **3,527 bushels**
- Woodland Cut SSG (S358) - **3,526 bushels**

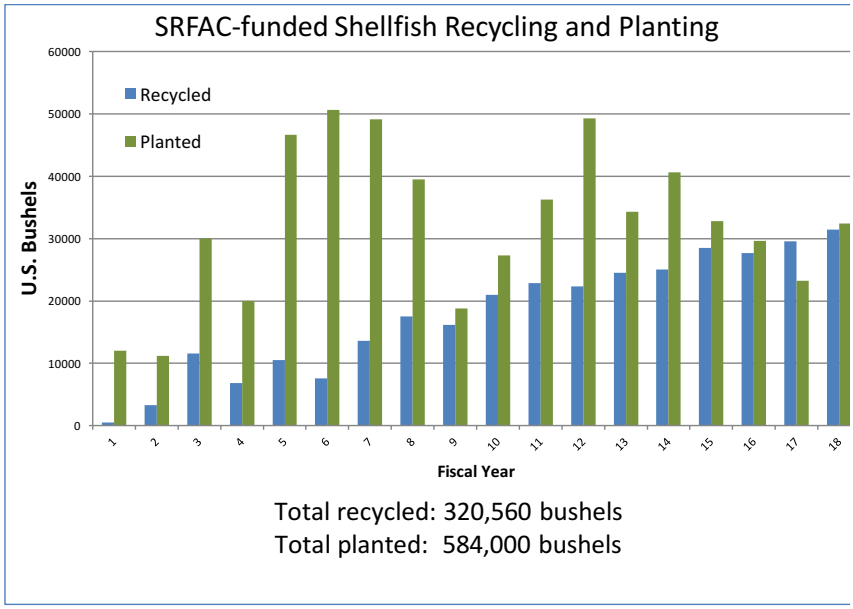
Beaufort County – 0.81 acres

- Harbor River (S105) – **9,577 bushels**

Charleston County was planted with recycled shell and by DNR's oyster barge funded by SRFAC. Georgetown County was planted with shell recycling reserves from Hobcaw Barony and planting was done by contractor using WREC funds. Beaufort County was planted with purchased shell from NC and was completed by contracted barge funded with WREC.

A decrease in delegation funding and shell availability have created a need to be frugal with delegation fund reserves and DNR shell reserves. This has led to a slight decrease in planting numbers over the past three years in order to stretch our reserves, to an average 30,000 bushels planted over the past 3 year period from the previous 38,000 bushels in prior years.

It is important to note that there is enough available funds from SRFAC surplus to plant next year (summer 2019) at our average volume, between 30,000-38,000 bushels. After that we will have exhausted all of our delegation funds and most if not all of our shell reserves.



6. Ten beds originally planted in 2014 were assessed to determine reef development success. Seven of the ten sites were ranked above average with two having average success and one marginal success. Overall success rate for the year is 90% with average and above considered successful plantings. Overall oyster bed success is determined using a composite scale which rates grounds based on density, size, quantity and quality of oysters and on footprint retention.

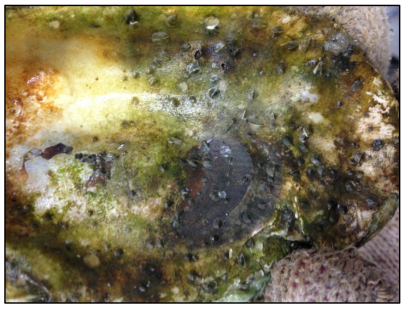
Mud bank in 2014 just before planting in the Sewee Bay.

The same bank taken while sampling in 2017, three years after planting.

2017 Assessment of beds planted in 2014

Site slope/creek width	Completion Date	Recruit-ment	Date Assessed	Quantity of oysters	Quality of oysters	Size of oysters	Coverage of bed	Strata	Overall	%\
Charleston										
Cape Romain/Sewee										
S272										
1	8/20/14	5	9/15/2017	5	5	5	5	F/G	5	8(
2	8/20/14	N/A	9/15/2017	5	4	3.5	4	G	4	
3	8/18/14	3	9/15/2017	3	3	3	3	F1	3	
4	8/19/14	3	9/15/2017	2.5	3	3	2	C	2.5	
2013 management										
sites 7&8	8/19/14	N/A								
Kiawah River S194E										
1	5/23/14	5	9/21/2017	5	5	3	5	F	4.5	
Georgetown										
Woodland Cut S358										
1	4/22/14	3	9/18/2017	5	4	3.5	5	F	4	
2	4/21/14	3	9/18/2017	1	3	3	2	C week	2	
3	4/22/14	3	9/18/2017	4	3.5	3.5	3	F1	3.5	
4	4/18/14	3	9/18/2017	5	5	4.5	5	F	4.5	
Beaufort										
Morgan River S124										
1	07/03/14	5		5	4	3.5	5	F1	4	
Slope-in Degrees		*Qualitative Rating from 1-5: 1 Poorest, 5 Best								
Creek Width-in meters		1-poor		2-marginal	3-Average	4-Good	5- Exceller			
	Total Bushels									
	Total Initial Area									

Eight beds planted in 2016 were sampled and spat measured with digital calipers to determine juvenile recruitment rates. Six of the eight had average to good recruitment with two having marginal recruitment.



Pictured is spat growing on shell planted 2014 in Green Creek. A single planted shell attracts many juvenile oysters. For monitoring purposes every live oyster, including those <1 mm is measured with digital calipers. Average density on SC oyster reefs exceeds 1000 oysters/m^2.

7. In FY2018 maps of recreational shellfish harvesting grounds were made available on the Internet. These maps are updated annually. Recreational shellfish maps (see Figure 1 for example) are available on the SCDNR website and are also provided in paper format upon request. Website for recreational shellfish maps:

   http://www.dnr.sc.gov/marine/shellfish/shellfishmaps.html

   In FY2018, public access to recreational shellfish maps was also maintained via a web-based interactive image service, increasing the accessibility of these materials to recreational anglers and shellfish harvesters (see Figure 2). This application allows users to interactively view the boundaries of the recreational shellfish harvesting grounds from any internet-enabled computer or device. Users can view their own geographic location within shellfish areas from GPS-enabled devices. The application also provides links to SCDNR online licensing websites, shellfish harvesting regulations, and to annually-produced recreational shellfish maps. Maintaining these GIS products and updating them annually for public access is an important part of the mission to encourage recreational use of South Carolina's shellfish resources.

8. All State and Public shellfish grounds have now been deployed with signs. Currently we are reassessing areas that are in need of sign replacement and/or repair due to lost or damaged signs. We are continually collecting GPS points for all new signs as well as existing signs in order to create a GIS map layer of all the collective shellfish boundary signs in the state.

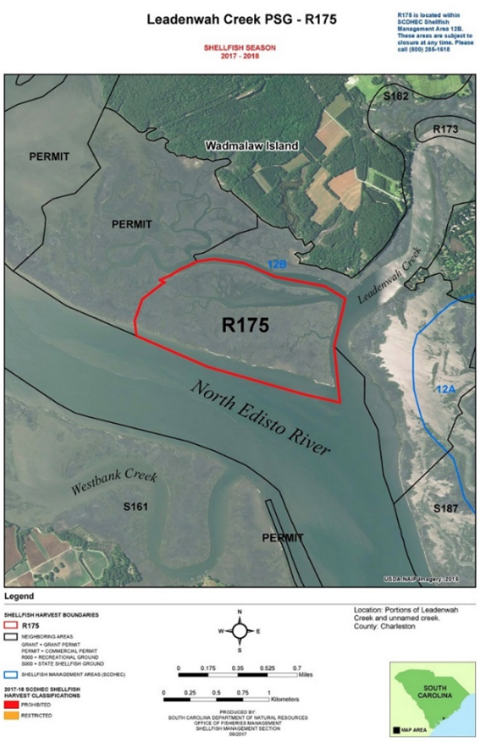


Figure 1. An example of an SCDNR recreational-only shellfish harvesting ground.

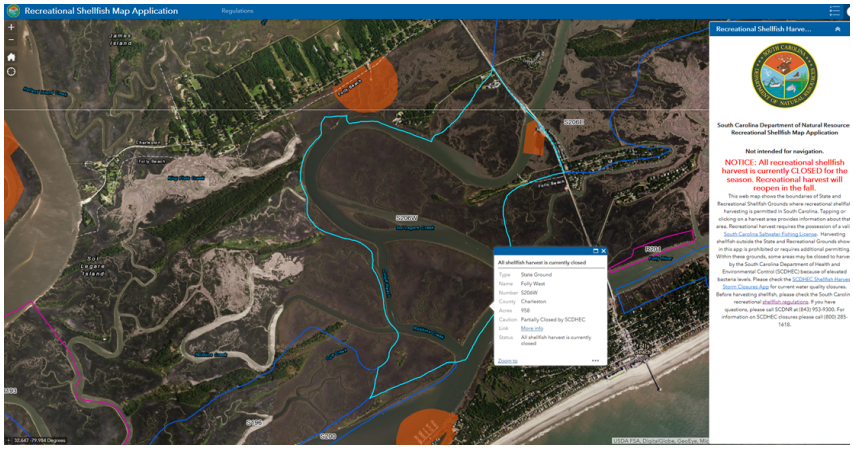


Figure 2. A representative screen shot from the interface of the new Recreational Shellfish Map Application developed in FY2017.

Shell Recycling/Planting, Research and Reef Management

Project PI/Participants: Nancy Hadley, Ben Dyar & Peter Kingsley-Smith

Reporting Period: July 1, 2017 – June 30, 2018.

Scope of Work:

1. Continue to evaluate and process backlog of acquired digital imagery captured from 2008-2016 and update existing map products.
2. Implement small unmanned aerial systems (sUAS) to accurately map intertidal oyster reefs considered to be key areas of importance to shellfish managers.
3. Re-visit approximately 30 index stations distributed statewide to collect oyster samples used to estimate naturally-occurring mortality of wild intertidal oysters.

Summary of Activities/Accomplishments

1. Staff continued to incorporate high-resolution photographs from the backlog of previous SCDNR oyster helicopter flights into the working oyster GIS layer. During FY2018, digital imagery edits were made to the working oyster GIS layer in the area of Bohicket Creek, in State Shellfish Grounds S187. This working layer is the foundation of the 2020 GIS oyster layer, which is the product that will become publicly available in 2020. The 2015 version is currently made available to the public as a downloadable dataset and via a web-based imagery viewer.
2. In FY2018, staff of the South Carolina Department of Natural Resources (SCDNR) Marine Resources Research Institute (MRRI)'s Shellfish Research Section (SRS) successfully implemented Unmanned Aerial Vehicle (UAV) methods to acquire and process low-altitude aerial imagery to update intertidal oyster mapping in South Carolina's oyster grounds in a cost- and time-effective manner. These emerging methods proved useful in creating a high-quality product ideal for supporting both research and management activities. Staff conducted field trials to establish a workflow for UAV data capture and processing and to empirically estimate the error and resolution of finished products. Results indicated that staff could reliably capture imagery of at least 200 acres of intertidal oyster habitat during a single mission spanning a low tide cycle. Furthermore, these data could be processed into fully georeferenced orthomosaic GIS products with a resolution of 2.5 cm ground sample distance or better, and with an estimated horizontal root mean square error (RMS) of 6 cm or better. In FY2018, intertidal oyster flights were conducted in the May River near Bluffton, SC and in Mark Bay, near Awendaw, SC. These flights produced orthomosaics of 670 acres of intertidal oyster habitat (see Figures 1 and 2). The data from Mark Bay were fully digitized and integrated into the working intertidal oyster GIS layer (see Figure 2). Integration of the data from the May River is ongoing. The integration process for the UAV data was determined to be quicker and more efficient than previous helicopter approaches. The orthomosaic imagery from these flights has been made available internally within the Agency to support research and management.
3. In FY2018 SRS staff continued statewide monitoring of naturally-occurring oyster mortality. Replicate oyster samples were collected between October 2017 and February 2018 from 35 index stations distributed throughout the state (Figure 3), and these samples were generally processed shortly after collected (Table 1). All samples were collected around low tide by hand using a ¼ meter quadrat in locations that were visually representative to the area, contained at least 30 animals, and were as close as possible to the pre-determined site coordinates. Three replicate samples were collected from

each site along with photographs and GPS coordinates. Collection time of day, surface water temperature, air temperature, salinity, dissolved oxygen, tidal stage, current, and basic meteorological observations were also recorded. All samples were transported to the MRD walk-in cooler until they could be processed.

Laboratory Processing – Clusters of oysters were manually separated to access all animals for shell height (point of the hinge to the center of the ventral margin) measurements to be collected. All live oysters and recent 'boxes' (i.e., two shell valves still attached to one another, but no tissue present) were measured in the laboratory using electronic digital calipers that recorded measurements to the nearest 0.01 mm and entered measurements directly into an Access database. Only boxes with no spat or other organisms attached inside the valves, and not packed with mud and debris, were considered, as indicators of recent mortality.

Analyses – In order to estimate relative mortality rates across sampled sites, the percent of dead oysters was calculated as an average (and standard deviation) for the three replicate samples collected at each location, and data compiled for the three sampling years for which this project has been implemented (Table 2). Live oyster shell height (mm) data, including size range, mean size, and standard deviation were also compiled for each site across the three each sampling years (Table 3). To visualize potential changes in oyster shell height frequencies through time, shell height frequency distributions were created for all sites at each sampling period. These size distributions are particularly useful for determining years with relatively low recruitment in a particular system. Only two examples are included in this report (Figures

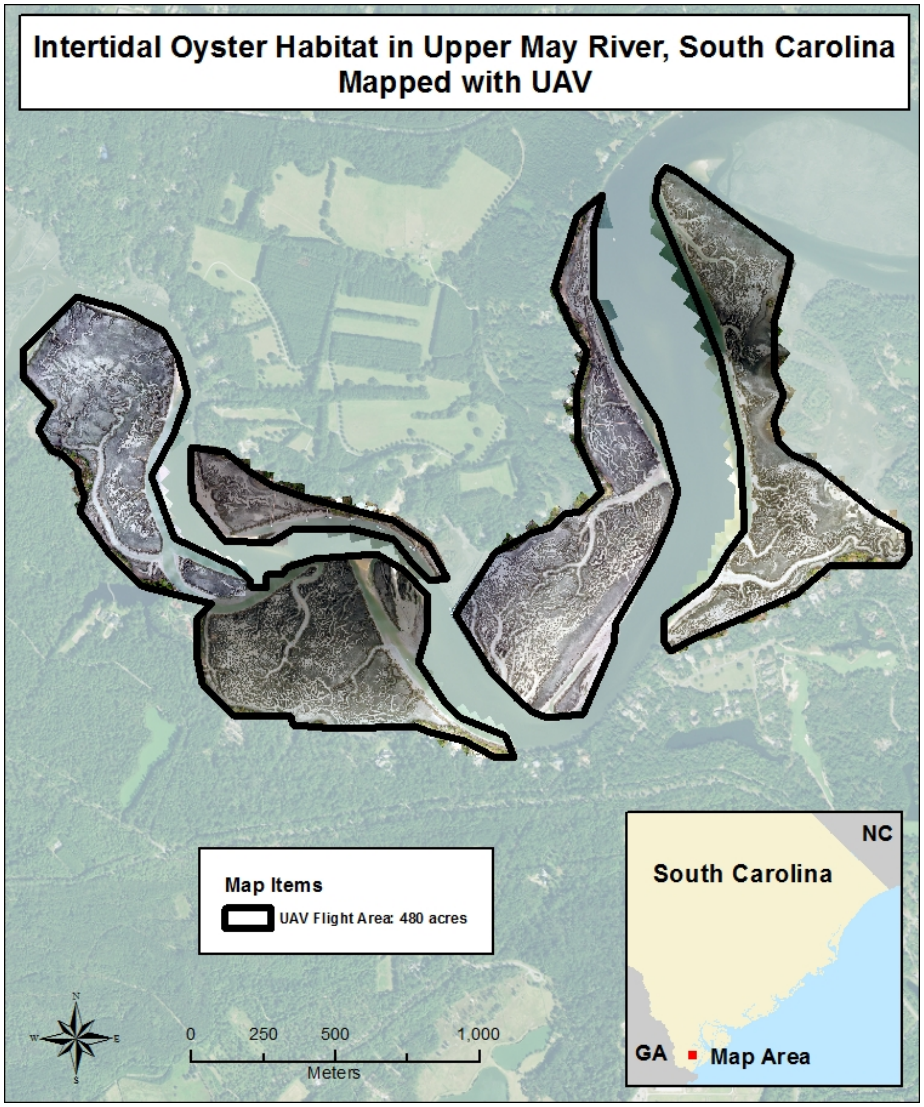


Figure 1. Area of intertidal oyster reef habitat in the upper May River that was mapped by UAV in FY2018. Flights were conducted over two days and the final product had a mean resolution of 2.49 cm ground sample distance.

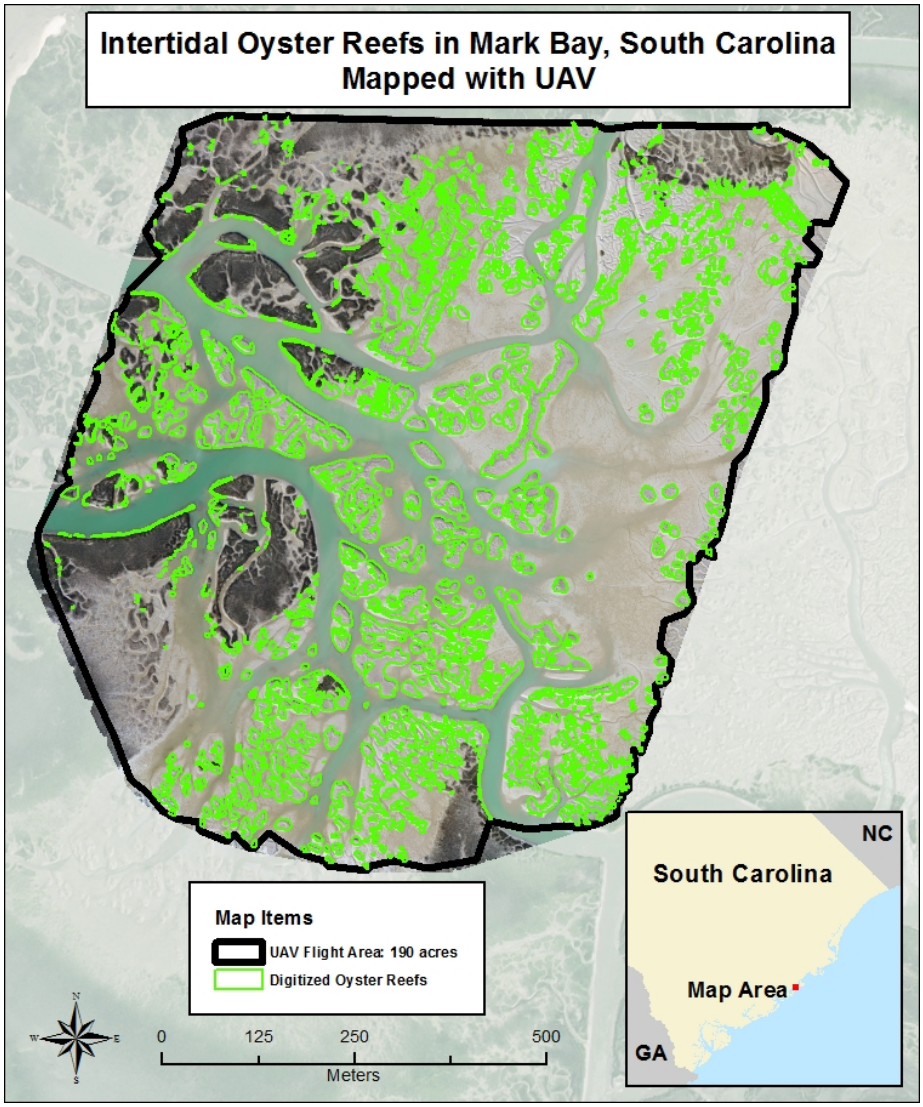


Figure 2. Area of intertidal oyster habitat in Mark Bay that was mapped by UAV in FY2018. Flights were conducted on a single day and the product had a resolution of 2.5 cm ground sample distance. The final oyster reef shapes digitized from the imagery are also shown in green.

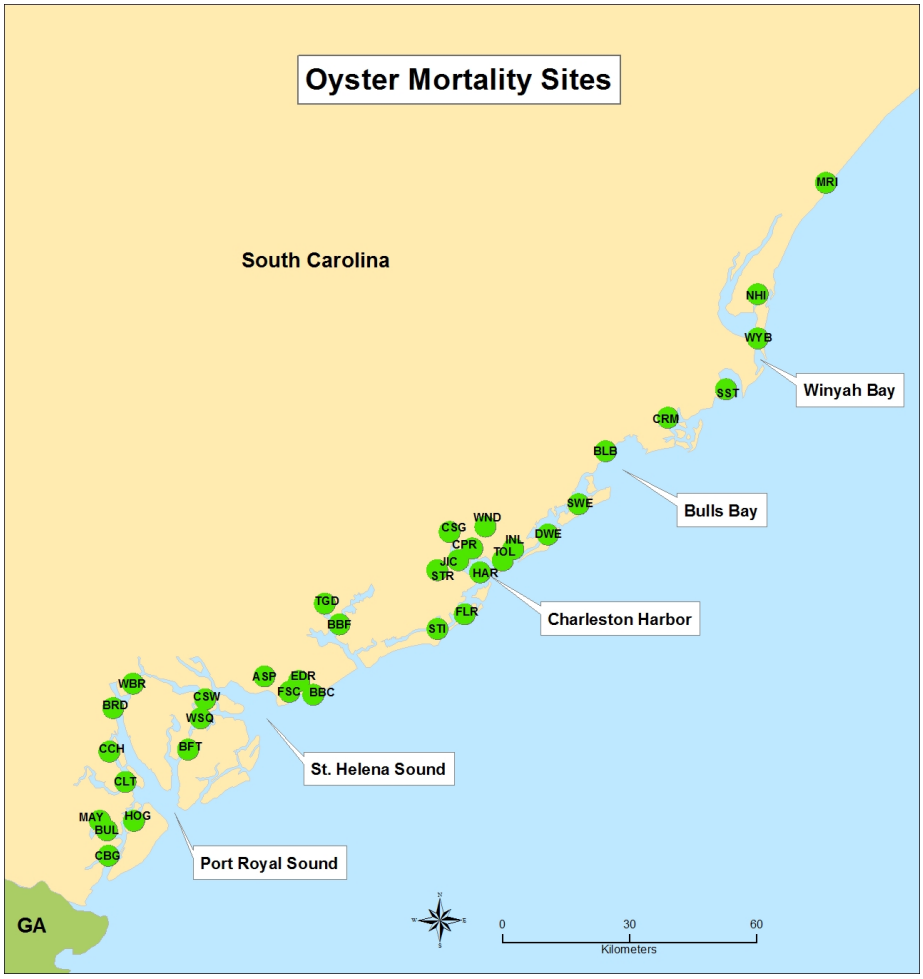


Figure 3. Locations of 35 sites where triplicate oyster samples were collected for natural mortality monitoring during FY2018, with three letter station codes included, that are also listed in Table 1 below.

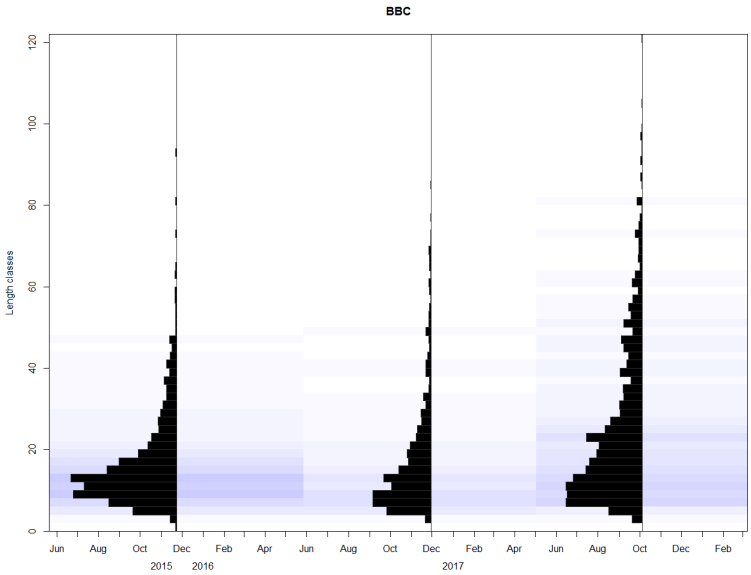


Figure 4. Example of shell height frequency of live oysters output for the Big Bay Creek (BBC) site. Length classes are given in mm. Note the relatively consistent high frequency of small oysters (<30mm) for each of the three sampling periods, indicative of consistent recruitment of newly settled oysters at this location (Big Bay Creek).

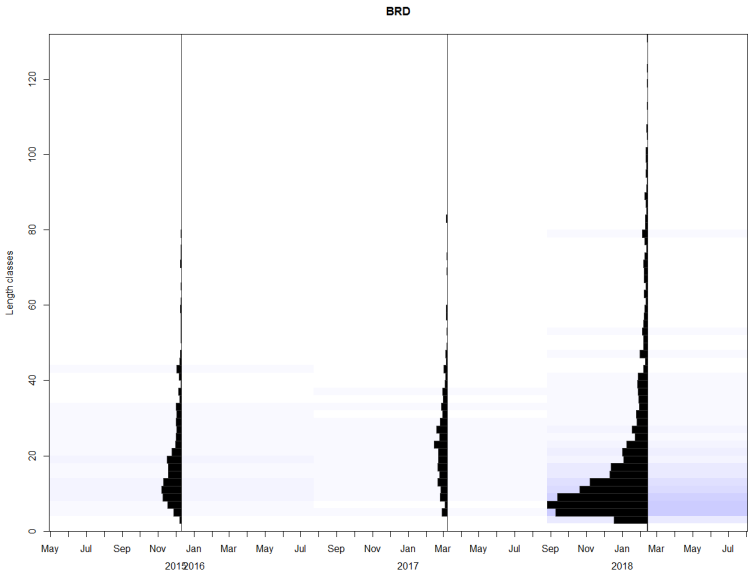


Figure 5. Example of shell height frequency of live oysters output for the Broad River (BRD) site. Length classes are given in mm. Note the relatively inconsistent frequency of small oysters (<30mm) through sampling periods: the 2015-2016 and 2016-2017 samplings revealed relatively low levels of newly settled live oysters, while the 2017-2018 sampling showed an apparent increase in the frequency of newly settled oysters.

Table 1. Location name, site code, sample date, process date, and geographic coordinates where oyster mortality samples were collected during FY2018.

Location	Site Code	Sample Date	Process Date	Latitude	Longitude
Ashepoo River	ASP	11/3/2017	12/20/2017	32.53386	-80.44788
Big Bay Creek	BBC	10/6/2017	10/11/2017	32.49424	-80.32558
Bears Bluff	BBF	10/16/2017	12/20/2017	32.64355	-80.25876
Beaufort River	BFT	2/13/2018	3/15/2018	32.37898	-80.64052
Bulls Bay	BLB	2/1/2018	2/9/2018	33.00586	-79.58381
Broad River	BRD	2/13/2018	2/22/2018	32.46759	-80.82794
Bull Creek	BUL	2/12/2018	3/19/2018	32.20761	-80.84412
Calibogue Sound	CBG	2/12/2018	3/15/2018	32.15367	-80.8404
Chechessee River	CCH	12/14/2017	1/11/2018	32.37515	-80.83768
Colleton River	CLT	11/15/2017	1/2/2018	32.31049	-80.79756
Cooper River	CPR	1/19/2018	2/8/2018	32.80263	-79.92296
Cape Romain	CRM	10/17/2017	10/27/2017	33.07507	-79.42551
Cosgrove Bridge	CSG	1/12/2018	1/23/2018	32.83793	-79.97968
Coosaw River	CSW	12/4/2017	1/10/2018	32.48594	-80.59693
Dewees Inlet	DWE	2/14/2018	2/22/2018	32.8301	-79.73216
Edisto River	EDR	11/13/2017	11/29/2017	32.52385	-80.36095
Folly River	FLR	1/18/2018	1/24/2018	32.66277	-79.9437
Fish Creek	FSC	11/13/2017	1/2/2018	32.50093	-80.38549
Charleston Harbor	HAR	10/3/2017	10/11/2017	32.75138	-79.90398
Hog Island	HOG	2/12/2018	3/19/2018	32.22778	-80.77631
Inlet Creek	INL	2/14/2017	2/22/2018	32.80034	-79.81962
James Island Connector	JIC	10/18/2017	10/27/2017	32.77762	-79.9583
May River	MAY	2/12/2018	3/19/2018	32.22803	-80.86178
Murells Inlet	MRI	1/17/2018	1/24/2018	33.56842	-79.0153
North Inlet	NHI	12/8/2017	1/11/2018	33.33444	-79.19357
South Santee	SST	2/1/2018	2/9/2018	33.13356	-79.2775
Stono Inlet	STI	1/18/2018	1/25/2018	32.63205	-80.01248
Stono River	STR	11/2/2017	11/29/2017	32.75698	-80.01175
Sewee Bay	SWE	2/14/2017	3/19/2018	32.89411	-79.65382
Toogoodoo Creek	TGD	1/22/2018	2/8/2018	32.68776	-80.29533
Tolers Cove	TOL	2/14/2017	2/22/2018	32.77625	-79.84664
Whale Branch	WBR	2/13/2018	2/22/2018	32.51939	-80.77802
Wando River	WND	1/19/2018	1/25/2018	32.84869	-79.88938
Warsaw Flats	WSW	11/17/2017	1/10/2018	32.44542	-80.60865
Winyah Bay	WYB	1/16/2018	1/23/2018	33.24042	-79.19501

Table 2. ***Calculated average percent dead (recent boxes) and standard deviation (SD) of total number of oysters by site and sampling period.***

Site Code	2015-2016		2016-2017		2017-2018	
	Dead (%)	SD	Dead (%)	SD	Dead (%)	SD
ASP	9.71	0.90	19.88	2.25	9.74	1.93
BBC	10.69	1.63	9.91	4.35	4.90	1.81
BBF	3.74	0.64	8.63	1.85	4.62	1.48
BFT	6.66	2.68	11.53	2.64	9.98	1.09
BLB	2.90	1.93	4.22	1.20	5.52	0.18
BRD	9.83	5.09	2.42	0.51	3.10	0.73
BUL	2.46	0.90	2.78	0.81	4.80	1.19
CBG	7.69	5.77	17.24	5.22	9.98	5.00
CCH	4.26	1.64	4.84	2.18	6.38	1.78
CLT	3.72	2.01	4.27	2.73	6.23	3.09
CPR	10.36	2.40	7.86	5.57	29.48	19.98
CRM	4.66	1.75	5.81	1.49	3.40	1.49
CSG	20.35	3.40	11.81	9.26	7.26	2.19
CSW	6.24	1.17	3.32	0.52	3.60	0.65
DWE	7.07	2.56	27.90	10.48	12.98	3.76
EDR	7.87	3.01	4.91	1.61	2.12	0.63
FLR	4.75	2.87	4.14	1.96	8.15	1.99
FSC	NA	NA	6.78	3.39	3.68	1.30
HAR	15.45	1.51	27.16	7.97	6.88	1.18
HOG	3.48	2.50	7.50	2.22	6.33	1.07
INL	6.41	1.98	9.34	7.24	6.76	1.45
JIC	19.41	6.91	8.93	2.12	9.25	1.19
MAY	3.16	0.61	3.13	1.75	6.58	2.33
MRI	NA	NA	3.65	1.06	5.04	0.19
NHI	4.41	1.33	5.08	4.65	6.55	3.14
SST	7.20	77.25	3.93	0.85	9.81	1.31
STI	6.04	1.78	8.76	1.06	5.04	1.57
STR	13.15	1.88	7.84	4.76	6.19	3.00
SWE	19.01	8.72	15.79	13.44	11.01	4.32
TGD	5.33	1.51	6.00	0.94	4.01	0.14
TOL	7.14	1.06	5.64	2.79	9.89	0.77
WBR	NA	NA	0.87	0.57	3.95	1.44
WND	9.70	2.39	26.93	21.11	5.55	0.84
WSW	3.29	0.81	4.91	0.57	5.50	0.95
WYB	33.29	2.84	24.07	13.32	5.80	2.67

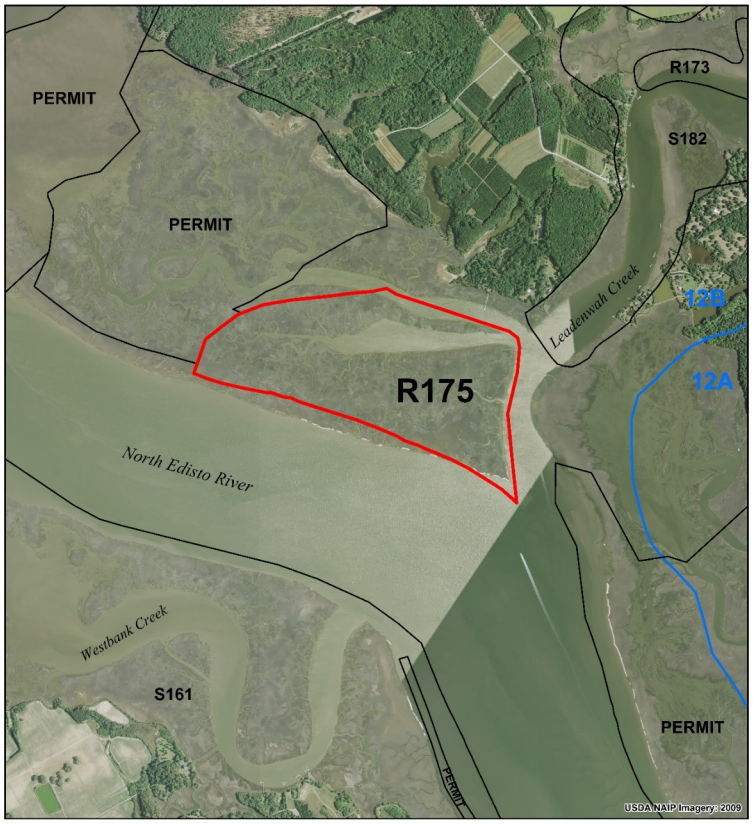
Table 3. ***Summary of live oyster shell heights, in mm, tabulated by site and by sampling period.***

	2015-2016			2016-2017			2017-2018		
Site	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**
ASP	2.42 - 63.01	15.74	8.66	4.46 - 50.36	18.31	9.82	2.19 - 52.01	19.77	10.54
BBC	0.24 - 94	16.81	11.14	3.19 - 84.5	17.80	14.20	2.95 - 121.21	25.51	18.80
BBF	1.97 - 110.98	19.81	18.53	4.25 - 119.46	34.51	20.12	0.31 - 86.55	15.70	14.32
BFT	0.24 - 98.39	25.31	21.23	4.42 - 137.08	44.40	30.00	4.62 - 132.74	39.38	29.40
BLB	NA	NA	NA	2.76 - 89.9	26.57	15.46	3.54 - 93.49	36.24	19.47
BRD	2.77 - 78.48	20.12	14.01	4.02 - 82.96	24.18	12.95	0.37 - 131.58	19.75	20.26
BUL	1.6 - 104.4	22.37	14.94	0.36 - 91.89	23.59	16.06	2.73 - 83.09	22.19	16.57
CBG	2.16 - 84.98	20.47	12.79	1.43 - 82.85	23.08	12.37	2.25 - 118.73	23.50	18.31
CCH	2.48 - 74.74	18.86	16.13	NA	NA	NA	0.93 - 95.72	20.84	15.49
CLT	2.51 - 93.06	24.34	20.47	4.38 - 78.96	26.60	14.72	2.44 - 137.73	29.09	22.93
CPR	0.89 - 72.65	15.21	9.82	3.47 - 88.88	32.33	19.26	2.68 - 76.31	22.75	15.67
CRM	3.09 - 102.77	31.61	20.61	1.54 - 108.92	25.48	21.93	2.84 - 117.44	30.23	21.28
CSG	3.32 - 87.5	22.41	14.30	3.49 - 80.85	18.86	13.79	2.89 - 79.43	21.66	16.02
CSW	1.63 - 104.37	21.47	17.83	1.59 - 100.95	24.52	20.09	3.49 - 127.71	27.63	20.54
DWE	2.76 - 108.18	23.51	19.18	3.36 - 103.46	31.55	25.48	2.94 - 101.99	22.97	15.51
EDR	1.81 - 79.17	16.42	13.96	1.36 - 78.95	22.53	16.43	1.64 - 94.77	23.20	16.58
FLR	0.98 - 121.19	27.65	23.20	3.85 - 134.74	40.07	27.05	4.53 - 122.05	41.24	27.65
FSC	NA	NA	NA	3.89 - 105.5	42.71	24.32	0.73 - 105.69	24.88	21.08
HAR	0.88 - 70.77	14.00	11.59	0.63 - 84.89	24.92	13.14	2.7 - 64.03	18.54	13.79
HOG	2.56 - 142.13	26.66	24.65	3.08 - 118.8	34.64	26.03	4.82 - 134.48	34.17	25.82
INL	3.44 - 117.87	25.99	19.50	2.14 - 116.38	29.93	19.48	2.43 - 124.55	30.29	26.54
JIC	0.96 - 80.64	21.24	14.79	2.19 - 82.18	13.75	13.64	0.72 - 95.5	24.78	19.95
MAY	2.76 - 124.41	26.56	19.65	3.73 - 178.48	46.75	38.77	3.98 - 103.88	38.90	24.94
MRI	NA	NA	NA	4.66 - 83.67	33.32	18.11	2 - 111.74	34.24	24.71
NHI	NA	NA	NA	5.16 - 139.3	54.51	33.47	0.35 - 141.24	37.46	30.77
SST	3.23 - 86.86	28.02	20.66	0.72 - 99.57	30.94	17.61	2 - 131.31	25.11	22.64
STI	1.18 - 113.43	21.84	19.60	3.3 - 114.93	26.33	19.30	0.57 - 123.42	29.91	22.04
STR	1.98 - 108.02	13.93	9.93	2.83 - 88.96	18.77	15.39	0.64 - 87.14	19.72	13.13
SWE	NA	NA	NA	1.83 - 121.48	37.87	26.88	4.08 - 111.87	39.92	20.85
TGD	3.55 - 115.24	25.84	20.00	0.44 - 108.12	32.16	20.41	2.99 - 149.97	41.24	28.89
TOL	4.03 - 88.3	25.88	16.41	2.67 - 103.53	32.51	17.97	3.72 - 87	32.47	20.21
WBR	NA	NA	NA	3.81 - 111.12	26.61	18.36	3.42 - 108.05	21.73	17.71
WND	2.22 - 111.29	19.96	15.15	5.8 - 60.09	28.11	13.97	2.22 - 138.87	32.15	21.97
WSW	2.12 - 91.64	18.55	13.94	2.62 - 88.4	31.11	20.83	0.46 - 120.22	27.24	23.01
WYB	NA	NA	NA	2.53 - 71.1	23.21	13.72	3.88 - 88.32	32.75	16.23

Leadenwah Creek PSG - R175

R175 is within SCDHEC Shellfish Management Area 12B. These areas are subject to closure at any time. Please call (800) 285-1618

SHELLFISH SEASON
2014 - 2015



Legend

SHELLFISH HARVEST BOUNDARIES

- R175
- NEIGHBORING AREAS
  PERMIT = COMMERCIAL PERMIT
  R000 = RECREATIONAL SHELLFISH GROUND
  S000 = STATE SHELLFISH GROUND
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

2014-15 SCDHEC SHELLFISH HARVEST CLASSIFICATIONS

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.25 0.5 0.75 1 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
09/2014

Location: Portions of Leadenwah Creek and unnamed creek.
County: Charleston

Core Funding Areas: (3) Recreational Crustacean
Program Title: Development of Crustacean Research and Fishery-Independent Monitoring to Address Significant Management Questions.

Program PI: Dr. Peter Kingsley-Smith, SCDNR MRRI Senior Marine Scientist
Program Co-PIs: Dr. Michael Kendrick, SCDNR MRRI Assistant Marine Scientist
Jeff Brunson, SCDNR MRRI Wildlife Biologist III

Program Period: July 1, 2017- June 30, 2018

Program Objectives:

a. **Monitor white and brown shrimp populations**
b. Monitor blue crab population

Sampling by the Crustacean Research and Monitoring Section (CRMS) focuses on the collection of recreationally-important crustacean species at critical life stages within estuarine waters. These sampling efforts facilitate timely analysis of the growth and development of crustacean species. These analyses are regularly used by the SCDNR Office of Fisheries Management to inform management decisions associated with these species. Focal species for the CRMS include white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), and blue crabs (*Callinectes sapidus*). Staff in the CRMS employ three survey methods to assess the abundance and growth of these crustacean species: 1) large trawl surveys; 2) creek trawl surveys; and 3) crab pot surveys.

1) **Large trawl survey**: The large trawl surveys are conducted on the R/V *Silver Crescent*, and involve the deployment of a 20-foot trawl net, with 1" stretch mesh, towed for 15 minutes at each station. Monthly sampling is conducted at four index stations within the Charleston Harbor/Ashley River waterbody. Sampling at 20 additional stations along the Atlantic Intracoastal Waterway from Charleston to Hilton Head Island is also conducted (termed the "south cruise") in March, April, August, and December. The south cruise sampling is timed to provide more information on the status of crustacean populations at important times in their life cycle (*e.g.*, availability for fall recreational harvest, population status prior to winter, and reproductive status in spring), and is critical for the informed management of these resources. Data presented in this report are derived from monthly and "south cruise" sampling activities. All of the planned large trawl surveys were successfully completed during the FY2018 Program Period.

2) **Creek trawl survey:** Like many fish species, juvenile stages of penaeid shrimp and blue crabs use tidal creeks as nursery grounds utilizing the resources provided for growth. Juvenile shrimp, in particular, remain in these tidal creeks to mature before migrating into larger water bodies, and ultimately into the ocean. Juvenile brown shrimp are typically found in tidal creeks from early May to late July, while juvenile white shrimp use these habitats from mid-June to mid-September. This survey is conducted to target juvenile stages of both shrimp species, as well as sub-adult and adult blue crabs that inhabit these tidal creeks. This survey is conducted using a 10-foot, ¼-inch mesh flat otter trawl, which is towed for 5 minutes. Sampling occurs at fixed stations around low tide, when animals are concentrated on creek bottoms. Although the catches from this survey tend to be quite variable, these data are useful for understanding the timing of ingress and egress of both shrimp species, and the use of tidal creeks by juvenile, sub-adult and adult blue crabs. Staff assess the crustacean catch (*i.e.,* numbers and sizes of white

shrimp, brown shrimp and blue crabs) in tidal creeks from May to September in the estuaries of South Carolina, with sampling concentrated in the Charleston area. During the Program Period, monthly, fixed-station sampling was successfully completed between July and September in 2017 and in May and June in 2018.

3) **Crab pot survey**: The crab pot survey uses standard wire crab traps deployed (or 'soaked') for 4 to 6 hours to provide an index of abundance for blue crabs. Although bi-monthly sampling is conducted in the Ashley River, effort is increased in October and November to include six stations from Winyah Bay to the Broad River, targeting crabs when they begin their seaward migration as water temperature decreases in the fall. Traps set in June and August in the Ashley River near Charleston give a general idea of what recreational crabbers may expect, and sampling in October to December provides increased spatial coverage in assessing blue crab abundance.

Results from Program Objective 1 (Monitor white and brown shrimp populations)

White Shrimp (*Litopenaeus setiferus*)

As in previous years, white shrimp followed a clear seasonal pattern from July 2017 to June 2018 with a relatively high abundance of smaller sub-adult shrimp collected during the late summer and fall prior to their migration offshore in the spring (Figure 1). Catch-per-unit-effort (CPUE) was generally higher during the summer and fall of 2017 compared to the long-term mean, making white shrimp available for recreational harvest during that time (Figure 2). CPUE in 2018 was low, however, following the severe cold weather event in January of that year (Figure 1).

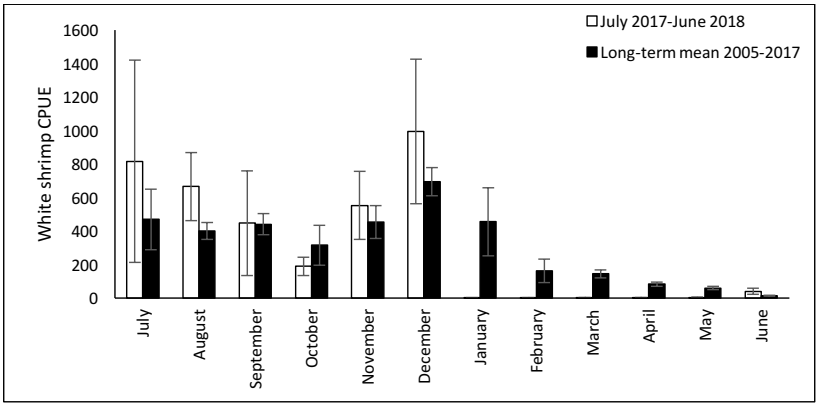


Figure 1. Monthly CPUE (± standard error) of white shrimp collected in the large trawl survey for July 2017 through June 2018 (open bars) and for the long-term mean (July 2005-June 2017; black bars).

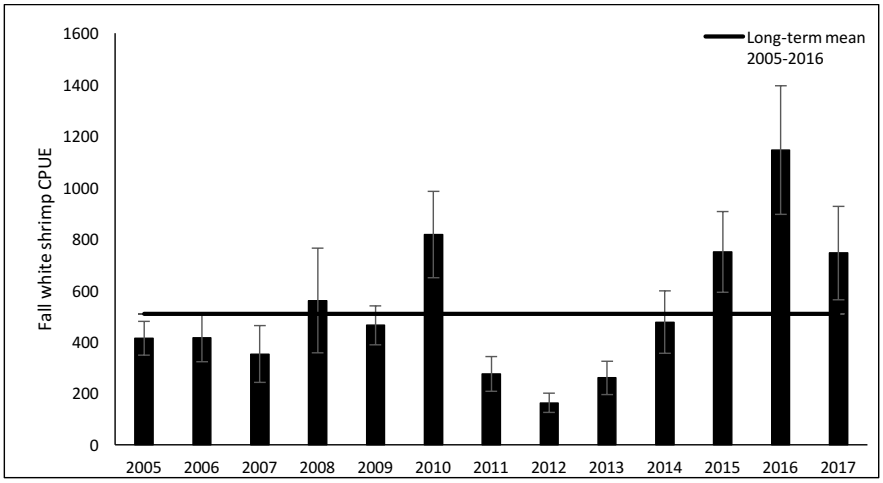


Figure 2. Fall CPUE (± standard error) for white shrimp caught in the large trawl survey from sample stations in SC from July to December.

White shrimp abundance in spring (March and April) 2018 was lower than the long-term average (2005-2017; Figure 3). Reduced abundance of overwintered white shrimp in the spring is typical during years when extremely cold winter water temperatures impact shrimp health and egress from estuaries. The catch of white shrimp in the creek trawl survey from May to July 2018 was also below the long-term mean (Figure 4), but the presence of juvenile white shrimp in the samples demonstrates a level of successful spawning activity during the spring and summer of 2018.

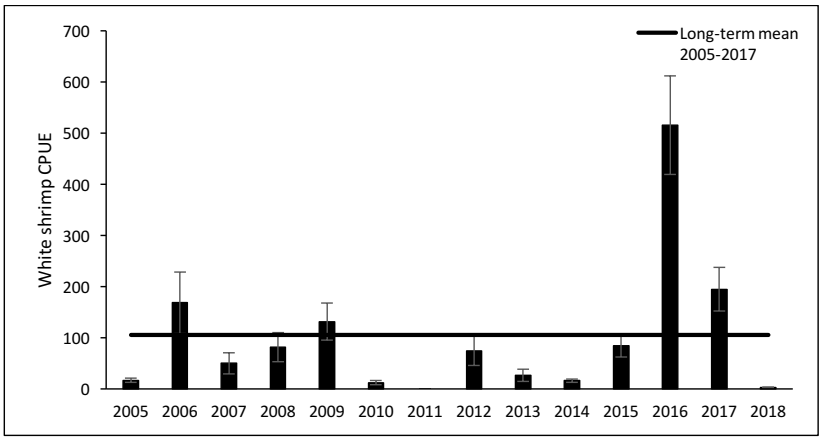


Figure 3. Spring CPUE (± standard error) of white shrimp caught in the large trawl surveys from sample stations in SC in March and April of each year from 2005 to 2018.

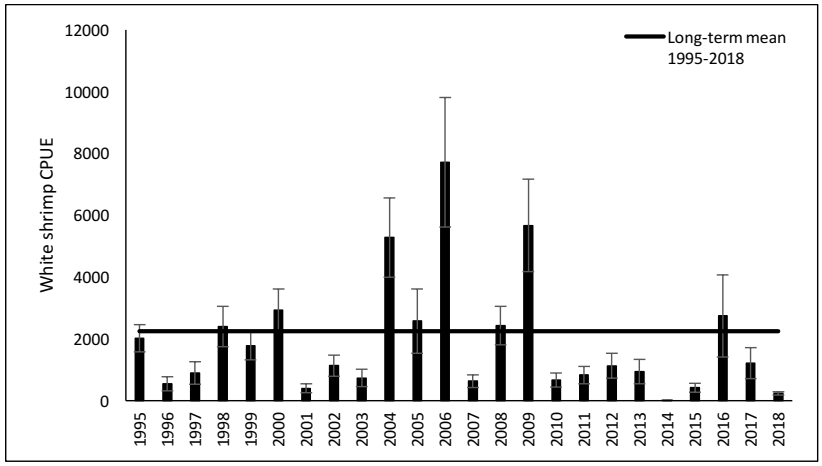


Figure 4. CPUE (± standard error) of white shrimp in the creek trawl survey in May-July for each year from 1995 to 2018.

Brown Shrimp (*Farfantepenaeus aztecus*)

Although the recreational harvest of brown shrimp is minor compared to that of white shrimp, brown shrimp are typically available for use as bait and for food. Brown shrimp catches in the large trawl survey in spring and summer (May to July) 2018 were similar to the long-term mean (Figure 5).

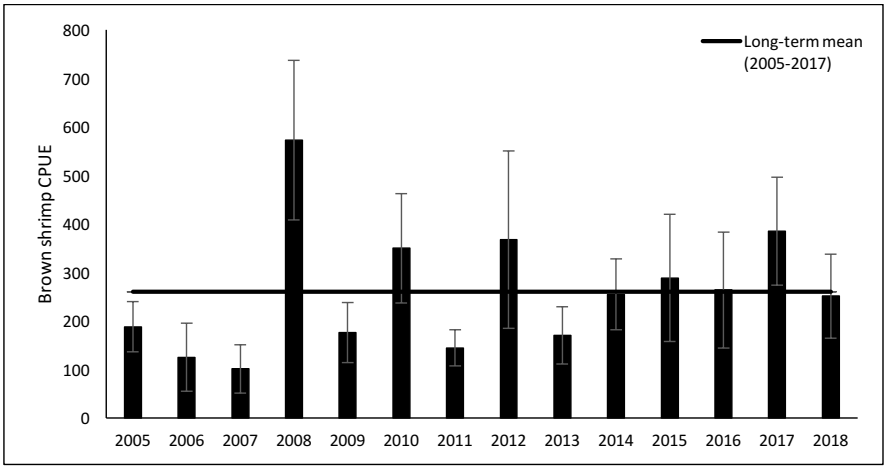


Figure 5. CPUE (± standard error) of brown shrimp caught in the large trawl survey from sample stations in SC in May to July of each year from 2005 to 2018.

Brown shrimp catches in the creek trawl survey in the spring and summer (May to July 2018), however, were slightly below the long-term average, although similar catches have occurred in all years since 2015 (Figure 6).

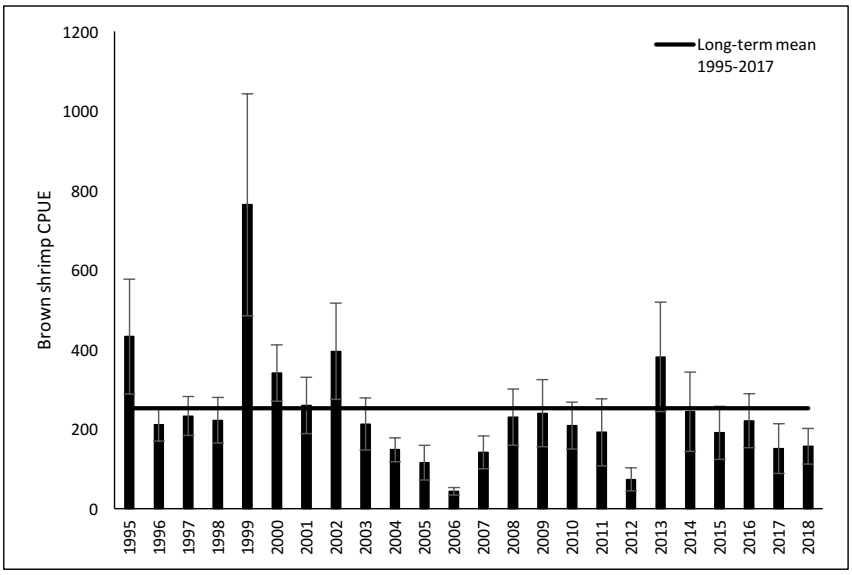


Figure 6. Mean CPUE (± standard error) of brown shrimp caught in the creek trawl survey in May-July from 1995 to 2018.

Results from Program Objective 2 (Monitor blue crab population)

Blue Crab (*Callinectes sapidus*)

During large trawl survey sampling efforts from July 2017 to June 2018, legal blue crabs were collected in numbers similar to the long-term mean, while sublegal crabs were collected in numbers less than the long-term mean (Figure 7). In the creek trawl surveys in May to July 2018, blue crabs across all sizes (*i.e.*, not separated as legal vs. sublegal) were collected in numbers below the long-term mean (Figure 8).

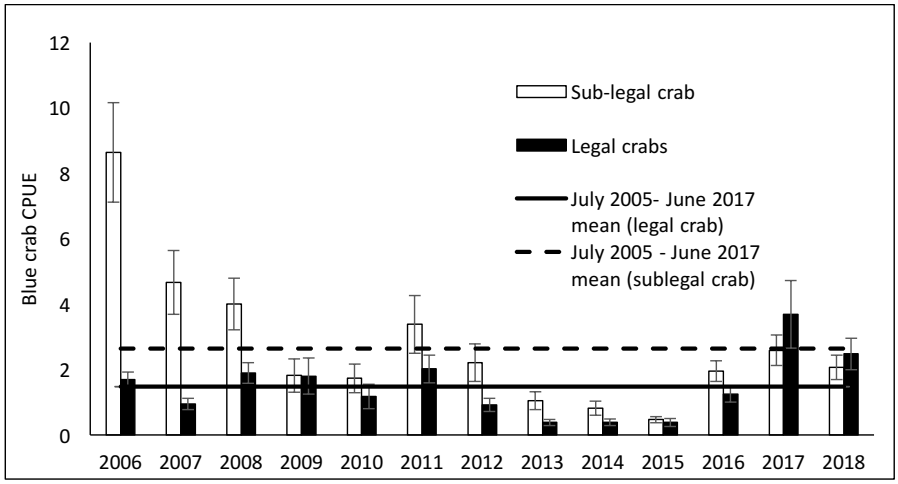


Figure 7. Mean CPUE (± standard error) of blue crabs of all sizes caught in large trawls from sample stations in SC from July through the following June from 2005 to 2018.

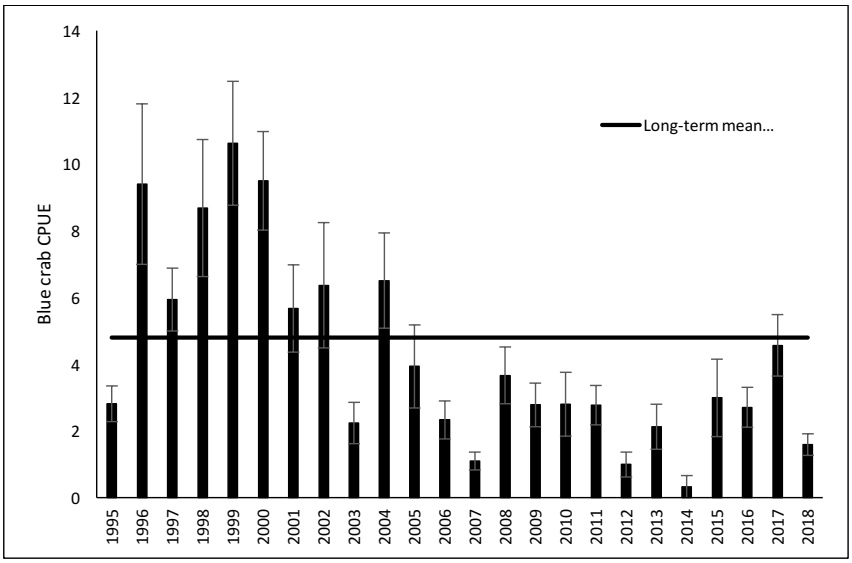


Figure 8. Mean number (± standard error) of blue crabs of all sizes per creek trawl surveys in May-July for each year from 1995-2018.

The number of juvenile blue crab (*i.e.,* those with a carapace width of less than 50mm), collected in the creek trawl survey from May to June 2018 was below the long-term average (Figure 9).

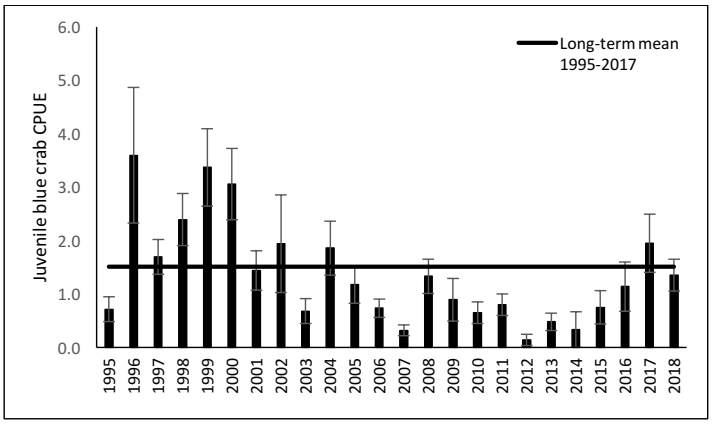


Figure 9. Mean CPUE (± standard error) of juvenile blue crabs (< 50 mm carapace width) caught in creek trawls from sample stations in SC from May through July of each year from 1995 to 2017.

Blue crab CPUE in the fall 2017 crab pot survey was below the long-term mean and comparable to catch rates in 2012, 2013 and 2014 (Figure 10).

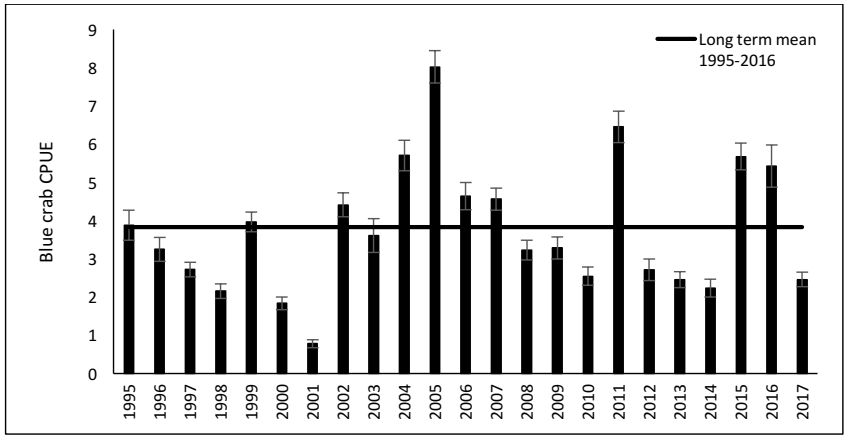


Figure 10. Annual CPUE (± standard error) of blue crabs caught in baited crab traps for all stations from 1995 to 2018. The long-term mean is presented as a solid horizontal line.

Marine Outreach and Education Program

Program PI: Morgan Hart

Program Period: July 1, 2017 through June 30, 2018

Program Objectives:

- The Educational Vessel *Discovery* will be utilized as an educational tool through which to teach students, teachers and general public audiences about the complexity and importance of marine resources in coastal South Carolina.
- The Marine Recreational Angler Conservation and Education initiative will promote marine resource stewardship through representation at major boat shows, expos and public presentations.
- Information will be disseminated through printed materials, as well as signs, posters and educational videos, and made accessible to constituents in all regions of South Carolina.
- The public recreational tagging program will be used as a tool for communicating with recreational anglers and providing a volunteer opportunity that supports the collection of marine fisheries data.

Summary of Activities:

- Through the Carolina Coastal Discovery Marine Education program, staff spent 20,344 contact hours with students. Just over 6,155 students and teachers participated in these programs. Six teacher workshops were held with a total of 84 teachers attending for 696 contact hours.

- Through the Carolina Coastal Discovery Marine Education program, staff completed 76 vessel-based education programs and 238 land-based programs to students and teachers from grades K-12. Just over 5,337 students and teachers participated in these programs. Six teacher workshops were held with a total of 104 teachers attending.

- Outreach staff represented the Marine Resources Division at five multi-day shows/expos including the Charleston Boat Show, Southeast Wildlife Expo, Palmetto Sportsman's Classic, Shallow Water Fishing Expo and the Black Expo (Fig. 2). Attendance at these events ranged from 3,000 - 42,000 attendees. The mobile touch tank was utilized at three events: the annual STEM festival, Hispanic Heritage Day and the weigh-in for the Edisto Marina Billfish Tournament.

- In anticipation of holding youth fishing tournaments at Colonial Lake in downtown Charleston, 1000 red drum were stocked in the lake. These tournaments will be held during Fall 2018 and Spring 2019.

- Outreach staff represented the Marine Resources Division at ICAST (International Convention for Allied Sportfishing Trades). The agency's primary purpose for attending

this 3-day tradeshow is to share with South Carolina industries affiliated with recreational fishing how SCDNR uses the excise tax monies collected on their products to manage aquatic resources and provide recreational opportunities. Building and maintaining long-term relationships with these companies will provide for greater support of recreational fishing, recreational access and natural resource protection and management.

- SCDNR sponsored the Boy Scouts 'Sea Spot Run' fishing tournament at the Mt. Pleasant pier and had over 100 youth anglers participate. A total of 115 fish were caught and released during the tournament.

- Five youth/family outdoor clinics were conducted, including beginner's courses in using a cast net, shrimp baiting, crabbing, and fishing at Pawley's Island and Botany Bay (Fig.3). These classes are designed to teach basic skills along with marine resource stewardship.

- Staff conducted a variety of other outreach and education activities, including 5 presentations to fishing clubs and civic groups.

- Once a month during the months of May - September, staff conducted general outreach at high-traffic coastal boat landings. This provides an additional means through which to engage recreational boaters and anglers.

- Public information material was distributed through the Coastal Information Distribution System (CIDS). Twenty days were spent delivering approximately 194,360 copies of printed material to 115 vendors located throughout the coastal counties of South Carolina. Materials included rules and regulations books, tide tables, fish rulers and fish identification charts.

- With funds from the Saltwater Recreational Fishing License Program, the following promotional items and public information material were printed and distributed.

Item	Number Produced and Distributed
Catch & Release Guide	10,000
Fish Ruler Stickers	35,000
Crab Rulers	10,000

- General public outreach occurs on a daily basis through response to public inquiries. Staff responded to over 400 requests for information. To facilitate the dissemination of information, the Saltwater Recreational License Program website is routinely updated to include informational videos and answers to frequently asked questions related to the use of marine resources and associated licensing requirements.

- Nine hundred and one (901) recreational anglers participated in the marine game fish tagging program through tagging and/or reporting the recovery of tagged fish. Program volunteers tagged and released 7,889 fish, of which 63 percent were red drum. Information was received from 796 recaptured fish and of those, 82 percent were released with the tag intact.

- An outreach campaign focusing on proper techniques for catching, handling and releasing adult red drum was continued this year. Three actions have been recommended that anglers can do to minimize fishing mortality: Use appropriate gear, use a rig that reduces the chances of gut hooking and keep the fish in the water. Cards detailing the recommendations are now disseminated at outreach events and to tagging program participants (Fig. 1). To further this campaign, a partnership with FishSmart is underway, and premade leader rigs are being sent to various anglers that fish for adult red drum.

- A coast-wide voluntary catch-and-release initiative was instituted for spotted sea trout in order to combat large trout kills due to a cold snap in January 2018. Anglers all over the state were urged to release all trout captured after the cold event through Fall 2018. This was achieved with posters placed at retail locations and blog posts and emails reaching thousands of anglers.

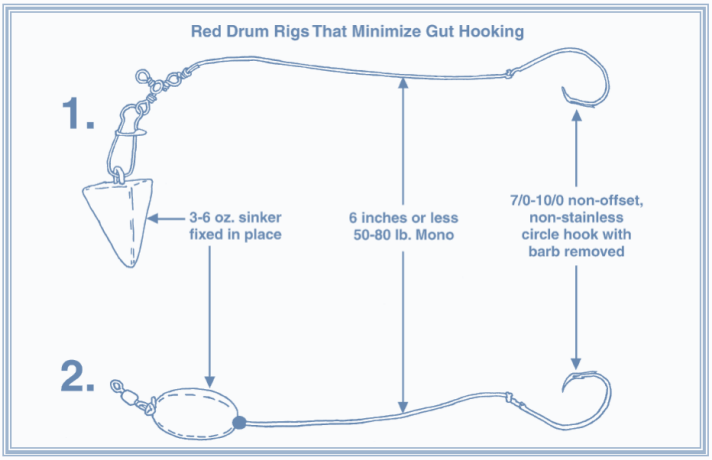


Fig.1 A postcard describing best practices for minimizing gut hooking adult red drum.

Fig.2 Participants at SCDNR photo booth at the Black Expo.

Fig.3 A family posing with the blue crabs they caught during a crabbing clinic in Mt. Pleasant.