SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2019

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Marine Fisheries Habitat Enhancement and Management

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

Reporting Period: July 2, 2018 - July 1, 2019

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:

Fourteen reef construction projects were carried out during this fiscal year on 11 separate artificial reef sites, adding over 235,000 cubic feet of hard bottom habitat to our offshore reefs. These projects are summarized below:

Date	Material	Reef Site
29 July 18	28 pieces concrete culvert & boxes	Georgetown Reef
21 Aug 18	7 concrete pyramids & culvert pipe	White Water Reef
21 Aug 18	5 concrete coated steel trees	White Water Reef
21 Aug 18	4 concrete pyramids	Fish America Reef
29 Aug 18	65-ft. deck barge	Charleston Nearshore Reef
23 Oct 18	4 designed steel & concrete units	Charleston 60' Reef
05 Dec 18	30 pieces concrete culvert	Pawleys Island Reef
13 Dec 18	60-ft. deck barge	White Water Reef
01 Feb 19	18 5-ft.concrete manholes	Pawleys Island Reef
24 Mar 19	32 pieces concrete culvert	North Inlet Reef
22 Apr 19	Eternal Reef Balls	Little River Reef
01 May 19	103-ft tugboat	Bill Perry Jr. Reef
18 May 19	memorial concrete pyramid	Area 51 research Reef
28 June 19	95-ft. tugboat	Vermilion Reef

- Twenty-seven days of offshore reef monitoring were completed, including monitoring of reef materials and fish populations, and side-scan sonar surveys of reef sites.
- Forty-nine 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.
- Four 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.
- A new edition (6^{th}) of the Guide to South Carolina Marine Artificial Reefs has been published and is being distributed as requested.
- Updates of reef construction activities continue to be presented to fishing and diving clubs around the state.

To maximize vessel time additional materials, like these concrete pyramids and culvert pipe, are brought along when replacing reef buoys.

The 103-foot tugboat, *JP McAllister*, is deployed on the Bill Perry Jr. Reef.

The 95-foot tug, *Susan Richards*, towed many barge-loads of material to reef sites all along the SC coast and is now itself an artificial reef off of Georgetown.

Inshore Fisheries Monitoring and Research

Program PI: Joseph C. Ballenger

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

Reporting Period: July 1, 2018 – June 31, 2019

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: (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, 2018 – June 30, 2019), inshore fisheries staff made 894 trammel sets in nine survey areas ('strata') along the South Carolina coast (**Table 1**). The survey caught 13,456 specimens belonging to 73 taxa (**Appendix 1**). We enumerated and measured all fish, and we released the majority of them alive at the site of capture. From the 13,456 specimens, we collected 4,583 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 subset 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, 2018 – June 30, 2019.

	2018						2019						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Winyah Bay	10	7	10	12	12	10	9	10	10	12	10	11	**123**
Cape Romain	10	10	11	12	12	10	9	10	9	11	9	12	**125**
Muddy & Bulls Bays		10	11	12	9	8	9	10	9	12	12	12	**114**
Lower Wando River	9	9	10	10	10	10	9	10	10	11	10	11	**119**
Charleston Harbor	9	8	1	10	12	8	9	10	10	10	10	10	**107**
Ashley River	11	10	12	11	12	10	10	13	12	13	12	12	**138**
ACE Basin	10	7	12		12	8	7	8	10	11	12	10	**107**
Broad River				10			8					12	**30**
Colleton River				10			10			11			**31**
Total	**59**	**61**	**67**	**87**	**79**	**64**	**80**	**71**	**70**	**91**	**75**	**90**	**894**

Table 2: Number of biological samples collected during July 1, 2018 – June 30, 2019.

		Gear				
Sample	**Purpose**	**Electrofishing**	**Hook and Line**	**Longline**	**Trammel**	**Total**
Fillet	SC DHEC mercury analysis	3			47	**50**
Fillet	SCDNR Sheepshead mercury study		4		10	**14**
Fin Clip	Genetics	1,027	291	619	3,065	**5,002**
Gonad	Sex, maturity, fecundity	118	130	85	400	**733**
Otoliths	Aging	119	300	86	816	**1,321**
Scales	Aging	13			52	**65**
Stomach	Graduate student study on environmental microplastics	13			74	**87**
Whole Specimen	Education programs	4			75	**79**
Whole Specimen	Invasive American Eel parasite study	90				**90**
Whole Specimen	Parasite study				3	**3**
Whole Specimen	SCDNR black gill-shrimp predation experiment				4	**4**
Whole Specimen	SCDNR Brood stock for stock enhancement studies				26	**26**
Whole Specimen	SCDNR study of invasive *Penaeus monodon*	7				**7**
Whole Specimen	SCDNR terrapin head start project				11	**11**
Total		**1,394**	**725**	**790**	**4,583**	**7,492**

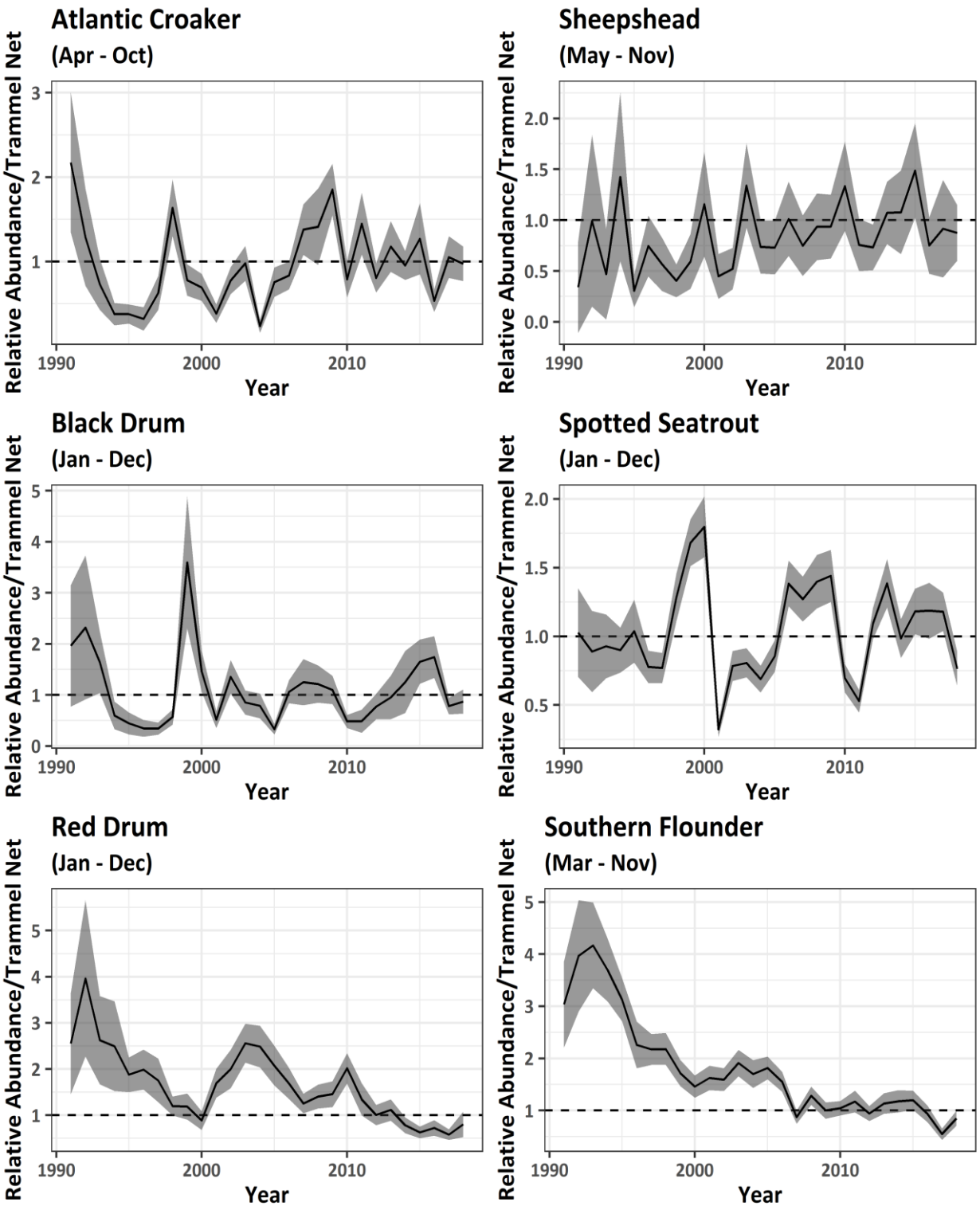


Figure 1: Examples of long-term population trends for selected species, as assessed by the SCDNR trammel net survey. The vertical axis is a relative index of fish abundance (annual average catch/2010-2018 average catch). Black lines show the statewide relative abundance across all strata, with gray shaded region representing the 95% confidence interval.

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 uses catch rates of American Eel as an index of abundance in their U.S. 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 325 electrofishing sets in five strata along the South Carolina coastline (**Table 3**). The survey caught 18,621 specimens belonging to over 67 taxa (**Appendix 2**). From those 18,621 specimens, staff took 1,394 biological samples (e.g. otoliths, scales, fin clips; **Table 2**). We present long-term population trends for a subset 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 years old) Red Drum. These older fish live in deeper waters than the subadults (<5 years old) that 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 use as brood stock.

During the reporting period, we made 3357 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 1,971specimens belonging to 30 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 86 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, 2019.

	2018						2019						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Winyah Bay	2	5	6	5	6	6	5	6	6	5	6		**58**
Cooper River	10	5	6	7	5	5	6	5	6	5	6	6	**72**
Ashley River	10	6	6	5	6	5	6	6	6	5	5	5	**71**
Edisto River	5	5	5	5	5	6	6		7	5	5	6	**60**
Combahee River	6	5	5	6	5	7	6	6	6	6	6		**64**
Total	**33**	**26**	**28**	**28**	**27**	**29**	**29**	**23**	**31**	**26**	**28**	**17**	**325**

Table 4: Number of one-third mile longline sets made during July 1, 2018 – June 30, 2019.

Stratum		**Month**				
Area	**Depth**	**August**	**September**	**October**	**November**	**Total**
Winyah Bay	Inner	0	12	6	10	**28**
Winyah Bay	Outer	0	18	21	20	**59**
Charleston Harbor	Inner	0	11	9	9	**29**
Charleston Harbor	Outer	0	19	21	21	**61**
Saint Helena Sound	Inner	13	0	14	12	**39**
Saint Helena Sound	Outer	17	0	16	18	**51**
Port Royal Sound	Inner	10	0	9	11	**30**
Port Royal Sound	Outer	20	0	21	19	**60**
	Total	**60**	**60**	**117**	**120**	**357**

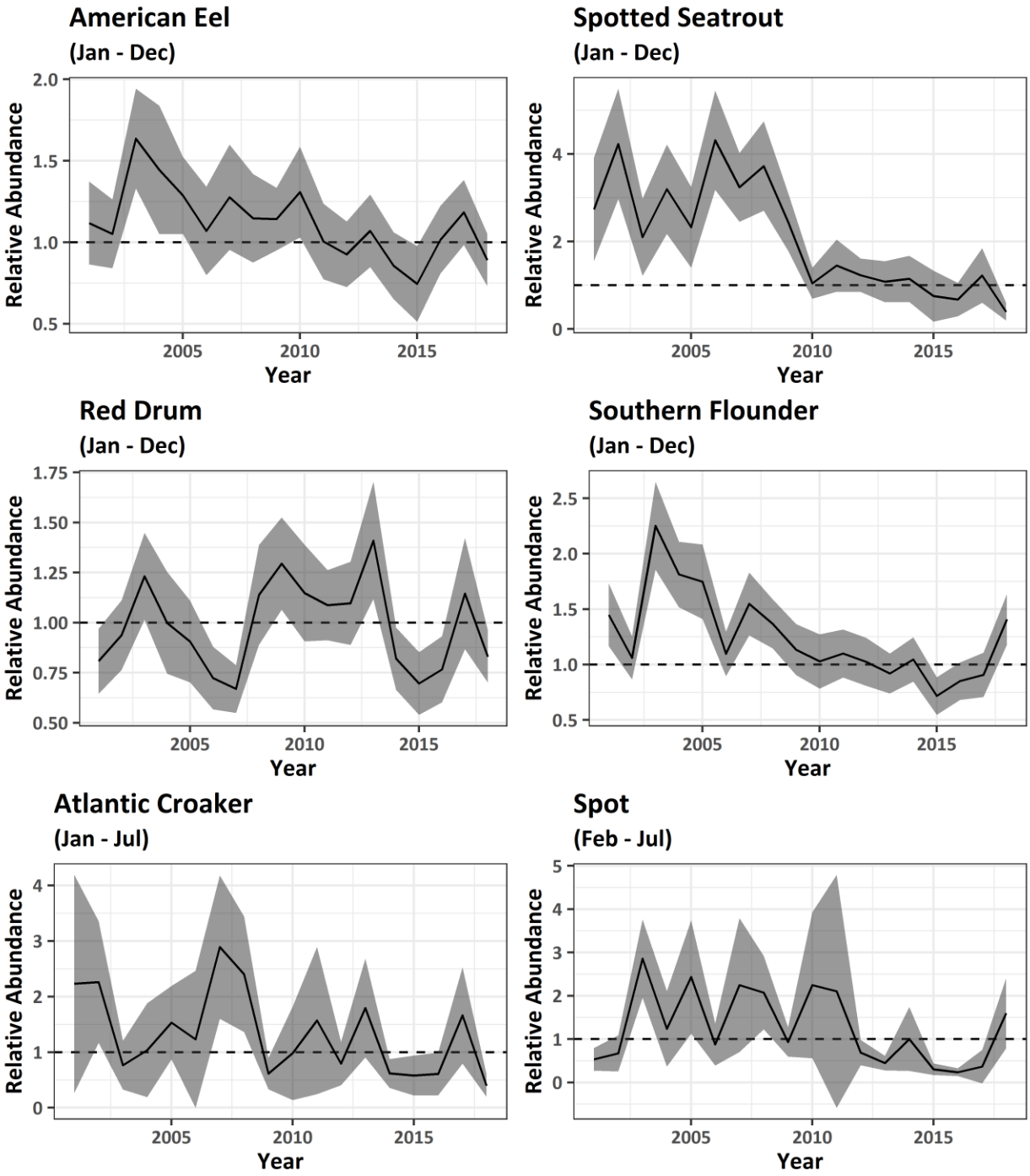


Figure 2: Examples of long-term population trends for selected species, as assessed by the SCDNR electrofishing survey. The vertical axis is a relative index of fish abundance (annual average catch per 15 minutes/2010-2018 average catch per 15 minutes). Black lines shows the statewide relative abundance across all strata with gray shaded region representing the 95% confidence interval.

Finfish Bycatch in the Crustacean Management Trawl Survey

Staff assessed the finfish catch in 81 trawls performed by SCDNR's crustacean management trawl survey. Forty-eight of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). Staff performed the remaining 33 trawls in the southern part of the state (August 2018, December 2018 and April 2019; **Table 5**).

The 81 trawls yielded 91,173 fish belonging to 70 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 fifth most numerous species captured in the trawl survey, with 3,022 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 to 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 substocks of the species, one of the research needs named in the 2016 stock assessment.

Table 5: Number of crustacean management trawls that we monitored for finfish from July 1, 2018 – June 30, 2019.

	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			**9**
ACE Basin		4				4				4			**12**
Port Royal Sound		1				1				1			**3**
Calibogue Sound		3				3				3			**9**
Total	**4**	**15**	**4**	**4**	**4**	**15**	**4**	**4**	**4**	**15**	**4**	**4**	**81**

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.

We acquired 129 fish carcasses belonging to four 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 aging. 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 172 fish belonging to seveb species, of which Sheepshead was the most numerous, followed by Bluefish (**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 recaptured fish.

The trammel and electrofishing surveys tagged 1,755 fish belonging to five species between July 1, 2018 and June 30, 2019, with the majority being Red Drum (**Table 7**). Over the same period, individuals recaptured 541 tagged fish, of which recreational anglers caught 457 and SCDNR survey staff caught 84 (**Table 8**). Anglers released alive approximately 77% (353/457) of the angler-caught fish (mostly Red Drum), while they harvested the remaining 23% (104/457).

Table 6: Number of fish acquired from the freezer and tournament monitoring programs during July 1, 2018 – June 30, 2019.

Species	Freezer	Tournament	Total
Black Drum	4	4	8
Bluefish		37	37
Red Drum	13	18	31
Sheepshead	109	72	181
Southern Flounder	3	26	29
Spotted Seatrout		13	13

Weakfish			2	2
	Total	**129**	**172**	**301**

Table 7: Number of fish tagged by the trammel net and electrofishing surveys during July 1, 2018 – June 30, 2019.

Species	**Electrofishing**	**Trammel**	**TOTAL**
Atlantic Tripletail		21	21
Black Drum	1	89	90
Red Drum	472	874	1,346
Sheepshead	6	51	57
Southern Flounder	60	181	241
Total	**539**	**1,216**	**1,755**

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

Publications during the reporting period (July 1, 2018 – June 30, 2019) in international, peer-reviewed journals that were co-authored by staff members (bold) of the Inshore Fisheries Section:

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.

Barker A.M., Adams D.H., Driggers III W.B., **Frazier B.S.**, Portnoy D.S (2019). Hybridization between sympatric hammerhead sharks in the western North Atlantic Ocean. Biol. Lett. 20190004. http://dx.doi.org/10.1098/rsbl.2019.0004.

Fair, P. A., N. D. White, B. Wolf, **S. A. Arnott**, K. Kannan, R. Karthikraj, and J. E. Vena. 2018. Persistent organic pollutants in fish from Charleston Harbor and tributaries, South Carolina, United States. Environmental Research 167: 598-613.

Lyons K, Bigman J.S., Kacev D., Mull C.G., Carlisle A.B., Imhoff J.L., Anderson J.M., Weng K.C., **Galloway A.S.**, Cave E., Gunn T.R., Lowe C.G., Brill R.W., Bedore C.N. (2019) Bridging disciplines to advance elasmobranch conservation: applications of physiological ecology. Conserv Physiol 7(1): coz011; doi:10.1093/conphys/coz011.

Table 8: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2018 – June 30, 2019.

Capture Method	Disposition	Black Drum	Red Drum	Sheepshead	Southern Flounder	Atlantic Tripletail	Total
Anglers	Harvested	8	81	5	9	1	104
	Released	12	339		2		353
	Anglers: sub-total	**20**	**420**	**5**	**11**	**1**	**457**
SCDNR Surveys	Harvested						0
	Released	1	78		4	1	84
	Survey: sub-total	**1**	**78**		**4**	**1**	**84**
Total		**21**	**498**	**5**	**15**	**2**	**541**

Appendix 1 Total catch of each species encountered by the trammel net survey during July 1, 2018 – June 30, 2019.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Spotted Seatrout	*Cynoscion nebulosus*	2,833	38	Blueback Herring	*Alosa aestivalis*	8
2	Striped Mullet	*Mugil cephalus*	2,493	39	Roughtail Stingray	*Dasyatis centroura*	6
3	Blue Crab	*Callinectes sapidus*	1,505	40	Smooth Butterfly Ray	*Gymnura micrura*	6
4	Red Drum	*Sciaenops ocellatus*	1,258	41	Tarpon	*Megalops atlanticus*	6
5	Spot	*Leiostomus xanthurus*	890	42	Weakfish	*Cynoscion regalis*	6
6	Longnose Gar	*Lepisosteus osseus*	659	43	Atlantic Bumper	*Chloroscombrus chrysurus*	5
7	Atlantic Croaker	*Micropogonias undulatus*	563	44	Atlantic Ridley Turtle	*Lepidochelys kempii*	5
8	Southern Flounder	*Paralichthys lethostigma*	443	45	Lookdown	*Selene vomer*	5
9	Black Drum	*Pogonias cromis*	309	46	Southern Stingray	*Dasyatis americana*	5
10	Atlantic Menhaden	*Brevoortia tyrannus*	264	47	American Eel	*Anguilla rostrata*	4
11	Bluefish	*Pomatomus saltatrix*	237	48	White Catfish	*Ameiurus catus*	4
12	Ladyfish	*Elops saurus*	235	49	Bay Whiff	*Citharichthys spilopterus*	3
13	Gizzard Shad	*Dorosoma cepedianum*	214	50	Bighead Searobin	*Prionotus tribulus*	3
14	Atlantic Stingray	*Dasyatis sabina*	186	51	Blue Catfish	*Ictalurus furcatus*	3
15	Bonnethead	*Sphyrna tiburo*	171	52	Horse-Eye Jack	*Caranx latus*	3
16	Southern Kingfish	*Menticirrhus americanus*	142	53	White Mullet	*Mugil curema*	3
17	Pinfish	*Lagodon rhomboides*	126	54	Atlantic Spadefish	*Chaetodipterus faber*	2
18	Sheepshead	*Archosargus probatocephalus*	95	55	Hickory Shad	*Alosa mediocris*	2
19	Finetooth Shark	*Carcharhinus isodon*	94	56	Inshore Lizardfish	*Synodus foetens*	2
20	Horseshoe Crab	*Limulus polyphemus*	87	57	Leatherjack	*Oligoplites saurus*	2
21	Silver Perch	*Bairdiella chrysoura*	79	58	Permit	*Trachinotus falcatus*	2
22	Cownose Ray	*Rhinoptera bonasus*	66	59	Pirate Perch	*Aphredoderus sayanus*	2
23	Hogchoker	*Trinectes maculatus*	66	60	Striped Anchovy	*Anchoa hepsetus*	2
24	Bluntnose Stingray	*Dasyatis say*	48	61	American Shad	*Alosa sapidissima*	1
25	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	47	62	Bay Anchovy	*Anchoa mitchilli*	1
26	American Harvestfish	*Peprilus paru*	40	63	Butterfish	*Peprilus triacanthus*	1
27	Pigfish	*Orthopristis chrysoptera*	34	64	Chain Pipefish	*Syngnathus louisianae*	1
28	Striped Burrfish	*Chilomycterus schoepfi*	28	65	Common Snook	*Centropomus undecimalis*	1
29	Atlantic Tripletail	*Lobotes surinamensis*	25	66	Fringed Flounder	*Etropus crossotus*	1
30	Crevalle Jack	*Caranx hippos*	18	67	Gulf Flounder	*Paralichthys albigutta*	1
31	Green Sea Turtle	*Chelonia mydas*	17	68	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	1
32	Northern Puffer	*Sphoeroides maculatus*	16	69	Live Loggerhead Turtle	*Caretta caretta - alive*	1
33	Spanish Mackerel	*Scomberomorus maculatus*	16	70	Striped Searobin	*Prionotus evolans*	1
34	Blacktip Shark	*Carcharhinus limbatus*	15	71	Threadfin Shad	*Dorosoma petenense*	1
35	Lemon Shark	*Negaprion brevirostris*	13	72	Tidewater Mojarra	*Eucinostomus harengulus*	1
36	Sandbar Shark	*Carcharhinus plumbeus*	12	73	Unknown Fish Species	*Unknown Fish Species*	1
37	Summer Flounder	*Paralichthys dentatus*	10				
Total							**13,456**

Appendix 2 Total catch of each species encountered by the electrofishing survey during July 1, 2018 – June 30, 2019.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Striped Mullet	*Mugil cephalus*	6,594	35	Flathead Catfish	*Pylodictis olivaris*	22
2	Bay Anchovy	*Anchoa mitchilli*	2,087	36	Common Carp	*Cyprinus carpio*	21
3	Inland Silverside	*Menidia beryllina*	1,390	37	Hogchoker	*Trinectes maculatus*	20
4	Spot	*Leiostomus xanthurus*	1,273	38	Gray Snapper	*Lutjanus griseus*	18
5	Atlantic Menhaden	*Brevoortia tyrannus*	1,268	39	Sheepshead	*Archosargus probatocephalus*	18
6	Red Drum	*Sciaenops ocellatus*	739	40	Bay Whiff	*Citharichthys spilopterus*	13
7	Longnose Gar	*Lepisosteus osseus*	643	41	Ladyfish	*Elops saurus*	12
8	Threadfin Shad	*Dorosoma petenense*	419	42	Spanish Mackerel	*Scomberomorus maculatus*	10
9	White Catfish	*Ameiurus catus*	373	43	Brook Silverside	*Labidesthes sicculus*	9
10	Blue Catfish	*Ictalurus furcatus*	366	44	Grass Carp	*Ctenopharyngodon idella*	8
11	American Eel	*Anguilla rostrata*	343	45	Pumpkinseed	*Lepomis gibbosus*	7
12	Southern Flounder	*Paralichthys lethostigma*	329	46	Spotted Sunfish	*Lepomis punctatus*	7
13	Largemouth Bass	*Micropterus salmoides*	328	47	Atlantic Needlefish	*Strongylura marina*	6
14	Bluegill	*Lepomis macrochirus*	261	48	Fat Sleeper	*Dormitator maculatus*	6
15	Blueback Herring	*Alosa aestivalis*	204	49	Goldern Shiner	*Notemigonus crysoleucas*	6
16	Redbreast Sunfish	*Lepomis auritus*	190	50	Highfin Goby	*Gobionellus oceanicus*	6
17	Silver Perch	*Bairdiella chrysoura*	168	51	Warmouth	*Lepomis gulosus*	4
18	Freshwater Goby	*Ctenogobius shufeldti*	158	52	White Perch	*Morone americana*	4
19	Atlantic Croaker	*Micropogonias undulatus*	147	53	Crevalle Jack	*Caranx hippos*	3
20	White Mullet	*Mugil curema*	142	54	Naked Goby	*Gobiosoma bosc*	3
21	Gizzard Shad	*Dorosoma cepedianum*	115	55	Southern Kingfish	*Menticirrhus americanus*	3
22	Redear Sunfish	*Lepomis microlophus*	109	56	Spotted Sucker	*Minytrema melanops*	3
23	Striped Bass	*Morone saxatilis*	107	57	Black Drum	*Pogonias cromis*	2
24	Mummichog	*Fundulus heteroclitus*	106	58	Irish Pompano	*Diapterus auratus*	2
25	Pinfish	*Lagodon rhomboides*	101	59	Tarpon	*Megalops atlanticus*	2
26	Tidewater Mojarra	*Eucinostomus harengulus*	89	60	Atlantic Stingray	*Dasyatis sabina*	1
27	Minnow - Species TBI	*Minnow - Species TBI*	68	61	Blue Crab	*Callinectes sapidus*	1
28	Bowfin	*Amiidae*	58	62	Chain Pickerel	*Esox niger*	1
29	Western Mosquitofish	*Gambusia holbrooki*	49	63	Channel Catfish	*Ictalurus punctatus*	1
30	Black Crappie	*Pomoxis nigromaculatus*	44	64	Flat Bullhead	*Ameiurus platycephalus*	1
31	Spotted Seatrout	*Cynoscion nebulosus*	39	65	Green Sunfish	*Lepomis cyanellus*	1
32	Common Snook	*Centropomus undecimalis*	35	66	Silver Anchovy	*Engraulis eurystole*	1
33	American Shad	*Alosa sapidissima*	33	67	Yellow Perch	*Perca flavescens*	1
34	Speckled Worm Eel	*Myrophis punctatus*	23				
						Total	**18,621**

Appendix 3: Total catch of each species encountered by the SCDNR longline survey during July 1, 2018 – June 30, 2019.

Rank	Common name	Scientific name	# Caught
1	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	735
2	Red Drum	*Sciaenops ocellatus*	639
3	Sandbar Shark	*Carcharhinus plumbeus*	157
4	Southern Stingray	*Hypanus americanus*	79
5	Blacktip Shark	*Carcharhinus limbatus*	77
6	Blacknose Shark	*Carcharhinus acronotus*	77
7	Finetooth Shark	*Carcharhinus isodon*	63
8	Bonnethead	*Sphyrna tiburo*	57
9	Spinner Shark	*Carcharhinus brevipinna*	21
10	Oyster Toadfish	*Opsanus tau*	11
11	Bull Shark	*Carcharhinus leucas*	7
12	Black Sea Bass	*Centropristis striata*	6
13	Lemon Shark	*Negaprion brevirostris*	6
14	Scalloped Hammerhead	*Sphyrna lewini*	5
15	Gafftopsail Catfish	*Bagre marinus*	4
16	Roughtail Stingray	*Bathytoshia centroura*	4
17	Tiger Shark	*Galeocerdo cuvier*	3
18	Atlantic Croaker	*Micropogonias undulatus*	3
19	Smooth Butterfly Ray	*Gymnura micrura*	2
20	Cownose Ray	*Rhinoptera bonasus*	2
21	Whiting	*Menticirrhus americanus*	2
22	Atlantic Cutlassfish	*Trichiurus lepturus*	2
23	Atlantic Stingray	*Hypanus sabinus*	2
24	Great Hammerhead	*Sphyrna mokarran*	1
25	Nurse Shark	*Ginglymostoma cirratum*	1
26	Tarpon	*Megalops Atlanticus*	1
27	Bluefish	*Pomatomus saltatrix*	1
28	Ladyfish	*Elops saurus*	1
29	Pinfish	*Lagodon rhomboides*	1
30	Inshore Lizardfish	*Synodus foetens*	1
		Total	**1,971**

Appendix 4: Total number of fish caught in the Crustacean Management Trawl Survey between July 1, 2018 and June 30, 2019, by species.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Atlantic Croaker	*Micropogonias undulatus*	35,784	36	Northern Pipefish	*Syngnathus fuscus*	15
2	Star Drum	*Stellifer lanceolatus*	32,144	37	Striped Cusk-Eel	*Ophidion marginatum*	15
3	Bay Anchovy	*Anchoa mitchilli*	7,698	38	Southern Hake	*Urophycis floridana*	14
4	Spot	*Leiostomus xanthurus*	5,604	39	Smooth Butterfly Ray	*Gymnura micrura*	11
5	Weakfish	*Cynoscion regalis*	3,022	40	Atlantic Spadefish	*Chaetodipterus faber*	10
6	Blackcheek Tonguefish	*Symphurus plagiusa*	1,870	41	Atlantic Thread Herring	*Opisthonema oglinum*	9
7	Hogchoker	*Trinectes maculatus*	655	42	Threadfin Shad	*Dorosoma petenense*	9
8	Spotted Hake	*Urophycis regia*	636	43	Striped Burrfish	*Chilomycterus schoepfii*	8
9	Bighead Searobin	*Prionotus tribulus*	454	44	Shrimp Eel	*Ophichthus gomesii*	8
10	Banded Drum	*Larimus fasciatus*	453	45	American Harvestfish	*Peprilus paru*	8
11	Silver Seatrout	*Cynoscion nothus*	444	46	Gafftopsail Catfish	*Bagre marinus*	5
12	Silver Perch	*Bairdiella chrysoura*	410	47	Highfin Goby	*Gobionellus oceanicus*	5
13	Southern Kingfish	*Menticirrhus americanus*	317	48	Naked Goby	*Gobiosoma bosc*	5
14	Fringed Flounder	*Etropus crossotus*	290	49	Planehead Filefish	*Stephanolepis hispidus*	5
15	Leopard Searobin	*Prionotus scitulus*	265	50	Southern Stargazer	*Astroscopus y-graecum*	4
16	White Catfish	*Ameiurus catus*	175	51	Pinfish	*Lagodon rhomboides*	4
17	Southern Flounder	*Paralichthys lethostigma*	101	52	Blue Catfish	*Ictalurus furcatus*	3
18	Striped Anchovy	*Anchoa hepsetus*	84	53	Chain Pipefish	*Syngnathus louisianae*	3
19	Butterfish	*Peprilus triacanthus*	72	54	Gizzard Shad	*Dorosoma cepedianum*	3
20	Atlantic Bumper	*Chloroscombrus chrysurus*	70	55	Northern Puffer	*Sphoeroides maculatus*	3
21	Gulf of Mexico Ocellated Flounder	*Ancylopsetta ommata*	61	56	Inshore Lizardfish	*Synodus foetens*	3
22	Atlantic Stingray	*Dasyatis sabina*	53	57	Longnose Gar	*Lepisosteus osseus*	3
23	Atlantic Moonfish	*Selene setapinnis*	39	58	Atlantic Sturgeon	*Acipenser oxyrinchus*	2
24	Summer Flounder	*Paralichthys dentatus*	37	59	Bluntnose Stingray	*Dasyatis say*	2
25	Atlantic Cutlassfish	*Trichiurus lepturus*	34	60	Spanish Mackerel	*Scomberomorus maculatus*	2
26	Seatrout spp.	*Cynoscion spp.*	32	61	Cownose Ray	*Rhinoptera bonasus*	2
27	Freshwater Goby	*Ctenogobius shufeldti*	30	62	Feather Blenny	*Hypsoblennius hentz*	2
28	Bay Whiff	*Citharichthys spilopterus*	27	63	Bluefish	*Pomatomus saltatrix*	2
29	Atlantic Menhaden	*Brevoortia tyrannus*	26	64	Shortnose Sturgeon	*Acipenser brevirostrum*	1
30	Lookdown	*Selene vomer*	24	65	Pigfish	*Orthopristis chrysoptera*	1
31	Prionotus species	*Prionotus sp.*	23	66	Irish Pompano	*Diapterus auratus*	1
32	Striped Searobin	*Prionotus evolans*	18	67	Gray Snapper	*Lutjanus griseus*	1
33	Oyster Toadfish	*Opsanus tau*	17	68	Black Drum	*Pogonias cromis*	1
34	Spotted Seatrout	*Cynoscion nebulosus*	16	69	Bonnethead	*Sphyrna tiburo*	1
35	Striped Mullet	*Mugil cephalus*	16	70	Gulf Pipefish	*Syngnathus scovelli*	1
						Total	**91,173**

Fish Stock Enhancement Research

Project PIs: Aaron Watson, Tanya Darden, Mike Denson

Project Title: Evaluating A Responsible Approach To Marine Finfish Stock Enhancement of Spotted Seatrout, Red Drum, and Cobia

Reporting Period: July 1, 2018 - June 30, 2019

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 have, 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 of multiple species occurred in several estuaries in South Carolina from Winyah Bay to Port Royal Sound 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:
2018 Production: During the fall of 2018, SRFAC funds were used to produce and stock 967,360 red drum into four estuaries throughout South Carolina. SCDNR staff released a total of 254,617 juvenile red drum during three distinct time periods after Hurricane Florence and utilizing three

unique genetic families within Winyah Bay: directly after the hurricane (39,632), two months after the hurricane (212,049), and six months after the hurricane (2,936). A total of 261,087 juvenile red drum from two unique families were produced for stocking into Port Royal Sound. The goal of these stockings is to determine the optimal size at release (small vs. medium) of juvenile red drum in this estuary. Medium juveniles (5,441) were also released by SCDNR staff into the ACE Basin. Two genetic families were provided to Bears Bluff National Fish Hatchery (BBNFH) from spawns at the Marine Resources Research Institute (MRRI). Stocking of small juveniles (446,215) into the North Edisto (Bohicket and Leadenwah Creeks) was conducted by BBNFH staff to evaluate timing of release (early vs. late). Approximately 5,000 fish were overwintered at the MRRI, of which 1,000 fish were stocked into Colonial Lake for a kids fishing tournament held in late September 2019. Production was impacted for the fourth year in a row by two major weather events, Hurricane Florence and Hurricane Michael. Their potential influences on contribution of these stocked fish will be evaluated next year following collection of 2018 year class samples.

Table 1. 2018 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)
39,632	Fall 2018	Winyah Bay (directly following hurricane)	1.6
212,049	Fall 2018	Winyah Bay (2 months after hurricane)	2.9
2,936	Spring 2019	Winyah Bay (6 months after hurricane)	3.7
257,479	Fall 2018	Port Royal (small)	1.6
3,608	Winter 2019	Port Royal (medium)	5.3
5,441	Winter 2019	ACE Basin	5.3
90,870	Fall 2018	North Edisto (early)	1.7
355,345	Fall 2018	North Edisto (late)	1.2

Evaluation of 2017 Year Class Stocking: Three unique genetic families contributed to the 2017 year class stock enhancement releases. Three estuaries were stocked including the ACE Basin, North Edisto River and Winyah Bay as part of our juvenile stocking efforts. An additional 1,000 yearling+ were stocked into four estuaries (Charleston Harbor, Winyah Bay, ACE Basin and Port Royal) as part of a tag reporting experiment conducted by Inshore Fisheries. Two additional stockings into Colonial Lake downtown Charleston were conducted for a youth fishing tournament in cooperation with the education and outreach section at MRD. Two distinct size classes were produced from the 2017 year class: small juveniles (mean TL 28-75 mm) and yearling+ fish (mean TL 300-542 mm) with stocking occurring from 9/25/2017 to 11/16/2017 for the small juveniles and 9/10/2018 to 7/11/2019 for the larger fish.

Table 2. 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

The red drum stocking strategy for 2017 was to evaluate the contribution of small juvenile red drum (~30-35 mm TL) to the wild population from two release locations within Winyah Bay (brackish water <8 g/L and saltwater >25 g/L) as well as their movement patterns following release. The experimental design was determined based on the high abundance of hatchery recaptures within the brackish water areas within Winyah Bay and the Ashley River, despite fish being stocked throughout the estuary. It is hypothesized that juvenile red drum require reduced salinity for early life history development, which is corroborated by poor contribution from small juvenile stockings (~30 mm TL) within Murrell's Inlet, which has no freshwater input. Two unique genetic families were used to test this hypothesis. The final two stocking locations (ACE Basin and North Edisto River) did not have a study design, and fish were released for stock enhancement purposes only. Fish utilized for the tag reporting study were released after the Inshore Fisheries collection of young of the year in quarter four of 2018 and thus are not represented in the genetic sample collections.

ACE Basin: A single genetic family was released on 11/8/2017 directly from the hauling trailer at the Bennett's Point boat ramp. A total of 13,081 small juveniles (mean TL 75.5 mm) were released for stock enhancement purposes with no scientific questions addressed.

Colonial Lake: Two separate releases occurred at Colonial Lake in downtown Charleston. A total of 369 large juveniles (mean TL 321.4 mm) were initially released on 9/10/2018. A second release of 366 large juvenile fish (mean TL 299.6 mm) was completed on 9/24/2018 with assistance from the education and outreach section. These fish were stocked for the Huck Finn kids fishing tournament which took place on September 29th, 2018. Based on feedback from Olivia Bueno with SCDNR's education and outreach section, approximately 50 red drum were caught and released, providing an educational opportunity for SCDNR personnel to train youth on proper handling and releasing techniques while fishing.

North Edisto: A single genetic family was spawned at MRRI and 2 dph larvae were provided to BBNFH for stocking into ponds at their facility on Wadmalaw Island, SC. A total of 359,970 small juvenile red drum were released on seven separate days from boat by staff at BBNFH in three different creeks within the North Edisto. Wee Creek received 5,635 (mean TL 53.4 mm) and 75 (mean TL 53.1 mm) small juvenile red drum on 9/25/2017 and 9/27/2017, respectively. Bohicket Creek received a total of 5,919 small red drum (mean TL 51.4 mm) on 9/28/2017, 92,288 fish (mean TL 28.1 mm) on 11/14/2017, and 110,160 fish (mean TL 31.7 mm) on 11/16/2017. Finally, Leadenwah Creek received 38,634 (mean TL 31.7 mm) and 107,259 (mean TL 31 mm) small

juvenile red drum on 10/11/2017 and 11/8/2017, respectively. Hatchery contribution to the wild year class within the system is the only information which can be obtained from the 2017 YC stockings due to only one genetic family being stocked.

Winyah Bay: Two unique genetic families were used for our experimental treatment groups, including brackish water and saltwater release treatments. Fish were released by boat near the mouth of the Waccamaw River for the brackish water release location and at Mother Norton Shoals for the saltwater release location. All releases were single-batch releases and occurred over multiple days for both families. Salinities at stocking were not recorded. A total of 406,218 small juvenile red drum (mean TL 35.57 mm) from the brackish water treatment were released on 8/17/2017 (208,947) and 9/29/2017 (125,271). A total of 566,755 small juvenile red drum (mean TL 34.43 mm) from the saltwater treatment were released on 9/28/2017 (255,793) and 10/2/2017 (310,962). Due to the large geographic distance between stocking locations (North Edisto River and the ACE Basin), it was assumed that there would be no movement of juveniles from the other stocked estuaries into Winyah Bay.

Tag Reporting Study:

A tag-reporting study is underway in collaboration between the Mariculture and Inshore Fisheries sections. A total of 921 red drum with average TL of 19.87 ± 0.24 inches were released into South Carolina estuaries between 3/26/2019 and 7/11/2019 for this study. Recapture information and summary of this study will be produced by the Inshore Fisheries Section.

Contribution:

A total of 311 red drum tissue samples, from 2017 year class (YC) individuals collected during July-December 2018, were included in the analysis of contribution to the ACE Basin, Winyah Bay and North Edisto River. A total of 10 cultured fish were recaptured for an overall hatchery contribution of 3.2% from stocking effort in 2017.

In the ACE Basin, 148 tissue samples were included in the analysis and there were no cultured fish recaptured for a stocked contribution of 0%. In Winyah Bay, 113 tissue samples were included in the analysis and 9 cultured fish were recaptured for a hatchery contribution of 8%. In the North Edisto River, 50 tissue samples were included in the analysis and 1 cultured fish was recaptured for a hatchery contribution of 2%.

The number of 2017YC hatchery returns was low for both Winyah Bay and North Edisto River, so all conclusions and inferences drawn from this data should be viewed in light of the small sample size of cultured individuals from these locations.

ACE Basin: Unlike the 2014YC and 2015YC, there was no hatchery contribution in the ACE Basin from stocking efforts in 2017. Hatchery contribution for the 2014YC and 2015YC were similar (2.2% and 2%, respectively) with relatively equal numbers of red drum juveniles released (166,255 and 182,097, respectively). The lack of contribution from the 2017YC may be due to the substantially lower number of red drum juveniles released that year in the ACE Basin (13,081). Another potential reason for no hatchery recaptures is the fact that these fish were released at

Bennett's Point which is five miles away from the nearest trammel net site, while in 2014 and 2015 fish were released from boat closer to Inshore Fishery's trammel sites. Higher contributions were seen in Winyah Bay (8%) and North Edisto River (2%) possibly due to greater numbers of hatchery individuals stocked in those estuaries (972,973 and 359,970, respectively).

Winyah Bay: In Winyah Bay, the brackish water released juveniles had a higher contribution (n=8, 7.1%) than the saltwater released juveniles (n=1, 0.9%). The brackish water released juveniles also had a significantly higher recapture rate (number recaptured / number stocked) than the saltwater released juveniles (0.002 vs. 0.0002; p=0.0002). Similar to previous years (2012YC, 2013YC, 2014YC, 2015YC, 2016YC), comparisons of gear showed that more of the 2017YC hatchery recaptures came from electrofishing gear (n=7; 77.8%) than from trammel netting gear (n=2; 22.2%). Hatchery individuals also made a higher contribution to the electrofishing samples (13.2%) than to the trammel netting samples (3.3%). This is in contrast to the 2013YC where hatchery individuals made a higher contribution to the trammel netting samples (38.5%) than to the electrofishing samples (20%), but is similar to what was seen for other year classes where hatchery individuals made a higher contribution to the electrofishing samples (2012YC: 25%; 2014YC: 21.4%; 2015YC: 21.6%; 2016YC: 37.2%) than to the trammel netting samples (2012YC: 4.7%; 2014YC: 7.1%; 2015YC: 6%; 2016YC: 3.4%). Hatchery contributions were moderate for the 2004YC (11.5%), 2007YC (13.7%), 2008YC (16.1%), 2012YC (12.8%), 2014YC (14.3%), 2015YC (12.7%), and 2017YC (8%), but high for the 2005YC (35.3%), 2013YC (25%), and 2016YC (27.6%). The number of small juvenile red drum released in 2005 (853,859), 2013 (411,086), and 2016 (518,407) was greater than in 2012 (148,787) and 2014 (287,520), which likely accounts for the difference in contribution. However, the 2004YC, 2007YC, 2008YC, and 2017YC had only moderate levels of contribution despite larger numbers of small juveniles being released (2004: 984,702, 2007: 587,157, 2008: 417,651; 2017: 972,973). Annual wild recruitment variation could account for the differences in contribution we see in Winyah Bay regardless of the number of juveniles stocked.

The brackish water release treatment in Winyah Bay had a higher contribution and significantly higher recapture rate than the saltwater release treatment, even though the two treatments had a similar size at release (35.57 mm vs. 34.43 mm), and the brackish water treatment had fewer fish released than the saltwater treatment (406,218 vs. 566,755). However, Fulton's Condition Factor (k) was higher in the brackish water release treatment (0.86 weighted average) compared to the saltwater release treatment (0.75 weighted average) which could explain the higher return rates seen with the brackish water treatment. Higher contribution from the brackish water release treatment was hypothesized due to higher return rates of hatchery individuals seen in the electrofishing survey within the lower salinity areas within Winyah Bay. This data supports the hypothesis that juvenile red drum may require reduced salinity for early life history development. An alternative explanation could be that fish released at the saltwater location, Mother Norton Shoals, have a higher probability of leaving the system due to the proximity to the mouth of Winyah Bay and tidal creek connections to the North Santee inlet.

North Edisto River: In the North Edisto River, there was only one hatchery fish captured at the Selkirk boat landing, in the upper waters of Leadenwah Creek, for a contribution of 2%. For both the 2013YC and 2016YC, there was a higher contribution to Leadenwah Creek than to Bohicket Creek, but it is difficult to make a direct comparison to the 2017YC due to the small sample size

of cultured fish (n=1). Hatchery contribution for the 2017YC was the lowest of any year class, with other year classes having contributions ranging from 3% to 39.4% (2003YC-2009YC, 2011YC-2013YC, 2016YC). The number of juveniles released in the North Edisto River has varied greatly over the years (77,636 – 1,117,801) and there has been no consistent relationship between stocking numbers and hatchery contribution.

Salinity Tolerance Trials:

After hurricane Florence passed close by the South Carolina coast on September 13, 2018, record flooding in the Pee Dee and Waccamaw rivers was observed. Our stocking plan changed slightly since this hurricane gave us the opportunity to ask a unique question looking at successful red drum recruitment based on time released after an extreme weather event. During a release on 10/30/2018, fish were acclimated in our hauling box and were behaving normally. However, when we put them completely into the water at the release site, a high percentage of fish experienced extreme, and ultimately fatal, tetany. The conditions at the acclimation site were 16.9°C, 5.28 mg/l oxygen, 6.72 pH all of which are relatively normal for location and time of year. Salinity, however was 0.06 which is significantly lower than normal. In order to evaluate this previously unobserved phenomenon, two days after the release we went up to the same boat ramp and filled up one of our hauling boxes with water. Two families of red drum were brought up from Waddell Mariculture Center, one smaller family and one larger family. The smaller juveniles were the same family that experienced the tetany response.

In controlled laboratory aquaria, water from Winyah Bay was mixed with our standard Charleston Harbor water to develop four different salinities of water (8.0, 2.0, 1.0, and 0.1) A 0.1 Control salinity was generated using reverse osmosis (RO) water and Instant Ocean. Four replicates of each salinity were run with 5 fish each. The entire experiment was repeated with both the small and large families. One family was run at a time. Fish were counted out of the main tank and placed into two larval boxes filled with full strength seawater. A control larval box used pure RO water to acclimate the fish down in salinity while our other larval box used Winyah water to acclimate the fish down in salinity. Water quality was recorded every 5 minutes during the course of the acclimation process and as soon as the larval box was in within 1-2ppt of a treatment salinity, 5 fish were counted out and placed in the desired treatment tank. Fish were observed for initial stressors and any mortality. Once the last group of fish was placed into their treatment tanks, mortalities at the 1h 2h and 3h mark were recorded. After 3 hours, fish were removed from their tanks, lengths and weights were taken of both living and dead fish. Remaining living fish were acclimated back up in salinity and placed into a separate holding tank. This process was done twice for the family of smaller fish and once for the family of larger fish. Although we were unable to mimic the rapidity of the onset of tetany and rapid mortality (most likely due to differences in local salinity from the release site and water collection site only two days later) the smaller juveniles experienced significant mortality, especially at the lowest salinities, in comparison to the larger juveniles.

Table 3. Total morality over 3-hour exposure to low salinity for juvenile red drum.

Experiment 1		
Treatment	Mortality - Small Juveniles	Mortality - Large Juveniles
Winyah 8.0ppt	0%	0%
Winyah 2.0ppt	0%	0%
Winyah 1.0ppt	0%	15%
Control 0.1ppt	65%	55%
Winyah 0.1ppt	100%	100%

To evaluate whether the rate of acclimation may have helped induce the mortality observed during the initial release, we repeated the previous experiment with several modifications. Fish were slowly acclimated to 4 ppt through the use of flow-through well water over the course of three days, and were held at this salinity for one week. Salinities in the controlled aquaria were 2.0, 1.0, and 0.1 with both Winyah water and control (RO + Instant Ocean) water. This trial was run once with smaller juveniles, again with 4 replicate treatments and 5 individual fish per aquaria. Keeping fish in the lower salinity decreased the number of mortalities after acclimation, and we saw no significant differences in mortality among salinity treatments. These trials have provided preliminary data for us to further evaluate our acclimation and release strategies, especially following major meteorological events.

Table 4. Total mortality after 3-hour exposure to low salinity following acclimation period to 4ppt salinity water.

Experiment 2	
Treatment	Mortality
Winyah 2.0	0%
Control 2.0	0%
Winyah 1.0	0%
Control 1.0	0%
Winyah 0.1	0%
Control 0.1	15%

Spotted Seatrout:
2018 Production: A total of 433,246 juvenile spotted seatrout were harvested from 16 ponds containing four unique families in 2018. Average survival in the ponds was 31.2%. Pond stocking density data from the 2018 season was combined with trials conducted in the 2017 and 2019 seasons to establish possible correlations between pond stocking density and seatrout survival. Survival was higher at both the highest and lowest densities than at the two median stocking densities. However, seatrout stocked at the highest stocking density were significantly smaller

upon harvest than seatrout stocked at lower densities. Seatrout survival significantly decreased with increased pond temperatures, which likely contributes to the high survival in the high density treatment that was only stocked in 2017 at an earlier time point than any of the other stocking density trials. Continued trials at different temperature and density regimes will be necessary to determine the appropriate stocking density that will result in high survival and robust fish.
A total of 309,301 spotted seatrout from four unique genetic families were released into the Charleston Harbor system in 2018. Small juveniles produced from the four unique families were released in Charleston Harbor and the Ashley River during June (65,456 and 105,913 into each location respectively) and July (37,410 and 100,522, respectively). A single unique family was stocked into each of these locations at each month, enabling comparisons to be made between stocking location. The 2018 stocking strategy was built upon and will complement the three-year replicated design from 2015 - 2017 comparing the location and timing of release.

Table 5. Spotted seatrout produced at Waddell Mariculture Center and stocked in South Carolina estuaries in 2018.

Year Class	Number Stocked	Total Length (inches)	Release Location	Release Treatment
2018	65,456	~1.5	Charleston Harbor	June – Early Small
2018	105,913	~1.7	Ashley River	June - Early Small
2018	37,410	~1.5	Charleston Harbor	July – Mid Small
2018	100,522	~1.4	Ashley River	July - Mid Small

Evaluation of 2015 thru 2018 YC Stockings:
To evaluate the contribution of stocked juvenile spotted seatrout, a total of 485 fin clip tissue samples were processed from spotted seatrout collected in the Charleston Harbor system from September-December during monthly independent random sampling in 2018.

Overall, 53 hatchery spotted seatrout representing two year classes were collected in 2018. Movements from the Ashley River or Charleston Harbor into the Wando or Cooper Rivers have been very rare over time (n=1) and 2018 was no exception, as all hatchery fish were collected on the southern shore of Charleston Harbor or in the Ashley River. As in previous years, movement of hatchery fish between Charleston Harbor and the Ashley River occurred (n=10 from CH to AR and n=1 from AR to CH). These strata represent a geographic continuum and movements between the two strata can occur without crossing the open Charleston Harbor system. These results suggest that seatrout contributions may be localized to the stocking location and adjacent areas. Efforts to increase contribution on a system-wide basis may require multiple stocking locations over the entire area.

Although contribution from the 2015 and 2016 YCs occurred in the Ashley River and Charleston Harbor during the 2017 sampling collections, no individuals were collected from those age classes in the 2018 sampling season (0% contribution). This is a significant reduction in percent contribution of 2-3 year old fish in the Charleston Harbor. In the 2017 collection, 2-3 year old fish represented 24.4% and 16.7% of the contribution, respectively. This significant reduction of these age classes may be due to the abnormally cold winter observed in January 2018. There was,

however, contribution from the 2017 YC as age 1 fish (5.9%). The 2017 YC represents the largest seatrout stocking effort to date, with 782,562 fish released in two locations (Charleston Harbor and Ashley River) and four treatments (early small juvenile, mid small juvenile, late small juvenile, late large juvenile). All hatchery fish collected from the 2017 YC belonged to small juvenile release treatments, most of which came from the early release treatment (69%) and all others from the mid-season release treatment (21%). All hatchery recaptures were collected within 12 km of the original stocking location.

Compared to the 2017 field collections, fewer spotted seatrout were stocked in 2018 (309,301). This planned reduction in stocking numbers was due to the abnormally cold winter and potential population bottleneck created by high mortality. A conservative approach to numbers stocked was utilized prior to population numbers being assessed by the SCDNR Inshore Fisheries Section to avoid any potential negative genetic impacts of swamping a small population with large numbers of stocked fish. All seatrout were released into the Ashley River and Charleston Harbor as small juveniles in either early or mid-season release treatments. All hatchery fish recaptured from the 2018 YC belonged to the early release treatments and were collected within 13 kilometers of the original stocking location. Small juveniles released earlier in the season are expected to recruit to the sampling gear before both the majority of wild fish and hatchery fish that are released later in the season and therefore typically make an increased contribution at age 0 relative to subsequent years. With the exception of the 2016 YC, when no hatchery fish were collected at age 0, overall hatchery contribution has decreased from age 0 to age 1 and we would expect to see a similar decrease with the 2018 YC as well. Collections from 2019, when 2018 YC wild and hatchery seatrout have fully recruited to the sampling gear, will provide a better understanding of contribution. The 2017 year class continued to contribute to the Charleston Harbor system at age one (5.9%). The 2018 year class made a 22.5% contribution to the Charleston Harbor system as age 0 fish and 2019 collections will provide more information on their ultimate contribution to the fishery as all fish recruit to the sampling gear.

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 2018, 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 was used in the SEDAR stock assessment during this year. In 2018, a total of 20 undersized cobia were collected by SEAMAP and provided to the EFR section for processing. Additional fin clip samples were collected through the CRP acoustic tagging study.

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 105 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 as well as fishing tournaments which includes fish racks, genetic samples, and catch information. A total of 56 genetic samples were collected in collaboration with our CRP project. 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 2019 to collect cobia broodstock from the Broad River annual inshore aggregation for hatchery production of fingerlings for stock enhancement research. Four wild cobia were collected by cooperating recreational anglers and SCNDR staff in the Broad River and transported back to WMC for use as broodstock. Cobia were prophylactically treated for any external parasites and introduced to flow-through tanks at WMC. During the past year, we also implemented a vitamin addition to the broodstock diet for cobia at MRRI in hopes of filling any maternal nutritional gaps present and improving spawn quality. Cobia broodstock at MRRI were injected with spawning hormones produced viable eggs which were hatched and stocked into ponds at the WMC. Unfortunately, relatively few juveniles (12) were harvested from the pond from this single successful spawn, so no releases occurred during the year, those juveniles are being used for in-house method and development testing. 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 and 2020 collection years when contribution to the wild population can be assessed.

A total of 305 cobia genetic samples were processed this year from all collection sources. Overall, four cultured fish were captured in the 2018 collections (all fish sampled in all locations) for a total contribution of 1.7%. However, samples used for calculating contribution must meet collection criteria, including a collection date from April- July. When including only these samples in the calculations, the total contribution was 2.1%. Furthermore, when samples were separated into Atlantic and Gulf of Mexico stocks using Cape Canaveral, FL as a stock boundary, the contribution to the Atlantic stock was 2.3%. As expected, there was no contribution to the Gulf of Mexico stock.

For the South Carolina collections, the total contribution was 3.2%. The highest contribution was seen from the inshore samples within the Broad River (where stocking occurred) at 6.5% (n=2) with a smaller contribution from offshore at 1.6% (n=1). Due to the fishing closure within the Port Royal and St. Helena Sounds during the May peak collection period, samples from inshore were limited primarily to genetic fin clips. The inability to determine otolith-based ages reduces our confidence in contribution numbers based on year class within the inshore population. Evaluating the 2012YC using otolith ages from all SC-collected samples (n=12), total contribution was 8.3% with one cultured fish captured offshore.

Contributions from cultured fish were observed only from the 2012YC. Genetic data suggests that all cultured fish were offspring from the parental cross of CB048 and CB076. Interestingly, all hatchery identified fish from the 2012YC to date have been from this male/female pairing even though there were three males and two females in the spawning tank. Only one of the cultured fish in the 2018 collections was verified as 2012YC using otolith data, with otolith data lacking for the remaining cultured fish. Hatchery contribution from fish stocked prior to 2008 was unlikely due to the limited occurrence of fish 10 years and older in the fishery. Only one fish has ever been caught from the 2008YC, and no fish have ever been caught from the 2009YC, supporting the 0%

contribution seen from stocking in those years. As expected, no fish were captured from the 2017YC since these fish typically don't enter the fishery until at least age 2.

SCDNR MRD Staff participated in the Stock Identification Workshop for the SEDAR Stock Assessment of cobia throughout 2018 as well assisting in completing the Data Assessment Workshop. MRD Staff have participated in numerous webinars and will remain engaged throughout the completion of the SEDAR process.

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, and cobia are three 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.

South Carolina Marine Recreational Fisheries Survey

Principal Investigators: Amy Dukes & Brad Floyd

Reporting Period: July 1, 2018 – June 30, 2019

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: During the reporting period from December 1, 2018 to March 31, 2019; 184 fishing parties were interviewed in private boat mode representing contact with 323 recreational fishermen. 97.83% of fishing parties interviewed fished in inshore waters, while 0.54% fished in nearshore state waters (0-3 miles offshore) and 1.63% 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 680 fish belonging to 24 species of which 15.7% were harvested by anglers and kept for consumption (**Table 2**). Of those fish harvested, a total of 91 finfish were measured by SCDNR staff belonging to 9 species. Spotted Seatrout accounted for 34% of all finfish measured (**Table 3**). Starting December of 2017, the state recreational survey was expanded to cover shellfish harvest. The data collected through this additional survey for the reporting period are also provided in the tables below.

MRIP: During the reporting period from July 1, 2018 to December 31, 2018 and March 1, 2019 to June 30, 2019; 419 assignments were completed resulting in 5,283 angler interviews in all modes (**Table 4**). NOAA Fisheries handles data from the MRIP survey and these data and the estimates generated are available on NOAA's website as they become finalized. NOAA Fisheries data access site: https://www.fisheries.noaa.gov/topic/recreational-fishing-data

Table 1. Number of site visits, completed interviews by SRS staff in each coastal region, and coastwide shellfish interviews during December 2018 – March 2019.

Region	Site Visits
	Total
Horry County	**2**
Georgetown County	**13**
Upper Charleston County	**21**
Beaufort and Jasper Counties	**18**
Total	**54**

Region	Interviews
	Total
Horry County	**6**
Georgetown County	**73**
Upper Charleston County	**81**
Beaufort and Jasper Counties	**24**
Total	**184**

Shellfish Interviews	Harvesters Interviewed
75	107

Table 2. Disposition of fish and shellfish caught by fishing parties interviewed by SRS staff during December 2018 – March 2019.

Disposition	Number of Fishes Caught	Percent Of Catch
Kept to eat	107	15.74%
Thrown Back (illegal, under)	209	30.74%
Thrown Back (illegal, over)	40	5.88%
Thrown Back (legal)	324	47.65%
Thrown Back (dead)	0	0.00%
Total	**680**	

Common Name (unit of measure)	Disposition	Number Harvested
Clams, Hard (each)	Kept to eat	1003
Ribbed Mussel (each)	Kept to eat	36
Eastern Oyster (bushel)	Kept to eat	123

Table 3. Mean total length (TL; mm), and size range (mm) of top nine finfish measured by SRS staff during December 2018 – March 2019.

Scientific Name	Species Name	Number of Fish Measured	Mean TL (mm)	Size Range TL (mm)
Archosargus probatocephalus	Sheepshead	5	520.40	415 - 615
Calamus leucosteus	Porgy, Whitebone	1	355.00	355 - 355
Centropristis striata	Seabass, Black	13	370.15	346 - 426
Cynoscion nebulosus	Seatrout, Spotted	31	433.00	370 - 613
Euthynnus alletteratus	Tunny, Little	3	732.67	699 - 759
Menticirrhus americanus	Kingfish, Southern	4	254.25	223 - 287
Pogonias cromis	Drum, Black	2	472.50	442 - 503
Sciaenops ocellatus	Drum, Red	30	454.23	370 - 582
Scomberomorus cavalla	Mackerel, King	2	800.00	793 - 807

Table 4. MRIP assignments and interviews obtained by mode in FY2019.

Wave 4 2018				
Mode	**July**		**August**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	42	651	40	633
Head Boat	5	82	5	65
Grand Total	**47**	**733**	**45**	**698**

Wave 5 2018				
Mode	**September**		**October**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	40	338	40	555
Head Boat	3	34	2	24
Grand Total	**43**	**372**	**42**	**579**

Wave 6 2018				
Mode	**November**		**December**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	35	382	34	103
Head Boat	2	28		
Grand Total	**37**	**410**	**34**	**103**

Wave 2 2019				
Mode	**March**		**April**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	33	307	34	413
Head Boat	2	59	2	48
Grand Total	**35**	**366**	**36**	**461**

Wave 3 2019				
Mode	**May**		**June**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**

Charter/Shore/Private	45	536	47	948
Head Boat	5	41	3	36
Grand Total	**50**	**577**	**50**	**984**

Item 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, 2018 – June 30, 2019; aligns values with fiscal year licensing) there were 595 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 10, 2019 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 2018 calendar year charter boat data (**Tables 5 and 6**).

Table 5. Top 10 species caught, landed, and released during reported charter vessel trips in 2018.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 78.46% of all species caught	Accounts for 76.04 % of all species landed	Accounts for 83.09% of all species released
Sea Bass, Black (28.65%)	Mackerel, Spanish (17.78%)	Sea Bass, Black (32.89%)
Drum, Red (19.65%)	Sea Bass, Black (13.79%)	Drum, Red (23.64%)
Seatrout, Spotted (5.73%)	Snapper, Vermilion (12.11%)	Seatrout, Spotted (6.71%)
Snapper, Vermilion (5.64%)	Drum, Red (5.64%)	Shark, Atlantic Sharpnose (4.66%)
Mackerel, Spanish (4.91%)	Whiting (Kingfish) (5.45%)	Snapper, Vermilion (3.8%)
Shark, Atlantic Sharpnose (4.24%)	Dolphin (5.12%)	Drum, Black (2.65%)
Drum, Black (2.67%)	Mackerel, King (4.92%)	Shark, Black Tip (2.57%)
Flounder, Unclassified (2.63%)	Grunt, White (4.4%)	Flounder, Unclassified (2.29%)
Whiting (Kingfish) (2.32%)	Flounder, Unclassified (3.84%)	Shark, Bonnethead (2.12%)
Shark, Black Tip (2.01%)	Porgy, Red (2.99%)	Sheepshead (1.76%)

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

Year	2013	2014	2015	2016	2017	2018
Trips	12,975	13,702	15,609	14,361	15,595	15,393
Boat Hours	53,261	56,952	63,692	58,534	63,108	61,802
Anglers	45,320	48,305	55,773	50,732	54,283	53,917
Angler Hours	186,409	199,622	226,281	206,025	219,345	214,076
Estuarine Trips (%)	54.6	50.7	48.4	50.1	55.14	54.15
Nearshore Trips (%)	25.56	32.5	31.2	31.0	27.30	28.60
Offshore Trips (%)	19.85	16.9	20.4	18.9	17.56	17.22

Shell Recycling/Planting, Research and Oyster Reef Management (1)

Project PI/Participants: Ben Dyar/ Trent Austin, Ann Clark Little, Barry Sturmer, Gary Sundin

Reporting Period: July 1, 2018 – June 30, 2019

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 FY2019 is 30,000 bushels of shell.
2. Build and maintain at least 2 new oyster shell recycling bins for public use.
3. Increase number of restaurants participating in oyster recycling program in the Charleston and Murrells Inlet areas.
4. Increase public awareness and participation by use of different marketing strategies including attending events to discuss and disseminate educational information.
5. Plant oyster shell on public grounds to provide substrate for oyster attachment, thereby enhancing and creating habitat. Using SCDNR equipment we will plant 20,000 bushels of shell in Charleston County to create 1.5-1.75 acres of new or enhanced oyster habitat.
6. Using Water Rec. or Game and Fish Funds, plant 20,000 bushels in other areas of the state using purchased shell and private contractors to create 1.5-1.75 acres of new oyster habitat.
7. Maintain assessment of all Public Shellfish Grounds (PSGs) to evaluate resource status.
8. 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.
9. Continue to evaluate previously acquired digital imagery and refine oyster maps accordingly.
10. Maintain maps of public grounds available for recreational harvest and make these available on the internet and as hard copy by request.
11. Develop and maintain mobile mapping applications. Coordinate with SCDHEC to provide the most accurate map information.
12. Deploy signs to mark boundaries of public and state shellfish grounds.

Summary of Activities/Accomplishments

1. In FY 2019, a **record total 34,817.7** bushels of shell were recycled (Figure 1). This puts DNR as one of the top two programs in the nation for quantity of shell and the largest state funded program. Twenty-three public drop-off sites were serviced in eight 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 **$105,000** by not

having to purchase an equivalent quantity of out of state shell.

Sub-Category Totals for 2018-2019 Recycling (bushels)					
Permanent Bins	**Restaurants**	**Events**	**Caterers**	**Public Trailers**	**Grand Total**
9692.70	**15050.35**	**6467.50**	**2820.18**	**786.96**	**34817.70**
Percent Contribution to Total					
27.84	43.23	18.58	8.10	2.26	100

2. Two new oyster shell recycling public drop-off locations were implemented. A local Charleston County seafood retailer, Carrigg's Seafood, in North Charleston agreed to host a public drop off for shell where bins have been placed on site for recycling purposes. The second location is the first oyster shell recycling public drop-off in the Upstate, which opened this past year in Greenville, SC. The design of the public drop-off bin (figure 2) is the first of its type. It is a large hopper0style dumpster located at the ReWa (Renewable Water Resources Treatment Facility). ReWa donated over $1,500 and purchased the receptacle. Staff at the facility empty the hopper on a regular basis at their shell quarantine site on campus.

A new oyster shell drop-off location in Greenville from 2019 at the Renewable Wastewater Treatment Facility (left). ReWa also quarantines shell recycled by the volunteer program and the public for SCDNR until transport to Charleston is arranged.

3. Eight new restaurants joined the program: six in Charleston and two in Greenville (Coosaw Crab House, Fish House, Grace & Grit, Long Island Café, The Royal Tern and The Darling Oyster Bar in Charleston and The Blockhouse and Bimini's Oyster Bar in Greenville). Due to employee persistance, the the Darling Oyster Bar (which is one of the largest, if not the largest producer of shell in Charleston) rejoined the program after a two-year break. Following a booming spring, the Darling has taken a brief break until temperatures rest and pest problems ease, which is standard operation for some restaurants. The program collects

shell from over 50 restaurants in total.

Staff worked with volunteers with Grit & Grace, a local Charleston company, to set up volunteer shell recycling at two downtown restaurants: Oyster House and Pearlz. These volunteers collected over 250 bushels of shell.

The volunteer recycling program in Greenville, SC has expanded to servicing three restaurants as well as multiple seasonal roasts. The Greenville oyster recycling volunteers in the Upstate collected over 750 bushels. The collection of the shells is made possible by a volunteer group from the SC Master Naturalist Program and will be stored at Renewable Water Resources facility, who is partnering with SCDNR to store the shell. This is the first coordinated shell collection by SCDNR in Greenville.

The program has partnered with The Outside Foundation to aquire shell from eight restaurants on Hilton Head Island. The Outside Foundation, with grant funding from Patagonia, set up a service to collect shell from the local Hilton Head restaurants. The program initially payed i2 Recycling Company to pick up from the restaurants for a year. SCDNR is providing rolling cans to the restaurants to recycle the shells. The restaurants are now charged a fee by i2 to collect and dump shells at the newly constructed shell drop-off site at the Coastal Discovery Museum. Another new, public drop-off site is scheduled for construction in October at Marshlands Landing. The amount of shell recycled in the Hilton Head area is growing quickly, and there is a great need for the second location.

An Oyster Shell Recycling Co-op headed by Dead Dog Saloon in Murrels Inlet continues to maintain their partnerships with eight local restaurants, 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 at Clambank Landing.

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

4. Staff conducted one interview for a local radio station, 96.3 OHM Radio, to promote shell recycling and SCDNR as a whole. Two presentations were given (to College of Charleston Office of Sustainability Event and the Coastal Discovery Museum) on shell recycling and planting and the importance of healthy oyster habitat. Staff presented a five-year review of

the program to the SRFAC Board.

The Oyster Shell Recycling Program continues its partnership with Good Catch based at the South Carolina Aquarium to spread the message of seafood sustainability within the restaurant industry in South Carolina. This symbiotic relationship with Good Catch helps create awareness for support of local fisheries and consumption of responsibly harvested seafood. Restaurants benefit through marketing and advertisement from being members of this program. The Good Catch program is under new management and early meetings have proven promising for further collaboration.

Through partnerships with CCA-SC, the program was able to secure a new route trailer with a can lift, as well as three other hydraulic dump trailers to help the recycling program capture shell from restaurants and events. The estimated value of the donated equipment exceeds $25,000.

The shell recycling and planting program is partnering with Toadfish Conservation Coalition (TCC), a local NGO, to plant shell in the Charleston area. The TCC is conducting a fundraiser event to spread the awareness and benefits of shell recycling and shell planting and will be donating funds raised to the program to increase oyster habitat.

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

5&6. A total of **26,493** bushels of oyster shells were planted on State and Public Shellfish Grounds between July 1, 2018 and June 30, 2019, creating 9,980.26 square meters (3.01 acres) of shellfish habitat along approximately 1.12 miles of shoreline.

Charleston County – 1.47 acres

- Clark Sound (S205) – **1,050 bushels**
- East Folly (S206E) - **1,733 bushels**
- West Folly (S206W) - **1,400 bushels**
- Lower Hamlin (S255) - **3,098 bushels**
- Swinton Creek (S251) - **2,100 bushels**

Georgetown County – 0.71 acres

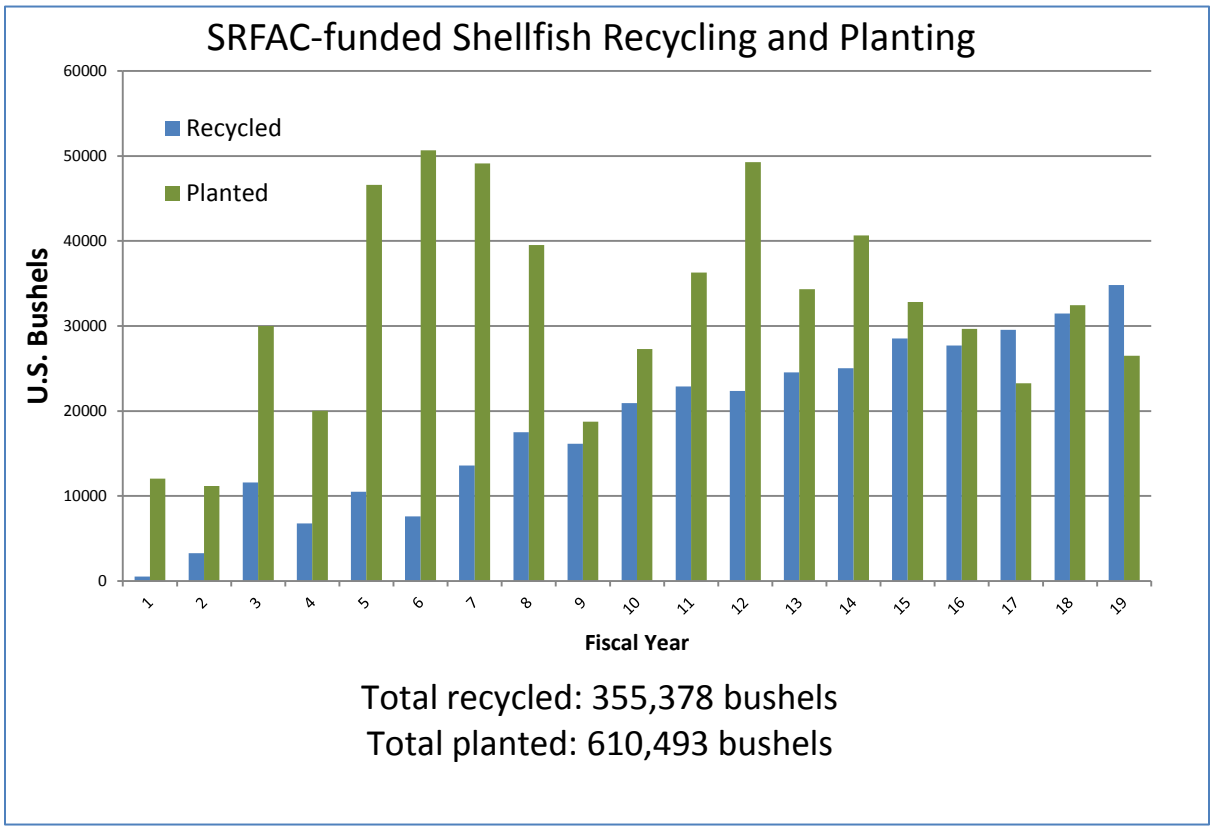
- Murrells Inlet (S358) – **1,450 bushels**
- Drunken Jack Island SSG (S357) - **6,642 bushels**

Beaufort County – 0.83 acres

- Bermuda Bluff (S090) - **9,020 bushels**

Charleston County was planted with SRFAC funds by SCDNR's oyster barge, *The*

Indigo Princess, using recycled shell. Georgetown and Beaufort Counties were planted with recycled shell as well as shell purchased from Lloyds Shucking House in Shallotte, NC. Planting was done by contractor and monitored by SCDNR using SRFAC & WREC funds.



7 During this reporting period, the duties of assessing Public Shellfish Harvest Grounds were delegated to shellfish management personnel outside of SRFAC funding and are currently ongoing.

8 Nine beds originally planted in 2015 were assessed to determine reef development success. Four of the nine sites were ranked above average, while another four showed average success. One site had no supporting data but showed an average rate of recruitment during a 1-year post planting monitoring period. Overall success rate for the year is 88%, with average and better considered successful plantings. 100% of sites with available data were 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.

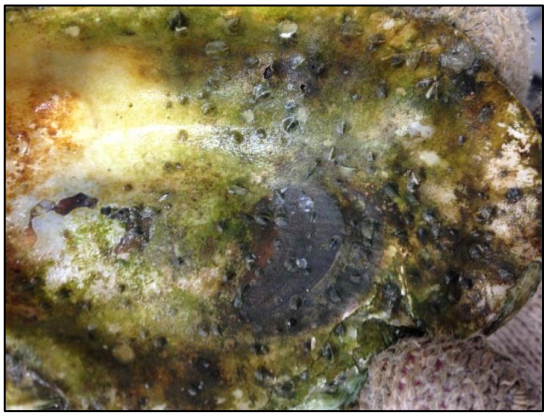
Mud bank in 2015 just before planting in Harbor River East.

The same bank photographed while sampling in 2018, three years after planting.

2018 assessment of beds planted in 2015

Site slope/creek width	Completion Date	Est. US Bu. by OFM	Shell Type	Initial Footprint (m^2)	Current Footprint (m^2)	Foot. Incr. Decr.	Recruit-ment	Date Assessed	Quantity of oysters	Quality of oysters	Size of oysters	Coverage of bed	Strata	Overall	%Vert
Charleston															
Sewee Bay - S272															
S272_1_15	7/7/15	2170	SC/G	687	752.78	65.8	4	10/8/18	4.5	4.5	4.5	4.5	G	4.5	90%
S272_2_15	7/6/15	543	SC/G	324	N/A		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
S272_2_14(management)		1410	SC/G	162			N/A								
S272_3_14(management)		1143	SC/G	809			N/A								
Kiawah River - S194E															
S194E_1_15	6/26/15	7,461	SC/G	3842	2640.18	-1201.8	5	11/1/18	2.5	3	3	2	D	2.5	40%
Georgetown															
Woodland Cut S358															
S358_1_15	8/19/15	2,976	SC/G	1,034	756.14	-277.9	4	11/6/18	5	5	4.5	4	F	4.75	85%
Oaks Creek R351															
R351_2_15	8/3/15	1400	SC/G	432	443.61	11.6	4	11/6/18	3	3	3.5	3.5	C	3.25	60%
R351_3_15	8/5/15	1488	SC/G	410	121.38	-288.6	5	11/6/18	3.5	3.5	2.5	2.5	Patchy G	3	50%
R351_4_15(management)	8/6/15	1488	SC/G	1012			N/A								
Beaufort															
Harbor River -S105															
S105_1_15	05/20/15	10,540	SC/G	3225.95	2082.19	-1143.8	5		4.5	5	4	4.5	G	4.5	85%
Chechessee Creek															
S058_1_15	06/04/15	2,307	SC/G	896	775.36	-120.6	5	10/5/18	4	3	3	4	F1	3.5	60%
S058_2_15	06/05/15	1,909	SC/G	600	137.75	-462.3	5	10/5/18	3	2.5	2.5	3	F1	3	50%
Slope-in Degrees			SC- Local Shell				*Qualitative Rating from 1-5: 1 Poorest, 5 Best								
Creek Width-in meters			G-Gulf				1-poor		2-marginal	3-Average	4-Good	5- Exceller			
			W-Whelk												
	Total Bushels		34,835												
	Total Initial Area		13,434												

Fourteen beds planted in 2017 were sampled and spat were measured with digital calipers to determine juvenile recruitment rates. Twelve of the fourteen beds showed average and above recruitment, including five sites showing excellent recruitment. Two sites do not have data reported, as one did not show enough crop while monitoring to responsibly sample. The other site's data was corrupted in the database.



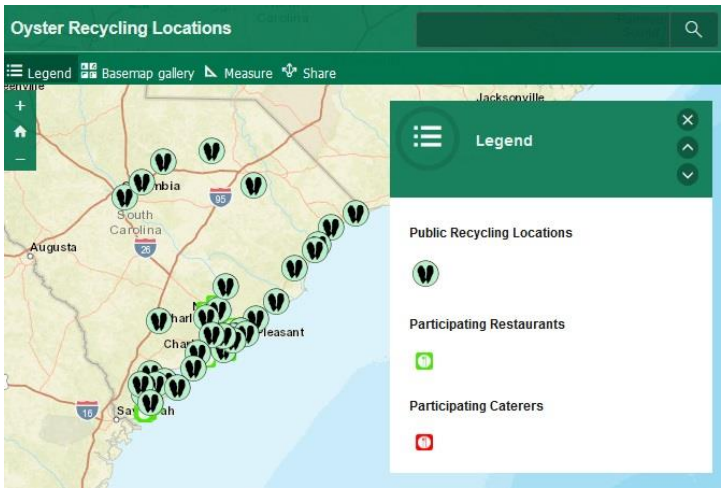
Pictured is spat growing on shell planted in 2015 in Green Creek. A single planted shell attracts many juvenile oysters. For monitoring purposes, every live oyster, including those <1 mm, is measured with digital calipers. Average density on South Carolina oyster reefs exceeds 1000 oysters/m^2.

9&10. In FY2019, 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:

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.

11 An interactive map for public drop off locations as well as locations for participating restaurants and caterers went live on the shell recycling website www.saltwaterfishing.sc.gov/oyster.html as well as the SCDNR website www.dnr.sc.gov/maps This allows a more user-friendly way for the public to find the nearest shell drop-off location and provides a mobile link to turn-by-turn directions on a cell phone. The public can also see where they can support shell recycling by dining at restaurants that recycle their shells, as well as caterers.



12 All State and Public Shellfish Grounds have now been equipped 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.

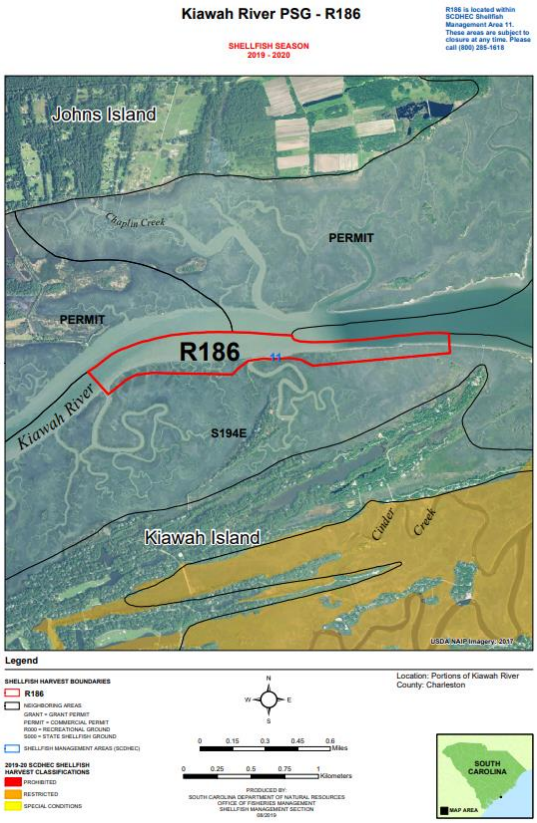
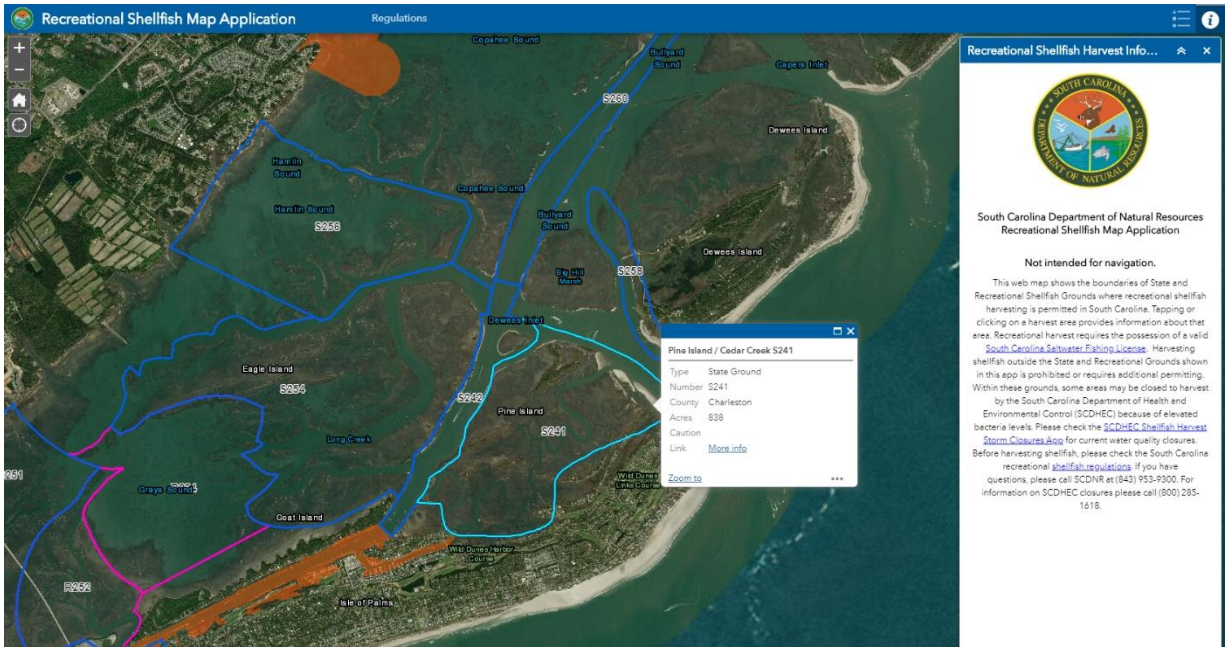


Figure 1. An example of an SCDNR recreational-only shellfish harvesting ground.

Figure 2. A representative screen shot from the interface of the Recreational Shellfish Map Application.



Shell Recycling/Planting, Research and Oyster Reef Management (2)

Project PI/Participants: Peter Kingsley-Smith & Gary Sundin

Reporting Period: July 1, 2018 – June 30, 2019

Project Title: Assessing the Spatial Extent and Condition of State-Managed Shellfish Grounds Using Small, Unmanned Aerial Systems (sUASs)

In FY2019, staff of the South Carolina Department of Natural Resources (SCDNR) Marine Resources Research Institute (MRRI)'s Shellfish Research Section (SRS) continued using small unoccupied aerial vehicle (UAV) to collect imagery to be used in mapping the extent and condition of intertidal oysters in South Carolina. UAVs were first used in FY2018. In FY2019, staff collected intertidal oyster imagery from state-managed shellfish harvest areas in Murrells Inlet, Sewee Bay and Folly River, as well as intertidal imagery from areas around Charleston Harbor. These flights totaled around 200 acres and the oysters in these imagery datasets have been digitized and are undergoing final QA/QC for addition into the statewide intertidal oyster GIS layer. As part of UAV flights conducted at the request of the Inshore Finfish Research Section, staff collected imagery of 320 acres of intertidal habitat in Charleston Harbor. Oyster reefs within these footprints were subsequently digitized by SRS staff. Additionally, oyster reefs from the May River, captured in FY2018, have been partially digitized, and this work is ongoing. Figure 1 shows examples of oyster reefs digitized in FY2019.

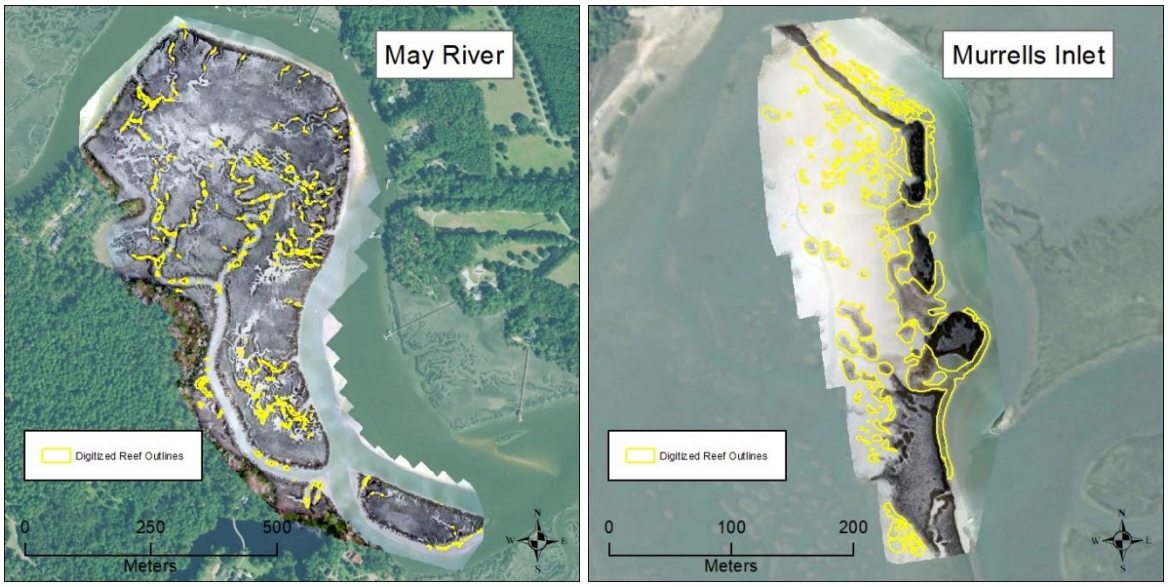


Figure 1. Examples of intertidal oyster reef outlines digitized from UAV orthomosaic imagery in FY2019.

In FY2019, staff began working towards developing metrics that can be calculated from UAV data to assess the condition of intertidal oyster reefs (see Figure 2 below). Additionally, staff began developing workflows to assist with monitoring the initial planning and subsequent success and condition of loose shell plantings (Figure 3, pg. 4). These efforts are ongoing and promise to result in useful tools for understanding and managing shellfish populations upon which many recreational fisheries depend.

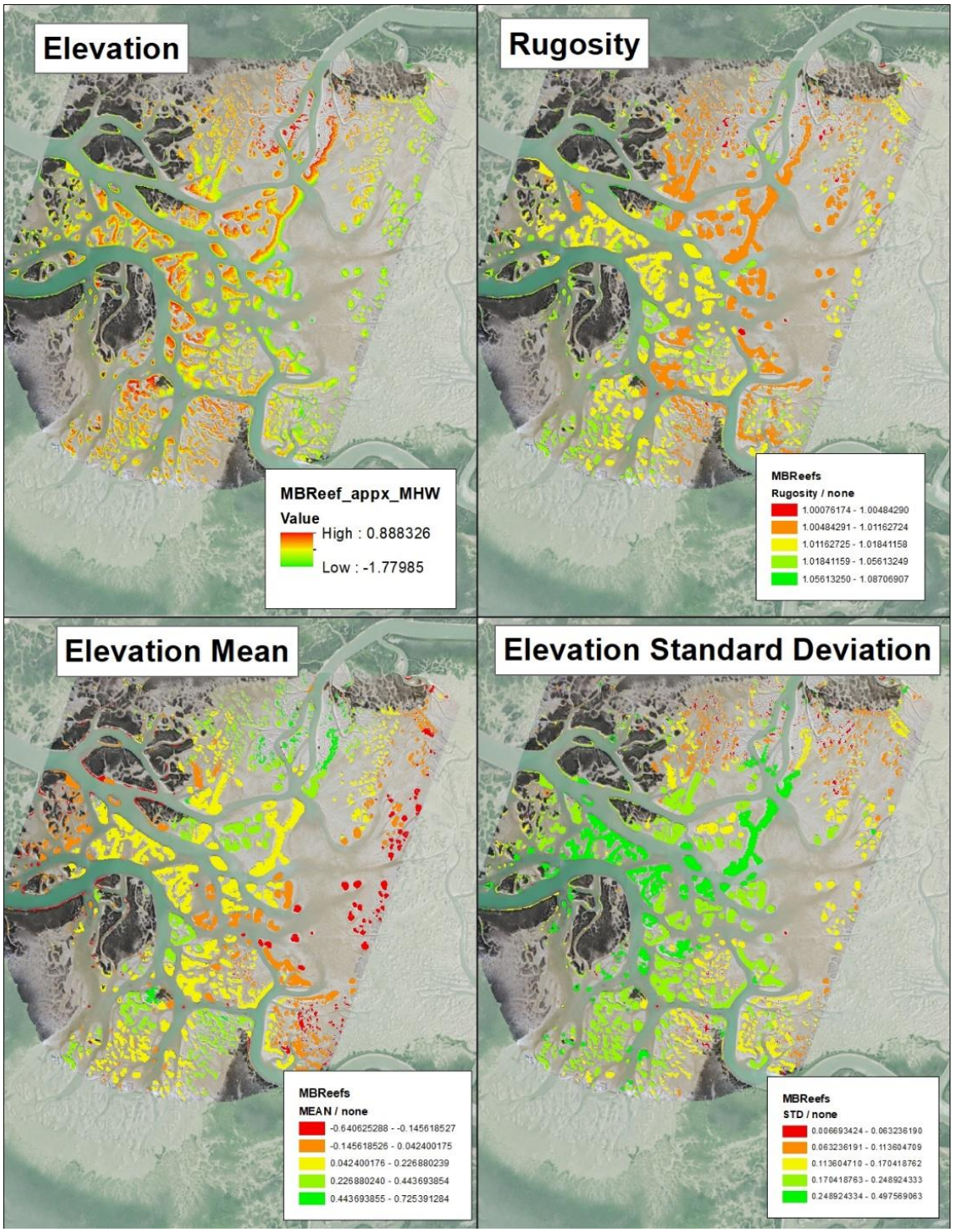


Figure 2. Example of metrics calculated at the individual reef scale from UAV-derived elevation data for oyster flats in Mark Bay, South Carolina. These efforts may lead to new methods of monitoring the condition intertidal oyster reefs at a landscape level.

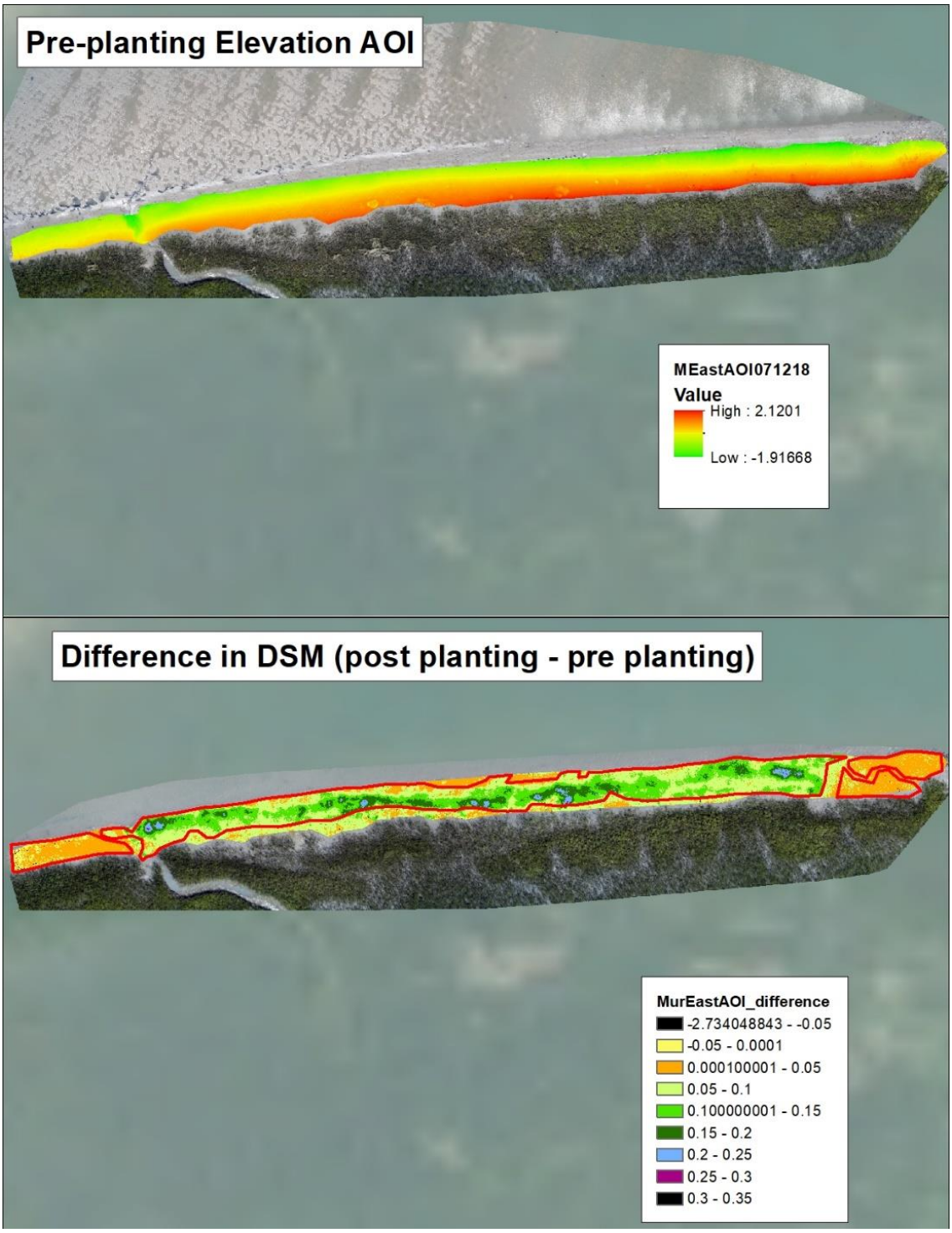


Figure 3. Example of using UAV data to measure elevation change resulting from the large-scale planting of loose shell at a site in Murrells Inlet, South Carolina. The upper figure shows the base elevation of the shoreline before shell planting, and the bottom figure shows the difference in elevation determined from UAV flights before and after shell planting. All values shown in the figure legend are in meters.

In FY2019, the recreational shellfish harvest web application was maintained with regular updates to provide the public with current information on the location and status of South Carolina recreational shellfish harvesting areas. This web-based application allows users to interactively view the boundaries of South Carolina recreational shellfish harvesting grounds from any internet-enabled computer or device (e.g., smartphone). From GPS enabled devices, users can also find and view their own location to determine whether or not they are within shellfish areas that are open to harvest at that time. The application further provides links to SCDNR online licensing websites, shellfish harvesting regulations, and to all annually produced recreational shellfish maps. Maps of recreational shellfish harvesting grounds were made available on the internet, with index maps to facilitate locating grounds of interest.

Project Title: Assessing natural mortality of South Carolina intertidal oyster reefs

Reporting Period: July 1, 2018 – June 30, 2019

Project PI/Participants: Peter Kingsley-Smith, Gary Sundin & Graham Wagner

In FY2019, staff continued to collect samples of wild intertidal oysters to assess levels of natural mortality. Oyster mortality sampling began during the 2015-2016 winter, with further sampling each winter on an annual basis since this effort began. During FY2019, the Shellfish Research Section (SRS) visited 37 index sites across the South Carolina coast to assess natural oyster mortality (Figure 4). At each sampling location, three replicate quadrat samples were collected and brought back to the Marine Resources Research Institute (MRRI) shellfish laboratory for processing. All living and dead oysters were measured (Table 1), and the shells were donated to the South Carolina Oyster Recycling and Enhancement (SCORE) program for the creation of new intertidal oyster reef habitat. This was the fourth monitoring year for many of the sampling sites, and thus far, over 100,000 oysters have been measured. This monitoring effort helps to determine state-wide baselines of oyster mortality, as well as more fine-scale spatial variations in mortality throughout the state, in order to determine whether anomalous mortality events have occurred. Furthermore, investigating the length-frequency of live and dead oysters across the state allows for the identification of specific length classes (and possibly age classes) that may denote periodic fluctuations in recruitment. Combining these data with environmental parameters, as well as comparing them to constructed oyster reefs near index sites, may shed light on the causes of recruitment fluctuations. This continued monitoring effort to determine naturally occurring oyster mortality is crucial for assessing the health and growth of oyster habitat, upon which numerous other marine and estuarine species rely.

During FY2019, the average size of live oysters was 24.4 mm, while the average size of dead oysters was 32.5 mm. Live oysters 3 inches or greater (commercial size minimum) comprised between 0% and16% of oysters among sites and comprised 3.9% of live oysters on average for site sampled across the state. Statewide, oyster mortality for all sites and years combined was 8.2% (Table 2). Mortality was significantly higher (10.9%) during the first year of sampling (2015-2016) and has decreased each year since (Table 2). This may be related to flooding and rainfall events; 2015-16 sampling was conducted immediately following Hurricane Joaquin (the "1000-year flood" in coastal SC), and the 2016-17 sampling was conducted following Hurricane Matthew. Mortality was also found to be higher on average in sites in the Santee, Cooper, and Winyah Bay catchments when compared to the other sites across the state.

Figure 4. Location of sites sampled for natural oyster mortality during FY2019. [Note: Site codes for locations sampled are explained in Table 2.]

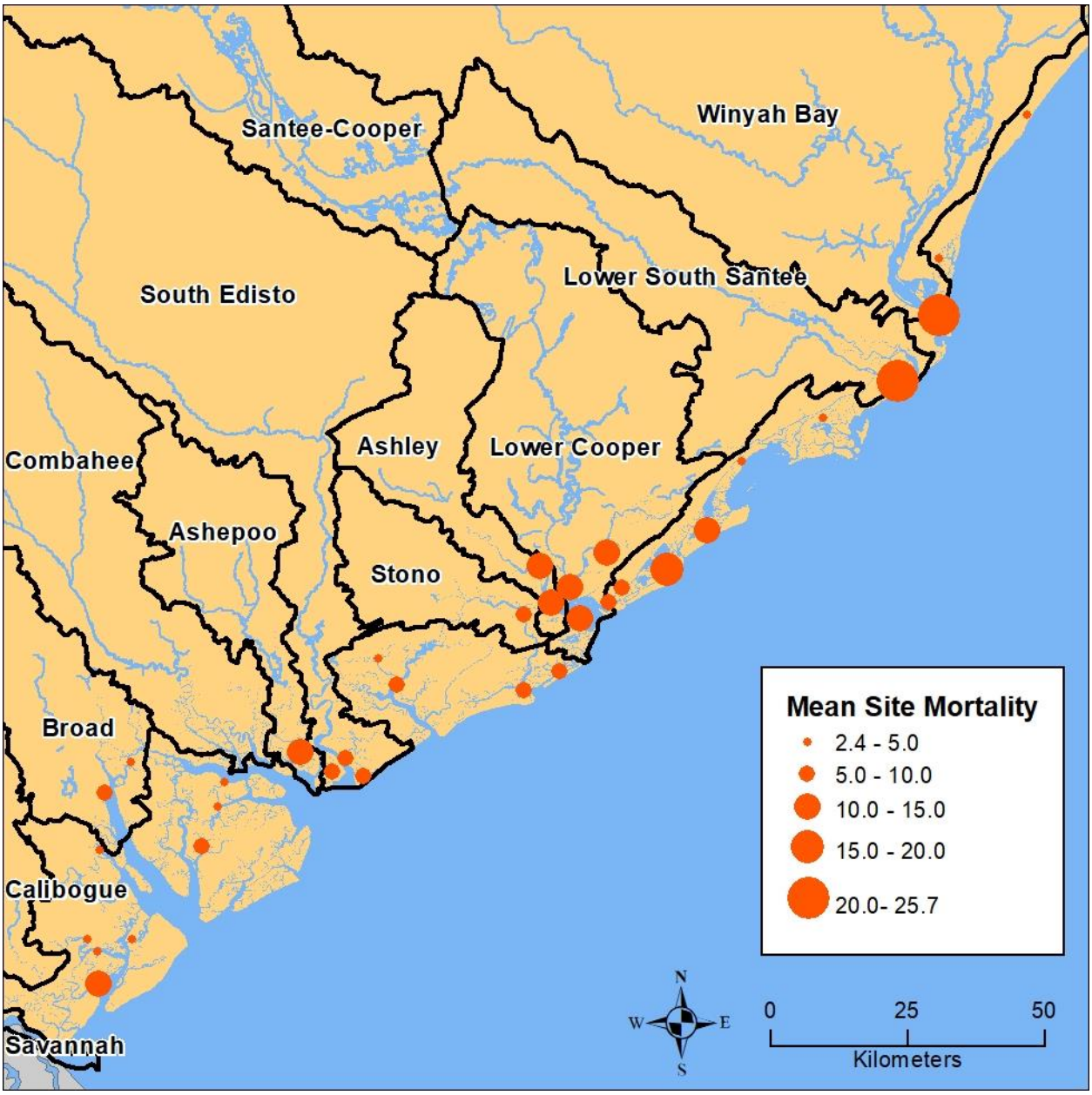


Figure 5. Mean site-specific natural oyster mortality, indicated by symbol size, from four years of annual fall/winter sampling in coastal South Carolina. Black lines show watershed catchment boundaries.

Table 1. Oyster shell heights (mm) tabulated by site for the four sampling years completed to date.

	2015-2016			2016-2017			2017-2018			2018-2019		
Site	**Range**	**Mean**	**SD**	**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	0.84 - 71.29	15.43	10.57
BBC	0.24 - 94	16.81	11.14	3.19 - 84.5	17.80	14.20	2.95 - 121.21	25.51	18.80	0.76 - 109.55	17.94	13.25
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	1.65 - 119.27	22.93	18.38
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	1.87 - 134.93	37.12	29.47
BLB	NA	NA	NA	2.76 - 89.9	26.57	15.46	3.54 - 93.49	36.24	19.47	2.19 - 95.55	24.42	16.04
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	1.42 - 81.12	17.27	12.58
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	2.00 - 106.06	23.43	15.94
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	1.86 - 87.09	21.11	14.82
CCH	2.48 - 74.74	18.86	16.13	NA	NA	NA	0.93 - 95.72	20.84	15.49	2.18 - 106.06	19.91	16.08
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	1.89 - 126.91	20.05	16.15
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	0.64 - 64.93	18.25	14.29
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	1.55 - 122.96	28.62	22.46
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	2.59 - 74.28	19.99	11.85
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	2.95 - 132.60	25.93	19.63
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	1.28 - 72.72	18.26	10.77
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	3.17 - 98.29	25.57	17.58
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	0.20 - 130.61	27.39	28.06
FSC	NA	NA	NA	3.89 - 105.5	42.71	24.32	0.73 - 105.69	24.88	21.08	0.73 - 105.69	24.97	21.02
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	0.32 - 95.94	18.03	13.58
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	2.41 - 114.67	24.98	18.95
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	2.70 - 114.56	30.76	20.59
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	0.66 - 122.90	19.92	15.86
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	2.38 - 92.12	26.10	20.67
MRI	NA	NA	NA	4.66 - 83.67	33.32	18.11	2 - 111.74	34.24	24.71	1.48 - 98.87	28.67	22.25
NHI	NA	NA	NA	5.16 - 139.3	54.51	33.47	0.35 - 141.24	37.46	30.77	0.49 - 120.89	28.76	26.44
SST	3.23 - 86.86	28.02	20.66	0.72 - 99.57	30.94	17.61	2 - 131.31	25.11	22.64	2.40 - 63.39	15.93	11.94
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	0.67 - 132.20	30.22	25.15
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	0.55 - 69.37	11.45	7.97
SWE	NA	NA	NA	1.83 - 121.48	37.87	26.88	4.08 - 111.87	39.92	20.85	1.91 - 121.97	29.49	21.56
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	2.60 - 127.59	28.73	22.75
TOL	4.03 - 88.3	25.88	16.41	2.67 - 103.53	32.51	17.97	3.72 - 87	32.47	20.21	0.79 - 104.11	31.39	24.43
WBR	NA	NA	NA	3.81 - 111.12	26.61	18.36	3.42 - 108.05	21.73	17.71	3.04 - 130.75	27.36	18.77
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	0.69 - 103.19	23.10	16.46
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	2.56 - 95.77	21.48	15.76
WYB	NA	NA	NA	2.53 - 71.1	23.21	13.72	3.88 - 88.32	32.75	16.23	3.12 - 78.58	25.43	15.17

Table 2. Mean oyster mortality (%) tabulated by and by sampling year years completed to date.

Site Code	Site Name	2015-2016	2016-2017	2017-2018	2018-2019	Mean
MAY	May River	3.2	3.1	6.6	4.8	**4.4**
ASP	Ashepoo River	9.7	19.9	9.7	11.5	**12.7**
BBC	Big Bay Creek	10.7	9.9	4.9	3.1	**7.1**
BBF	Bears Bluff	3.7	8.6	4.6	3.5	**5.1**
BFT	Beaufort River	6.7	11.5	10	4.7	**8.2**
BLB	Bulls Bay	2.9	4.2	5.5	2.9	**3.9**
BRD	Broad River	9.8	2.4	3.1	5.4	**5.2**
BUL	Bull Creek	2.5	2.8	4.8	2.6	**3.2**
CBG	Calibogue Sound	7.7	17.2	10	9.8	**11.2**
CCH	Chechessee River	4.3	4.8	6.4	1.8	**4.3**
CLT	Colleton River	3.7	4.3	6.2	1.9	**4**
CPR	Cooper River	10.4	7.9	29.5	4.3	**13**
CRM	Cape Romain	4.7	5.8	3.4	4.3	**4.5**
CSG	Cosgrove Bridge	20.3	11.8	7.3	2.8	**10.5**
CSW	Coosaw River	6.2	3.3	3.6	3.1	**4.1**
DWE	Dewees Inlet	7.1	27.9	13	16.8	**16.2**
EDR	Edisto River	7.9	4.9	2.1	6	**5.2**
FLR	Folly River	4.8	4.1	8.2	3.4	**5.1**
FOS	Foster Creek	-	-	-	2.4	**2.4**
FSC	Fish Creek	-	6.8	3.7	-	**5.2**
GRC	Grice Cove	-	-	-	6.4	**6.4**
HAR	Charleston Harbor	15.5	27.2	6.9	6.8	**14.1**
HOG	Hog Island	3.5	7.5	6.3	2.2	**4.9**
INL	Inlet Creek	6.4	9.3	6.8	2.7	**6.3**
JIC	James Island Connector	19.4	8.9	9.2	5.5	**10.8**
MRI	Murells Inlet		3.6	5	3.8	**4.2**
NHI	North Inlet	4.4	5.1	6.6	0.6	**4.2**
SST	South Santee	77.3	3.9	9.8	12	**25.7**
STI	Stono Inlet	6	8.8	5	6.7	**6.6**
STR	Stono River	13.2	7.8	6.2	3.4	**7.6**
SWE	Sewee Bay	19	15.8	11	3	**12.2**
TGD	Toogoodoo Creek	5.3	6	4	3.4	**4.7**
TOL	Tolers Cove	7.1	5.6	9.9	2.1	**6.2**
WBR	Whale Branch	-	0.9	4	4.5	**3.1**
WND	Wando River	9.7	26.9	5.6	4.2	**11.6**
WSW	Warsaw Flats	3.3	4.9	5.5	2.9	**4.2**
WYB	Winyah Bay	33.3	24.1	5.8	22	**21.3**
	Mean	**10.9**	**9.4**	**7.1**	**5.3**	**8.2**

Crustacean Research and Fishery-Independent Monitoring

Program PI: Peter Kingsley-Smith

Program Co-PIs: Michael Kendrick
Jeff Brunson

Reporting Period: July 1, 2018- June 30, 2019

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*). CRMS staff 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*. Over the course of the past year, CRMS staff have documented trends in these focal species, with white shrimp and brown shrimp abundance values largely consistent with long-term averages, and blue crab abundance values showing greater-than-average values.

CRMS 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 July 1, 2018 to June 30, 2019 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 completed between July and September in 2018 and in May and June in 2019. Additionally, since data from July and August 2019 are available for this report, those data are also included in this report to provide a more complete analysis of the current status of these populations.

3) Crab pot survey: The crab pot survey uses standard commercial-style wire crab traps deployed for 4 to 6 hour soak times. In October and November, six stations from Winyah Bay to the Broad River target crabs when they begin their seaward migration as water temperatures decrease. These data provide an index of crab abundance during this time of year.

Program Objective 1) Monitor white and brown shrimp populations

Overview of white shrimp this year: As in previous years, white shrimp catch per unit effort (CPUE) generally followed a seasonal pattern from July 2018 to June 2019 (Figure 1), with a relatively high abundance of smaller subadult shrimp collected during the late summer and fall, prior to their migration offshore in the spring. With abundances similar to the long-term mean, white shrimp were available for recreational harvest during late summer and fall of 2018.

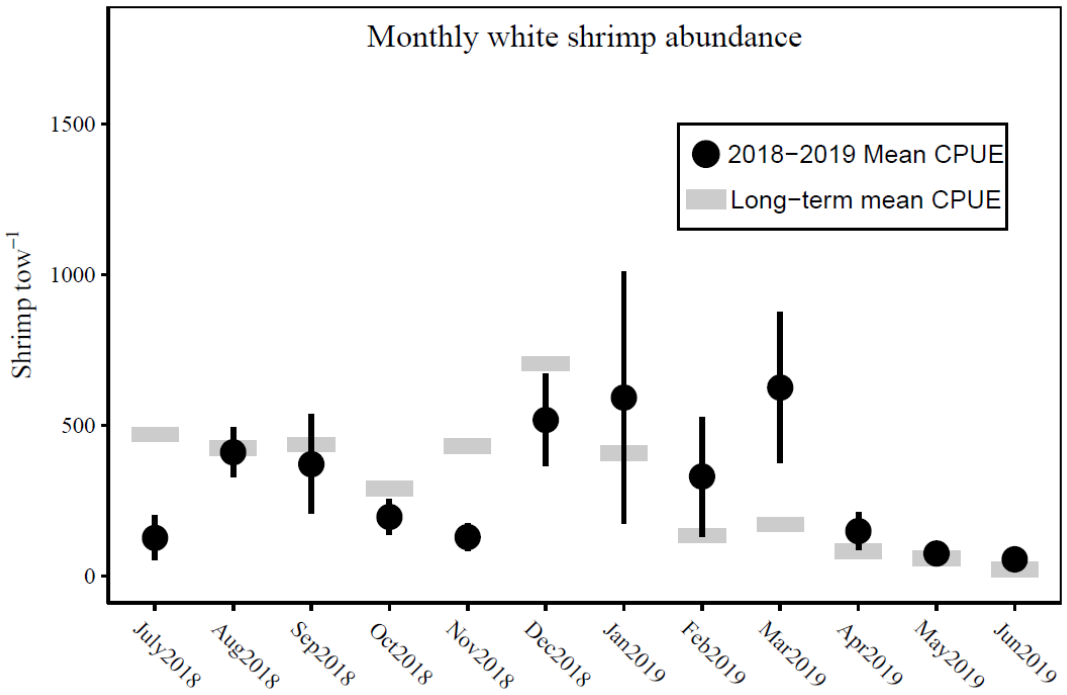


Figure 1. Monthly white shrimp CPUE (mean ± standard error) from large trawl surveys. Samples from March, April, August and December are collected from statewide surveys (see Fig. 12), while samples from other months are collected from the Charleston Harbor watershed.

Seasonal trends in white shrimp abundance: White shrimp abundance in fall (August to December) 2018 was below the long-term mean (2005-2018; Figures 1 & 2). White shrimp abundances in spring (March and April) 2019, however, were well above the long-term mean (2005-2018; Figure 2), suggesting that adequate numbers of shrimp successfully overwintered to form a spawning population. Although the catches of white shrimp in the Charleston area creek trawl survey from summer (May to July) 2019 were below the long-term mean (Figure 2, bottom panel), the presence of juvenile white shrimp in the samples demonstrates successful spawning activity and recruitment of shrimp throughout the spring 2019.

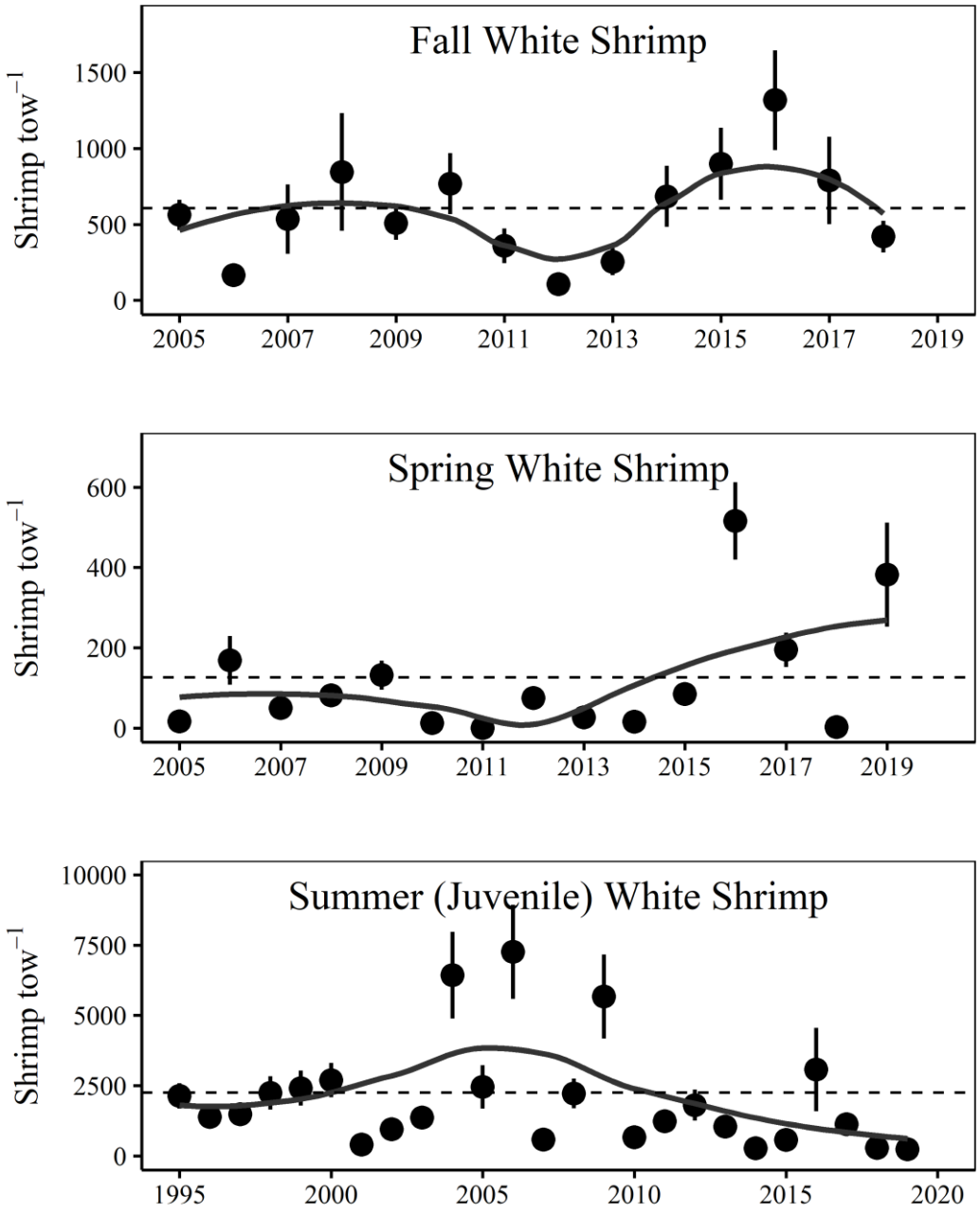


Figure 2. White shrimp CPUE (mean ± standard error) from fall (top), spring (middle), and summer (bottom) surveys. Fall and spring samples were collected from statewide large trawls,

while summer samples were collected from creek trawls in the Charleston Harbor watershed. Dashed lines represent long-term means and solid lines represent smoothed trends.

Overview of brown shrimp this year: Although the recreational harvest of brown shrimp is minor compared to that of white shrimp, brown shrimp are still an important component of the recreational fishery, as they are typically available for use as bait and for food during the summer. Brown shrimp catches in both creek trawl (Figure 3) and large trawl (Figure 4) surveys in 2019 were substantially above the long-term means.

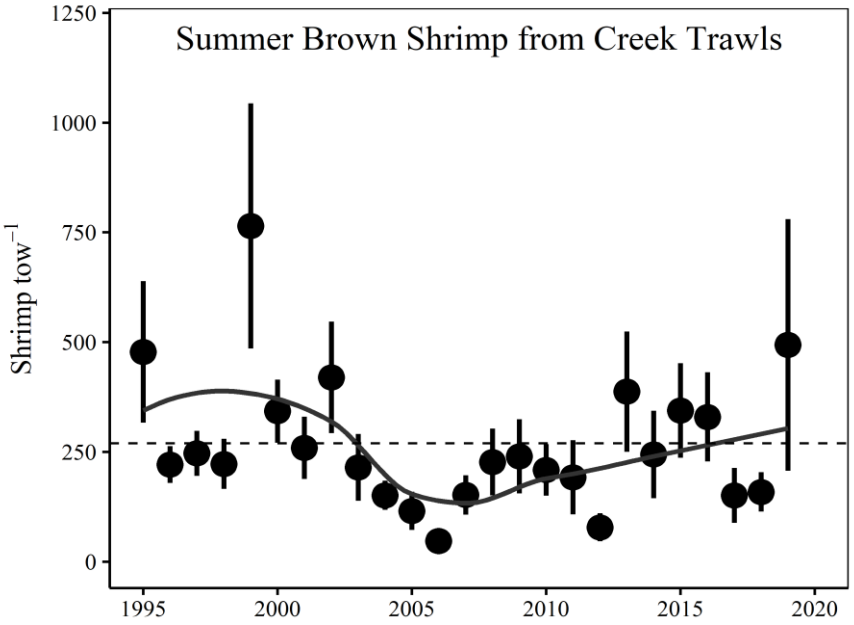


Figure 3. Summer (May-July) brown shrimp CPUE (mean ± standard error) from creek trawl survey. Dashed lines represent long-term means and solid lines represent smoothed trends.

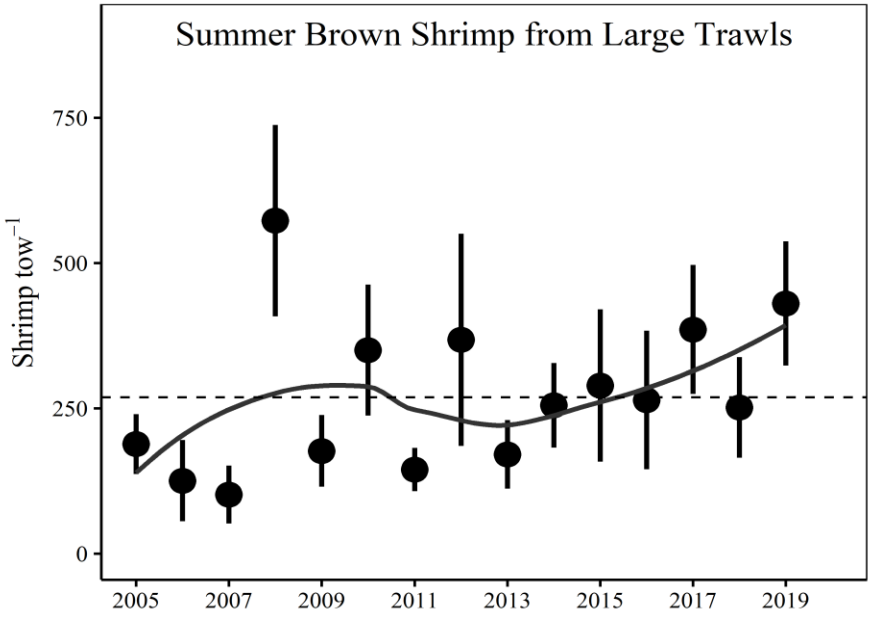


Figure 4. Summer (May-July) brown shrimp CPUE (mean ± standard error) from large trawl survey. Dashed lines represent long-term means and solid lines represent smoothed trends.

Program Objective 2) Monitor blue crab population

During large trawl survey sampling efforts from July 2018 to June 2019, monthly blue crab abundances (expressed as CPUE) were generally near the long-term mean (Figure 5). When separated by size, both legal and sublegal blue crabs were generally above the long-term mean, with legal-sized crabs, in particular, showing increasing abundance over the past few years (Figure 6).

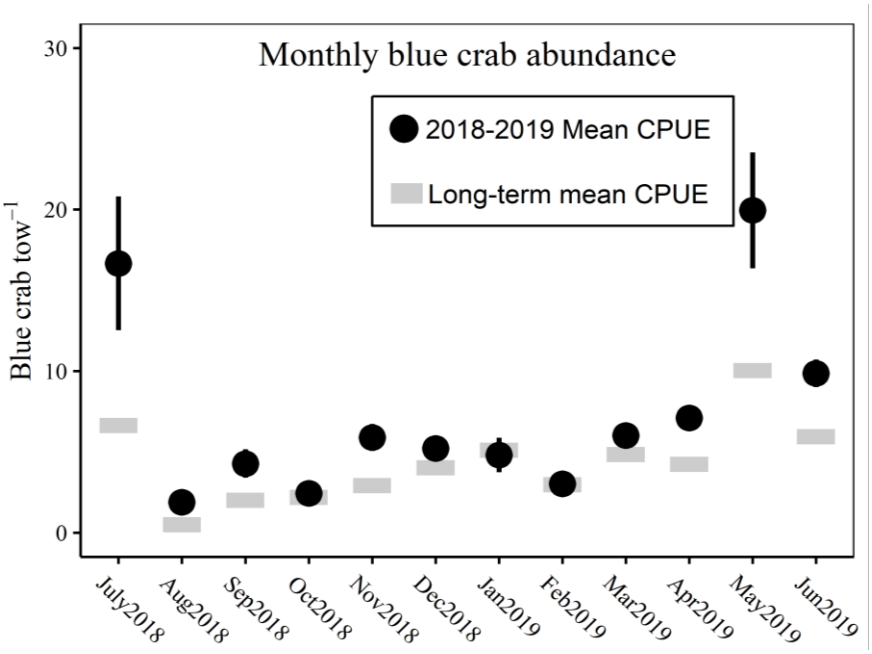


Figure 5. Monthly blue crab CPUE (mean ± standard error) from large trawl survey.

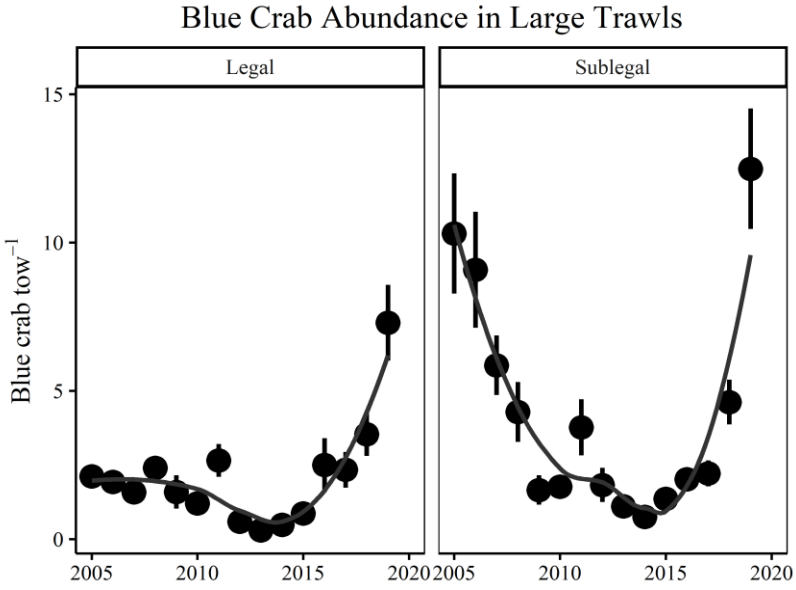


Figure 6. Annual blue crab CPUE (mean ± standard error) for legal (>126mm) and sublegal (<127mm) crabs collected during statewide large trawls. Solid lines represents smoothed trend.

Blue crab from creek trawl survey: From May to July 2019, blue crabs of all sizes were collected in numbers below or near the long-term mean (Figure 7). The number of juvenile (<61mm) blue crabs (i.e., carapace width of less than 61mm), however, were similar to the long-term mean (Figure 8).

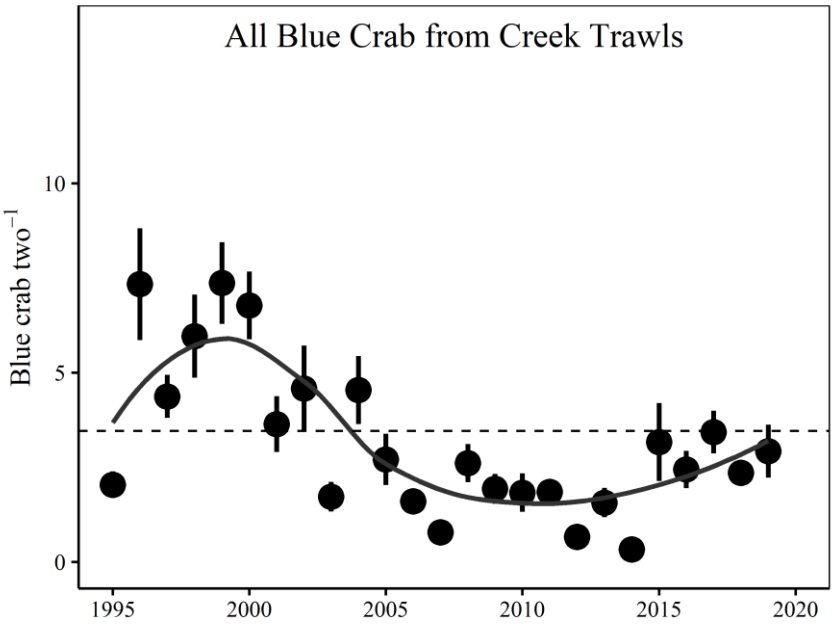


Figure 7. Juvenile blue crab CPUE (mean ± standard error) from creek trawls in the Charleston Harbor watershed (May-Aug). Dashed line represents long-term mean and solid line represents smoothed trend.

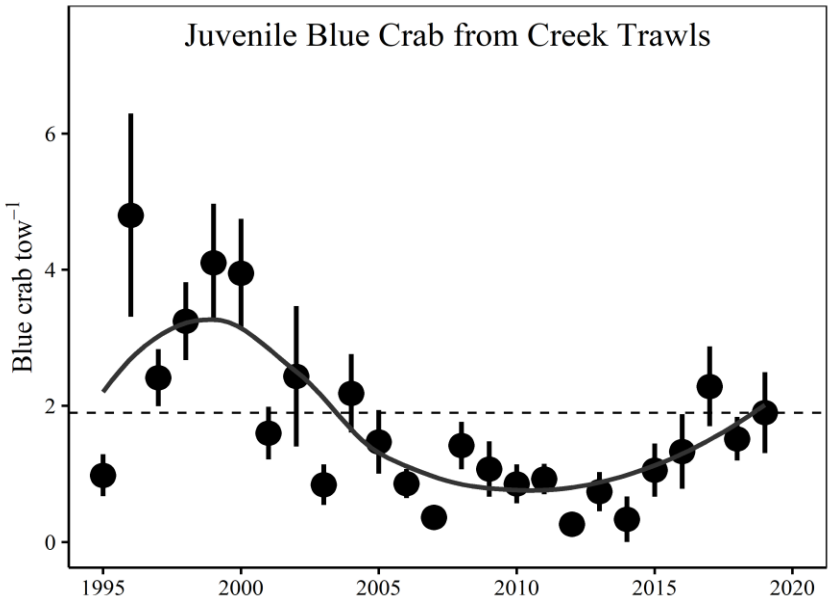


Figure 8. Juvenile blue crab CPUE (mean ± standard error) from creek trawls in the Charleston Harbor watershed (May-Aug). Dashed line represents long-term mean and solid line represents smoothed trend.

Fall 2018 crab pot survey: Crab abundances in the fall 2018 crab pot survey were above the long-term mean and comparable to catches in 2015 and 2016 (Figure 9).

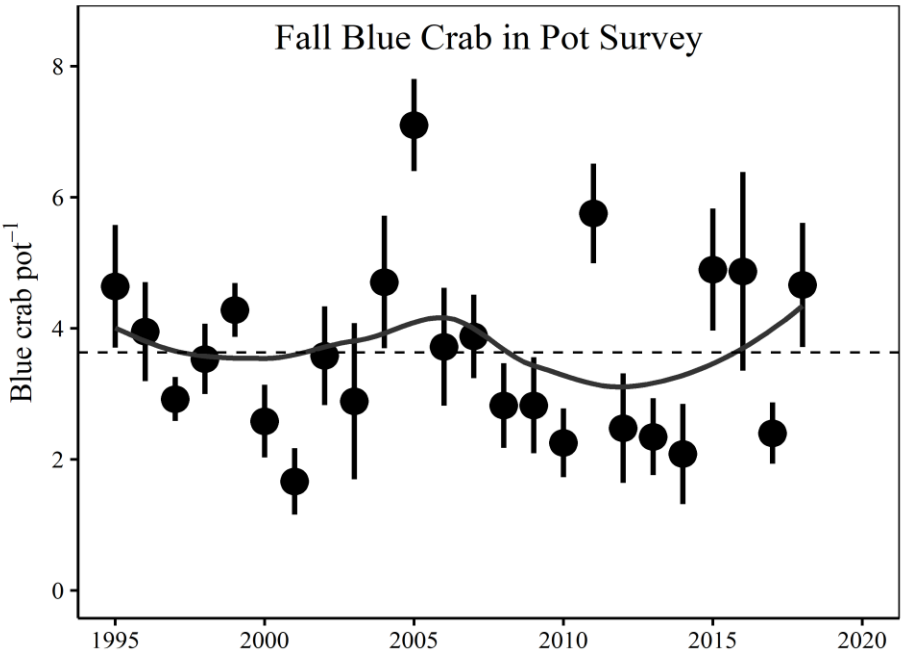


Figure 9. Fall blue crab CPUE (mean ± standard error) from statewide pot survey. Dashed line represents long-term mean and solid line represents smoothed trend.

Marine Outreach and Education Program

Program PIs: Matt Perkinson and Olivia Bueno

Reporting Period: July 1, 2018 through June 30, 2019

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, volunteer programs 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 completed 66 vessel-based education programs and 373 land-based programs to 5,089 students from grades K-12. Staff spent 15,204 contact hours with students and teachers. Six teacher workshops were held with a total of 113 teachers attending.

- Outreach staff represented the Marine Resources Division at four multi-day shows/expos including the Grand Strand Boat Show, Charleston Boat Show, Southeast Wildlife Expo, and the Palmetto Sportsmen's Classic. Attendance at these events ranged from 1,000 - 42,000 attendees. The mobile observation tank was utilized at six events: the annual STEM festival, Palmetto Sportsmen's Classic, Sea Spot Run Fishing Tournament, Wildlife Refuge Day at Pinckney Island, James Island Yacht Club Fishing Tournament, and the Governor's Cup in Edisto.

- In anticipation of the Huck Finn Kids Fishing Tournament, 1,000 red drum were stocked at Colonial Lake in downtown Charleston. The tournament was held in September 2018 and approximately 100 participants caught over 50 red drum as well as other saltwater fish species (Fig. 1).

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

- Once a month, trained SCDNR volunteers have conducted public campus tours of Fort Johnson. Participants get an overview of the research and conservation projects the Marine Resources Division is working on as well as an opportunity to speak with a biologist. Three volunteers have been trained and have contributed 52 hours in hosting five tours that have reached 56 members of the public.

- Staff began conducting saltwater family fishing clinics through the SCDNR Certified Fishing Instructor Course. Twenty-two volunteers have been trained through the course and have contributed 273 hours. Volunteers hosted four fishing clinics reaching 76 participants (Fig. 2). These clinics are designed to teach basic fishing skills along with marine resource stewardship. Volunteers have also assisted with kids fishing camps as well as other saltwater recreational outreach events.

- Staff led five youth/family outdoor clinics, including beginner courses in using a cast net, crabbing, and fishing.

- Staff conducted a variety of other outreach and education activities, including 4 presentations to fishing clubs and civic groups.

- 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 119 vendors located throughout the coastal counties of South Carolina. Materials included rules and regulations books, fish rulers, crab rulers, fish identification charts, guides to saltwater fishes, and beginner guides to saltwater fishing.

- 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
FISH ID CHART	60,000
SW FISH RULER STICKERS	50,000
CRAB RULERS	10,000
GUIDE TO SW FISHES	7,500
BEGINNER GUIDES TO SW FISHING	5,600

- General public outreach occurs daily 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.

- A total of 1,235 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 10,238 fish, of which 76 percent were red drum. Information was received from 1,698 recaptured fish and of those, 85 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 for anglers 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. 3). To further this campaign, SCDNR has partnered with FishSmart, an initiative driven by members of the fishing industry as well as state and federal government agencies. As part of this partnership, SCDNR is able to distribute agency-recommended rigs to anglers that fish for adult red drum free of charge.

- Additionally, the FishSmart initiative provided SCDNR with descending devices that are designed to mitigate the effects of barotrauma in reef fish. SCDNR outreach staff have distributed these devices directly to interested constituents, as well as provided information on best fish handling practices. During 2018-2019, staff distributed 59 descending devices (Fig.4).

Figure 1. A youth angler with red drum caught during the Huck Finn Kids Fishing Tournament.

Figure 2. An SCDNR Certified Fishing Instructor helps participants during a family fishing clinic in Edisto.

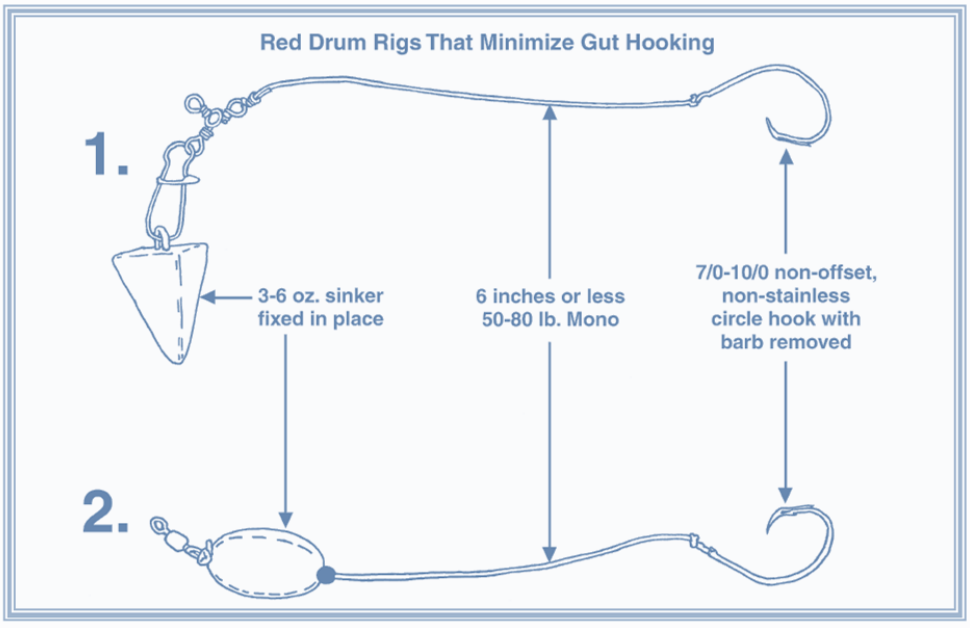


Figure 3. A postcard describing best practices to minimize gut hooking in adult red drum.

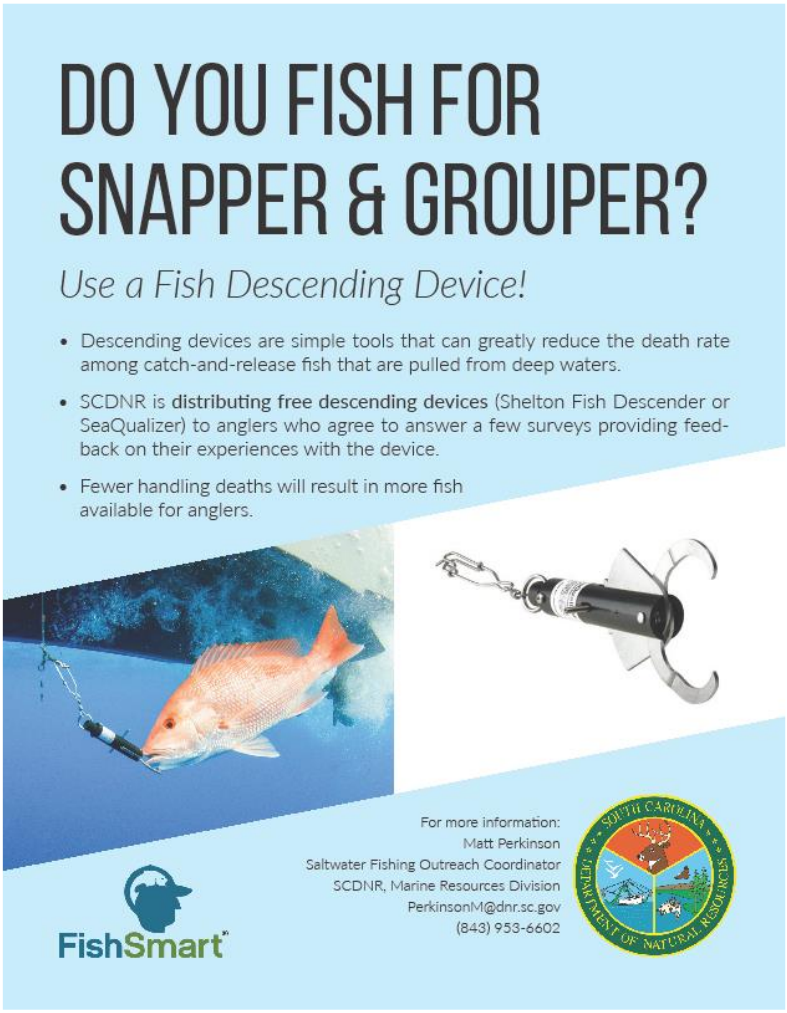


Figure 4. A descending device flyer distributed to coastal tackle shops and marinas.