SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2020

Project **Page**

Marine Fisheries Habitat Enhancement and Management

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

Reporting Period: July 2, 2019 - July 1, 2020

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:

Ten reef construction projects were carried out during this fiscal year on 8 separate artificial reef sites, adding approximately 140,000 cubic feet of hard bottom habitat to our offshore reefs. Due to the closure of state offices and work regulations mandated by COVID-19 concerns, several planned deployments were postponed or canceled. Projects that were completed are summarized below:

Date	Material	Reef Site
31 July 19	26 pieces concrete culvert & boxes	Paradise Reef
20 Aug 19	28 pieces culvert pipe	Georgetown Reef
28 Aug 19	30-ft. concrete-hulled boat	Charleston Nearshore Reef
29 Sept 19	106-ft. tugboat	Betsy Ross Reef
29 Oct 19	26 pieces concrete culvert & boxes	Capers Reef
08 Jan 20	28 pieces concrete culvert pipe	Little River Reef
11 Mar 20	26 pieces concrete culvert pipe	C.J. Davidson Reef
10 May 20	53-ft. concrete-hulled boat	Georgetown Reef
10 May 20	26 pieces concrete culvert pipe	Georgetown Reef
30 May 20	6 concrete pilings	Parris Island Reef

- Fifteen days of offshore reef monitoring were completed, including monitoring of reef materials and fish populations and side-scan sonar surveys of reef sites.

- Twenty-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.

- Two missing reef buoys were replaced.

- Monitoring of acoustic radio receivers on offshore artificial reefs was interrupted, as was all fieldwork, as state offices were shut down through much of April, May and June.

- Updates of reef construction activities were presented to fishing and diving clubs around the state, although several presentations were canceled during the pandemic.

To add vertical relief to a 53-foot concrete hulled boat, steel framing was welded to the deck.

The 106-foot tugboat *Grace McAllister* is deployed on the Betsy Ross Reef off Hilton Head Island.

Many spectators came out to watch the sinking of the *Grace McAllister*.

Inshore Fisheries Monitoring and Research

Project PI: Joseph C. Ballenger (Data compiled with assistance from John Archambault, Ashley Galloway & Katie Anweiler)

Reporting Period: July 1, 2019 - June 30, 2020

Summary of Activities / Accomplishments to Date:

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

Trammel net survey

The trammel net survey operates in lower estuary (high-salinity) habitats targeting species such as red drum, black drum, spotted seatrout, southern flounder and sheepshead. The survey, which began in November 1990, uses 600 ft x 8 ft nets that are set along marsh-front and oyster reef habitat with the survey design remaining unchanged since 2009 until this year. 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, 2019 - June 30, 2020), Inshore Fisheries staff made 735 trammel sets in nine survey areas ('strata') found in five broad geographic areas along the South Carolina coast (**Table 1**). The survey caught 10,510 specimens belonging to 68 taxa (**Appendix 1**). We enumerated and measured all fish, releasing the majority of them alive at the site of capture. From the 10,510 specimens, we collected 3,968 biological samples (**Table 2**), mostly using non-lethal methods (e.g. fin clips for genetic investigations into population structure and stocking contributions). We present long-term population trends for a sub-set of species in **Figure 1** (Atlantic croaker, black drum, red drum, sheepshead, spotted seatrout, and southern flounder).

Table 1: Number of trammel sets in each sampling stratum during July 1, 2019 - June 30, 2020.

	2019						2020						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Port Royal Sound	20			23				25					**68**
ACE Basin	11	12	9	12	11	12	12		13				**92**
Charleston Harbor	31	31	30	29	31	32	37	35	12			28	**296**
Cape Romain	23	21	22	24	13	12	26	24	12			9	**186**
Winyah Bay	11	12	12	10	12	12	12	12					**93**
Total	**96**	**76**	**73**	**98**	**67**	**68**	**87**	**96**	**37**	**0**	**0**	**37**	**735**

Table 2: Number of biological samples collected during July 1, 2019 - June 30, 2020.

		Gear					
Sample	**Purpose**	**Electrofishing**	**Hook and Line**	**Longline**	**Trammel**	**Trawl**	**Total**
Fillet	SC DHEC mercury analysis	8			61		**69**
Fillet	SCDNR study of mercury in Sheepshead				22		**22**
Fin Clip	Genetics	354	271	629	2584	693	**4,532**
Gonad	Sex, maturity, fecundity	73	107	79	350	4	**612**
Otoliths	Aging	74	274	79	819	4	**1,250**
Scales	Aging	10	1		27		**38**
Stomach	Graduate student study on environmental microplastics	2			1		**3**
Whole Specimen	Educational programs	1			89		**90**
Whole Specimen	Invasive American Eel parasite study	38					**38**
Whole Specimen	Parasite study	2			15		**17**
Whole Specimen	SCDNR Brood stock for stock enhancement investigations			6			**6**
Whole Specimen	SCDNR study of invasive Penaeus monodon	5					**5**
Total		**567**	**653**	**793**	**3968**	**701**	**6,682**

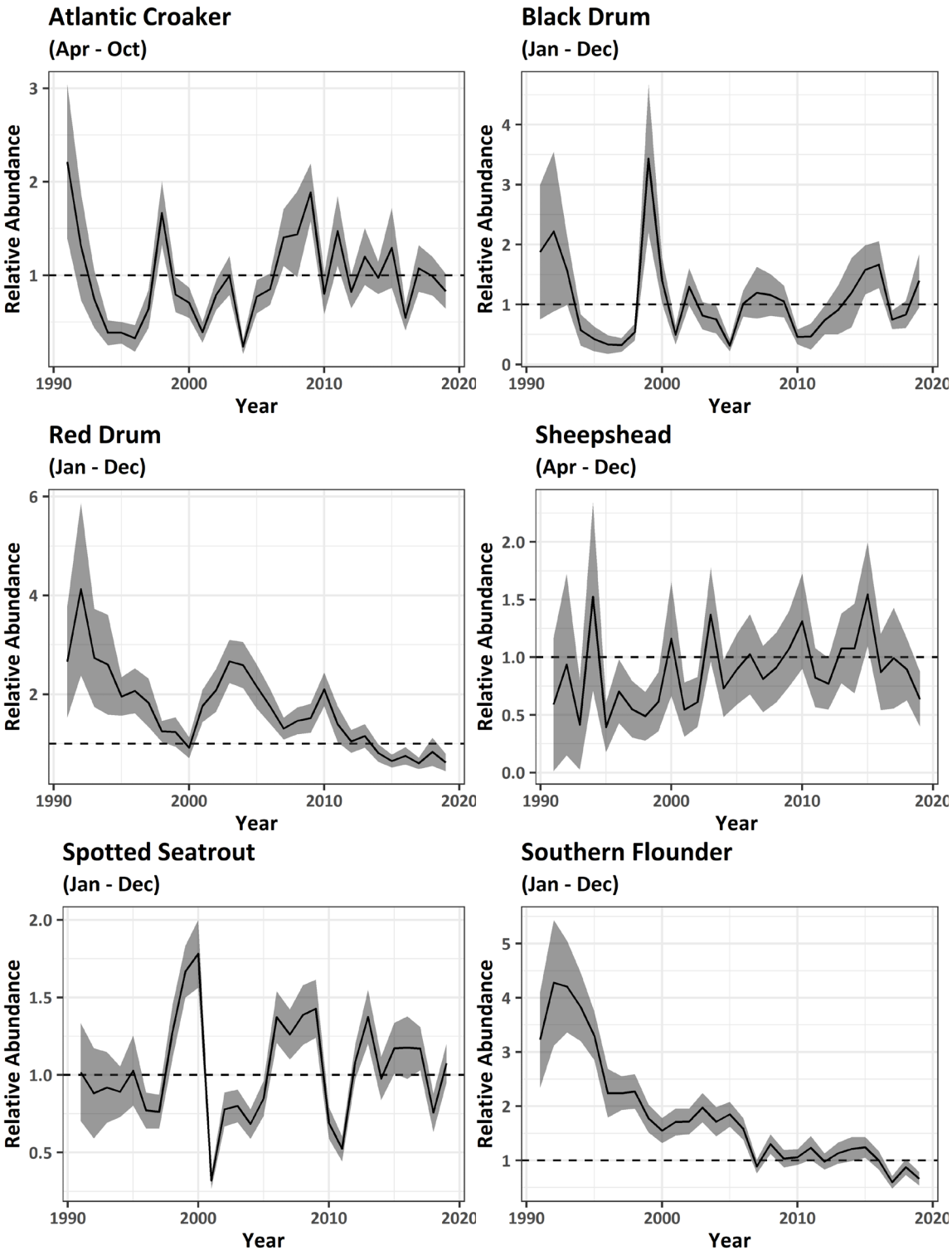


Figure 1: Examples of long-term population trends for selected species, as assessed by the SCDNR trammel net survey. The vertical axis is a relative index of fish abundance (annual average catch / 2010-2019 average catch). Black lines show the statewide relative abundance across all strata with gray 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 use 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. Until this year, the survey design had remained unchanged since 2003, when sampling in the Waccamaw River/Winyah Bay strata commenced.

During the reporting period, Inshore Fisheries staff made 242 electrofishing sets in five strata along the South Carolina coastline (**Table 3**). The survey caught 4,911 specimens belonging to 67 taxa (**Appendix 2**). From those 4,911 specimens, staff collected 567 biological samples (e.g. otoliths, scales, fin clips; **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 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 sub-adults (< 5 years old), which we sample through the trammel net and electrofishing surveys. The survey also provides information on several regionally managed coastal shark species.

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

During the reporting period we made 351 longline sets (each longline is one-third of a mile long) in four survey strata along the South Carolina coast (**Table 4**). These sets caught 2,127 specimens belonging to 27 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 79 red drum for otolith aging and reproductive analysis, as requested by the Atlantic States Marine Fisheries Commission, and nearly all red drum were fin clipped for genetic analysis (**Table 2)**.

Table 3: Number of electrofishing sets made in each stratum during July 1, 2019 - June 30, 2020.

	2018						2019						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Combahee River	6	6	5	6	6	6	6	6	2			6	**55**
Edisto River	6	4	5	5	5		5	5	6				**41**
Ashley River	6	6	5	6	6	6		6				6	**47**
Cooper River	6	6	6	5	6	5	6		4			6	**50**
Winyah Bay	5	5	5		5	6	6	6	6			5	**49**
Total	**29**	**27**	**26**	**22**	**28**	**23**	**23**	**23**	**18**	**0**	**0**	**23**	**242**

Table 4: Number of one-third mile longline sets made during July 1, 2019 - June 30, 2020.

Stratum		**Month**				
Area	**Depth**	**August**	**September**	**October**	**November**	**Total**
Winyah Bay	Inner	0	10	12	11	**33**
Winyah Bay	Outer	0	20	18	19	**57**
Charleston Harbor	Inner	9	0	11	9	**29**
Charleston Harbor	Outer	9	11	20	21	**61**
Saint Helena Sound	Inner	10	0	13	5	**28**
Saint Helena Sound	Outer	20	0	15	21	**56**
Port Royal Sound	Inner	9	0	11	5	**25**
Port Royal Sound	Outer	21	0	19	22	**62**
	Total	**78**	**41**	**119**	**113**	**351**

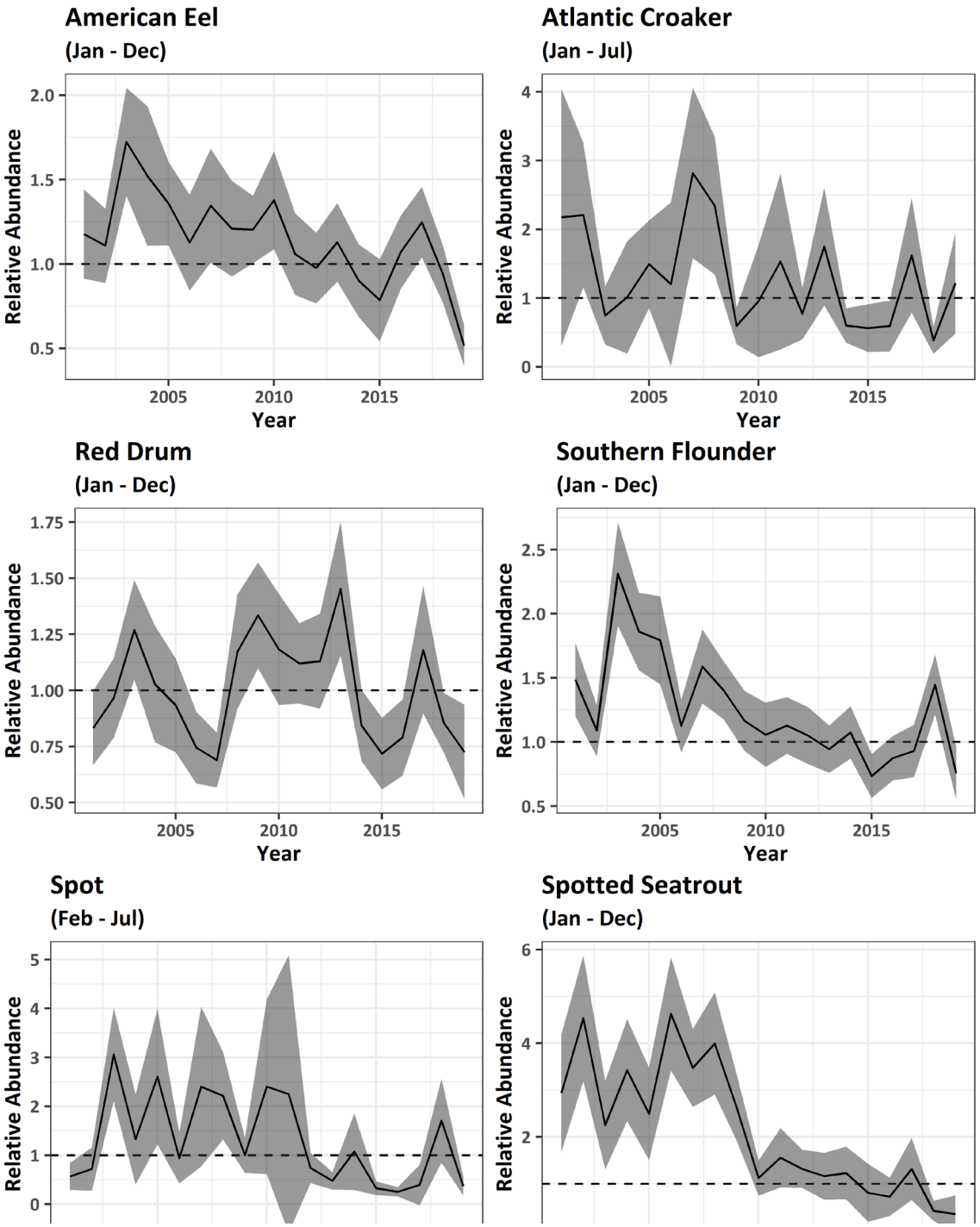


Figure 2: Examples of long-term population trends for selected species, as assessed by the SCDNR electrofishing survey. The vertical axis is a relative index of fish abundance (annual average catch per 15 minutes/2010-2019 average catch per 15 minutes). Black lines show the statewide relative abundance across all strata with gray shaded region representing the 95% confidence interval.

Finfish Bycatch in the Estuarine Trawl Survey

Staff assessed the finfish catch in 50 trawls performed by the Estuarine Trawl Survey. Twenty-eight of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). The remaining 22 trawls were performed in the southern part of the state (August and December 2019; **Table 5**). Due to vessel availability (in February 2019) and cessation of sampling during the COVID-19 pandemic, no trawls were performed February - June 2020.

The 50 trawls yielded 63,863 fish belonging to 57 species (**Appendix 4**), of which 11 fall under federal/regional management plans. From these 63,863 specimens, staff collected 701 biological samples (e.g. otoliths, scales, fin clips; **Table 2**). Fin clips were collected from the first 50 specimens of each species encountered within the calendar year. These fin clips have been archived by the SCDNR Genetics Laboratory as part of a continuing effort to collect historical DNA samples, which will form a valuable resource for generating future funding proposals and research. Voucher specimens are also being archived for each species encountered by the survey. We present long-term population trends for a subset of species as observed in the estuarine trawl survey in **Figure 3** (Atlantic croaker, southern whiting, spot and weakfish).

Finfish monitoring of the Crustacean Management Trawl Survey began in 2010. However, many of the sites visited were also surveyed by a historical (now discontinued) survey performed by the Bears Bluff Laboratory. As more data are accumulated, 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 data are accumulated, 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. A total of 1,782 weakfish were captured, with most of these specimens being young-of-year. The 2016 ASMFC Weakfish Stock Assessment incorporates data from seven young-of-year fisheries-independent surveys, representing areas from Rhode Island through North Carolina. Data from the Estuarine 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 are taken and catalogued every year may also be used in the future to aid in identifying potential sub-stocks of the species, one of the research needs named in the 2016 stock assessment.

Table 5: Number of Estuarine Trawl Survey trawls that we monitored for finfish from July 1, 2019 - June 30, 2020.

	2019						2020						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Charleston Harbor	2	2	2	2	2	2	2						**14**
Ashley River	2	2	2	2	2	2	2						**14**
Stono River/Kiawah River		3				3							**6**
ACE Basin		4				4							**8**
Port Royal Sound		1				1							**2**
Calibogue Sound		3				3							**6**
Total	**4**	**15**	**4**	**4**	**4**	**15**	**4**	**0**	**0**	**0**	**0**	**0**	**50**

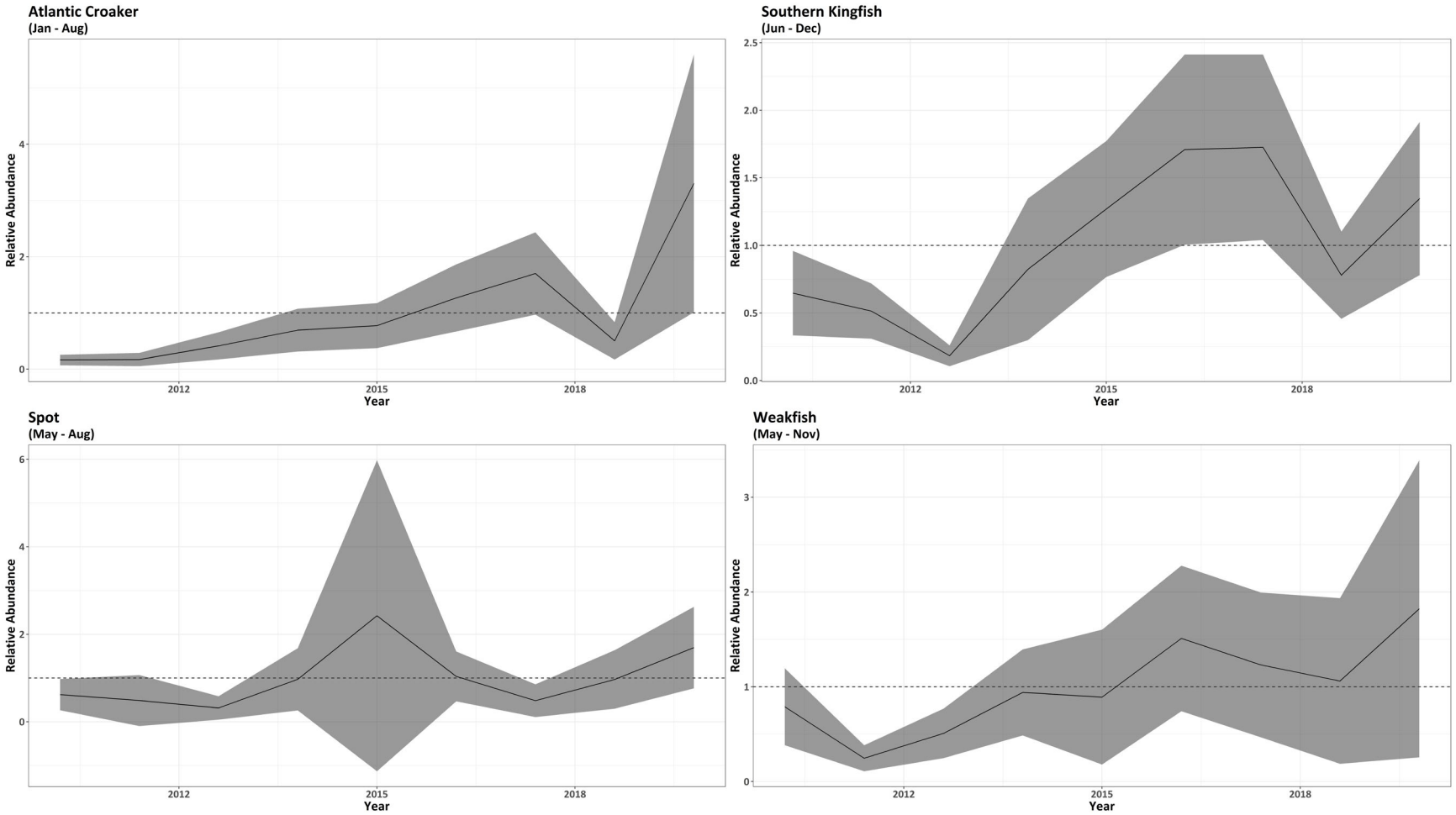


Figure 3: Examples of long-term population trends for selected species, as assessed by the SCDNR estuarine trawl survey. The vertical axis is a relative index of fish abundance (annual average catch per trawl/average catch per trawl across all years). Black lines show the statewide relative abundance across all strata with gray shaded region representing the 95% confidence interval.

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 156 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 115 fish belonging to seven species, of which spotted seatrout was the most numerous, followed by red drum (**Table 6**).

Tagging program

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

The trammel and electrofishing surveys tagged 803 fish belonging to five species between July 1, 2019 and June 30, 2020, with the majority being red drum (**Table 7**). Over the same period, individuals recaptured 493 tagged fish, of which recreational anglers caught 461 and SCDNR survey staff caught 32 (**Table 8**). Anglers released alive 77% (356/461) of the angler-caught fish (mostly red drum), while they harvested the remaining 23% (105/461).

Table 6: Number of fish acquired from the freezer and tournament monitoring programs during July 1, 2019 - June 30, 2020.

Species	Freezer	Tournament	Total
Black Drum	8	9	17
Bluefish		6	6
Red Drum	1	24	25
Sheepshead	147	15	162
Southern Flounder		18	18
Spotted Seatrout		43	43
Total	**156**	**115**	**271**

Table 7: Number of fish tagged by the trammel net and electrofishing surveys during July 1, 2019 - June 30, 2020.

Species	Electrofishing	Trammel	TOTAL
Atlantic Tripletail		8	8
Black Drum	2	114	116
Red Drum	186	322	508
Sheepshead	3	25	28
Southern Flounder	27	116	143
Total	**218**	**585**	**803**

Inshore Fisheries Section Peer-Reviewed Publications

Publications during the reporting period (July 1, 2019 - June 30, 2020) in international, peer-reviewed journals that were co-authored by staff members (bold) of the Inshore Fisheries Section:

Anweiler, K. V., Brenkert, K., Darden, T. L., McElroy, E. J., & Denson, M. R. (2019). Effects of temperature and hypoxia on the metabolic performance of juvenile striped bass (*Morone saxatilis*). *Fishery Bulletin*, *117*(4), 337-348.

Barker, A. M., **Frazier, B. S.**, Gelsleichter, J., Grubbs, R. D., Hollenbeck, C. M., & Portnoy, D. S. (2019). High Rates of Genetic Polyandry in the Blacknose Shark, *Carcharhinus acronotus*. *Copeia*, *107*(3), 502-508.

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. *Biology letters*, *15*(4), 20190004.

ek Moravec, F., Dalrymple, K. M., **Galloway, A. S.**, Barker, A. M., & de Buron, I. (2020). First record of *Piscicapillaria bursata* (Nematoda: Capillariidae), a parasite of hammerhead sharks *Sphyrna* spp., in the western Atlantic Ocean. *Diseases of Aquatic Organisms*, *138*, 133-136.

McElroy, E. J., Nowak, B., Hill-Spanik, K. M., Granath, W. O., Connors, V. A., Driver, J., **Tucker, C. J.**, Kyle, D. E., & Isaure de Buron, I (2020). Dynamics of infection and pathology

induced by the aporocotylid, *Cardicola laruei*, in Spotted Seatrout, *Cynoscion nebulosus* (Sciaenidae). *International journal for Parasitology, 50*(10-11), 809-823.

Parker, B. W., Beckingham, B. A., Ingram, B. C., **Ballenger, J. C.**, Weinstein, J. E., & Sancho, G. (2020). Microplastic and tire wear particle occurrence in fishes from an urban estuary: Influence of feeding characteristics on exposure risk. *Marine Pollution Bulletin*, *160*, 111539.

Passerotti, M. S., Helser, T. E., Benson, I. M., Barnett, B. K., **Ballenger, J. C.**, Bubley, W. J., ... & Quattro, J. M. (2020). Age estimation of red snapper (*Lutjanus campechanus*) using FT-NIR spectroscopy: feasibility of application to production ageing for management. *ICES Journal of Marine Science,* fsaa131, https://doi.org/10.1093/icesjms/fsaa131.

Perkinson, M., Darden, T., **Jamison, M.**, Walker, M. J., Denson, M. R., Franks, J., Hendon, R., Musick, S., & Orbesen, E. S. (2019). Evaluation of the stock structure of cobia (Rachycentron canadum) in the southeastern United States by using dart-tag and genetics data. *Fishery Bulletin*, *117*(3), 220-234.

Vinyard, E. A., Frazier, B. S., Drymon, J. M., Gelsleichter, J. J., & Bubley, W. J. (2019). Age, growth, and maturation of the Finetooth Shark, *Carcharhinus isodon*, in the Western North Atlantic Ocean. *Environmental Biology of Fishes*, *102*(12), 1499-1517.

Table 8: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2019 - June 30, 2020.

Capture Method	Disposition	Black Drum	Red Drum	Sheepshead	Southern Flounder	Atlantic Tripletail	Total
Anglers	Harvested	11	89		4	1	105
	Released	10	341	2	3		356
	Anglers: sub-total	**21**	**430**	**2**	**7**	**1**	**461**
SCDNR Surveys	Harvested		3				3
	Released	2	22		5		29
	Survey: sub-total	**2**	**25**	**0**	**5**	**0**	**32**
Total		**23**	**455**	**2**	**12**	**1**	**493**

Appendix 1 Total catch of each species encountered by the trammel net survey during July 1, 2019 - June 30, 2020.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Spotted Seatrout	*Cynoscion nebulosus*	3,170	35	Atlantic Spadefish	*Chaetodipterus faber*	16
2	Spot	*Leiostomus xanthurus*	1,338	36	Blueback Herring	*Alosa aestivalis*	12
3	Blue Crab	*Callinectes sapidus*	1,014	37	White Catfish	*Ameiurus catus*	12
4	Red Drum	*Sciaenops ocellatus*	820	38	Tarpon	*Megalops atlanticus*	10
5	Striped Mullet	*Mugil cephalus*	810	39	Blacktip Shark	*Carcharhinus limbatus*	9
6	Atlantic Croaker	*Micropogonias undulatus*	473	40	Lookdown	*Selene vomer*	7
7	Longnose Gar	*Lepisosteus osseus*	410	41	Bighead Searobin	*Prionotus tribulus*	5
8	Atlantic Menhaden	*Brevoortia tyrannus*	276	42	Florida Pompano	*Trachinotus carolinus*	4
9	Southern Flounder	*Paralichthys lethostigma*	276	43	Smooth Butterfly Ray	*Gymnura micrura*	4
10	Pinfish	*Lagodon rhomboides*	200	44	Spanish Mackerel	*Scomberomorus maculatus*	4
11	Black Drum	*Pogonias cromis*	170	45	Blue Catfish	*Ictalurus furcatus*	3
12	Southern Kingfish	*Menticirrhus americanus*	155	46	Roughtail Stingray	*Dasyatis centroura*	3
13	Gizzard Shad	*Dorosoma cepedianum*	153	47	Sharksucker	*Echeneis naucrates*	3
14	Bonnethead	*Sphyrna tiburo*	142	48	Summer Flounder	*Paralichthys dentatus*	3
15	Ladyfish	*Elops saurus*	126	49	Weakfish	*Cynoscion regalis*	3
16	Atlantic Stingray	*Dasyatis sabina*	104	50	Atlantic Bumper	*Chloroscombrus chrysurus*	2
17	Bluefish	*Pomatomus saltatrix*	94	51	Cobia	*Rachycentron canadum*	2
18	Sheepshead	*Archosargus probatocephalus*	70	52	Gulf Flounder	*Paralichthys albigutta*	2
19	Hogchoker	*Trinectes maculatus*	57	53	Hardhead Catfish	*Ariopsis felis*	2
20	Silver Perch	*Bairdiella chrysoura*	49	54	Live Loggerhead Turtle	*Caretta caretta - alive*	2
21	Cownose Ray	*Rhinoptera bonasus*	48	55	Spinner Shark	*Carcharhinus brevipinna*	2
22	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	46	56	American Shad	*Alosa sapidissima*	1
23	Horseshoe Crab	*Limulus polyphemus*	42	57	Atlantic Cutlassfish	*Trichiurus lepturus*	1
24	Finetooth Shark	*Carcharhinus isodon*	41	58	Bay Anchovy	*Anchoa mitchilli*	1
25	Pigfish	*Orthopristis chrysoptera*	41	59	Bay Whiff	*Citharichthys spilopterus*	1
26	Crevalle Jack	*Caranx hippos*	40	60	Gafftopsail Catfish	*Bagre marinus*	1
27	American Harvestfish	*Peprilus paru*	37	61	Gulf Pipefish	*Syngnathus scovelli*	1
28	Bluntnose Stingray	*Dasyatis say*	36	62	Horse-Eye Jack	*Caranx latus*	1
29	Green Sea Turtle	*Chelonia mydas*	32	63	Permit	*Trachinotus falcatus*	1
30	White Mullet	*Mugil curema*	31	64	Southern Stingray	*Dasyatis americana*	1
31	Northern Puffer	*Sphoeroides maculatus*	26	65	Spotted Eagle Ray	*Aetobatus narinari*	1
32	Atlantic Tripletail	*Lobotes surinamensis*	22	66	Striped Anchovy	*Anchoa hepsetus*	1
33	Striped Burrfish	*Chilomycterus schoepfi*	20	67	Tidewater Mojarra	*Eucinostomus harengulus*	1
34	Lemon Shark	*Negaprion brevirostris*	18	68	Unknown Fish Species		**1**
						Total	**10,510**

Appendix 2 Total catch of each species encountered by the electrofishing survey during July 1, 2019 - June 30, 2020.

	Common Name	Scientific Name	# Caught		Common Name	Scientific Name	# Caught
1	Striped Mullet	*Mugil cephalus*	984	35	Spotted Seatrout	*Cynoscion nebulosus*	9
2	Inland Silverside	*Menidia beryllina*	837	36	Ladyfish	*Elops saurus*	8
3	Spot	*Leiostomus xanthurus*	540	37	Western Mosquitofish	*Gambusia holbrooki*	8
4	Bay Anchovy	*Anchoa mitchilli*	321	38	Black Crappie	*Pomoxis nigromaculatus*	7
5	Blue Catfish	*Ictalurus furcatus*	284	39	Sheepshead	*Archosargus probatocephalus*	7
6	Red Drum	*Sciaenops ocellatus*	246	40	Spinycheek Sleeper	*Eleotris pisonis*	7
7	Atlantic Menhaden	*Brevoortia tyrannus*	206	41	Spotted Sucker	*Minytrema melanops*	5
8	Largemouth Bass	*Micropterus salmoides*	143	42	Bay Whiff	*Citharichthys spilopterus*	4
9	Bowfin	*Amia calva*	137	43	Common Snook	*Centropomus undecimalis*	4
10	Silver Perch	*Bairdiella chrysoura*	129	44	Hogchoker	*Trinectes maculatus*	4
11	White Catfish	*Ameiurus catus*	109	45	Irish Pompano	*Diapterus auratus*	4
12	American Eel	*Anguilla rostrata*	95	46	Naked Goby	*Gobiosoma bosc*	4
13	Longnose Gar	*Lepisosteus osseus*	85	47	Speckled Worm Eel	*Myrophis punctatus*	3
14	Southern Flounder	*Paralichthys lethostigma*	83	48	Spotted Sunfish	*Lepomis punctatus*	3
15	Threadfin Shad	*Dorosoma petenense*	82	49	Striped Anchovy	*Anchoa hepsetus*	3
16	Bluegill	*Lepomis macrochirus*	66	50	Warmouth	*Lepomis gulosus*	3
17	American Shad	*Alosa sapidissima*	57	51	Black Drum	*Pogonias cromis*	2
18	Redbreast Sunfish	*Lepomis auritus*	48	52	Brown Bullhead	*Ameiurus nebulosus*	2
19	Brook Silverside	*Labidesthes sicculus*	42	53	Chain Pickerel	*Esox niger*	2
20	Redear Sunfish	*Lepomis microlophus*	42	54	Gray Snapper	*Lutjanus griseus*	2
21	Striped Bass	*Morone saxatilis*	35	55	Hickory Shad	*Alosa mediocris*	2
22	Atlantic Croaker	*Micropogonias undulatus*	30	56	Highfin Goby	*Gobionellus oceanicus*	2
23	Pinfish	*Lagodon rhomboides*	29	57	Spottail Shiner	*Notropis hudsonius*	2
24	Mummichog	*Fundulus heteroclitus*	25	58	Atlantic Herring	*Clupea harengus*	1
25	Flathead Catfish	*Pylodictis olivaris*	24	59	Atlantic Needlefish	*Strongylura marina*	1
26	Common Carp	*Cyprinus carpio*	22	60	Blackcheek Tonguefish	*Symphurus plagiusa*	1
27	Gizzard Shad	*Dorosoma cepedianum*	19	61	Bluefish	*Pomatomus saltatrix*	1
28	Freshwater Goby	*Ctenogobius shufeldti*	18	62	Fat Sleeper	*Dormitator maculatus*	1
29	Tidewater Mojarra	*Eucinostomus harengulus*	13	63	Grass Carp	*Ctenopharyngodon idella*	1
30	Blueback Herring	*Alosa aestivalis*	11	64	Great Barracuda	*Sphyraena barracuda*	1
31	Pumpkinseed	*Lepomis gibbosus*	11	65	Leatherjack	*Oligoplites saurus*	1
32	White Mullet	*Mugil curema*	11	66	Silver Jenny	*Eucinostomus gula*	1
33	Channel Catfish	*Ictalurus punctatus*	10	67	White Perch	*Morone americana*	1
34	Goldern Shiner	*Notemigonus crysoleucas*	10				
						Total	**4,911**

Appendix 3: Total catch of each species encountered by the SCDNR longline survey during July 1, 2019 - June 30, 2020.

Rank	Common name	Scientific name	# Caught
1	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	801
2	Red Drum	*Sciaenops ocellatus*	641
3	Sandbar Shark	*Carcharhinus plumbeus*	181
4	Blacknose Shark	*Carcharhinus acronotus*	143
5	Blacktip Shark	*Carcharhinus limbatus*	104
6	Finetooth Shark	*Carcharhinus isodon*	74
7	Southern Stingray	*Hypanus americanus*	69
8	Spinner Shark	*Carcharhinus brevipinna*	40
9	Bonnethead	*Sphyrna tiburo*	21
10	Black Sea Bass	*Centropristis striata*	12
11	Oyster Toadfish	*Opsanus tau*	9
12	Atlantic Stingray	*Hypanus sabinus*	5
13	Lemon Shark	*Negaprion brevirostris*	4
14	Nurse Shark	*Ginglymostoma cirratum*	3
15	Bull Shark	*Carcharhinus leucas*	3
16	Smooth Butterfly Ray	*Gymnura micrura*	3
17	Cownose Ray	*Rhinoptera bonasus*	3
18	Tiger Shark	*Galeocerdo cuvier*	2
19	Sandtiger Shark	*Carcharias taurus*	1
20	Scalloped Hammerhead	*Sphyrna lewini*	1
21	Great Hammerhead	*Sphyrna mokarran*	1
22	Roughtail Stingray	*Bathytoshia centroura*	1
23	Gafftopsail Catfish	*Bagre marinus*	1
24	Atlantic Croaker	*Micropogonias undulatus*	1
25	Atlantic Cutlassfish	*Trichiurus lepturus*	1
26	American Conger Eel	*Conger oceanicus*	1
27	Weakfish	*Cynoscion regalis*	1
		Total	**2,127**

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	Star Drum	*Stellifer lanceolatus*	41,774	30	Summer Flounder	*Paralichthys dentatus*	9
2	Bay Anchovy	*Anchoa mitchilli*	8,053	31	Oyster Toadfish	*Opsanus tau*	8
3	Atlantic Croaker	*Micropogonias undulatus*	6,329	32	Feather Blenny	*Hypsoblennius hentz*	7
4	Spot	*Leiostomus xanthurus*	1,979	33	Inshore Lizardfish	*Synodus foetens*	5
5	Weakfish	*Cynoscion regalis*	1,782	34	Spinycheek Sleeper	*Eleotris pisonis*	5
6	Blackcheek Tonguefish	*Symphurus plagiusa*	1,398	35	Shrimp Eel	*Ophichthus gomesii*	4
7	Silver Perch	*Bairdiella chrysoura*	554	36	Striped Burrfish	*Chilomycterus schoepfii*	4
8	Southern Kingfish	*Menticirrhus americanus*	428	37	Atlantic Menhaden	*Brevoortia tyrannus*	3
9	Hogchoker	*Trinectes maculatus*	406	38	Crevalle Jack	*Caranx hippos*	3
10	Silver Seatrout	*Cynoscion nothus*	278	39	Highfin Goby	*Gobionellus oceanicus*	3
11	Fringed Flounder	*Etropus crossotus*	267	40	Bighead Searobin	*Prionotus tribulus*	3
12	Banded Drum	*Larimus fasciatus*	65	41	Gulf of Mexico Ocellated Flounder	*Ancylopsetta ommata*	3
13	Atlantic Moonfish	*Selene setapinnis*	48	42	Bluntnose Stingray	*Dasyatis say*	2
14	Striped Anchovy	*Anchoa hepsetus*	47	43	Butterfish	*Peprilus triacanthus*	2
15	Atlantic Bumper	*Chloroscombrus chrysurus*	46	44	Blue Catfish	*Ictalurus furcatus*	2
16	Southern Flounder	*Paralichthys lethostigma*	42	45	Irish Pompano	*Diapterus auratus*	2
17	Atlantic Stingray	*Dasyatis sabina*	35	46	Shortnose Sturgeon	*Acipenser brevirostrum*	1
18	White Catfish	*Ameiurus catus*	35	47	Skilletfish	*Gobiesox strumosus*	1
19	Atlantic Cutlassfish	*Trichiurus lepturus*	35	48	Chain Pipefish	*Syngnathus louisianae*	1
20	Smooth Butterfly Ray	*Gymnura micrura*	31	49	Rock Sea Bass	*Centropristis philadelphica*	1
21	Atlantic Spadefish	*Chaetodipterus faber*	28	50	Gray Snapper	*Lutjanus griseus*	1
22	Spotted Seatrout	*Cynoscion nebulosus*	25	51	Pigfish	*Orthopristis chrysoptera*	1
23	Bay Whiff	*Citharichthys spilopterus*	22	52	Pinfish	*Lagodon rhomboides*	1
24	American Harvestfish	*Peprilus paru*	18	53	Spanish Mackerel	*Scomberomorus maculatus*	1
25	Atlantic Thread Herring	*Opisthonema oglinum*	14	54	Striped Searobin	*Prionotus evolans*	1
26	Guaguanche	*Sphyraena guachancho*	14	55	Leopard Searobin	*Prionotus scitulus*	1
27	Lookdown	*Selene vomer*	12	56	Planehead Filefish	*Stephanolepis hispidus*	1
28	Northern Puffer	*Sphoeroides maculatus*	12	57	Threadfin Shad	*Dorosoma petenense*	1
29	Gafftopsail Catfish	*Bagre marinus*	9				
						Total	**63,863**

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, 2019 - June 30, 2020

Introduction:

The South Carolina Department of Natural Resources (SCDNR) 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 wellbeing 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 one-two 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:
***2019 Production*:** During the fall of 2019, SRFAC funds were used to produce and stock 914,768 small juvenile red drum into four estuaries throughout South Carolina. A total of 280,773 juvenile red drum were released into two stocking locations within Winyah Bay

utilizing two unique genetic families by SCDNR staff: small juveniles stocked in the brackish water (<8 g/L) and small juveniles stocked in saltwater (>25 g/L).

A total of 366,552 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 release strategy (boat vs. trailer) of juvenile red drum in this estuary. Small juveniles (62,736) were also released by SCDNR staff into the ACE Basin. One genetic family was provided to Bears Bluff National Fish Hatchery (BBNFH) from spawns at MRRI. Stocking of small juveniles (204,707) into the North Edisto (Adams, Bohicket, and Leadenwah creeks) was conducted by BBNFH staff to evaluate contribution to the system. Approximately 3,000 fish were overwintered at the MRRI. These fish were scheduled to be stocked into Colonial Lake for an annual kid's fishing tournament in late September 2020. Due to COVID-19, the fishing tournament was cancelled and will hopefully occur during the spring of 2021. The 2019 production year was impacted for the fifth consecutive year by a tropical system, Hurricane Dorian in September 2019. Hurricane Dorian hugged the east coast in early September 2019 bringing high winds and heavy rains. This storm caused a delayed harvest of the first round of production, resulting in fewer but larger fish, and prevented a full second round of production being completed due to the delays.

Table 1. The 2019 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)
148,282	Fall 2019	Winyah Bay (brackish water)	1.7
132,491	Fall 2019	Winyah Bay (saltwater)	2.3
62,736	Fall 2019	ACE Basin	2.8
204,707	Fall 2019	North Edisto	1.4
193,300	Winter 2019	Port Royal (trailer)	0.9
173,252	Winter 2019	Port Royal (boat)	1.0

Evaluation of 2018 Year Class Stocking: Three unique genetic families (HML118, HML119, and OWL 3) contributed to the 2018 YC stock enhancement releases. Four estuaries were stocked, including the ACE Basin, North Edisto River, Port Royal Sound and Winyah Bay, as part of our juvenile stocking efforts. Two additional stockings of legal-sized fish into Colonial Lake downtown Charleston were conducted for a youth fishing tournament in cooperation with the education and outreach section at MRD. Three distinct size classes were produced from the 2018 YC: small juveniles (mean TL 31-75 mm), medium juveniles (mean TL 94-135 mm) and large juveniles (mean TL 274-341 mm), with stocking occurring from 9/18/2018 to 12/3/2018 for the small juveniles, 1/10/2019 and 3/29/2019 for the medium juveniles and 9/11/2019 and 9/12/2019 for the larger fish.

The initial red drum stocking strategy for 2018 was to evaluate 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. Unfortunately, Hurricane Florence made landfall on September 14, 2018 in Wilmington, NC approximately 100 miles north of Winyah Bay as a category 1 storm. Hurricane Florence broke the record for highest recorded rainfall total in South Carolina from a tropical system, with

Loris, SC receiving 23.63 inches, well exceeding the 1,000-year flood predictions for that area. Most of the rainfall fell within the Pee Dee watershed, with nine river locations setting new peak flood and flow levels and two river stations ranking second. These rivers empty into Winyah Bay, which created hypoxic conditions and lowered the salinity for months within the system. A comprehensive interactive story map of the event can be found at http://www.dnr.sc.gov/florence2018.

Due to this meteorological event, the red drum stocking strategy for 2018 was revised to include a pre-flood stocking utilizing one unique genetic family, a post-flood stocking released approximately 2-3 months after the event with an additional genetic family and a third family, which was released in early spring, at which point water quality metrics returned to normal levels within Winyah Bay. Unfortunately, due to the dramatic reduction in saltwater within the estuary, stocking locations were different for the pre-flood and post-flood releases, which may complicate our genetic evaluation. The hope of this stocking strategy was to evaluate the effects that increased precipitation, creating major reductions in salinity and dissolved oxygen within a nursery system, has on hatchery juvenile red drum survival and distribution in Winyah Bay and potential impacts to wild larval recruitment to the system. This is the third stocking year where effects of increased precipitation on hatchery success and wild recruitment have been examined, with stocking occurring in the Charleston Harbor System in 2015 after the 1,000-year flood, 2016 stocking in Winyah Bay after Hurricane Matthew and 2018 within Winyah Bay after Hurricane Florence.

ACE Basin: A single genetic family from HML 119 was released during two separate stocking events. The first occurred on 1/10/2019, with a total of 5,441 medium juveniles (mean TL 135.35 mm) being released. The second stocking occurred on 9/11/2019, totaling 512 large juveniles (mean TL 273.5 mm). Hatchery contribution to the wild year class within the system is the only information that can be obtained from the 2018 YC stockings due to only one genetic family being stocked.

Colonial Lake: Two separate releases utilizing fish from HML 119 occurred at Colonial Lake in downtown Charleston. A total of 390 large juveniles (mean TL 291.5 mm) were initially released on 9/12/2019. A second release of 394 large juvenile fish (mean TL 387.7 mm) was completed on 9/23/2019 with assistance from the education and outreach section. These fish were stocked for the Huck Finn kids fishing tournament, which took place on September 25, 2019. Based on feedback from Matt Perkinson with SCDNR education and outreach section, a total of 115 kids ranging in age from 4-12 caught and released approximately 83 red drum, providing an educational opportunity for SCDNR personnel to train youth on the proper handling and releasing techniques while fishing.

North Edisto: Two genetic families (HML 119 and OWL 3) were spawned at MRRI and 2 dph larvae provided to BBNFH for stocking into ponds at their facility on Wadmalaw Island, SC. These two family groups allowed researchers to examine differences in stocking season on contribution of juvenile red drum.

A total of 90,840 small juvenile red drum from OWL 3 were released as part of the early season stocking on three separate days from boat by staff at BBNFH in three different creeks within the North Edisto. Adams Creek received 29,664 (mean TL 49.4 mm) small juvenile red drum on

9/24/2018. Bohicket Creek received a total of 55,860 small red drum (mean TL 40.3 mm) on 9/21/2018. Finally, Leadenwah Creek received 5,346 (mean TL 54 mm) small juvenile red drum on 9/18/2018.

A total of 355,345 small juvenile red drum from HML 119 were released later in the season by boat on three dates in two creeks within the North Edisto. Bohicket Creek received 115,342 (mean TL 40 mm) small red drum on 10/31/2018 and 116,863 (mean TL 25.5 mm) on 11/5/2018. Leadenwah Creek received 123,140 (mean TL 31.3 mm) small juvenile red drum on 10/22/2018.

Port Royal Sound: Two unique genetic families were used for our experimental treatment groups, including small juvenile (HML118) and medium juvenile (HML 119). Fish were released directly from the hauling trailer at the Broad River Boat Landing beside the SC Hwy 17 bridge.

A total of 257,479 (mean TL 40.67 mm) red drum were released on 10/4/2018 from HML 118 representing the small juvenile release group. An additional 3,608 (mean TL 135.35 mm) medium juveniles were released from genetic family HML 119 on 1/10/2019.

Winyah Bay: Three unique genetic families were used for our experimental treatment groups, including pre-flood (HML118), post-flood (HML 119), and spring release treatment (OWL 3). Fish were released by boat or trailer near the mouth of the Waccamaw River, Carroll Ashmore Campbell Marine Complex, Mosquito Creek, and at Mother Norton Shoals based on salinity due to flooding potentially making results difficult to interpret.

A total of 39,632 small juvenile red drum (mean TL 39.49 mm) from the pre-flood treatment were released on 9/18/2018. These fish were released by boat near the mouth of the Waccamaw River. The post-flooding release occurred on four separate stocking days, with a total of 212,049 small juvenile red drum (mean TL 74.69 mm) being released. The first release occurred on 10/30/2018, with a total of 85,585 stocked at the mouth of the Waccamaw River and the Carroll Ashmore Campbell Marine Complex. Salinity levels at release in both locations were below 0.2 ppt, so fish were acclimated within 1 ppt before release. Fish appeared healthy in the hauling container, but immediately after the fish were introduced to the estuary, they became erratic, stilled, and then floated away ventral side up. Based on field observations, it appeared that most fish did not survive. This prompted the stock enhancement section to delay further releases until salinity levels rose above 5 ppt, shifting remaining releases towards the mouth of Winyah Bay. The second release occurred on 11/16/2018, with 34,200 being released at Mother Norton Shoals. The third and fourth releases were split between Mother Norton Shoals and Mosquito Creek on 11/30/2018 and 12/3/2018 with 49,554 and 42,710 juvenile red drum stocked, respectively. The final spring stocking of 2,936 medium-sized red drum (mean TL 135.35 mm) was completed on 3/29/2019 at Mother Norton Shoals.

Due to the large geographic distance between stocking locations (North Edisto River, Port Royal Sound, and the ACE Basin), it was assumed that there would be no movement of HML 118 and HML 119 juveniles from the other stocked estuaries into Winyah Bay.

Table 2. Stocking information for the 2018YC juvenile hatchery red drum.

Estuary	Release Treatment	Family	Date stocked	Mean TL (mm)	Number stocked
ACE Basin		HML 119	1/10/2019, 9/11/2019	135.35	5,441
Colonial Lake		HML 119	9/12/2019, 9/23/2019	339.8	784
North Edisto	Early/small	OWL 3	9/18/2018, 9/21/2018, 9/24/2018	44.07	90,870
North Edisto	Late/small	HML 119	10/22/2018, 11/5/2018	30.78	355,345
Port Royal Sound	Small	HML 118	10/4/2018	40.67	257,479
Port Royal Sound	Medium	HML 119	1/10/2019	135.35	3,608
Winyah Bay	Pre-flood	HML 118	9/18/2018	39.49	39,632
Winyah Bay	Post-flood	HML 119	10/30/2018, 11/16/2018, 11/30/2018, 12/3/2018	74.69	212,049
Winyah Bay	Spring	OWL 3	3/29/2019	94.01	2,936

Contribution: A total of 297 red drum tissue samples from 2018YC individuals collected during January-December 2018 were included in the analysis of contribution to the ACE Basin, North Edisto River, Port Royal Sound, St. Helena Sound and Winyah Bay. A total of 38 cultured fish were recaptured for an overall hatchery contribution of 12.8% from stocking effort in 2018.

ACE Basin

Similar to results from the 2017YC, there was no hatchery contribution in the ACE Basin from 2018YC stocking efforts. There were two releases of relatively few individuals that occurred in January 2019 (5,441) and September 2019 (512). Historically, 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 2018YC may be due to the 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 Fisheries' trammel sites.

Winyah Bay

In Winyah Bay, the pre-flood release near the mouth of the Waccamaw River resulted in zero recaptures of cultured fish. The post-flood release from genetic family 18HML119 had 19 recaptures, and a recapture rate of 0.009%. Release dates for this family spanned four days from October 30, 2018 to December 3, 2018 and were released at four sites depending upon salinity. Since the same family was used for these releases, it is impossible to determine the contribution the stocking events separately. However, based on field observations at the time of stocking, it is likely the October 30 release would have reduced, if any, survival compared to the other stocking

events. The spring release from genetic family 18OWL3 resulted in one recapture and a recapture rate of 0.0341%.

In 2019, comparisons of gear showed that slightly more hatchery fish were recaptured by trammel netting (n=11, 22%) than electrofishing (n=9, 18%), but hatchery fish accounted for 56.3% of the electrofishing samples compared to 32.4% of the trammel net samples. This observation could potentially be due to the bulk of the stocking occurring in the saltier portions of the estuary, since the fish from the pre-flood and October 30, 2018 release likely died due to reduced salinity. Also, twice as many samples were collected in the lower estuary (trammel net), which could influence the number of recaptures. 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 it 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%; 2017YC: 13.2%) than to the trammel netting samples (2012YC: 4.7%; 2014YC: 7.1%; 2015YC: 6%; 2016YC: 3.4%; 2017YC: 3.3%).

Hatchery contributions for the 2018YC were the highest on record at 40%, joining other years of high contribution (2005YC: 35.3%; 2013YC: 25%; 2016YC: 27.6%). 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%). Historically, 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). The 2018YC had record high contribution despite modest stocking numbers (212,049) of medium-sized individuals, along with a larger spring release (2,936). Based on the Inshore Fisheries Section CPUE data from the trammel boat survey, relative abundance was lower in Winyah Bay than in previous years. As hatchery fish provided a 40% contribution to the Winyah Bay systems, wild recruitment in the area appears to have been depressed due to the significant flooding caused by Hurricane Florence. All other trammel net strata saw average or above average age one catches except the Charleston Harbor, which showed a similar negative trend compared with Winyah Bay; however, no stocking occurred in the Charleston Harbor. These findings are supported by the other two years of stocking before and after a major meteorological event. In 2015, fish stocked after the 1,000-year flood made up the highest contribution numbers to date in all the Charleston Harbor strata. In 2016, the post-hurricane stocking in Winyah Bay made up a significantly higher contribution than fish stocked pre-hurricane. These data suggest that major precipitation events during the fall spawning period for red drum can have devastating effects on wild recruitment and that stocking after these events may be a way to offset the negative trends in abundance.

North Edisto River

In the North Edisto River, a total of 17 hatchery fish from the 2018YC were recaptured; ten near the Maybank dock boat landing at the mouth of Bohicket Creek, and seven in Leadenwah Creek. Hatchery contribution in the North Edisto was 25.0%, with 14.7% contribution in Bohicket Creek and 10.3% in Leadenwah Creek. All recaptures were from the late/small release from family HML119 (355,345), and none were from the early/small release of from family OWL3 (90,870). Interestingly, the early release was much larger (44.1 mm TL) compared with the late

release (30.8 mm TL) but had zero percent contribution. Typically, larger fish have better survival rates, but stocking numbers may account for the higher contribution of the late stocked fish, with 355,345 versus 90,870 in the early release. For both the 2013YC and 2016YC, there was a higher contribution to Leadenwah Creek than to Bohicket Creek. Hatchery contributions in the North Edisto River have ranged from 2% to 39.4% (2003YC-2009YC, 2011YC-2013YC, 2016YC-2017YC), placing the 2018YC in upper end of contribution values. 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 contribution.

Port Royal Sound

In Port Royal Sound, one hatchery fish was recaptured by an angler in Broad Creek for a hatchery contribution of 1.1%. This fish came from the late release of medium individuals from the HML119 genetic family. One fish is not enough to draw conclusions about whether a later release leads to higher contribution than an early release of smaller individuals. It is important to note that location data with angler caught samples are approximate based on the water body the angler reports. These low hatchery numbers may reflect the low total samples of age one red drum collected near the release site. The number of 2018YC hatchery returns was low for Port Royal Sound, so all conclusions and inferences drawn from this data should be viewed considering the small sample size of cultured individuals from that location.

Release Strategies and Contribution

Red drum released in Winyah Bay pre-flood had zero contribution to the fishery; whereas the post-flood treatment saw a record high in contribution, along with the spring release's low contribution. More hatchery individuals were caught in the trammel net survey compared with the electrofishing survey for the first time since the 2013YC. This is likely due to the increased sample size within the trammel net strata, stocking location towards the mouth of the bay and the extended lower salinity levels within the estuary remaining well into the spring and summer of 2019. However, the hatchery contribution to electrofishing samples was still much higher than the contribution to trammel netting samples, which is a trend that has stayed consistent within Winyah Bay. The record high contribution from the post-flood hatchery fish is likely due to the reduction in wild young of the year recruitment caused from the extensive flooding by Hurricane Florence. This similar trend was documented in 2015 with stockings occurring within the Ashley River before and after the 1,000-year flood and in 2016 within Winyah Bay before and after Hurricane Matthew. In both cases the post-event stockings significantly outperformed the pre-event stockings, with the Charleston Harbor system accounting for the highest contribution numbers to date within that system.

Movement

In the North Edisto River, 17 hatchery fish were recaptured with more caught in Bohicket Creek (n=10) than Leadenwah Creek (n=7). Sampling coverage is not extensive enough to allow for examination of movement throughout the estuary.

In Winyah Bay, slightly more hatchery individuals from the 2018YC were found in the lower (higher-salinity) portion of the estuary than in the upper (lower-salinity) portion. This is in contrast with what was seen for the 2012YC, 2014YC, 2015YC, 2016YC, and 2017YC but is

likely a result of stocking location and the reduction in salinity for most of the winter and spring of 2019. For the 2013YC, hatchery individuals showed equal distribution between the upper and lower portions of the estuary. Results from previous year classes (2012-2017) indicate that there is a slight overall movement of hatchery individuals from the release site to the upper portion of Winyah Bay; however, some hatchery red drum do move downstream from the release site to the lower portions of the estuary. For the 2018YC, most of the recaptures came from a single genetic family (n=19), which were released in 4 locations encompassing the upper and lower estuary. It should be noted that observations of high mortality during stockings of the brackish portion of Winyah Bay may point to fish moving from lower bay stockings to the upper bay. However, since these fish are from the same family, it is impossible to resolve from which release site they originated. The one fish recaptured from the spring treatment was released at Mother Norton Shoals, and caught in the lower estuary, which provides no evidence of movement.

***Spotted Seatrout*:**
2019 Production: A total of 651,445 small juvenile spotted seatrout were harvested from 16 ponds stocked with larvae. Of these, 448,576 small juvenile spotted seatrout from 12 ponds were released into the Charleston Harbor system in 2019 (Table 3). Not all harvested fish were stocked into the wild; some were held back for externally funded research projects at the Waddell Mariculture Center, Marine Resources Research Institute, and with College of Charleston collaborators. Additionally, to maintain our responsible approach and research design we stocked approximately equivalent numbers of fish per family, regardless of total production. Most of the production (60.0%) occurred from ponds that were harvested in June at a mean size of 37.9±3.5 mm TL. The remaining 40.0% of spotted seatrout were harvested during July at mean size of 37.9±4.8 mm TL. Mean age-at-harvest was 26.8±2.5 days and mean survival was 32.5±0.2% with pond survival ranging from 0.0% to 85.3%. In addition to the small juvenile seatrout released, 50,000 small juveniles were transferred from a pond into a recirculating aquaculture system and used for additional experiments.

The stocking design for 2019 examined impacts of method of release on hatchery contribution and recapture rate. Unlike the 2015-2017 stocking seasons, however, only small juvenile seatrout were released either by boat or trailer at the boat landing. All fish stocked in Charleston Harbor were transported to the James Island Yacht Club ramp and all fish stocked in the Ashley River were transported to the W.O. Thomas, Jr./ Leeds Avenue Boat Landing and all fish stocked in the Wando River were transported to the Ralston Creek boat ramp. Each release treatment was made up of a single genetic family created by a group of seven males and three females.

For boat landing releases, upon arrival at the release location, a gas-powered two horsepower water pump was used to provide flow-through water and acclimate juvenile spotted seatrout to the water conditions of the release site. Once water conditions inside the hauling trailer were within 1°C and 1 ppt salinity of the release site, the contents of the trailer were discharged through two 6” diameter PVC slides directly into the estuary.

For boat releases, upon arrival at the release location boat landing, fish were transferred from the hauling trailer to a boat-mounted tank filled with hauling trailer water. Fish were then transported by boat to optimal estuary habitat and several 25-50% water exchanges were conducted to introduce release location water to the tank on the boat and acclimate the fish. Once water conditions inside the tank were within 1°C and 1 ppt salinity of the release site, the

contents of the tank were discharged through one 4” diameter pipe that exits at the back of the boat, directly into the estuary.

Table 3. Spotted seatrout juveniles stocked in the Charleston Harbor estuary system in 2019.

Genetic Family	Number Released	Average TL (mm)	Release Location	Treatment
NWL4A	97,733	37.05	Charleston Harbor	Trailer
NWL5A	59,831	42.42	Charleston Harbor	Boat
NWL4B	80,181	33.50	Ashley River	Boat
NWL4B	45,816	36.77	Wando River	Trailer
NWL5C	59,891	35.90	Ashley River	Boat
NWL4C	105,424	33.33	Ashley River	Trailer
Total	**448,876**			

Evaluation of 2015 thru 2019 YC Stockings: To evaluate the contribution of stocked juvenile spotted seatrout, a total of 571 fin clip tissue samples were processed from spotted seatrout collected in the Charleston Harbor system from September-December during monthly independent random sampling in 2019.

The overall stocking question for the 2018YC was to evaluate contribution to the wild population after a potential winter kill. Based on water quality data from the Charleston Harbor, water temperatures during the winter of 2017-2018 fell below 7°C for a much longer period than in previous winters. Prior temperature tolerance studies conducted by SCDNR suggests that prolonged exposure to temperatures around 5°C can cause fish to become lethargic and lose equilibrium, and temperatures below 5°C can be lethal. From CPUE data generated by the Inshore Fisheries Section, catches of spotted seatrout in the trammel net survey were significantly reduced compared with previous years in the first quarter of 2018. This information suggests that wild spotted seatrout numbers declined due to the low temperatures that winter. Stock enhancement of seatrout in 2018 yielded the second highest contribution (12.3%) of one-year old fish since the beginning of the program in 2012. Other year classes (2012, 2013, 2014, 2016, and 2017YCs) only contributed 1.3% - 9.2% as one-year old fish. The highest contribution to date (24.2%) was from stockings in 2015. Total number of small juveniles released early in the season was 268,000 in 2015 and 171,000 in 2018. Size at release was similar in both 2015 and 2018, at 39 mm TL and 41 mm TL, respectively. However, condition factor was somewhat higher for fish released in 2015 (0.85) versus 2018 (0.77). In addition, all the fish in 2015 were released in late May to early June, compared with early to mid-June in 2018, with release water temperature averages 26.7°C in 2015 compared to 28.3°C in 2018. The increased numbers of juveniles released in 2015, the higher condition factor or better health of these fish, and lower water temperatures at release in 2015 all likely contributed to the higher contribution numbers seen in 2015 compared with 2018. These data suggest that stocking spotted seatrout after a winter kill can demonstrably increase hatchery contribution – although this conclusion is based on a single data point, since these events are rare and stocking has only occurred during one winter kill event.

The 12.3% hatchery contribution from the 2018YC is a substantial decrease from the 36.5% contribution from this YC at age zero. A similar decrease in contribution estimates from age zero to age one fish has previously been observed in the 2012, 2013, 2014, 2015, and 2017YCs. This decrease from age zero to age one is expected especially when the bulk of production and stocking occurred early in the season making hatchery seatrout more likely to recruit to the Inshore Fishery's gear before the entire wild year class. The same pattern was not observed for the 2016YC as no hatchery fish were collected at age zero, and there was a 1.3% contribution from age one fish. An explanation for the reverse trend in 2016 is likely because there was no early-season release due to water issues at the Waddell Mariculture Center and all production was limited to the mid/late season. The 9.1% (n=2) hatchery contribution from the 2017YC is slightly higher than its contribution in 2018 (7.3%). The one hatchery fish collected from the 2015YC had a much higher contribution (50.0%) compared to the last time this year class was collected in 2017 (24.4%), but there were only two fish total collected in 2019 from the 2015YC. The lack of hatchery fish from the 2016YC in 2019 collections was likely due to the low stocking densities that year, the lack of contribution as age zero and age two fish, and the low contribution as age one fish.

This marks the fifth consecutive year with no hatchery fish collections in the Wando River. This was expected as there has been no stocking in the Wando River since 2013, other than the stocking done in July 2019, and movement from stocking locations within the Ashley River or Charleston Harbor to the Wando River is rare. The one hatchery fish from the 2015YC and the two hatchery fish from the 2017YC were all released and recaptured in the Charleston Harbor. For the 2018YC that were released in the Ashley River, 64% of the fish were collected there, with the remaining 36% collected in the Charleston Harbor. Likewise, for the 2018YC that were released in the Charleston Harbor, 82% of the fish were collected there, with the remaining 18% collected in the Ashley River. For the 2019YC, two fish were collected from the family released in both the Ashley and Wando Rivers. Both fish were collected in the Ashley River and most likely came from the Ashley River release due to the limited movement previously observed between the Ashley and Wando Rivers. For the 2019YC that were released in the Charleston Harbor, 37.5% of the fish were collected there, while the other 62.5% were collected in the Ashley River. This movement between the Ashley River and Charleston Harbor is similar to what has been seen in previous years, with a majority of cultured fish collected in the same stratum from which they were released, except for the 2019YC released in the Charleston Harbor.

Looking at the replicated size and season of release treatments across the 2015, 2016, 2017, and 2018YCs, the small early release treatment represented the majority of the hatchery fish collected in 2015, 2017, and 2018. This was not the case in 2016 where no early-season releases occurred. In the 2015 and 2016YCs, there were a small number of the large juvenile late season returns, and in the 2017 and 2018YCs, there were a limited number of the small juvenile mid-season returns. For the 2015, 2017, and 2018YCs, season of release appears to be an influential variable as treatments released early in the season had a greater contribution compared to later in the season. This was most apparent for the 2018YC in which there were early and mid-season releases in both the Ashley River and Charleston Harbor and stocking numbers were comparable between the two releases in the Ashley River. However, there were too few hatchery fish collected in all three years to statistically evaluate a difference in treatments. Across all four

years, total release numbers also appear to influence contribution with the greatest release numbers yielding the highest return rates.

Cobia:
Mariculture staff have been collecting cobia carcasses from recreational anglers as well as from tournaments over the last 13 years. Cobia fishing closures continued in state waters south of Edisto Island during 2019 for the entire month of May. This has significantly reduced the number of inshore samples collected in that region with only 68 samples collected, most of which were genetic fin clips, so no age or size data is available. Undersized fish caught by SCDNR's SEAMAP section and fin clips from acoustically tagged fish utilizing funds from a Cooperative Research Program (CRP) grant did provide additional 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. In 2019, a total of 19 undersized cobia were collected by SEAMAP and provided to the EFR section for processing. An additional 108 fin clip samples were collected through the CRP acoustic tagging study. In total 318 genetic samples were collected in 2019 (93 fin clip vials, 71 charter boat samples, 11 recreational angler samples, 13 tournament samples, 108 CRP samples, and 22 SCDNR collected samples).

In addition to the collection of life history data, recreational license funds were used to make several trips from April - June 2020 to collect cobia broodstock from the Broad River annual inshore aggregation for hatchery production of fingerlings for stock enhancement research. Eight wild cobia were collected by cooperating recreational anglers and SCNDR staff in the Broad River and transported back to the Waddell Mariculture Center (WMC) for use as broodstock. Four females and four males were prophylactically treated for any external parasites and introduced to flow-through tanks at WMC.

During the past two years, we implemented a vitamin addition to the broodstock diet for cobia at MRRI in hopes of filling any potential maternal nutritional gaps and improving spawn quality. During the 2020 production season, cobia broodstock at MRRI were injected utilizing two spawning hormones on five separate occasions resulting in five spawns with viable eggs. Approximately five million eggs were produced from the combined spawns with 2.5 million being viable eggs. These eggs were hatched in incubation cones and approximately 1.3 million larvae were produced of which 710,000 were stocked into ponds at the Waddell Mariculture Center. In addition to spawning at MRRI, five attempts were made at WMC to induce the newly captured cobia. This resulted in two separate spawns, the first containing 1.04 million eggs that were non-viable, and the second containing 950,000 eggs which yielded over 364,000 larvae of which 200,000 were stocked into ponds at WMC and the remaining larvae used for intensive husbandry experimentation

A total of 13,740 juvenile cobia (mean TL 80.7 mm) were released from the hauling trailer at H.E. Trask Landing. Two distinct genetic families were released: 12,337 from the WMC family and 1,403 from the MRRI family. An additional 1,000 fish were retained in the hatchery at WMC for future studies.

Analysis of contribution or previous YC releases: Overall, nine cultured fish were captured in the 2019 collections (all fish sampled in all locations) for a total hatchery contribution of 2.6%. 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 hatchery contribution across the South Atlantic Bight was 3.0%. All hatchery fish were collected within SC and in the near vicinity of the original stocking location.

For the SC collections, the total hatchery contribution was 4.5%. The highest hatchery contribution was seen from the inshore samples within the Broad River (where stocking occurred) and St. Helena Sound at 12.9% (n=8), with a smaller hatchery contribution from offshore at 0.7% (n=1). Hatchery contribution based on year class could not be determined due to lack of otolith data, but will be calculated and updated when data become available.

Contributions from cultured fish were observed from the 2012 and 2017YCs. For the one cultured fish from the 2012YC, genetic data suggest it was 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 during the 2012 production season. Likewise, genetic data suggest that all cultured fish from the 2017YC were offspring from the parental cross of CB084 and CB085, even though there were two males and two females in the spawning tank during the 2017 production season. The 2019 field collections represent the first year that fish were recaptured from the 2017YC. Hatchery contribution from fish stocked prior to 2009 was unlikely due to the limited occurrence of fish 10 years and older in the fishery, and no fish have been caught from the 2009YC to date.

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 addressing 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 increase 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

Period Covered: July 2, 2019 - July 1, 2020

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 SCDNR 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 of 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 NOAA Fisheries to produce estimates for stock assessments and management of species on a regional basis.

SRS – During the reporting period from January 1, 2020 to February 29, 2020, 41 fishing parties were interviewed in private boat mode, representing contact with 67 recreational fishermen. Interviews were conducted at public and selected private boat landings in 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 324 fish belonging to 12 species (**Table 2**).

MRIP – During the reporting period from July 1, 2019 to December 31, 2019 and March 1, 2020 to June 30, 2020, 309 assignments were completed resulting in 4,051 angler interviews in all modes (**Table 3**). On March 20, 2020, Governor McMaster issued an executive order in response to the COVID-19 pandemic; all sampling efforts ceased and did not resume until May 18, 2020. 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, intercepts, anglers interviewed, and fish measured by SRS staff during January 2020 - February 2020.

SRS TOTALS	
Site Visits	83
Intercepts	41
Anglers Interviewed	67
Fish Measured	19

Table 2. Fish and shellfish caught by fishing parties interviewed by SRS staff during January 2020 - February 2020.

Species Name	Number Caught	Percent Of Total
Clams, Hard	328	49.47%
Drum, Red	126	19.00%
Seabass, Black	107	16.14%
Seatrout, Spotted	62	9.35%
Eastern Oyster	11 (bushels)	1.66%
Drum, Black	6	0.90%
Pigfish	4	0.60%
Unidentified Fish	3	0.45%
Tunny, Little	3	0.45%
Toadfish, Oyster	3	0.45%
Flounder, Paralichthidae	3	0.45%
Sheepshead	2	0.30%
Pinfish, Spottail	2	0.30%
Grunt Family	2	0.30%
Mullet, Striped	1	0.15%

Table 3. MRIP assignments and interviews obtained by mode in FY2020.

Wave 4 2019				
Mode	**July**		**August**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	42	737	40	488
Head Boat	6	59	4	51
Grand Total	**48**	**796**	**44**	**539**

Wave 5 2019				
Mode	**September**		**October**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	30	368	37	503
Head Boat	4	42	1	7
Grand Total	**34**	**410**	**38**	**510**

Wave 6 2019				
Mode	**November**		**December**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	33	252	28	205
Head Boat	0	0	0	0
Grand Total	**33**	**252**	**28**	**205**

Wave 2 2020				
Mode	**March**		**April**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	19	96	0	0
Head Boat	0	0	0	0
Grand Total	**19**	**96**	**0**	**0**

Wave 3 2020				
Mode	**May**		**June**	
	Assignments	**Intercepts**	**Assignments**	**Intercepts**
Charter/Shore/Private	20	148	44	852
Head Boat	0	0	0	0
Grand Total	**20**	**148**	**44**	**852**

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 in 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, 2019 - June 30, 2020; aligns values with fiscal year licensing) there were 611 licensed six passenger or fewer charter boat vessels in South Carolina. Trip level data is

submitted by licensed vessel owners/operators on a monthly basis. June's charter data was not required to be submitted to the agency until July 10th, 2020 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 2019 calendar year charter boat data (**Tables 4 and 5**).

Table 4. "Top 10 Species" caught, landed and released during reported charter vessel trips in 2019.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 79.43% of all species caught	Accounts for 76.14 % of all species landed	Accounts for 83.64% of all species released
Sea Bass, Black (30.24%)	Mackerel, Spanish (17.76%)	Sea Bass, Black (33.95%)
Drum, Red (14.23%)	Sea Bass, Black (14.67%)	Drum, Red (16.47%)
Tuna, Little (8.00%)	Snapper, Vermilion (10.63%)	Tuna, Little (9.84%)
Seatrout, Spotted (7.81%)	Seatrout, Spotted (5.54%)	Seatrout, Spotted (8.35%)
Snapper, Vermilion (4.79%)	Mackerel, King (5.44%)	Shark, Atlantic Sharpnose (3.43%)
Mackerel, Spanish (3.98%)	Whiting (Kingfish) (5.14%)	Snapper, Vermilion (3.40%)
Shark, Atlantic Sharpnose (3.37%)	Drum, Red (4.81%)	Drum, Black (2.70%)
Drum, Black (2.68%)	Grunt, White (4.50%)	Shark, Black Tip (1.87%)
Whiting (Kingfish) (2.21%)	Dolphin (4.36%)	Flounder, Unclassified (1.82%)
Flounder, Unclassified (2.11%)	Flounder, Unclassified (3.30%)	Shark, Bonnethead (1.81%)

Table 5. Overall comparisons of effort by charter vessels over the past six years with percentage of effort by area fished.

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Trips	13,702	15,610	14,381	15,620	15,660	16,649
Boat Hours	56,952	63,697	58,627	63,196	62,696	66,578
Anglers	48,305	55,779	50,794	54,385	55,462	60,358
Angler Hours	199,622	226,311	206,317	219,674	217,697	235,659
Estuarine Trips (%)	50.74	48.35	49.92	55.12	54.07	52.99
Nearshore Trips (%)	32.42	31.19	31.12	27.34	28.79	27.70
Offshore Trips (%)	16.84	20.42	18.96	17.54	17.10	19.30

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

Project PI/Participants: Ben Dyar/Trent Austin (resigned), Ann Clark Little, Michael Hodges, Barry Sturmer, Gary Sundin

Reporting Period: July 1, 2019 to June 30, 2020

Project Objectives:

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 SCDNR. Recycling goal for FY2020 is 32,000 bushels of shell.
2. Build and maintain at least two new oyster shell recycling bins for public use.
3. Increase number of restaurants participating in oyster recycling program in the Charleston, Murrells Inlet, Beaufort/Hilton Head, Greenville, Florence and Columbia 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 Recreation and/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 oyster habitat.
7. Maintain assessment of all Public Shellfish Grounds to evaluate resource status.
8. Monitor status of recently planted shellfish grounds to evaluate recruitment rates and the 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

Due to the global pandemic caused by the COVID-19 outbreak, personnel worked in a limited capacity in FY2020. These unprecedented circumstances have impacted the program in several different areas. Effort has been made to outline the impacts to fieldwork and reporting where

possible throughout this report, but specifically it negatively impacted the ability to recycle and plant shell.

1. In FY2020, **32,710** bushels of shell were recycled. This makes SCDNR the largest state-funded program and one of the top programs in the nation for quantity of shell. Twenty-three public drop-off sites were serviced in ten 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 **$114,000** by not having to purchase an equivalent quantity of out of state shell. We saw a slight decrease in the amount of bushels recycled this year from last directly due to the impacts of COVID-19. The program was on track to have another record year.

Sub-Category Totals for 2019-2020 Recycling (bushels)					
Permanent Bins	Restaurants	Events	Caterers	Public Trailers	Grand Total
10914	10810	7713.25	2367	907	32710.25
Percent Contribution to Total					
33.37	33.05	23.58	7.23	2.77	100

2. One new oyster shell recycling public drop-off location was constructed in Bluffton, and another is planned for Hilton Head Island. The new bin (Fig. 2) was constructed in collaboration with the Palmetto Bluff community in Bluffton. Ongoing volunteer and education with Palmetto Bluff will aid in the servicing of this public drop-off site. A second bin was sited and planned for Hilton Head Island at the Marshland Road Public Landing with the assistance of Beaufort County Public Works Department, but an alternate site is now required due to conflict of use from adjacent property owners. An alternate site is currently being identified.

(Fig. 2) A new oyster shell drop-off location at Palmetto Bluff in Bluffton, SC.

3. Due to impacts from COVID-19 there was a reduction in participation in our shell recycling program from many of our partnered restaurants.

Six new restaurants and one catering company joined the program in Charleston: Amen Street Fish and Raw Bar, Blossom, Carolina Yacht Club, Delaney Oyster House, Parcel 32, Salty Dog Café, Kiawah Beach Club and Cru Catering. The program collects shell from over 50 restaurants, 32 of which are active weekly contributors in the Charleston area. Educational presentations are continually being offered to partner restaurants to raise awareness within the restaurant community and increase recycling totals.

The volunteer recycling program in Greenville, SC is still servicing two restaurants and one catering company as well as multiple seasonal roasts. The Greenville oyster recycling volunteers in the Upstate collected over 625 bushels. The collection of the shells is made possible by a volunteer group from the SC Master Naturalist and is stored at a Renewable Water Resources facility. Staff gave a presentation to the Upstate Stewards in Greenville to solicit volunteers and raise awareness of the program within the volunteer base.

The program partners with the Outside Foundation to aquire shell from restaurants on Hilton Head Island and now collects from 15 restaurant on the island. The Outside Foundation has currently received funding from PEW Charitable Trust, another program partner, to continue the collection of shell via contractor and then dump the shells at the public shell drop-off site at the Coastal Discovery Museum. This funding is scheduled to last a year. Other funding oportunities are being pursued by Outside Foundation staff to continue this work. SCDNR staff gave a presentation to the Hilton Head Realtors Association to solicit volunteers and raise awareness of the program within the Hilton Head area.

A second drop-off site is schduled for construction in FY21 on Hilton Head, and the identification of the new site is ongoing in coordination with Beafort County Public Works Department. The amount of shell recycled in the Hilton Head area is growing quickly and there is a great need for a 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: Bovine's, Bubbas Dockside, Claw House, Creek Rats, Dead Dog Saloon, Jumping Jacks, Wicked Tuna and Wahoo's Fish House. The Co-Op takes their shells to the Murrells Inlet drop-off location at Clambank Landing.

The new restaurant can-lift trailer donated by CCA, as highlighted in last year's annual report, has been a critical upgrade to the program and gives SCDNR staff the ability to recycle shell from restaurants and smaller venues with increased efficiency.

4. In FY2020, staff conducted several media interviews, including wth two South Carolina news stations, two print outlets and an SCDNR blog story, which highlighted a day on the job with our restaurant recycling manager, Ann Clark Little.

   The shell recycling program, in partnership with the SCORE program, both under the

Shellfish Management Section within MRD, created a new logo (below) with an updated design aimed at wider acceptance and use by the public.

The shell recycling program continues its collaboration with the Coastal Reserves and Outreach section at MRD on a pilot program for outreach and education to increase shell recycling numbers at public drop off locations. This came after a survey that identified barriers to recycling as well as incentives to make recycling shell easier for SC citizens. Targeted media such as informational signs at seafood retail locations, oyster roast events, tackle shops and SCDNR licensing offices were utilized to inform the public on where and how to recycle shell and its importance. Social media platforms managed by SCDNR were also utilized to notify the public. Although recycling number totals are down for the entire state the Charleston area saw a slight increase in public recycling and staff therefore have deemed this program effective and will continue into FY21 by expanding efforts. As part of this work, there has been a concerted effort by staff to get our entire fleet of shell recycling dump trailers to have a uniform color and logos. The logos for the trailers were designed, printed and applied by CRO staff.

Restaurant partners were given framed certificates of appreciation as part of a new initiative to further engage restaurants and to show appreciation. The certificates outlined bushel count totals recycled from each restaurant from FY2020 and their equated square foot of contribution of habitat created from shells recycled.

The shell recycling and planting program has partnered with the PEW Foundation and the Coastal Conservation League (CCL) for PEW and CCL's assistance in increasing shell recycling with restaurants in the Charleston, Beaufort, and Columbia areas. Surveys are

being conducted at area restaurants to gauge the barriers to recycling and some incentives that would increase participation from restaurants. Educational video shorts for shell recycling outreach are being created for use in varying applications for the education and promotion of shell recycling for oyster roasts/caterer, restaurants and the public. The addition of these two organizations as a partnership will greatly expand the outreach footprint to the public for our recycling program. The office of Coastal Reserves and Outreach with MRD is also part of the collaboration.

The oyster shell recycling program continued 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 relationship with Good Catch will continue to help raise awareness to support local fisheries and consumption of responsibly harvested seafood. Restaurants benefit through marketing and advertisement being a member of this program. The Good Catch program is under new management and early meetings have proven promising for further collaboration.

The shell recycling and planting program has also partnered with Toadfish Conservation Coalition (TCC), a local NGO, to plant shell in the Charleston area. The TCC conducted a fundraiser event to spread the awareness and benefits of shell recycling and shell planting and raised $20,000, which was donated 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 will gather a range of information to aid in the estimation of recreational harvest totals. Creel clerks will also disseminate information and handouts on proper cull-in-place techniques and the importance of recycling oyster shells at specified drop-off locations.

5&6. A total of **25,573** bushels of oyster shells were planted on State and Public Shellfish Grounds between July 1, 2019 and June 30, 2020, creating **10,788** square meters (**2.66 acres**) of shellfish habitat along approximately **1.12 miles** of shoreline.

<u>Charleston County</u> – 0.42 acres

- Leadenwah Creek (S182) – **2,696 bushels**
- Adams Creek (S187) - **3,140 bushels**

<u>Georgetown County</u> – 0.81 acres

- Murrells Inlet (S358) – **4,250 bushels**
- Drunken Jack Island (S357) - **2,630 bushels**
- Oaks Creek (S354) - **1,080 bushels**

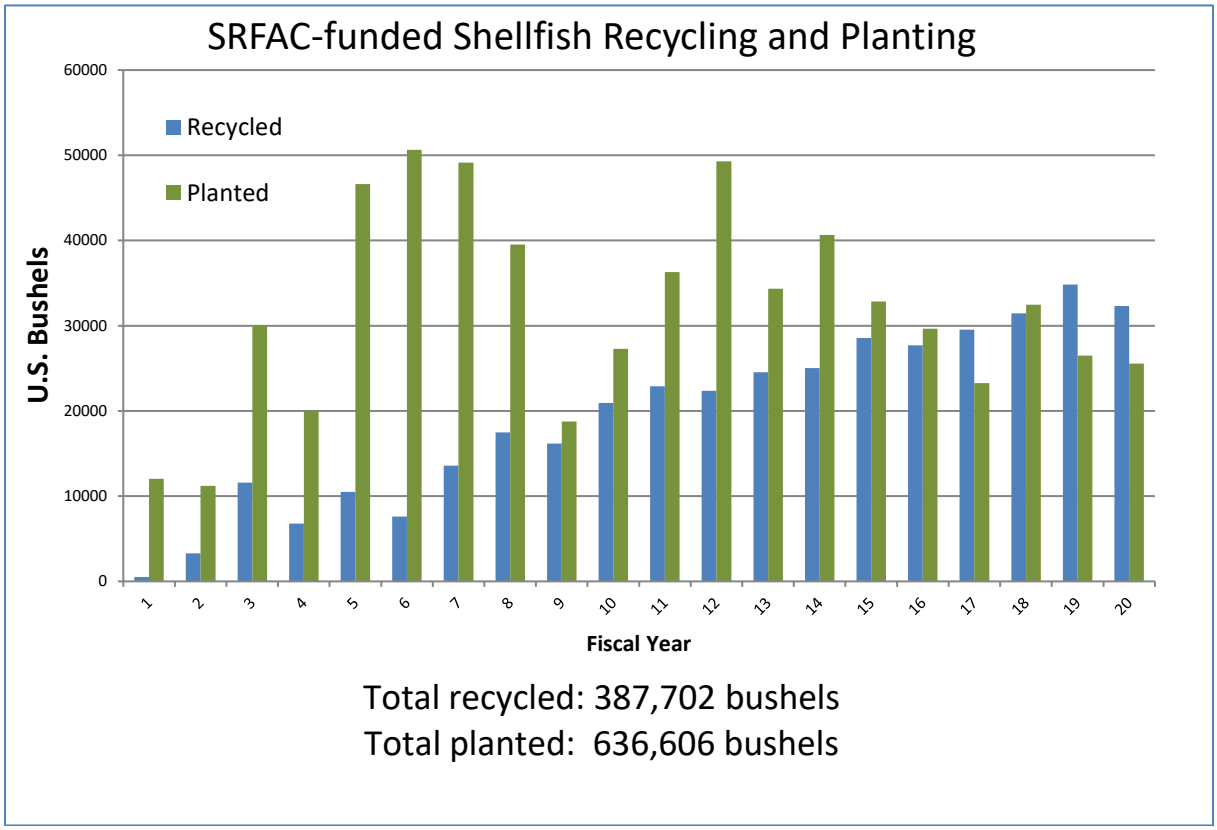
<u>Beaufort County</u> – 1.43 acres

- Station Creek (R089) - **1,267 bushels**
- Trenchards Inlet (S100) - **4,028 bushels**
- Story River (S101) - **2,000 bushels**
- Harbor River (S105) - **4,482 bushels**

*Due to the quarantine caused by COVID-19 there were delays in planting shell for the

2020 summer planting season. This caused all the planting to take place after June 2020, which will therefore be captured in the FY21 annual report.

Charleston County was planted with SRFAC funds and 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 North Carolina and Florida. 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 working outside of SRFAC funding.

8 **Three-Year Assessment:** Nine beds originally planted in 2016 were assessed to determine reef development success. Five of the nine sites could not be assessed, although the five sites with no supporting data did show an average to above-average rate of recruitment during one-year post planting monitoring. Of the four planting sites that were assessed, one had average success, two were above average and one was rated excellent. One hundred percent of sites with available data were therefore considered successful plantings. Overall, oyster bed success is determined using a composite scale that rates grounds based on density, size, quantity and quality of oysters and footprint retention.

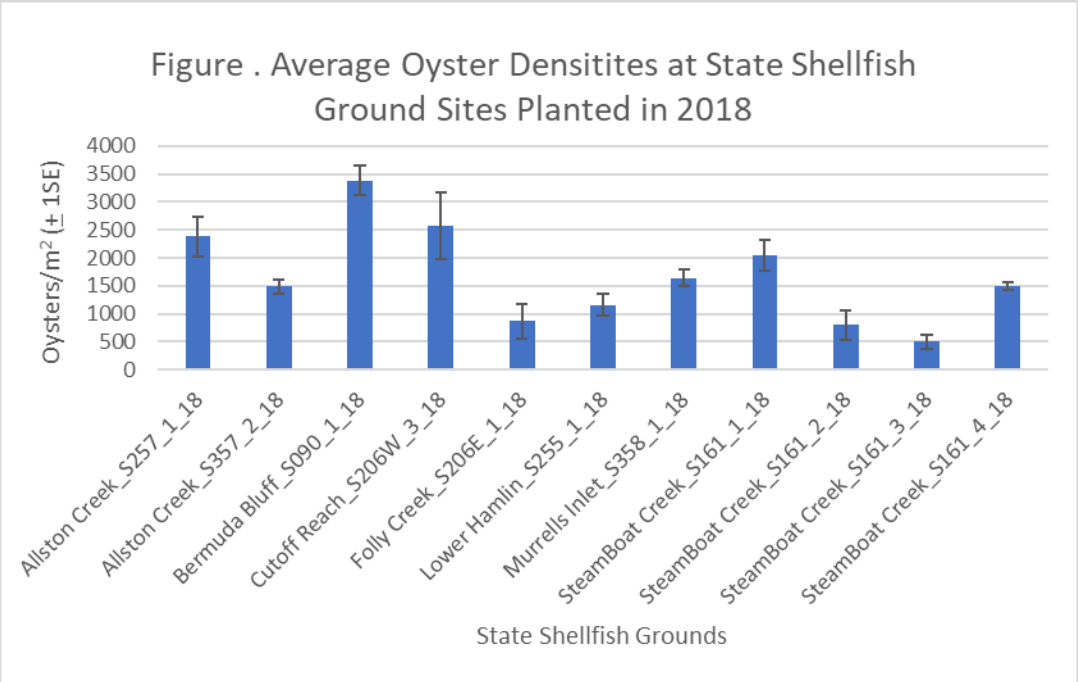
Mud bank in 2016 just before planting in Cutoff Reach off of Folly River.

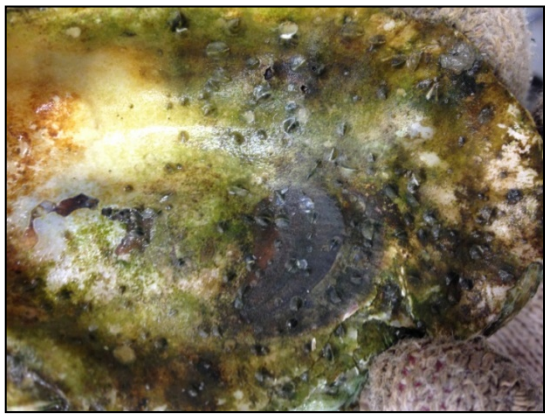
The same bank taken while sampling in 2017, just one year after planting.

2019 Assessment of beds planted in 2016

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															
Folly River _R201															
R201_1_16	5/23/16	6930	SC/G	2026			4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Folly Creek - S206W															
S206W_1_16	5/25/16	2030	SC/G	482			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
S206W_2_16	5/24/16	1050	SC/G	216			3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cutoff Reach - 206W															
S206W_3_16	5/11/16	1050	SC/G	322			3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sewee Bay - R274															
R274_1_16	6/28/16	2835	SC/G	672	800	128.0	2	1/9/2020	4		3	3.5	C	3.375	
S. Bulls Bay - S272															
S272_1_16	6/23/16	1050	SC/G	374	207.5	-166.0	2	1/9/2020	4	4	4	3.5	F	3.875	
Kiawah River - S194E															
S194E_1_16	6/8/16	1080	SC/G	622			3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
S194E_management_16	6/9/16	1020	SC/G												
Georgetown															
Allston Cr_S357															
S357_1_16	8/26/16	3245	SC/G	773			4	8/28/2019	5	4	4	5	A	4.5	
Oaks Cr_R351															
R351_1_16	8/25/16	4436	SC/G	730			4	8/28/2019	3.5	3	3.5	4	G	3.5	
Beaufort															
Did Not Plant Due to Lack of Delegation Funding															
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- Excellent			
			W-Whelk			Recruitment	Less than 450		450-900	900-1400	1400-1700	> 1700			
	Total Bushels		24,726												
	Total Initial Area		6,217												

One-Year Recruitment Rates: Eleven beds planted in 2018 were sampled and spat measured with digital calipers to determine juvenile recruitment rates. Three sites had marginal recruitment, one had average and the remaining six had above average to excellent recruitment. Six sites were not assessed.





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

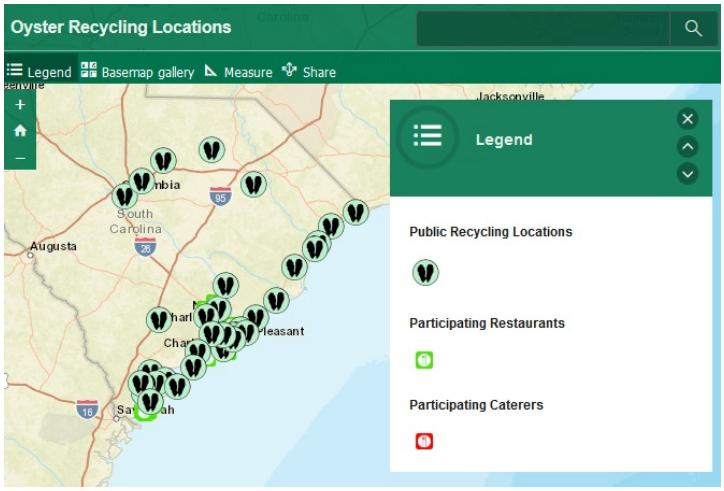
9&10. In FY2020, maps of recreational shellfish harvesting grounds were made available on the internet. These maps are updated annually. Recreational shellfish maps (see Figure 1 for example) are available on the SCDNR website and are also provided in paper format upon request. Website for recreational shellfish maps:

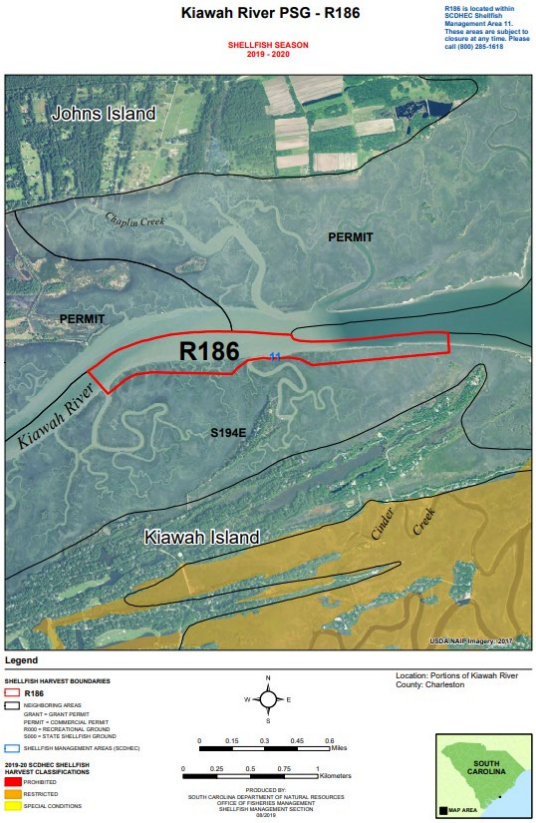
www.dnr.sc.gov/marine/shellfish/shellfishmaps.html

In FY2020, public access to recreational shellfish maps was also maintained via a web-based interactive application, increasing the accessibility of these materials to

recreational anglers and shellfish harvesters (see Figure 2). This app 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 last year and is currently available on the shell recycling website www.saltwaterfishing.sc.gov/oyster.html as well as the SCDNR website. www.dnr.sc.gov/maps. Although the map is live and currently available as is, this map application is undergoing an update that will to allow a more user-friendly way for the public to find the nearest shell drop-off location and provide a mobile link to turn-by-turn directions. The public can also see where they can support shell recycling by dining at restaurants that recycle their shells (as well as participating caterers_.

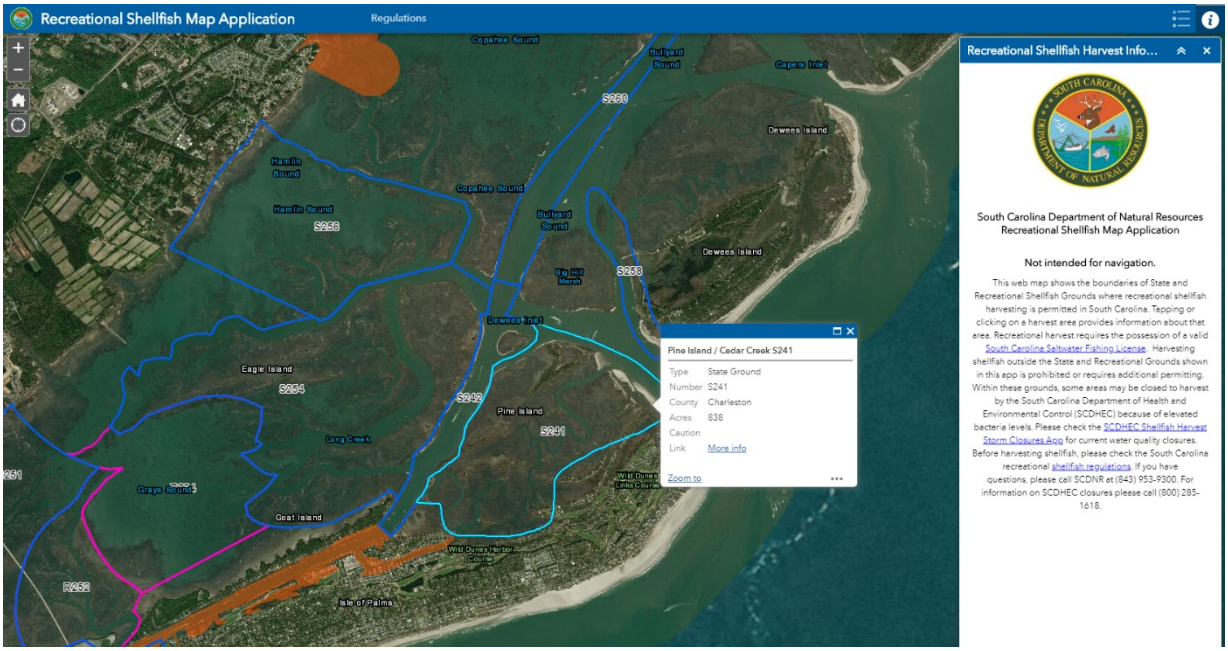




12 All State and Public Shellfish Grounds have now been outfitted with signs. Currently, we are reassessing areas that are in need of sign replacement and/or repair due to lost or damaged signs. We are continually collecting GPS points for all new signs as well as existing signs in order to create a 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 screenshot from the interface of the Recreational Shellfish Map Application.



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

Reporting Period: July 1, 2019 - June 30, 2020

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

Project PI/Participants: Dr. Peter Kingsley-Smith, Senior Marine Scientist
Gary Sundin, Wildlife Biologist III
Graham Wagner, Wildlife Biologist III

In FY2020, staff of the South Carolina Department of Natural Resources (SCDNR) Marine Resources Research Institute (MRRI)'s Shellfish Research Section (SRS) continued using a small, unoccupied aerial system (sUAS) to map intertidal oysters and other intertidal fish habitat in South Carolina. Such systems were first used in FY2018, and since that time SRS staff have continued to collect habitat mapping data that are being explored for their utility to assess the extent and condition of the oyster resources, the effectiveness of resource management and the changes attributable to harvesting activities. In FY2020, 11 flights, covering a combined total of 88 acres, were conducted to map sites for both management and restoration monitoring purposes (Table 1). These flights were conducted over relatively small areas at low altitude to capture imagery of < 2 cm resolution. Four flights were completed in State Shellfish Grounds (SSG-182, SSG-187) in the North Edisto area to document shorelines before and after the placement of loose oyster shell. Three flights were conducted in lower Hamlin Creek (SSG-255) near the Isle of Palms to document the placement of loose shell and to capture pre-and post-harvesting imagery. One flight was conducted in SSG-357 in Murrells Inlet to document the progress of loose shell planted there in FY2019. Two flights, one in King Flats Creek near Folly Beach and one on Fenwick Island in the ACE Basin, were completed to track the progress of sites where repurposed derelict crab traps have been used to create new restoration oyster reefs. A flight was also conducted at Heritage Shores Preserve, in collaboration with managers from the City of North Myrtle Beach, to collect data in preparation for the future installation of a restoration oyster reef in the spring of 2021.

Table 1.
Flights conducted in FY2020 using the sUAS to map intertidal oysters and other intertidal fish habitat in coastal South Carolina.

Location	**State Shellfish Ground Management**	**Flight Date**
Lower Hamlin Creek	Year 1 post-planting	7/11/2019
Adams Creek	Pre-planting	7/15/2019
Leadenwah Creek	Pre-planting	7/15/2019
Adams Creek	Post-planting	8/13/2019
Leadenwah Creek	Post-planting	8/13/2019
Lower Hamlin Creek	Pre-harvest season	11/26/2019
Murrells Inlet	Year 2 post-planting	3/10/2020
Lower Hamlin Creek	Post-harvest season	6/18/2020
Location	**Restoration Site Monitoring**	**Flight Date**
King Flats Creek	Post-installation baseline data	8/2/2019
Fenwick Island	Monitoring reefs built 2017 - 2019	9/24/2019
Heritage Shores Preserve	Pre-installation assessment	3/10/2020

In FY2020, staff finished processing all sUAS imagery collected in FY2019 in preparation for updating the statewide oyster GIS map, which will be made accessible to the public in calendar year 2021. Staff continued to incorporate the backlog of previously collected helicopter imagery as part of updates to this oyster GIS layer, completing updates for over 1,100 individual intertidal reefs in the Bohicket Creek area in SSG-187 (Figure 1).

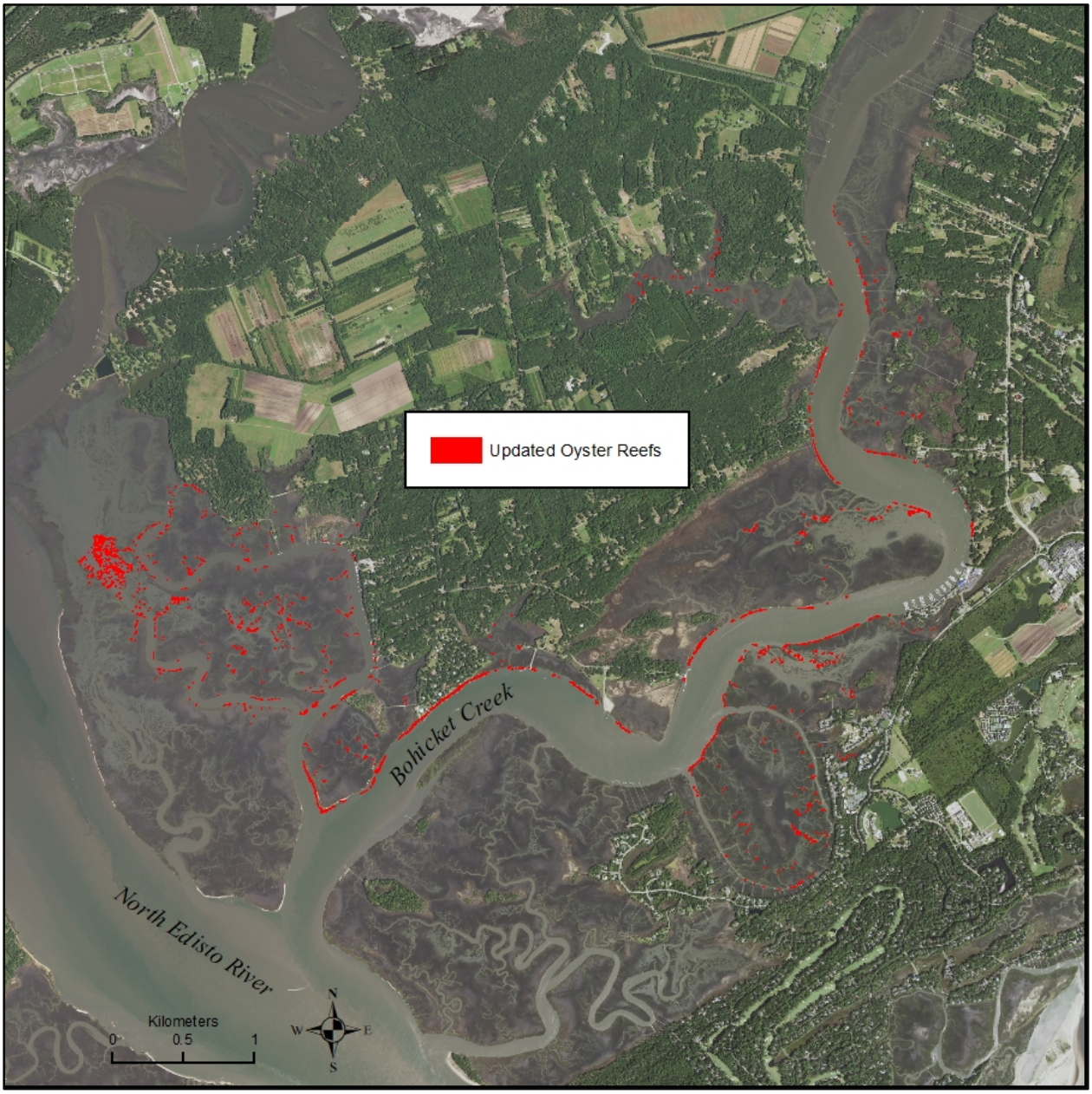


Figure 1. In FY2020, low-altitude helicopter imagery was used to update over 1,100 intertidal oyster reefs (shown in red) in the Bohicket Creek area in SSG-187.

In FY2020, staff used sUAS imagery collected in FY2019 to digitize intertidal oyster reefs and other habitat types for 319 acres of intertidal habitat around Charleston Harbor (Figure 2). These data were collected at trammel net sites sampled by the MRD Inshore Finfish Research Section as part of a long-term survey focused on recreationally important finfish species. In collaboration with this group (led by Dr. Joseph Ballenger), SRS staff are developing metrics for use in analyzing intertidal habitat utilization by finfish species.

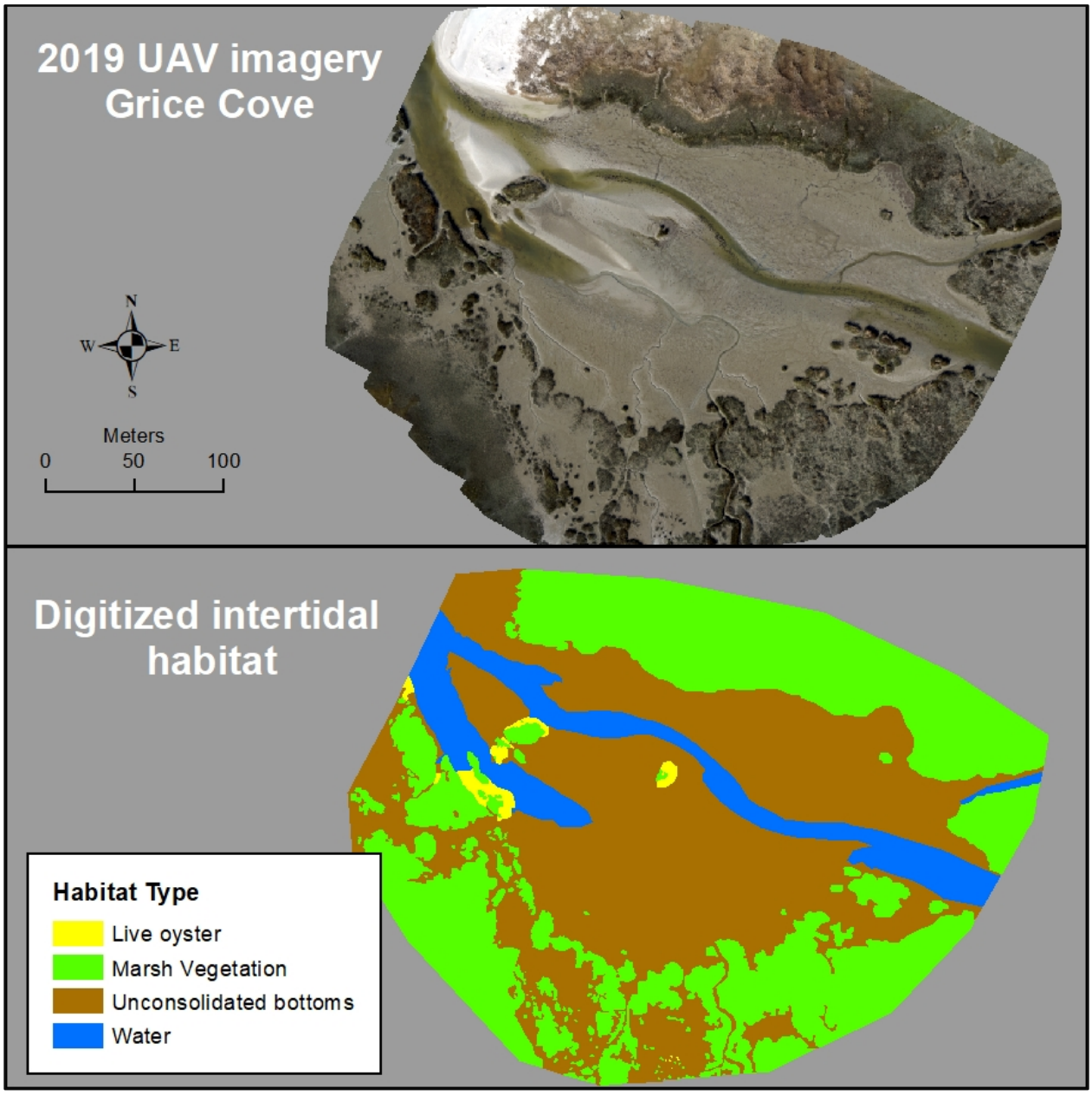


Figure 2. Example of intertidal habitat digitized from sUAS imagery collected at a long-term finfish sampling site at Grice Cover in Charleston Harbor, SC.

In FY2020, the recreational shellfish harvesting 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 view their own current location to determine whether or not they are within shellfish areas that are open to harvest. The application further provides links to SCDNR online licensing websites, shellfish harvesting regulations and 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

Project PI/Participants: Dr. Peter Kingsley-Smith, Senior Marine Scientist
Gary Sundin, Wildlife Biologist III
Graham Wagner, Wildlife Biologist III

In FY2020, SRS staff collected 27,840 oysters from 35 index stations across coastal South Carolina to continue the effort of investigating natural mortality rates, as well as other demographic information, for wild intertidal oysters (Figure 3). This was the fifth year of demographic monitoring, and to date nearly 130,000 oysters have been collected through the survey. When sampling in the field, triplicate oyster samples are collected using a standardized quadrat and brought back to the Marine Resources Research Institute (MRRI) shellfish laboratory to be processed. All oysters collected are categorized as living or dead, and each oyster is measured (Table 2). After processing, oyster shells are donated to the South Carolina Oyster Recycling and Enhancement (SCORE) Program to be placed out in intertidal habitats, facilitating new oyster reef growth. The data collected from the five years of this project have helped to determine baseline natural mortality rates for oysters in South Carolina, as well as identify times and areas with higher mortality rates, possibly linked to anomalous die-off events (Figure 4, Table 3). Furthermore, the collection of length-frequency information across five years of sampling is allowing staff to compare relative recruitment trends across sites and years (Figure 5), and to estimate growth rates of oysters at each index site (Figure 6). These pieces of information can be related to physical and environmental characteristics to investigate the causes of variation in recruitment, mortality and growth rate. An improved understanding of oyster demographics in South Carolina and the factors influencing them is crucial for assessing the health of oysters as a resource, which ultimately results in more informed management decisions.

With five years of natural mortality and length-frequency data collected through this survey thus far, some statewide patterns have begun to emerge. First, natural mortality rates of oysters were at their highest when the survey first started in 2015-2016, a statewide average of 10.9% (Table 2). This sampling season immediately followed the occurrence of Tropical Storm Joaquin, which produced more than 20 inches of rain in some coastal watersheds. This surge of freshwater likely increased oyster mortality and may explain the high natural mortality rates in the first year of the survey. Each year of demographic sampling since 2015-2016 has revealed steady declines in the natural mortality rates of oysters in South Carolina, with the most recent statewide average of 5.3%, suggesting oysters are experiencing a steady recovery from Joaquin (Table 3).

Figure 3. Location of sites sampled for natural oyster mortality during FY2020. Site codes for locations sampled are explained in Table 3.

Another observable pattern in these data involved the overall statewide recruitment of oysters. By looking at length-frequency distributions of oysters from a single index site across multiple years of sampling, relative changes in the length-frequency distributions may indicate changes in recruitment from year to year (Figure 5). For example, a decrease in the number of small individuals on the left side of a length-frequency distribution may indicate poor recruitment success, which would result in fewer small oysters. Statewide, the 2016-2017 season had the overall worst recruitment success when using length-frequency distributions to assess recruitment. The preceding season (2015-2016) had the highest statewide natural mortality rates of oysters, likely resulting from Tropical Storm Joaquin. The fact that the subsequent year was characterized by poor overall recruitment success may be indicative of the poor year class that was caused by high natural mortality event. By using length-frequency data to compare relative recruitment success among both sampling years and sampling sites, weak year classes can be identified, and management decisions can be made proactively, instead of in response to declines in the oyster resource.

Lastly, the demographic data produced through this survey has provided an opportunity to use length-frequency information to estimate growth rates of oysters. When pooling the lengths of oysters collected in multiple years at a single site, distinct cohorts of oysters can be identified, and growth rates can be estimated from the sizes of individuals in consecutive year classes. While these growth rate estimates have not been confirmed with *in situ* measurements, they can be useful for identifying areas with lower oyster growth rates (Figure 6). Ultimately, growth rates of oysters in South Carolina can be related to physical and environmental parameters to gain a better understanding of the conditions in which oysters thrive and grow optimally. Natural resource managers can use this information to make decisions regarding harvest ground closures, so that oysters in areas characterized by slow growth rates do not become overharvested.

Figure 4. Mean site-specific natural oyster mortality, indicated by symbol size, from five years of annual fall/winter sampling in coastal South Carolina.

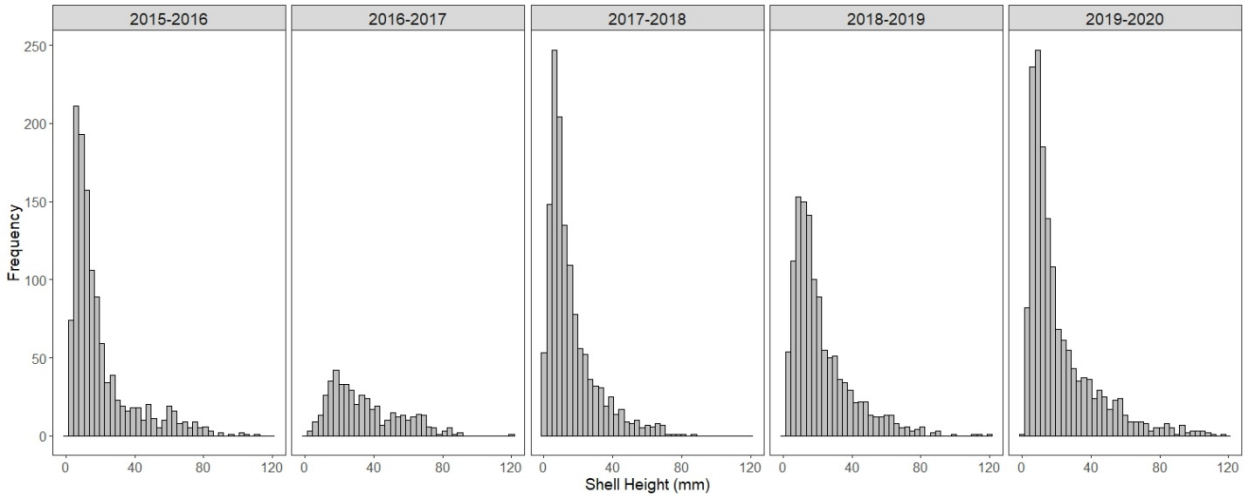


Figure 5. Length-frequency distributions of oysters from the Bears Bluff (BBF) index site for each year of sampling. Relative changes in recruitment success can be identified by comparing the distributions between years. In 2016-2017 there is a marked lack of small individuals on the left side of the distribution, possibly indicating poor recruitment success.

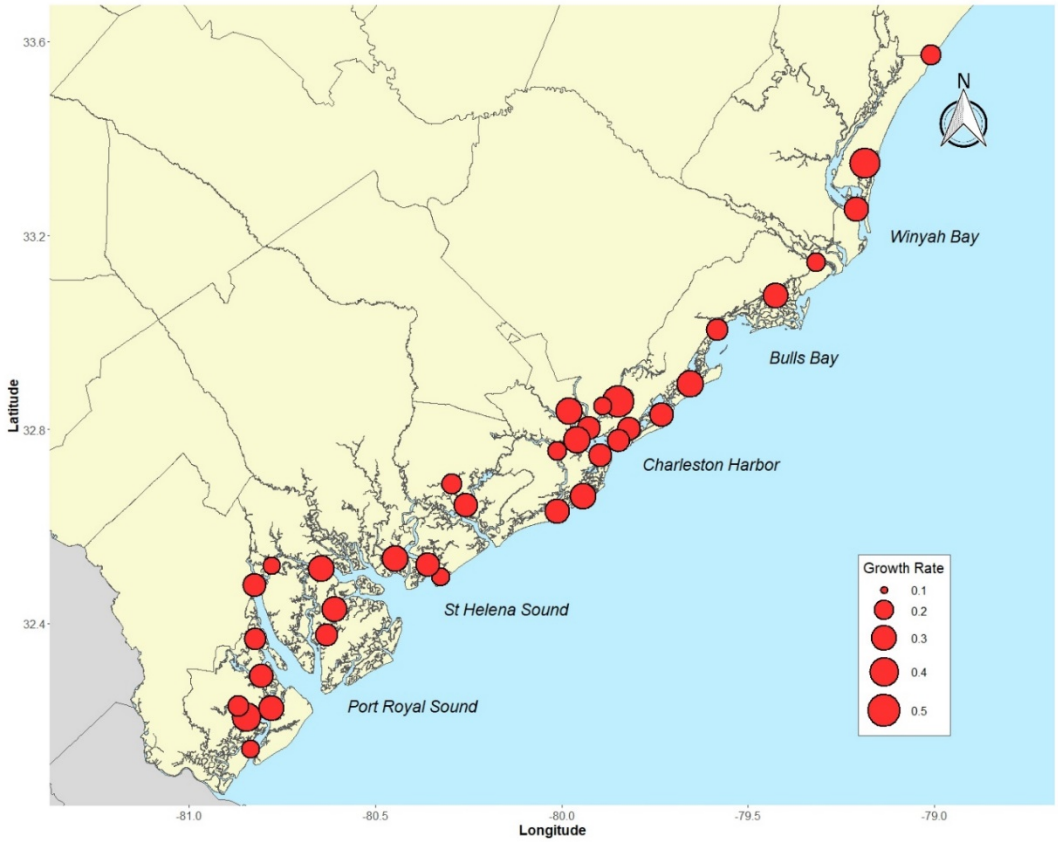


Figure 6. Growth rates of oysters in South Carolina, represented by symbol size, as estimated from length-frequency distributions. The growth rates correspond to the von Bertalanffy growth coefficient K, which is a unitless value describing how quickly individuals tend to grow towards their maximum size.

Table 2. Oyster shell heights (mm) tabulated by sampling site and sampling year.

	2015-2016			2016-2017			2017-2018			2018-2019			2019-2020		
Site	**Range**	**Mean**	**SD**	**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	2.11 – 61.25	19.83	12.05
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	0.59 – 109.39	19.25	17.66
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	1.41 – 116.65	21.76	19.85
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	1.51 – 128.98	23.63	21.12
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	1.11 – 146.19	25.53	21.56
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	2.06 – 146.74	29.51	26.45
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	0.53 – 106.52	25.82	19.67
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	1.58 – 110.01	23.75	17.96
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	1.45 – 90.14	22.20	18.92
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	1.55 – 99.05	28.79	21.79
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	0.68 – 95.23	21.05	19.62
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	3.02 – 115.75	30.96	22.45
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	0.76 – 98.76	20.84	18.11
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	1.34 – 101.62	26.59	19.62
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	0.56 – 128.53	21.79	20.14
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	1.08 – 119.80	17.71	16.59
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	1.83 – 142.00	30.21	29.86
FOS	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.51 – 126.15	29.29	25.56	0.99 – 125.76	25.13	22.08
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	NA	NA	NA
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	NA	NA	NA
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	2.34 – 134.58	29.78	24.23
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	0.59 – 113.19	21.90	18.51
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	1.54 – 112.09	22.49	19.47
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	2.48 – 129.63	32.61	24.11
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	0.69 – 89.86	30.98	19.00
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	2.42 – 122.09	30.75	25.60
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	1.60 – 97.05	23.81	18.74
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	0.67 – 133.35	24.50	25.86
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	1.20 – 85.57	18.62	15.88
SWE	4.38 – 123.25	29.01	21.06	1.83 - 121.48	37.87	26.88	4.08 - 111.87	39.92	20.85	1.91 - 121.97	29.49	21.56	1.86 – 125.24	26.00	22.85
TGD	3.55 - 115.24	25.84	20.00	0.44 - 108.12	32.16	20.41	2.99 - 149.97	41.24	28.89	2.60 - 127.59	28.73	22.75	1.66 – 116.45	25.80	22.58
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	0.33 – 119.39	31.18	24.71
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	2.64 – 137.77	25.47	21.73
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	0.93 – 58.18	19.45	11.49
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	1.18 – 136.42	31.36	22.94
WYB	4.66 – 76.99	31.89	22.94	2.53 - 71.1	23.21	13.72	3.88 - 88.32	32.75	16.23	3.12 - 78.58	25.43	15.17	1.25 – 83.04	26.70	16.43

Table 3. Mean oyster mortality (%) tabulated by sampling site and sampling year.

Site Code	Site Name	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Mean
MAY	May River	3.2	3.1	6.6	4.8	6.3	**4.8**
ASP	Ashepoo River	9.7	19.9	9.7	11.5	12.3	**12.6**
BBC	Big Bay Creek	10.7	9.9	4.9	3.1	6.1	**6.9**
BBF	Bears Bluff	3.7	8.6	4.6	3.5	4.8	**5.0**
BFT	Beaufort River	6.7	11.5	10	4.7	2.5	**7.1**
BLB	Bulls Bay	2.9	4.2	5.5	2.9	2.9	**3.7**
BRD	Broad River	9.8	2.4	3.1	5.4	2.2	**4.6**
BUL	Bull Creek	2.5	2.8	4.8	2.6	3.4	**3.2**
CBG	Calibogue Sound	7.7	17.2	10	9.8	7.6	**10.5**
CCH	Chechessee River	4.3	4.8	6.4	1.8	3.2	**4.1**
CLT	Colleton River	3.7	4.3	6.2	1.9	7.0	**4.6**
CPR	Cooper River	10.4	7.9	29.5	4.3	3.7	**11.1**
CRM	Cape Romain	4.7	5.8	3.4	4.3	5.2	**4.7**
CSG	Cosgrove Bridge	20.3	11.8	7.3	2.8	7.9	**10.0**
CSW	Coosaw River	6.2	3.3	3.6	3.1	2.2	**3.7**
DWE	Dewees Inlet	7.1	27.9	13	16.8	10.0	**15.0**
EDR	Edisto River	7.9	4.9	2.1	6	3.7	**4.9**
FLR	Folly River	4.8	4.1	8.2	3.4	9.8	**6.1**
FOS	Foster Creek	-	-	-	2.4	3.3	**2.9**
FSC	Fish Creek	-	6.8	3.7	-	-	**5.2**
GRC	Grice Cove	-	-	-	6.4	5.4	**5.9**
HAR	Charleston Harbor	15.5	27.2	6.9	6.8	-	**14.1**
HOG	Hog Island	3.5	7.5	6.3	2.2	6.7	**5.2**
INL	Inlet Creek	6.4	9.3	6.8	2.7	3.5	**5.7**
JIC	James Island Connector	19.4	8.9	9.2	5.5	9.6	**10.5**
MRI	Murells Inlet	-	3.6	5	3.8	9.7	**5.5**
NHI	North Inlet	4.4	5.1	6.6	0.6	7.4	**4.8**
SST	South Santee	77.3	3.9	9.8	12	7.1	**22.0**
STI	Stono Inlet	6	8.8	5	6.7	6.5	**6.6**
STR	Stono River	13.2	7.8	6.2	3.4	3.3	**6.8**
SWE	Sewee Bay	19	15.8	11	3	10.8	**11.9**
TGD	Toogoodoo Creek	5.3	6	4	3.4	3.3	**4.4**
TOL	Tolers Cove	7.1	5.6	9.9	2.1	2.8	**5.5**
WBR	Whale Branch	-	0.9	4	4.5	1.8	**2.8**
WND	Wando River	9.7	26.9	5.6	4.2	4.3	**10.1**
WSW	Warsaw Flats	3.3	4.9	5.5	2.9	2.7	**3.9**
WYB	Winyah Bay	33.3	24.1	5.8	22	9.4	**18.9**
	Mean	**10.9**	**9.4**	**7.1**	**5.3**	**5.3**	**7.6**

Marine Outreach and Education Program

Program PIs: Matt Perkinson and Olivia Bueno

Reporting Period: July 1, 2019 - June 30, 2020

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.
- Given the limitations to in-person programming during COVID-19 restrictions, virtual outreach tools such as webinar-based fishing clinics will be used to reach a broader audience.
- 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 37 vessel-based education programs and 273 land-based programs to 5,526 students from grades K-12. Staff spent 6,581 contact hours with students and teachers. Six teacher workshops were held with a total of 106 teachers attending. Program numbers were reduced when school and government building closed in March due to the coronavirus. Education staff continued to conduct marine science education virtually during the spring and summer.

- Staff implemented an outreach campaign to make the public aware of decreased southern flounder numbers in South Carolina and throughout the region. The campaign included a web-based public survey to gather constituent opinions on the state of the current southern flounder fishery and potential paths to recovery (Fig. 1). Approximately 2,000 individuals responded to the survey. Additionally, staff presented information on the flounder fishery to ten different fishing clubs and civic groups (Fig. 2) throughout the coastal region, as well as during the large events detailed below. Outreach staff worked with science and fisheries management staff to develop agency recommendations and present that information to the Marine Advisory Committee.

- Outreach staff represented the Marine Resources Division at three multi-day shows/expos, including the Haddrell's Point Fishing Expo, Charleston Boat Show and Southeastern Wildlife Expo. On average, staff interacted with 1,500 attendees during

each of these events. The mobile observation tank was utilized at four events: the annual STEM festival, Sea Spot Run Fishing Tournament, James Island Yacht Club Fishing Tournament and the Governor's Cup tournament in Edisto.

- In anticipation of the Huck Finn Kids Fishing Tournament, 900 red drum were stocked at Colonial Lake in downtown Charleston. The tournament was held in September 2019 and approximately 110 participants caught over 100 red drum, as well as other saltwater fish species (Fig. 3).

- 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 conducted public campus tours of Fort Johnson. Attendees get an overview of the research and conservation projects conducted by Marine Resources Division staff, as well as an opportunity to speak with a biologist. Four volunteers have been trained and have contributed 76 hours in hosting eight tours that have reached 110 members of the public.

- Staff continued the saltwater family fishing clinic program through the SCDNR Certified Fishing Instructor Course and started offering virtual clinics as well. Twenty-seven new volunteers have been trained through the course, bringing the total number of certified fishing instructors to 49. This past year the volunteers contributed 88 hours. Volunteers hosted six in-person fishing clinics reaching 76 participants (Fig. 4) and one virtual fishing clinic reaching 15 participants. 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 seven youth/family outdoor clinics, including beginner courses in using a cast net, fishing, and saltmarsh cleanups. Staff also participated in the "Outside In" virtual education series of webinars. These clinics and educational presentations allowed outreach staff and other biologists to reach over 1,000 constituents virtually during a time when in-person events were not possible.

- Public information material was distributed through the Coastal Information Distribution System (CIDS). Staff spent seven days delivering approximately 194,360 copies of printed material to 119 vendors 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
SW FISH RULER STICKERS	50,000
CRAB RULERS	10,000
FISH ID CHART	20,000
GUIDE TO SW FISHES	2,500
BEGINNER GUIDES TO SW FISHING	3,000

- General public outreach occurs daily through response to public inquiries. Staff responded to over 500 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 1,090 recreational anglers participated in the Marine Game Fish Tagging program through tagging and/or reporting the recovery of tagged fish. Program volunteers tagged and released 7,662 fish representing 27 different species. Red drum were most commonly tagged and recaptured. Information was received from 1,419 recaptured fish and of those, 87% were released.

- Staff continued an outreach campaign focusing on proper techniques for catching, handling and releasing adult red drum this year. Three actions are 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. 5). To further this campaign, SCDNR partnered with FishSmart, an initiative driven by members of the fishing industry as well as state and federal agencies. As part of this partnership, SCDNR distributes agency-recommended rigs to anglers that fish for adult red drum free of charge. During 2019-2020, staff distributed 193 adult red drum rigs to South Carolina anglers.

- 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 2019-2020, staff distributed 110 descending devices to anglers that agreed to provide feedback during a follow-up email survey. Staff also presented information about the use of descending devices during five fishing club meetings and tournament captain’s meetings.

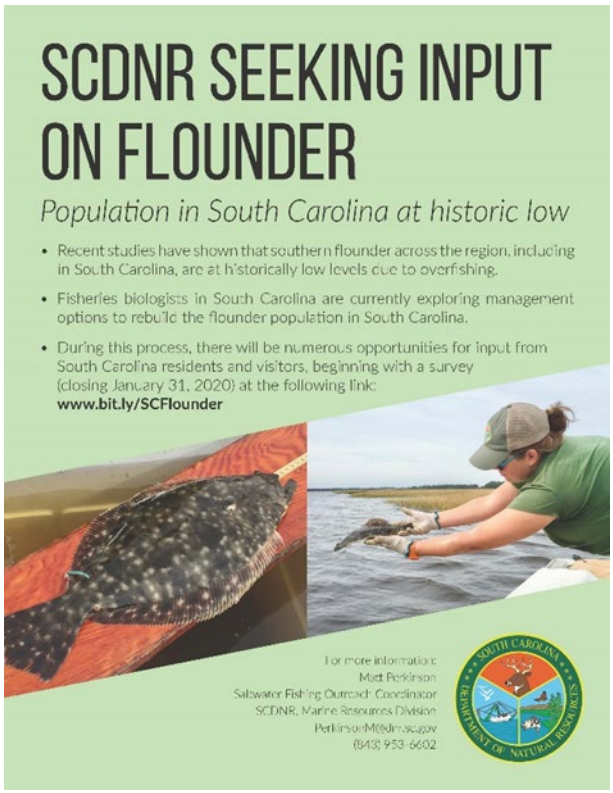


Figure 1. A flyer advertising a public opinion survey on southern flounder that was distributed to local tackle shops and marinas.

Figure 2. Southern flounder information presented at fishing clubs and civic organizations along the South Carolina coast.

Figure 3. Youth angler with a red drum caught during the Huck Finn Kids Fishing Tournament.

Figure 4. Youth angler teaches others how to tie a fishing knot during a family fishing clinic in Port Royal.

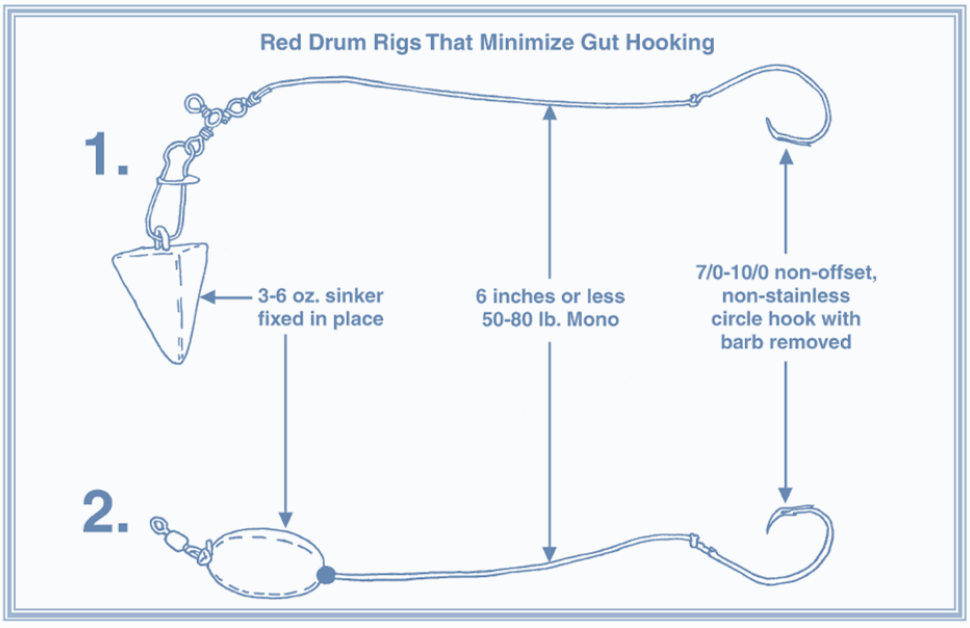


Figure 5. A postcard describing best practices to minimize gut hooking in adult red drum.