SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2021

Project **Page**

Marine Fisheries Habitat Enhancement and Management

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

Reporting Period: July 2, 2020 - July 1, 2021

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:

Fifteen reef construction projects were carried out during this fiscal year on 12 separate artificial reef sites, adding approximately 190,000 cubic feet of hard bottom habitat to our offshore reefs. Projects that were completed are summarized below:

Date	Material	Reef Site
19 Aug 20	40-ft. deck barge and crane	N. Edisto Nearshore Reef
15 Sept 20	2 hopper barge loads dredge marl	Charleston Nearshore Reef
13 Oct 20	8 concrete octagonal towers	Charleston 60' Reef
15 Oct 20	65-ft. trawler	C.J. Davidson Reef
16 Oct 20	2 concrete cones w/ instrumentation	Ron McManus Memorial Reef
09 Mar 21	50-ft. tugboat	CCA-McClellanville Reef
09 Mar 21	22 pieces 48" concrete culvert pipe	CCA-McClellanville Reef
07 Apr 21	50-ft. aluminum-hulled boat	Little River Offshore Reef
07 Apr 21	38-ft. concrete-hulled boat	Ron McManus Memorial Reef
07 Apr 21	23 pieces concrete culvert & boxes	Ron McManus Memorial Reef
12 Apr 21	9 Memorial Reef Balls	Little River Reef

Date	Material	Reef Site
27 Apr 21	2000 pounds of concrete rubble	Hunting Island (6HI) Reef
27 Apr 21	5 designed concrete structures	General Gordon Reef
16 June 21	26 concrete culvert pipes	Georgetown Nearshore Reef
30 June 21	3 concrete Sea Caves	Area 51 SSMZ

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

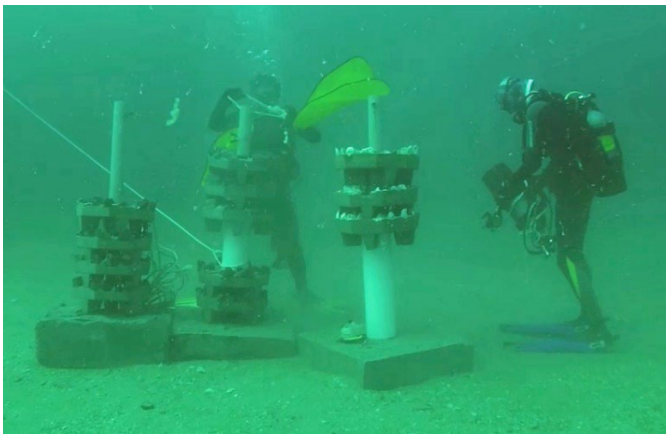
- Forty-eight scuba dives were made to conduct video surveys, arrange placement of new reef structures, document colonization and service acoustic receivers.

- Two aerial flights were made to determine where reef buoys were missing.

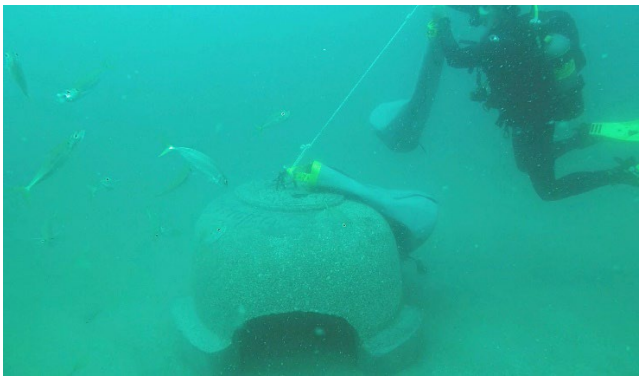
- Seven missing reef buoys were replaced.

- Presentations to fishing and diving clubs, as well as press releases and media events resumed after being postponed by the pandemic. Included in these presentations were two nationally broadcast webinars attended by over 300 people across the country.

A 65-foot steel hulled trawler is deployed on the C.J. Davidson Reef off Georgetown. Organizations such as CCA and Sea Hunt Boats often contribute to the reef program to help procure vessels such as this one.



New, experimental concrete reef structures include shelved towers with rock and shell inserts that can be rearranged once placed on the sea floor.



Concrete Sea Caves™ were deployed on Area 51, one of MRD's federally protected Spawning Special Management Zones. These structures were designed and built by the Fish Reef Project, an environmental non-profit helping to create marine habitat in locations around the world.

To comply with height restrictions on some reef sites, vessels like this 50-foot tugboat may need to have their pilot houses cut down.

Inshore Fisheries Monitoring and Research

Program PI: Joseph C. Ballenger

(Data compiled with assistance from John Archambault, Ashley Galloway and Brock Renkas)

Reporting Period: July 1, 2020 – June 31, 2021

Summary of Activities / Accomplishments to Date:

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

Trammel net survey

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

During the reporting period (July 1, 2020 – June 30, 2021), Inshore Fisheries staff made 641 trammel sets in nine survey areas ('strata') found in five broad geographic areas along the South Carolina coast (Table 1). The survey caught 12,537 specimens belonging to 65 taxa (Table 2). We enumerated and measured all fish, releasing most alive at the site of capture. From the 12,537 specimens, we collected 3,761 biological samples (Table 3), 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, Southern Flounder, and Spotted Seatrout).

Electrofishing survey

The electrofishing survey's main purpose is to monitor upper estuary (low-salinity) waters, which are important habitat for juvenile stages of fish (e.g. Red Drum, Spotted Seatrout,

Southern Flounder, Spot, Atlantic Menhaden). The Atlantic States Marine Fisheries Commission also uses catch rates of American Eel as an index of abundance in their U.S. stock assessment models. The survey, which began in May 2001, uses a specially designed electrofishing boat that temporarily stuns fish, enabling staff to collect, measure, and enumerate individual fish before releasing them alive.

During the reporting period, Inshore Fisheries staff made 250 electrofishing sets in five strata along the South Carolina coastline (Table 4). The survey caught 6,656 specimens belonging to 60 taxa (Table 5). From those 6,656 specimens, staff collected 867 biological samples (e.g., otoliths, scales, fin clips; Table 3), 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 as observed in the electrofishing survey in Figure 2 (American Eel, Atlantic Croaker, Red Drum, Southern Flounder, Spot, and Spotted Seatrout).

Longline survey

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

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

During the reporting period we made 360 longline sets (each longline is one-third of a mile long) in four survey strata along the South Carolina coast (Table 6). These sets caught 2,434 specimens belonging to 33 taxa, of which Atlantic Sharpnose Shark was the most abundant (Table 7). Project staff took length measurements from all specimens before releasing most 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 all Red Drum were fin clipped for genetic analysis (Table 3).

Estuarine Trawl Survey

Staff assessed the finfish catch in 65 trawls performed by the Estuarine Trawl Survey. Forty of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). The remaining 25 trawls were performed in the southern part of the state

(December 2020 and April 2021; Table 8). Due to ongoing cessation of sampling during the COVID-19 pandemic, no trawls were performed in July and August 2020.

The 65 trawls yielded 106,807 fish belonging to 66 species (Table 9), of which at least 13 fall under federal/regional management plans. From these specimens, staff collected 1,641 biological samples (e.g., otoliths, scales, fin clips; Table 3). Fin clips were collected from the first fifty specimens of each species encountered within the calendar year. The SCDNR Genetics Laboratory archives these fin clips as part of a continuing effort to collect historical DNA samples, which will form a valuable resource for generating future funding proposals and research. 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, the Bears Bluff Laboratory surveyed many sites currently visited historically. As we accumulate more data, we will compare our contemporary data with historical Bears Bluff information from the 1950s and 1960s. This will create the longest timeframe fish survey available from anywhere in South Carolina coastal waters.

As we accumulate data, the data will also become increasingly useful for stock assessments for managed species. In the past year, Weakfish were the eleventh most numerous species captured in the trawl survey; we captured 285 Weakfish, with most 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. Assessment scientists may use data from the Estuarine Trawl Survey in future stock assessments to supplement data from the current young-of-year surveys and such data will provide representation of the stock south of what is currently included. Additionally, the up to 50 genetic samples taken and catalogued every year for Weakfish may prove useful in identifying sub-stocks of the species, one of the research needs named in the 2016 stock assessment.

Freezer Program

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

We acquired 104 fish carcasses belonging to six species through the freezer program during the reporting period, with the largest number coming from Sheepshead (Table 10). Length, sex, and maturity (where possible) were determined from each specimen, and otoliths were extracted for ageing. We also preserved a fin clip from each specimen for genetic investigations.

Fish Tournament Program

Like the freezer program, the tournament program enables us to gather information on the size, age, and sex composition of harvested fish. SCDNR staff members attend weekend tournaments and collect measurements and biological samples from certain species of interest. To minimize bias in the sizes of fish sampled, we examine all 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 128 fish belonging to three species, of which Southern Flounder were the most numerous, followed by Sheepshead (Table 10).

Tagging Program

During Inshore Fishery surveys, SCDNR Inshore Fisheries staff tag certain species of fish before release; overtime we gather information on recapture frequency, movement patterns, selectivity patterns, and fate of recaptured fish.

The trammel and electrofishing surveys tagged 1,127 fish belonging to four species between July 1, 2020 and June 30, 2021, with the majority being Red Drum (Table 11). Over the same period, individuals recaptured 414 tagged fish, of which recreational anglers caught 357 and SCDNR survey staff caught 57 (Table 12). Anglers released alive 91% (318/357) of the angler-caught fish (mostly Red Drum), while they harvested the remaining 9% (39/357).

Inshore Fisheries Section Peer-Reviewed Publications

Inshore fisheries staff leverage our long-term monitoring programs to collect the data necessary for publication of scientific findings in peer reviewed journals. A list of publications authored by staff members (bold) of the Inshore Fisheries Section over the last 5 years is below:

Barker, A. M., **B. S. Frazier**, D. H. Adams, C. N. Bedore, C. N. Belcher, W. B. Driggers III, **A. S. Galloway**, J. Gelsleichter, R. D. Grubbs, E. A. Reyier, & D. S. Portnoy. 2021. Distribution and relative abundance of Scalloped (*Sphyrna lewini*) and Carolina (*S. gilberti*) hammerheads in the western North Atlantic Ocean. Fish Res 242: https://doi.org/10.1016/j.fishres.2021.106039. (October 2021)

Jacoby, D. M. P., B. S. Fairbairn, **B. S. Frazier**, A. J. Gallagher, M. R. Heithaus, S. J. Cooke, & N. Hammerschlag. 2021. Social network analysis reveals the subtle impacts of tourist provisioning on the social behavior of a generalist marine apex predator. Frontiers Mar Sci 8: https://doi.org/10.3389/fmars.2021.665726. (September 2021)

Nash, C. S., P. C. Darby, **B. S. Frazier**, J. M. Hendon, J. M. Higgs, E. R. Hoffmayer, & T. S. Daly-Engel. 2021. Multiple paternity in two populations of finetooth sharks (*Carcharhinus isodon*) with varying reproductive periodicity. Ecol & Evol 11(17): 11799-11807 (https://doi.org/10.1002/ece3.7948). (September 2021)

Weber, D. N., M. G. Janech, L. E. Burnett, G. Sancho, & **B. S. Frazier**. 2021. Insights into the origin and magnitude of capture and handling-related stress in a coastal elasmobranch *Carcharhinus limbatus*. ICES J Mar Sci 78(3): 910-921 (https://doi.org/10.1093/icesjms/fsaa223). (July 2021)

Diaz-Jaimes, P., N. J. Bayona-Vasquez, E. Escatel-Luna, M. Uribe-Alcocer, C. Pecoraro, D. H. Adams, **B. S. Frazier**, T. C. Glenn, & M. Babbucci. 2021. Population genetic divergence of Bonnethead Sharks *Sphyrna tiburo* in the western North Atlantic: Implications for conservation. Aquatic Conservation: Marine & Freshwater Ecosystems 31(1): 83-98 (https://doi.org/10.1002/aqc.3434). (January 2021)

Borucinska, J., D. H. Adams, & **B. S. Frazier**. 2020. Histological observations of dermal wound healing in a free-ranging Blacktip Shark from the southeastern US Atlantic coast: A case report. Journal of Aquatic Animal Health 32(4): 141-148 (https://doi.org/10.1002/aah.10113). (December 2020)

Brown, A. N., **B. S. Frazier**, & J. Gelsleichter. 2021. Re-evaluation of reproductive cycle and fecundity of Finetooth Sharks *Carcharhinus isodon* (Valenciennes 1839) from the northwest Atlantic Ocean, with new observations on ovarian cycle and reproductive endocrinology of biennially reproducing sharks. J Fish Biol 97(6): 1780-1793 (https://doi.org/10.1111/jfb.14542). (December 2020)

Gonzales de Acevedo, M., **B. S. Frazier**, C. Belcher, & J. Gelsleichter. 2020. Reproductive cycle and fecundity of the Bonnethead *Sphyrna tiburo* L. from the northwest Atlantic ocean. J. Fish Biol 97(6): 1733-1747 (https://doi.org/10.1111/jfb.14537). (December 2020)

Lyons, K., **A. S. Galloway**, D. H. Adams, E. A. Reyier, A. M. Barker, D. S. Portnoy, & **B. S. Frazier**. 2020. Maternal provisioning gives young-of-the-year Hammerheads a head start in early life. Mar Biol 67(11): 1-13 (https://doi.org/10.1007/s00227-020-03766-y). (November 2020)

Borucinska J., D. H. Adams, & **B. S. Frazier**. 2020. Histological observations of dermal wound healing in a free ranging Blacktip Shark *Carcharhinus limbatus* from the southeastern US Atlantic coast: a case report. Journal of Aquatic Animal Health 32(4): 141-148 (https://10.1002/aah.10113). (November 2020)

Parker, B. W., B. A. Beckingham, B. C. Ingram, **J. C. Ballenger**, J. E. Weinstein, & G. Sancho. 2020. Microplastic and tire wear particle occurrence in fishes from an urban estuary: Influence of feeding characteristics on exposure risk. Marine Pollution Bulletin 160: https://doi.org/10.1016/j.marpolbul.2020.111539. (November 2020)

Passerotti, M. S., T. E. Helser, I. M. Benson, K. A. Barnett, **J. C. Ballenger**, W. J. Bubley, M. J. M. Reichert, & J. M. Quattro. 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 77(6): 2144-2156 (https://doi.org/10.1093/icesjms/fsaa131). (November 2020)

Frazier, B.S., D. M. Bethea, R. E. Hueter, C. T. McCandless, J. P. Tyminski, & W. B. Driggers III. 2020. Growth rates of Bonnetheads (*Sphyrna tiburo*) estimated from tag-recapture data. Fish Bull 118(4): 329-355. (October 2020)

McElroy, E. J., B. Nowak, K. M. Hill-Spanik, W. O. Granath, V. A. Connors, J. Driver, **C. J. Tucker**, D. E. Kyle, & I. de Buron. 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 (https://doi.org/10.1016/j.ijpara.2020.03.016). (September 2020)

Moravec, F., K. M. Dalrymple, **A. S. Galloway**, A. M. Barker & I. de Buron. 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 (https://doi.org/10.3354/dao03458). (March 2020)

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

Vinyard, E. A., B. S. Frazier, J. M. Drymon, J. J. Gelsleichter, & W. J. Bubley. 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 (https://doi.org/10.1007/s10641-019-00929-9). (October 2019)

Barker, A. M., **B. S. Frazier**, J. Gelsleichter, R. D. Grubbs, C. M. Hollenbeck, & D. S. Portnoy. 2019. High rates of genetic polyandry in the Blacknose Shark, *Carcharhinus acronotus*. Copeia 107(3): 502-508 (https://doi.org/10.1643/CG-19-180). (September 2019)

Barker, A. M., D. H. Adams, W.B. Driggers II, **B. S. Frazier**, & D. S. Portnoy. 2019. Hybridization between sympatric hammerhead sharks in the western North Atlantic Ocean. Biology letters 15(4): https://doi.org/10.1098/rsbl.2019.0004. (April 2019)

Fair, P. A., B. Wolf, N. D. White, **S.A. Arnott**, K. Kannan, R. Karthikraj, & J. E. Vena. 2019. Perfluoroalkyl substances (PFASs) in edible fish species from Charleston Harbor and tributaries, South Carolina, United States: Exposure and risk assessment. Env Res 171: 266-277 (https://doi.org/10.1016/j.envres.2019.01.021). (April 2019)

Perkinson, M., T. Darden, **M. Jamison**, M. J. Walker, M. R. Denson, J. Franks, R. Hendon, S. Musick, & E. S. Orbesen. 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. (March 2019)

Fair, P. A., N. D. White, B. Wolf, **S. A. Arnott**, K. Kannan, R. Karthikraj, & J. E. Vena. 2018. Persistent organic pollutants in fish from Charleston Harbor and tributaries, South Carolina, United States: A risk assessment. Env Res 167: 598-618 (https://doi.org/10.1016/j.envres.2018.08.001). (November 2018)

Adams, G. D., R. T. Leaf, **J. C. Ballenger**, **S. A. Arnott**, & C. J. McDonough. 2018. Spatial variability in the growth of Sheepshead (*Archosargus probatocephalus*) in the southeast US: Implications for assessment and management: Fish Res 206: 35-43 (https://doi.org/10.1016/j.fishres.2018.04.023). (October 2018)

Wang, V. H., J. W. White, **S. A. Arnott**, & F. S. Scharf. 2018. Population connectivity of southern flounder in the US South Atlantic revealed by otolith chemical analysis. Mar Ecol Prog Ser 596: 165-179 (https://doi.org/10.3354/meps12576). (May 2018)

De Buron, I. K. M. Hill-Spanik, L. Haselden, S. D. Atkinson, S. L. Hallett, & **S. A. Arnott**. 2017. Infection dynamics of *Kudoa inornate* (Cnidaria: Myxosporea) in Spotted Seatrout *Cynoscion nebulosus* (Teleostei: Sciaenidae). Diseases of Aquatic Organisms 127(1): 29-40 (https://doi.org/10.3354/dao03174). (December 2017)

Peterson, C. D., C. N. Belcher, D. M. Bethea, W. B. Driggers III, **B. S. Frazier**, & R. J. Latour. 2017. Preliminary recovery of coastal sharks in the south-east United States. Fish & Fisheries 18(5): 845-859 (https://doi.org/10.1111/faf.12210). (September 2017)

Barker, A. M., **B. S. Frazier**, D. M. Bethea, J. R. Gold, & D. S. Portnoy. 2017. Identification of young-of-the-year Great Hammerhead Shark *Sphyrna mokarran* in northern Florida and South Carolina. J Fish Biol 91(2): 664-668 (https://doi.org/10.1111/jfb.13356). (August 2017)

Arnott, S. A., I. Dykova, **W. A. Roumillat**, & I. de Buron. 2017. Pathogenic endoparasites of the Spotted Seatrout, *Cynoscion nebulosus*: patterns of infection in estuaries of South Carolina, USA. Parasitology Research 116(6): 1729-1743 (https://doi.org/10.1007/s00436-017-5449-3). (June 2017)

Portnoy, D. S., C. M. Hollenbeck, D. M. Bethea, **B. S. Frazier**, J. Gelsleichter, & J. R. Gold. 2016. Population structure, gene flow, and historical demography of a small coastal shark (*Carcharhinus isodon*) in US waters of the Western Atlantic Ocean. ICES J Mar Sci 73(9): 2322-2332 (https://doi.org/10.1093/icesjms/fsw098). (September 2016)

Smylie, M. S., C. J. McDonough, L. A. Reed, & V. R. Shervette. 2016. Mercury bioaccumulation in an estuarine predatory: Biotic factors, abiotic factors, and assessments of fish health. Env Poll 214: 169-176 (https://doi.org/10.1016/j.envpol.2016.04.007). (July 2016)

Bowden, J. A., T. M. Cantu, R. W. Chapman, S. E. Somerville, M. P. Guillette, H. Botha, A. Hoffman, W. J. Luus-Powell, W. J. Smit, J. Lebepe, J. Myburgh, D. Govender, **J. Tucker**, A. S. P. Boggs, & L. J. Guillette Jr. 2016. Predictive blood chemistry parameters for pansteatitis-affected Mozambique Tilapia (*Oreochromis mossambicus*). PloS One 11(4): https://doi.org/10.1371/journal.pone.0153874. (April 2016)

Smylie, M., V. Shervette, & **C. McDonough**. 2016. Age, growth, and reproduction in two coastal populations of Longnose Gars. Trans Am Fish Soc 145(1): 120-135 (https://doi.org/10.1080/00028487.2015.1111256). (January 2016)

O'Donnell, **S. A. Arnott**, M. R. Denson, & T. L. Darden. 2016. Effects of cold winters on the genetic diversity of an estuarine fish, the Spotted Seatrout. Mar & Coast Fish 8(1): 263-276 (https://doi.org/10.1080/19425120.2016.1152333). (January 2016)

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Taliercio, M. A., T. L. Darden, V. A. Connors, **W. A. Roumillat**, & I. de Buron. 2016. Striped Bass, *Morone saxatilis*, a new intermediate host for the heterophyid *Ascocotyle nana*. Comparative Parasitology 83(1): 29-35 (https://doi.org/10.1654/1525-2647-83.1.29). (January 2016)

Hein, J. L., I. de Buron, **W. A. Roumillat**, W. C. Post, A. P. Hazel, & **S. A. Arnott**. 2016. Infection of newly recruited American Eels (*Anguilla rostrata*) by the invasive swimbladder parasite *Anguillicoloides crassus* in a US Atlantic tidal creek. ICES J Mar Sci 73(1): 14-21 (https://doi.org/10.1093/icesjms/fsv097). (January 2016)

Tables:

Table 1: Number of trammel net sets in each sampling stratum during July 1, 2020 – June 30, 2021.

	2020						2021						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Port Royal Sound		12	11		12	11		12	12	11	11		**92**
ACE Basin		12	12	10	13		12		11		12	11	**93**
Charleston Harbor	19	25	23	23	12	37	13	22	33	22	21	23	**273**
Cape Romain		11	9	11		12	11	12		12		12	**90**
Winyah Bay	12		10		12	12	13		13	11	10		**93**
Total	**31**	**60**	**65**	**44**	**49**	**72**	**49**	**46**	**69**	**56**	**54**	**46**	**641**

Table 2: Catch of species encountered by the trammel net survey during July 1, 2020 – June 30, 2021

	Common Name	**Scientific Name**	**# Caught**
1	Spotted Seatrout	*Cynoscion nebulosus*	2,978
2	Striped Mullet	*Mugil cephalus*	2,210
3	Atlantic Menhaden	*Brevoortia tyrannus*	1,039
4	Red Drum	*Sciaenops ocellatus*	1,037
5	Spot	*Leiostomus xanthurus*	853
6	Blue Crab	*Callinectes sapidus*	805
7	Atlantic Croaker	*Micropogonias undulatus*	643
8	Diamondback Terrapin	*Malaclemys terrapin centrata*	494
9	Longnose Gar	*Lepisosteus osseus*	399
10	Southern Flounder	*Paralichthys lethostigma*	357
11	Pinfish	*Lagodon rhomboides*	189
12	Gizzard Shad	*Dorosoma cepedianum*	166
13	Southern Kingfish	*Menticirrhus americanus*	150
14	Atlantic Stingray	*Dasyatis sabina*	141
15	Bonnethead	*Sphyrna tiburo*	134
16	Ladyfish	*Elops saurus*	124
17	Silver Perch	*Bairdiella chrysoura*	97
18	Black Drum	*Pogonias cromis*	82
19	American Harvestfish	*Peprilus paru*	60
20	Striped Burrfish	*Chilomycterus schoepfi*	53
21	White Mullet	*Mugil curema*	52
22	Cownose Ray	*Rhinoptera bonasus*	49
23	Horseshoe Crab	*Limulus polyphemus*	48
24	Sheepshead	*Archosargus probatocephalus*	48
25	Green Sea Turtle	*Chelonia mydas*	43
26	Hogchoker	*Trinectes maculatus*	40
27	Bluefish	*Pomatomus saltatrix*	34
28	Crevalle Jack	*Caranx hippos*	30
29	Bluntnose Stingray	*Dasyatis say*	27
30	Finetooth Shark	*Carcharhinus isodon*	18
31	Pigfish	*Orthopristis chrysoptera*	17
32	Northern Puffer	*Sphoeroides maculatus*	12
33	Lemon Shark	*Negaprion brevirostris*	11

Table 2: cont.

	Common Name	Scientific Name	# Caught
34	Blacktip Shark	*Carcharhinus limbatus*	9
35	Spanish Mackerel	*Scomberomorus maculatus*	9
36	White Catfish	*Ameiurus catus*	9
37	Atlantic Tripletail	*Lobotes surinamensis*	8
38	Summer Flounder	*Paralichthys dentatus*	8
39	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	7
40	Gray Snapper	*Lutjanus griseus*	4
41	Sandbar Shark	*Carcharhinus plumbeus*	4
42	Atlantic Spadefish	*Chaetodipterus faber*	3
43	Bighead Searobin	*Prionotus tribulus*	3
44	Permit	*Trachinotus falcatus*	3
45	Roughtail Stingray	*Dasyatis centroura*	3
46	Striped Bass	*Morone saxatilis*	3
47	Gafftopsail Catfish	*Bagre marinus*	2
48	Leatherjack	*Oligoplites saurus*	2
49	Lookdown	*Selene vomer*	2
50	Silver Seatrout	*Cynoscion nothus*	2
51	Tarpon	*Megalops atlanticus*	2
52	Atlantic Moonfish	*Selene setapinnis*	1
53	Atlantic Sturgeon	*Acipenser oxyrinchus*	1
54	Bay Whiff	*Citharichthys spilopterus*	1
55	Black Crappie	*Pomoxis nigromaculatus*	1
56	Butterfish	*Peprilus triacanthus*	1
57	Common Snook	*Centropomus undecimalis*	1
58	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	1
59	Hickory Shad	*Alosa mediocris*	1
60	Horse-Eye Jack	*Caranx latus*	1
61	Inshore Lizardfish	*Synodus foetens*	1
62	Oyster Toadfish	*Opsanus tau*	1
63	Smooth Butterfly Ray	*Gymnura micrura*	1
64	Striped Anchovy	*Anchoa hepsetus*	1
65	Weakfish	*Cynoscion regalis*	1
Total			**12,537**

Table 3: Number of biological samples collected during July 1, 2020 – June 30, 2021.

		Gear					
Sample	**Purpose**	**Electrofishing**	**Hook and Line**	**Longline**	**Trammel**	**Trawl**	Total
Digestive Tract	Microplastic Studies	132			41		**173**
Fillet	SCDHEC Mercury analysis	20	7		100		**127**
Fin Clip	Genetics	501	233	696	2,593	1,641	**5,664**
Otoliths	Ageing	98	154	79	555		**886**
Reproductive Tissue	Sex and maturity	81	78	78	329		**566**
Whole Specimen	Educational programs	31			84		**115**
Whole Specimen	Diamondback Terrapin Studies				50		**50**
Whole Specimen	Stock Enhancement Program Brood Stock			12	5		**17**
Whole Specimen	Parasite Study				4		**4**
Whole specimen	Largemouth Bass and Bowfin Evolution Study	4					**4**
Total		**867**	**472**	**865**	**3,761**	**1,641**	**7,606**

Table 4: Number of electrofishing sets made in each stratum during July 1, 2020 – June 30, 2021.

	2020						2021						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec[a]**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Combahee River		6	5	6	6			4	6	6	6	6	**51**
Edisto River	5		6	6	5		1	5	6	5	6		**45**
Ashley River	5	6		6	6		6	6	6		6		**47**
Cooper River	6	6	6	5				6	6	6	6		**47**
Winyah Bay	6	6	6	6	6		6	6	6	6		6	**60**
Total	**22**	**24**	**23**	**29**	**23**	**0**	**13**	**27**	**30**	**23**	**24**	**12**	**250**

[a] – Electrofishing boat was unavailable due to necessary mechanical repairs.

Table 5: Catch of species encountered by the electrofishing survey during July 1, 2020 – June 30, 2021.

	Common Name	**Scientific Name**	**# Caught**
1	Atlantic Menhaden	*Brevoortia tyrannus*	1,473
2	Spot	*Leiostomus xanthurus*	1,299
3	Striped Mullet	*Mugil cephalus*	1,075
4	Bay Anchovy	*Anchoa mitchilli*	496
5	Inland Silverside	*Menidia beryllina*	300
6	Blue Catfish	*Ictalurus furcatus*	290
7	Red Drum	*Sciaenops ocellatus*	246
8	Mummichog	*Fundulus heteroclitus*	200
9	Largemouth Bass	*Micropterus salmoides*	143
10	Longnose Gar	*Lepisosteus osseus*	125
11	American Eel	*Anguilla rostrata*	121
12	Southern Flounder	*Paralichthys lethostigma*	110
13	Silver Perch	*Bairdiella chrysoura*	75
14	White Catfish	*Ameiurus catus*	66
15	Atlantic Croaker	*Micropogonias undulatus*	60
16	Bowfin	*Amia calva*	59
17	Pinfish	*Lagodon rhomboides*	49
18	Bluegill	*Lepomis macrochirus*	48
19	Blueback Herring	*Alosa aestivalis*	47
20	Freshwater Goby	*Ctenogobius shufeldti*	46
21	Redear Sunfish	*Lepomis microlophus*	44
22	Western Mosquitofish	*Gambusia holbrooki*	40
23	Redbreast Sunfish	*Lepomis auritus*	39
24	Flathead Catfish	*Pylodictis olivaris*	23
25	American Shad	*Alosa sapidissima*	19
26	Common Carp	*Cyprinus carpio*	16
27	Striped Bass	*Morone saxatilis*	16
28	Brook Silverside	*Labidesthes sicculus*	14
29	Sheepshead	*Archosargus probatocephalus*	12
30	Gizzard Shad	*Dorosoma cepedianum*	11
31	Tidewater Mojarra	*Eucinostomus harengulus*	11
32	Golden Shiner	*Notemigonus crysoleucas*	8
33	Minnow - Species TBI	TBI Minnow Species	8
34	Threadfin Shad	*Dorosoma petenense*	8

Table 5: cont.

	Common Name	Scientific Name	# Caught
35	Hogchoker	*Trinectes maculatus*	7
36	Atlantic Needlefish	*Strongylura marina*	6
37	Spotted Sucker	*Minytrema melanops*	5
38	Channel Catfish	*Ictalurus punctatus*	4
39	Spinycheek Sleeper	*Eleotris pisonis*	4
40	Bay Whiff	*Citharichthys spilopterus*	3
41	Ladyfish	*Elops saurus*	3
42	Black Drum	*Pogonias cromis*	2
43	Chain Pickerel	*Esox niger*	2
44	Eucinostomus Species	*Eucinostomus* sp.	2
45	Grass Carp	*Ctenopharyngodon idella*	2
46	Highfin Goby	*Gobionellus oceanicus*	2
47	Rainwater Killifish	*Lucania parva*	2
48	Speckled Worm Eel	*Myrophis punctatus*	2
49	White Perch	*Morone americana*	2
50	Atlantic Stingray	*Dasyatis sabina*	1
51	Black Crappie	*Pomoxis nigromaculatus*	1
52	Brown Bullhead	*Ameiurus nebulosus*	1
53	Gray Snapper	*Lutjanus griseus*	1
54	Naked Goby	*Gobiosoma bosc*	1
55	Pumpkinseed	*Lepomis gibbosus*	1
56	Redfin Pickerel	*Esox americanus*	1
57	Sailfin Molly	*Poecilia latipinna*	1
58	Sheepshead Minnow	*Cyprinodon variegatus*	1
59	Spotted Seatrout	*Cynoscion nebulosus*	1
60	Spotted Sunfish	*Lepomis punctatus*	1
Total			**6,656**

Table 6: Number of one-third mile longline sets made during July 1, 2020 – June 30, 2021.

Stratum		**Month**					
Area	**Depth**	**August**	**September**	**October**	**November**	**December**	**Total**
Winyah Bay	Inner		10	8	11		**29**
	Outer		20	22	19		**61**
Charleston Harbor	Inner	8	3	10	8		**29**
	Outer	8	11	20	18	4	**61**
Saint Helena Sound	Inner	11		14	8		**33**
	Outer	19		16	12	10	**57**
Port Royal Sound	Inner	12		9	10		**31**
	Outer	18		21	6	14	**59**
TOTAL		**76**	**44**	**120**	**92**	**28**	**360**

Table 7: Catch of species encountered by the SCDNR longline survey during July 1, 2020 – June 30, 2021.

	Common Name	**Scientific Name**	**# Caught**
1	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	1,007
2	Red Drum	*Sciaenops ocellatus*	695
3	Sandbar Shark	*Carcharhinus plumbeus*	195
4	Blacknose Shark	*Carcharhinus acronotus*	130
5	Southern Stingray	*Hypanus americanus*	91
6	Finetooth Shark	*Carcharhinus isodon*	78
7	Bonnethead	*Sphyrna tiburo*	65
8	Blacktip Shark	*Carcharhinus limbatus*	54
9	Spinner Shark	*Carcharhinus brevipinna*	33
10	Black Sea Bass	*Centropristis striata*	14
11	Atlantic Stingray	*Hypanus sabinus*	11
12	Oyster Toadfish	*Opsanus tau*	11
13	Smooth Butterfly Ray	*Gymnura micrura*	7
14	Cownose Ray	*Rhinoptera bonasus*	6
15	Scalloped Hammerhead	*Sphyrna lewini*	6
16	Lemon Shark	*Negaprion brevirostris*	5
17	Bull Shark	*Carcharhinus leucas*	3
18	Gafftopsail Catfish	*Bagre marinus*	3
19	Whiting	*Menticirrhus americanus*	3
20	Atlantic Croaker	*Micropogonias undulatus*	2
21	Bluntnose Stingray	*Hypanus say*	2
22	Great Hammerhead	*Sphyrna mokarran*	2
23	Bluefish	*Pomatomus saltatrix*	1
24	Bullnose Ray	*Myliobatis freminvillii*	1
25	King Mackerel	*Scomberomorus cavalla*	1
26	Ladyfish	*Elops saurus*	1
27	Longnose gar	*Lepisosteus osseus*	1
28	Nurse Shark	*Ginglymostoma cirratum*	1
29	Pigfish	*Orthopristis chrysoptera*	1
30	Roughtail Stingray	*Bathytoshia centroura*	1
31	Southern Flounder	*Paralichthys lethostigma*	1
32	Tiger Shark	*Galeocerdo cuvier*	1
33	Unidentified Stingray	*Hypanus* sp.	1
Total			**2,434**

Table 8: Number of Estuarine Trawl Survey trawls monitored for finfish from July 1, 2020 – June 30, 2021.

	2020						2021						
Stratum	**Jul[a]**	**Aug[a]**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Charleston Harbor			2	2	2	2	2	2	2	2	2	2	**20**
Ashley River			2	2	2	2	2	2	2	2	2	2	**20**
Stono River/Kiawah River						3				3			**6**
ACE Basin						4				5			**9**
Port Royal Sound						1				2			**3**
Calibogue Sound						3				4			**7**
Total	**0**	**0**	**4**	**4**	**4**	**15**	**4**	**4**	**4**	**18**	**4**	**4**	**65**

[a] – No estuarine trawl survey sampling occurred during July and August due to ongoing COVID-19 social distancing protocols.

Table 9: Catch of finfish species encountered by the SCDNR estuarine trawl survey during July 1, 2020 – June 30, 2021.

	Common Name	Scientific Name	# Caught
1	Star Drum	*Stellifer lanceolatus*	62,126
2	Atlantic Croaker	*Micropogonias undulatus*	18,380
3	Bay Anchovy	*Anchoa mitchilli*	14,310
4	Spot	*Leiostomus xanthurus*	5,028
5	Silver Seatrout	*Cynoscion nothus*	1,256
6	Blackcheek Tonguefish	*Symphurus plagiusa*	1,152
7	Bighead Searobin	*Prionotus tribulus*	1,123
8	Spotted Hake	*Urophycis regia*	557
9	Hogchoker	*Trinectes maculatus*	452
10	Atlantic Cutlassfish	*Trichiurus lepturus*	295
11	Weakfish	*Cynoscion regalis*	289
12	Fringed Flounder	*Etropus crossotus*	262
13	Silver Perch	*Bairdiella chrysoura*	238
14	Southern Kingfish	*Menticirrhus americanus*	233
15	Atlantic Menhaden	*Brevoortia tyrannus*	158
16	Atlantic Moonfish	*Selene setapinnis*	146
17	Butterfish	*Peprilus triacanthus*	97
18	Southern Flounder	*Paralichthys lethostigma*	89
19	Lookdown	*Selene vomer*	63
20	White Catfish	*Ameiurus catus*	61
21	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	48
22	Striped Anchovy	*Anchoa hepsetus*	43
23	Atlantic Bumper	*Chloroscombrus chrysurus*	42
24	American Harvestfish	*Peprilus paru*	38
25	Bay Whiff	*Citharichthys spilopterus*	37
26	Banded Drum	*Larimus fasciatus*	34
27	Atlantic Stingray	*Dasyatis sabina*	33
28	Spotted Seatrout	*Cynoscion nebulosus*	25
29	Threadfin Shad	*Dorosoma petenense*	24
30	Cynoscion Seatrout	*Cynoscion* sp.	18
31	Atlantic Silverside	*Menidia menidia*	13
32	Leopard Searobin	*Prionotus scitulus*	13
33	Oyster Toadfish	*Opsanus tau*	13
34	Pinfish	*Lagodon rhomboides*	10
35	Atlantic Spadefish	*Chaetodipterus faber*	8
36	Blue Catfish	*Ictalurus furcatus*	8
37	Smooth Butterfly Ray	*Gymnura micrura*	8
38	Highfin Goby	*Gobionellus oceanicus*	7
39	Guaguanche	*Sphyraena guachancho*	6
40	Spanish Mackerel	*Scomberomorus maculatus*	6
41	Northern Puffer	*Sphoeroides maculatus*	5
42	Shrimp Eel	*Ophichthus gomesii*	5
43	Blueback Herring	*Alosa aestivalis*	4
44	Northern Pipefish	*Syngnathus fuscus*	4
45	Southern Hake	*Urophycis floridana*	4

Table 9: cont.

	Common Name	Scientific Name	# Caught
46	Freshwater Goby	*Ctenogobius shufeldti*	3
47	Naked Goby	*Gobiosoma bosc*	3
48	Planehead Filefish	*Stephanolepis hispidus*	3
49	Striped Burrfish	*Chilomycterus schoepfi*	3
50	Bluefish	*Pomatomus saltatrix*	2
51	Feather Blenny	*Hypsoblennius hentz*	2
52	Gizzard Shad	*Dorosoma cepedianum*	2
53	Rock Sea Bass	*Centropristis philadelphica*	2
54	Skilletfish	*Gobiesox strumosus*	2
55	Striped Cusk-Eel	*Ophidion marginatum*	2
56	Summer Flounder	*Paralichthys dentatus*	2
57	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	1
58	Atlantic Sturgeon	*Acipenser oxyrinchus*	1
59	Atlantic Thread Herring	*Opisthonema oglinum*	1
60	Black Drum	*Pogonias cromis*	1
61	Bluntnose Stingray	*Dasyatis say*	1
62	Chain Pipefish	*Syngnathus louisianae*	1
63	Darter Goby	*Ctenogobius boleosoma*	1
64	Gafftopsail Catfish	*Bagre marinus*	1
65	Inshore Lizardfish	*Synodus foetens*	1
66	Speckled Worm Eel	*Myrophis punctatus*	1
Table			**106,807**

Table 10: Fish acquired from the freezer and tournament monitoring programs during July 1, 2020 – June 30, 2021.

Species	Freezer	Tournament	Total
Black Drum	2		**2**
Gulf Kingfish	1		**1**
Red Drum	1		**1**
Sheepshead	83	53	**136**
Southern Flounder	1	73	**74**
Southern Kingfish	16		**16**
Weakfish		2	**2**
Total	**104**	**128**	**232**

Table 11: Fish tagged by the trammel net and electrofishing surveys during July 1, 2020 – June 30, 2021.

Species	Electrofishing	Trammel	TOTAL
Black Drum	1	45	**46**
Red Drum	164	716	**880**
Sheepshead	2	30	**32**
Southern Flounder	19	150	**169**
Total	**186**	**941**	**1,127**

Table 12: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2020 – June 30, 2021.

Capture Method	Disposition	Black Drum	Red Drum	Sheepshead	Southern Flounder	Total
Anglers	Harvested	4	29	1	5	**39**
	Released	4	308	1	5	**318**
	Anglers: sub-total	8	337	2	10	**357**
SCDNR Surveys	Harvested					**0**
	Released	4	53			**57**
	Survey: sub-total	4	53	0	0	**57**
Total		**12**	**390**	**2**	**10**	**414**

Figures

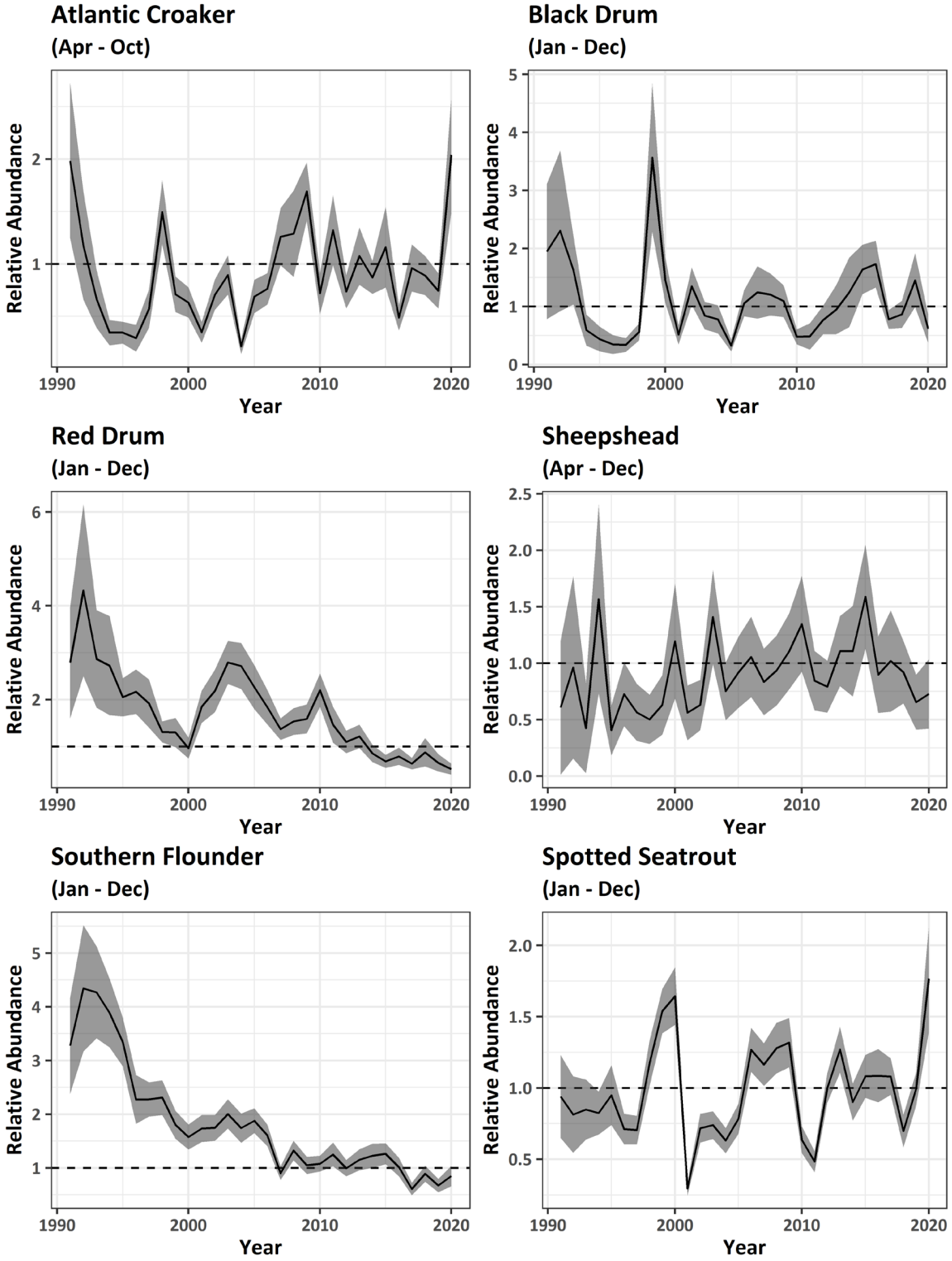


Figure 1: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR trammel net survey. Vertical axis is a relative index of fish abundance, with annual average catch shown relative to 2010-2020 average catch (dashed black line).

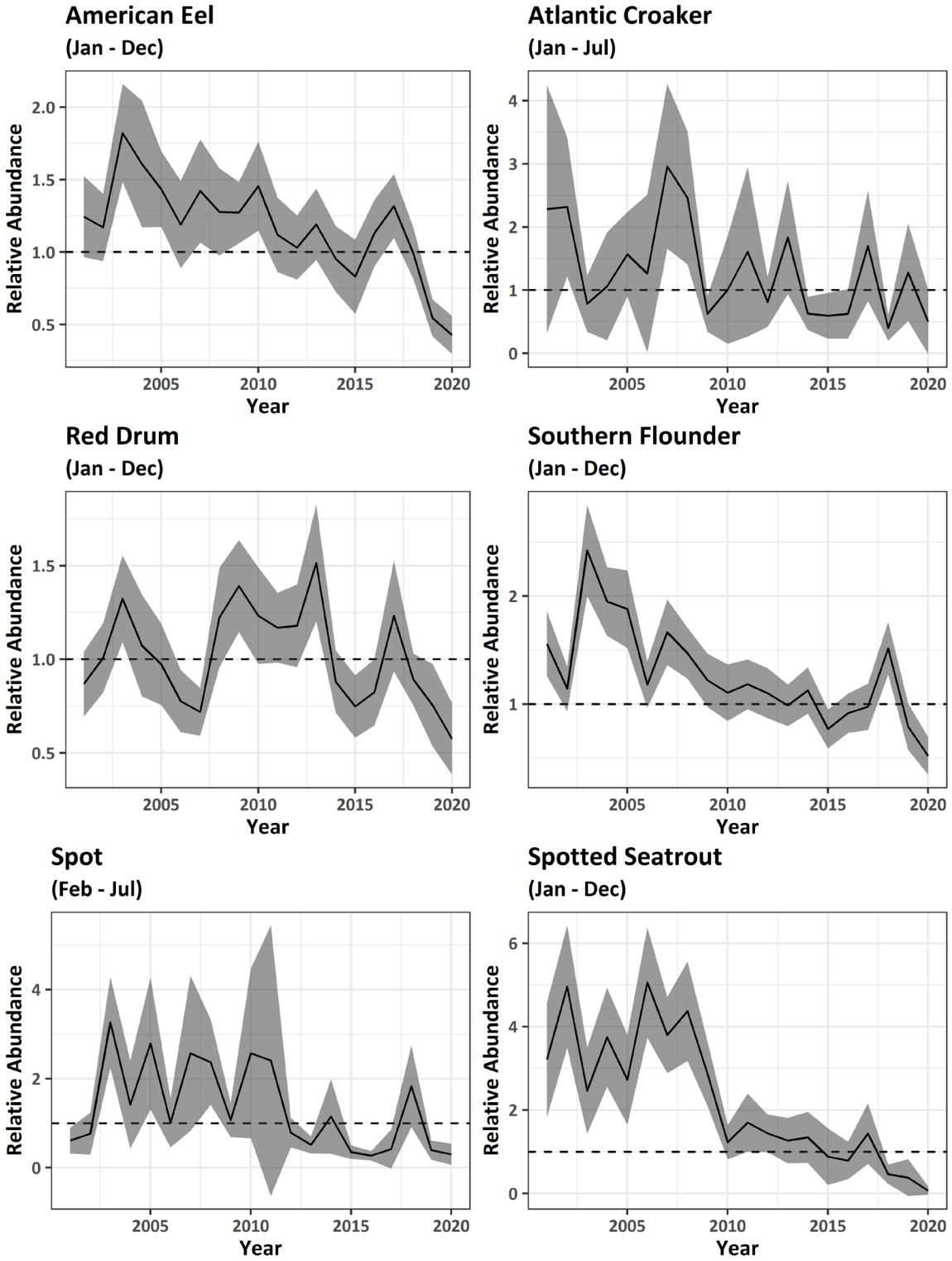


Figure 2: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR electrofishing survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes electrofishing shown relative to 2010-2020 average catch per 15 minutes electrofishing (dashed black line).

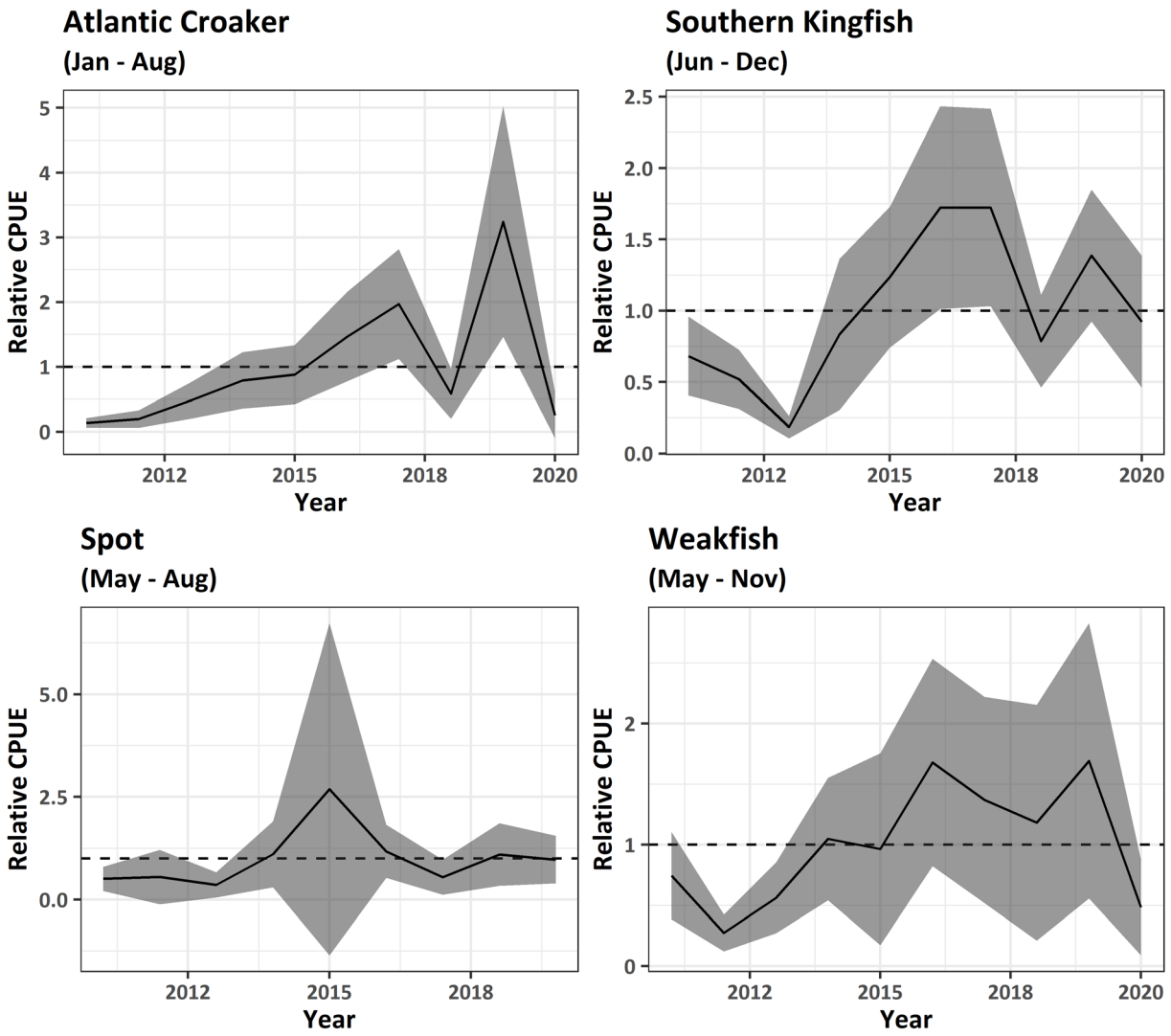


Figure 3: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR estuarine trawl survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes trawling shown relative to time series average catch per 15 minutes trawling (dashed black line). Note, estuarine trawl efforts in 2020 severely affected by vessel availability and COVID-19 social distancing protocols so we advise interpreting 2020 trends with caution.

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, 2020 - June 30, 2021

Introduction:

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

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

Project Objectives:

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

Summary of Accomplishments/Activities:

***2020 Production*:** Four unique genetic families (HML118, HML119, NWL1, and OWL 3) contributed to the 2020 YC stock enhancement releases. Three estuaries were stocked including Port Royal Sound, Charleston Harbor (Wando and Ashley Rivers), and North Edisto River. With

the exception of one release of medium size fish (194.08 avg. TL), the majority of fish produced for YC 2020 releases were small (30.78-50.4 avg. TL by release) with stocking of small fish occurring from 9/10/2020-10/15/2020 and the medium fish released on 2/18/2021.

The red drum stocking strategy for 2020 was to evaluate contribution of small juvenile red drum (~30-50 mm TL) to the wild population from different release and time of year strategies. For the Wando River, fish were released by boat either early and late in the season and in the Ashley, fish were released directly from the hauling trailer at a boat ramp early and late in the season in order to evaluate differences between release timing via the most optimal/accessible release method for each system. One family was stocked into the Port Royal Sound, but no design was employed. This family was excess fish from a previous harvest that grew too large for the release treatment in other systems.

Only one family was stocked into the North Edisto so no comparative questions can be addressed. Movement and contribution, however, will be evaluated.

Ashley River: A total of 284,105 small juvenile red drum (mean TL 33.2 mm) from NWL1 were released at the W.O. Thomas Jr. boat landing for the early release treatment. Releases occurred on 9/11/2020 (183,031 fish), 9/21/2020 (17,469 fish), and 9/24/2020 (83,605 fish). A total of 339,498 juvenile red drum (mean TL 41.0 mm) were released at the W.O. Thomas Jr. boat landing for the late release treatment. Releases occurred 12/10/2020 (172,792 fish) and 12/13/2020 (166,706 fish).

Wando River: A total of 303,801 small juvenile red drum (mean TL 50.4 mm) from OWL3 were released in Foster Creek via boat for the early release treatment. Releases occurred on 9/10/2020 (72,345 fish), 9/22/2020 (74,338 fish), 9/23/2020 (82,274 fish), and 10/1/2020 (74,844 fish). A total of 411,452 juvenile red drum (mean TL 35.4 mm) from NWL1 were released in Foster Creek via boat for the late release treatment. Releases occurred on 11/19/2020 (117,240 fish) and 12/8/2020 (294,212 fish).

North Edisto: One genetic family (HML 118) was spawned at MRRI and 2 dph larvae provided to Bears Bluff National Fish Hatchery (BBNFH) for stocking into ponds at their facility on Wadmalaw Island, SC. A total of 447,682 small juvenile red drum (mean TL 31.90 mm) were released on five separate days from boat by staff at BBNFH in three different creeks within the North Edisto. Leadenwah Creek received 155,430 small juvenile red drum (mean TL 30.14 mm) on 10/5/2020 and 10/15/2020. Bohicket Creek received a total of 197,839 small red drum (mean TL 30.4 mm) on 10/8/2020. Finally, Adams Creek received 94,413 small juvenile red drum (mean TL 32.65 mm) on 10/20/2020 and 10/22/2020.

Port Royal Sound: One unique genetic family (OWL3) released directly from the hauling trailer (mean TL 194.08 mm) at the Trask Boat Landing into the Colleton River on 2/18/2021.

Table 1. Stocking information for the 2020YC juvenile hatchery red drum.

Avg. TL	Number Released	Release Location	Treatment
50.4	303,801	Wando River	Boat/Early
33.2	284,105	Ashley River	Trailer/Early
35.4	411,452	Wando River	Boat/Late
41	339,498	Ashley River	Trailer/Late
30.78	447,682	North Edisto	N/A
194.08	2,803	Port Royal Sound	N/A

***Contribution**:*

Out of a total of 172 red drum tissue samples from 2019YC individuals collected during July-December 2020, 170 samples were included in the analysis of contribution to the ACE Basin, North Edisto River, Port Royal Sound, and Winyah Bay. One sample was removed after being determined to be a recapture of an earlier fish and another was removed because contamination prevented genotyping. A total of 21 cultured fish were recaptured for an overall hatchery contribution of 12.4% from stocking effort in 2019.

In the ACE Basin, 34 tissue samples were included in the analysis and there were no cultured fish recaptured for a stocked contribution of 0%. In Winyah Bay, 77 tissue samples were included in the analysis and 9 cultured fish were recaptured for a hatchery contribution of 11.7%. In the North Edisto River, 46 tissue samples were included in the analysis and 11 cultured fish were recaptured, with 23.9% hatchery contribution.

In the Port Royal Sound, 13 tissue samples were included in the analysis and 1 cultured fish was recaptured for a hatchery contribution of 7.7%. The number of 2019YC 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.

ACE Basin: As was the case in 2017 and 2018, there was no hatchery contribution in the ACE basin from stocking efforts in 2019. There were two releases that occurred in Oct. 2019 of 34,822 and 27,914. 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 2019YC is likely due to the low release numbers and the abundance of habitat that is available to young of the year red drum that is not sampled by the Inshore Fisheries Section. This year represents the first time fish

were released at Live Oak Boat Landing. This location was chosen due to the proximity to the trammel net survey compared to relatively long-distance Bennett's Point is from the survey.

Winyah Bay: In Winyah Bay, the brackish water release near the mouth of the Waccamaw River resulted in 6 recaptures and a recapture rate of 0.004%. The saltwater release had 3 recaptures, and a recapture rate of 0.0023%. Releases took place over one week in September 2019 and spanned five release sites. This is the second year that a comparison between hatchery fish released into brackish water versus saltwater was compared. Unlike in 2017, fish in the two salinities were released in multiple locations to eliminate the chance that the comparison was testing a release location instead of a release salinity. In both years, fish were stocked at similar numbers and size, however in 2017 fish stocked at the saltwater release location were stocked into the brackish water a month later. In both years, 2017 and 2019, the brackish water release contributed higher to the wild population (2017: 7.1% brackish versus 0.9% saltwater 2019: 7.8% brackish versus 3.9% saltwater). The higher contribution from the saltwater releases in 2019 compared to 2017 could be attributed to the timing of release, the slightly higher TL of the saltwater release, and/or the distribution of fish within the salinity treatment. A greater question is why fish stocked into brackish water contribute more to the wild population in Winyah Bay. It is possible that juvenile red drum require lower salinities than older red drum, that food availability for juvenile red drum is higher in these lower salinity regions of Winyah Bay, or fish released in the higher salinities are not accounted for in the Inshore Fishery surveys due to migration out of the system. The proximity to North Inlet, the Intercoastal Waterway, and the mouth of Winyah Bay provide a greater opportunity for the saltwater released juveniles to leave the system thus having a lower contribution to Winyah Bay. Replicating this experiment in a more confined system like the Ashley River would provide researchers a better experimental design to test this question.

In 2020, 5 hatchery fish were recaptured by trammel netting for 6.5% contribution and accounted for 10% of the trammel net samples, while 4 hatchery fish were recaptured with electrofishing for 5.2% contribution, accounting for 14.8% of the electrofishing samples. This observation could potentially be due to twice as many samples being collected in the lower estuary (trammel net). This is in contrast to the 2013YC where hatchery individuals made a higher contribution to the trammel netting samples (38.5%) than to the electrofishing samples (20%), but is similar to what was seen for other year classes where hatchery individuals made a higher contribution to the electrofishing samples (2012YC: 25%; 2014YC: 21.4%; 2015YC: 21.6%; 2016YC: 37.2%; 2017YC: 13.2%; 2018YC: 56.3%) than to the trammel netting samples (2012YC: 4.7%; 2014YC: 7.1%; 2015YC: 6%; 2016YC: 3.4%; 2017YC: 3.3%; 2018YC: 32.4%).

Hatchery contributions for the 2019YC was 11.7% (Table 2), joining other years of moderate contribution (2004YC, 2007YC, 2008YC, 2012YC, 2014YC, 2015YC, 2017YC). This was a large decline after the record high contribution from the 2018 YC, which may be due to increased wild recruitment after a calm hurricane season in SC. Historically, the number of small juvenile red drum released in 2005, 2013 and 2016 was greater than in 2012 and 2014

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. The 2018YC had record high contribution despite modest stocking numbers of small sized individuals and a small number of medium sized red drum released in the spring, which may have been the result of wild recruitment in the area being depressed due to the significant flooding caused by Hurricane Florence.

Table 2. The number of fish stocked for a given year class and their percent contribution in Winyah Bay.

Year Class	# Stocked	% Contribution
2004	984,702	11.50%
2005	853,859	35.30%
2007	587,157	13.70%
2008	417,651	16.10%
2012	148,787	12.80%
2013	411,086	25.00%
2014	287,520	14.30%
2015	11,643	12.70%
2016	518,407	27.60%
2017	972,973	8.00%
2018	214,985	40.00%
2019	280,773	11.70%

North Edisto River: In the North Edisto River there were 11, 2019YC hatchery fish captured; 10 near the Maybank dock boat landing at the mouth of Bohicket Creek, and 1 in Leadenwah Creek. Hatchery contribution in the North Edisto was 23.9%, with 21.7% contribution in Bohicket Creek and 2.2% in Leadenwah Creek. This lower contribution rate in Leadenwah is surprising since half of the fish released into the North Edisto were released into Leadenwah Creek. However, all samples collected in the North Edisto were captured in Bohicket Creek except the one hatchery fish caught in Leadenwah Creek. Efforts are underway by Bears Bluff National Fish Hatchery to expand the capture area of YOY red drum. 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 2019YC 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 hatchery contribution.

Spotted Seatrout:

2020 Production*:* No production. Wild seatrout populations, both inside and outside of previously stocked estuaries, monitored by SCDNR's inshore fisheries group have naturally responded well to recent cold winter events so we have made the decision to scale back seatrout production and capacity in favor of an increased focus on cobia. We still maintain a limited capacity to produce seatrout, and therefore expand the program again rapidly, if need be, through the maintenance of a broodstock system if a stocking response is needed.

Evaluation of 2018 and 2019 YC Stockings:

To evaluate the contribution of stocked juvenile spotted seatrout, a total of 550 fin clip tissue samples were processed from spotted seatrout collected in the Charleston Harbor system from September-December during monthly independent random sampling in 2020.

Overall, 29 hatchery spotted seatrout representing two year classes were collected in 2020. Movements from the Ashley River or Charleston Harbor into the Wando or Cooper Rivers have been very rare over time (n=1) and 2020 was no exception, as all hatchery fish were collected on the southern shore of Charleston Harbor or in the Ashley River. As in previous years, movement of hatchery fish between Charleston Harbor and the Ashley River occurred (n=1 from CH to AR and n=1 from AR to CH). These strata represent a geographic continuum and movements between the two strata can occur without crossing the open Charleston Harbor system. These results suggest that seatrout contributions may be localized to the stocking location and adjacent areas. Efforts to increase contribution on a system-wide basis may require multiple stocking locations over the entire area.

The overall stocking question for the 2019YC was to evaluate contribution to the wild population using either trailer or boat releases of stocked small juvenile seatrout in three locations in the Charleston Harbor system (Charleston Harbor, Ashley River, and Wando River). Due to poor pond production for one family, only five families/treatments were used and there was no Wando River boat release. When comparing the trailer and boat releases for the Charleston Harbor and Ashley River, the trailer releases did have slightly higher contributions, but there were too few hatchery fish collected to statistically evaluate a difference in treatments. In both cases, total release numbers also appeared to influence contribution with the greatest release numbers yielding the highest return rates.

The 9.0% hatchery contribution from the 2019YC is a slight decrease from the 11.5% contribution from this YC at age 0. A similar decrease in contribution estimates from age 0 to age 1 fish has previously been observed in the 2012, 2013, 2014, 2015, 2017, and 2018YCs. This decrease from age 0 to age 1 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 0, and there was a 1.3% contribution from age 1 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 9.0% hatchery contribution from the 2019YC at age 1 is about average when looking across YCs (Table 3). The 5.9% (n=2) hatchery contribution from the 2018YC is much lower than its contribution in 2019 (12.3%). The lack of hatchery fish from the 2015 and 2016YCs was likely due to the fact that only one individual was collected from each YC, suggesting gear selectivity is occurring causing older individuals within the population not to be sampled. There were no hatchery or otolith-aged fish collected from the 2017YC, but there were 10 times fewer otolith-aged individuals as normal due to COVID-19. We are unable to tell if cultured fish from the 2017YC were not sampled due to gear selectivity, or if this YC of stocked fish are contributing at a low level that is not detected with our sampling.

Table 3. Contribution at age 1 across year classes. All contribution statistics are calculated for the entire Charleston Harbor system.

Year Class	Contribution at Age 1
2012	2.2%
2013	3.1%
2014	9.2%
2015	24.2%
2016	1.3%
2017	7.3%
2018	12.3%
2019	9.0%

Cobia:

***Sample Collection**:* Mariculture staff have been collecting cobia carcasses from recreational anglers as well as from tournaments over the last 10 years. Because of cobia fishing closures in state and federal waters in recent years, collection of cobia in the Port Royal and St. Helena sounds as well as offshore to produce life history information has not occurred.

The federal government opened the fishery in 2018, however the inshore fishery remained closed during May which coincides with the peak of inshore intercepts in South Carolina. A total of 21 samples were collected from offshore and fish captured inshore outside of the May closure through a cooler program working cooperatively with local charter boat captains which includes fish racks, genetic samples, and catch information. Our cooperative fin clip program provided an additional 148 samples collect from offshore Charleston south into upper Georgia waters. An additional 69 genetic samples were collected in collaboration with our federally-funded NOAA CRP project. Genetic samples of all cobia are utilized to evaluate population structure as well as identify the contribution of stocked fish to the population. Due to CoVid 19, no fishing tournaments were held during the spring cobia migration.

***Broodstock Collection and Production**:* 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. Nine wild cobia were collected by cooperating recreational anglers and SCNDR staff in the Broad River and transported back to WMC for use as broodstock. Cobia were prophylactically treated for any external parasites and introduced to flow-through tanks at WMC. We have continued the vitamin addition to the broodstock diet regime for cobia at MRRI and WMC in hopes of filling any maternal nutritional gaps present and improving spawn quality. Cobia broodstock at MRRI and WMC were injected with spawning hormones as well as allowed to spawn volitionally and multiple families produced viable eggs which were hatched and stocked into ponds at the WMC. Four releases totaling 13,741 juvenile cobia occurred during this reporting period. Three releases came from a WMC family of cobia (WMCSC8) and one from an MRRI family (OWL1). WMCSC8 releases occurred on 7/22/2020 (2,014 fish, 74.7 avg. TL), 7/30/2020 (6,348 fish, 76.3 avg. TL), and 7/31/2020 (3,976 fish, 76.3 avg TL) and the OWL1 release occurred on 7/30/2020 (1,403 fish, 113.08 avg. TL).

***Contribution**:* A total of 247 cobia genetic samples were processed this year from all collection sources. Overall, 14 cultured fish were captured in the 2020 collections (all fish sampled in all locations) for a total hatchery contribution of 5.8%. 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 was 6.9%. Furthermore, when samples were separated into Atlantic and Gulf of Mexico stocks using Cape Canaveral, FL as a stock boundary, the contribution to the Atlantic stock was 7.0%. As expected, there was no contribution to the Gulf of Mexico stock.

For the South Carolina collections, the total contribution was 7.3%. Hatchery contribution was only seen from the inshore samples within the Broad River (where stocking occurred) at 21.2% (n=14), with no hatchery contribution from offshore. Due to the fishing closure within the Port Royal and St. Helena Sounds during the May peak collection period, samples from inshore were limited primarily to genetic fin clips. Contribution based on year class could not be determined due to a lack of otolith data for cultured fish. When looking at hatchery contribution by year class across collection years (using only genetic designation for year class), the 2017YC had a much higher inshore contribution in 2020 compared to 2019 (19.7% vs. 12.9%). The 2012YC had higher inshore contributions in 2015 and 2016 (22.2% and 20.0%, respectively), but there were a small number of inshore samples collected overall in those years (9 and 5, respectively). There has been no hatchery contribution from offshore by the 2017YC in 2019 or 2020. The 2012YC also had no hatchery contribution from offshore in 2020, although there have been low levels of offshore contribution in last years (0.7% to 1.6%).

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. Likewise, genetic data suggest that all cultured fish from the 2017YC to date have been offspring from the parental cross of CB084 and CB085 even though there were two males and two females in the spawning tank. Year class could not be verified for any of the cultured fish due to a lack of otolith data. 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 ever been caught from the 2009YC to date.

Development, Optimization, and laboratory testing of eDNA Tool to investigate DNA accumulation/degradation and biomass*:* In an effort exploring new tools to assess the status of the inshore distinct population segment (DPS) of cobia in Port Royal Sound (PRS) SC, we developed and optimized an environmental DNA (eDNA) detection tool. The ultimate goal of the tool will be relating quantities of cobia eDNA found in water sample to a measure of biomass or abundance. Here we present the first steps required to determine the plausibility of relating eDNA detections to biomass. During this funding cycle, we designed PCR primers that will only amplify cobia DNA. To reduce background signal and decrease the chances of false positives, an internal hydrolysis probe was designed and optimized into a qPCR assay. Initial laboratory testing was conducted using our cobia broodstock tanks at the Marine Resources Research Institute (MRRI), Charleston. These tests use a series of diluted cobia broodstock tank water to test the functionality and sensitivity of the qPCR assay to detect cobia DNA from filtered water samples. The optimized assay can detect minute amounts of cobia DNA found in filter water samples.

After optimization and laboratory testing, we conducted two controlled experiments to investigate how cobia DNA accumulates and degrades in water sample over time with varying densities of fish. These studies were conducted at the Hollings Marine Laboratory (HML), Charleston and at WMC. At the HML we utilized 3 tanks system each with 8 tanks. In each system, 4 tanks were experimental and 4 were used as barriers to cross contamination. Our experimental tanks contained one of 4 densities of hatchery produced juvenile cobia: 0 cobia, 1 cobia, 5 cobia, and 10 cobia. Water sampling for eDNA occurred on day 0 (before fish were added), 1, 2, 3, 4, 7, and 10 to evaluate DNA accumulation. After day 10, ~ 55 L of water from each experimental tank was siphoned into a secondary covered container from which water sampling for eDNA occurred on day 1, 2, 3, 5, 7, and 11 to evaluate DNA degradation. Not all filtered water samples have been processed to date; however, our preliminary results are showing consistent differences between the amount of cobia DNA between densities of 1 and 5-10 fish (Figure 1). Once all samples have been processed, we will better understand the dynamics of DNA accumulation/degradation and biomass in these systems.

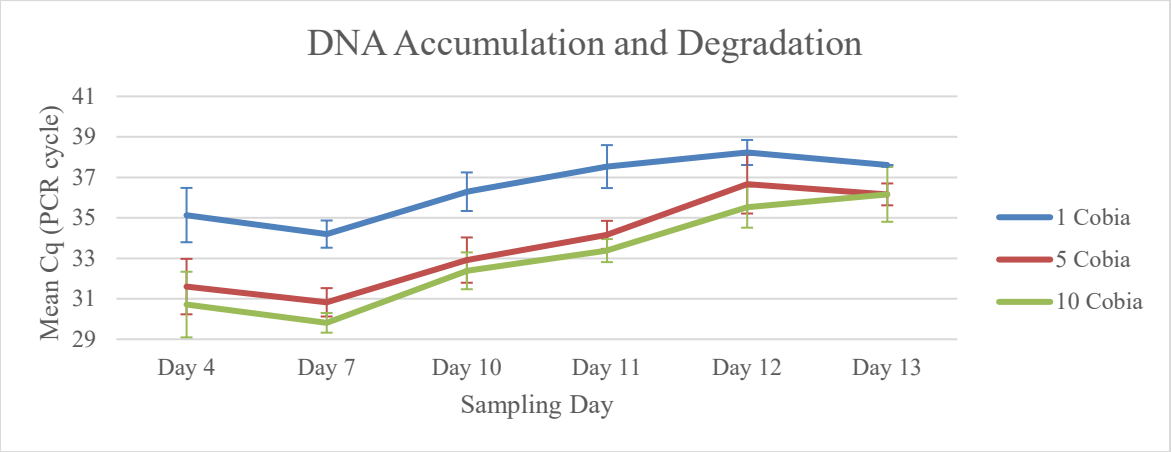


Figure 1. Mean Cq values for our DNA accumulation/degradation samples processed to date. Cobia were not present in the water sampled after the Day 10 sampling event (i.e. Day 11 marks the beginning of the DNA degradation period). Larger Cq values on the y-axis indicated lower levels of DNA detected.

At WMC we utilized a tank housing 4 adult broodstock cobia to investigate DNA degradation in an outdoor environment. Ultra-violet light, along with other environmental conditions, affect the rate at which DNA degrades. Testing in the outdoor environment is more similar to conditions that we might encounter while sampling in PRS. Water samples were collected and filter while the broodstock were in the tank, right after they were moved out of the tank, and for the next 6 days. We found that cobia DNA was detectable up to 4 days after the fish were removed, with a steep drop in the amount of detectable DNA between days 2-3. These results suggest that if cobia DNA is detected in PRS, cobia were likely present within the past few days.

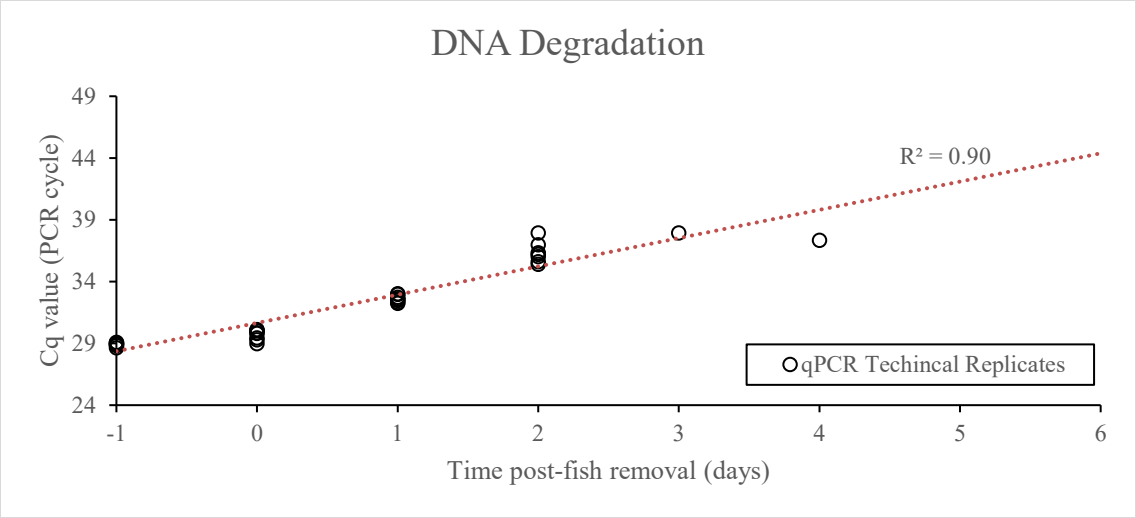


Figure 2. Scatter plot of cobia DNA degradation showing time after cobia broodstock were removed verse the amount of DNA detected. Larger Cq values on the y-axis indicated lower levels of DNA detected.

These experiments in closed systems will allow us to understand the dynamics of cobia eDNA in a controlled environment, which is the first step towards developing a robust eDNA sampling program. Translating our results and conclusion to what we may find cobia's natural environment presents a challenge given the dynamics of coastal and estuarine habitats, specifically Port Royal Sound (PRS) in South Carolina - host of a genetically distinct spawning aggregation. Field samples have been collected from PRS at various times of the year, specifically in and out of the know spawning season and at different tide and moon cycles. A total of 143 filtered water samples have been collected and are being stored at -20 °C. We are in the process of analyzing the remaining field ample filters.

Evaluation of Side Scan Sonar Tool*:* Side scan sonar has recently been utilized to assess total abundance of a multiple species including sturgeon, alligator gar, and reef fish species. Effectiveness of this tool is still being evaluated but promising results have been seen in larger, unique bodied species particularly sturgeon, that inhabit ecosystems with minimal species of similar size and shape. The goal during this reporting period was to conduct a pilot scale study to examine if side scan sonar technology could be used to obtain abundance estimates for cobia in our southern distinct population segment.

SCDNR's artificial reef program provided an Edgetech 4125 dual frequency 1600/60 hx towfish and one staff member familiar with its operation during the height of the cobia aggregation inshore. Multiple transects were conducted around known capture locations within the Port Royal Sound to maximize chances of encountering cobia. Images were processed utilizing Sonarwiz 7 software creating a contour map of the bottom with specific "artifacts" or potential

fish species visible. Each “artifact” was measured to determine if size was within known cobia measurements. Resulting images were inconclusive particularly with species identification. Multiple shark species are the most likely animals of similar size and shape to cobia we would encounter and can sometimes be differentiated based on the triangular shaped dorsal fin signal created by the sonar. Unfortunately, fish need to be oriented parallel to the boat track, within the water column, and close enough to the boat to provide clear images. Weather conditions also play an important role in image clarity with increased wave action causing images to look choppy and unrecognizable. This may be the most difficult hurtle to overcome since the month of May is associated with increased winds from passing cold fronts creating choppy conditions.

Based on results from this pilot scale study, additional testing would need to be performed during ideal, calm conditions to determine if cobia can be identified compared to the many shark species within the river. If it is determined cobia can be differentiated, a scientific based survey of the river needs to be developed and conducted over multiple years to examine potential changes to cobia abundance.

Management Implications:

The stocking results presented here build upon our comprehensive applied fisheries research programs to provide sound scientific data upon which appropriate and responsible natural resource management decisions are based. Red drum, spotted seatrout, and cobia are three of the most important recreational sportfish in SC. The Marine Resources Division is coordinating efforts to more efficiently and effectively evaluate the most pressing questions associated with these species using applied and conventional fishery research techniques. The information gained will enhance the effectiveness of the SCDNR in addressing natural resource issues by refining stocking strategies to improve survival and contribution, as well as address the impacts of population growth, habitat loss, environmental alterations, and other challenges faced in protecting, enhancing, and managing these valuable resources. Results from this research will also allow managers to utilize the most effective stocking strategies given local characteristics, improve enhancement efficiency, and increase post-stocking survival while providing data that will allow us to better understand ecosystem limitations to full recruitment. Our stock enhancement research programs not only 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

Reporting Period: July 1, 2020 – June 30, 2021

Project Objectives:

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

Summary of Activities/Accomplishments:

Item 1: State Recreational Survey (SRS) and Marine Recreational Information Program (MRIP)
Recreational fisheries surveys allow MRD staff to monitor recreational catch and fishing effort as well as provide an opportunity for staff to interact with the angling public. These interactions provide an opportunity for DNR biologists to distribute rules & regulations booklets/fish rulers, inform anglers of changes to size/bag limits, and collect anecdotal data on fishing trends and angler opinions on a variety local fisheries. MRD staff interview recreational anglers at public and selected private access sites throughout SC's coastal counties. Data collected during interviews include: mode fished, body of water fished, angler's county of residence, species targeted, time spent fishing, angling trips taken previous year, catch/disposition by species, length/weight measurements for retained fish, and otoliths from selected species when permissible. The survey provides data to help determine the components of finfish stocks that are being targeted by recreational anglers as well as recreational fishing effort and behavior. This information is used for decision making by managers on a state level, to supplement and verify recreational fishing data collected by SCDNR's Charter Boat Logbook Program, and by National Marine Fisheries Service (NMFS) to produce estimates for stock assessments and management of species on a regional basis.

SRS: During the reporting period from January 1, 2021 to February 31, 2021; 129 fishing parties were interviewed in private boat and shore mode representing contact with 205 recreational fishermen. Interviews were conducted at public and selected private boat landings in coastal counties throughout the reporting period (**Table 1**). The top finfish species targeted by fishing parties was red drum. Fishing parties interviewed caught a total of 328 fish belonging to 10 species (**Table 2**).

MRIP: During the reporting period from July 1, 2020 to December 31, 2020 and March 1, 2021 to June 30, 2021; 309 assignments were completed resulting in 4,051 angler interviews in all modes (**Table 3**). Head boat assignments did not resume until June of 2021 due to concerns over COVID-19. 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 2021 – February 2021.

SRS TOTALS	
Site Visits	94
Intercepts	129
Anglers Interviewed	205
Fish Measured	32

Table 2. Fish and shellfish caught by fishing parties interviewed by SRS staff during January 2021 – February 2021.

Species Name	# Kept (bushels for oysters)	# Released (bushels for oysters)	# Caught (bushels for oysters)
Clams	1192	0	1192
Drum, Red	15	160	175
Seatrout, Spotted	22	102	124
Oysters	72	0	72
Sea Bass, Black	0	8	8
Drum, Black	6	2	8
Flounder, Unclassified	0	5	5
Catfish, Blue	0	3	3
Catfish, Ictaluridae	0	3	3
Bass, Striped	0	2	2

Table 3. MRIP assignments and interviews obtained by mode in FY2021.

Wave 4 2020				
Mode	July		August	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	42	677	40	664
Head Boat	0	0	0	0
Grand Total	42	677	40	664

Wave 5 2020				
Mode	September		October	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	50	561	50	603
Head Boat	0	0	0	0
Grand Total	50	561		603

Wave 6 2020				
Mode	November		December	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	46	406	38	240
Head Boat	0	0	0	0
Grand Total		406		240

Wave 2 2021				
Mode	March		April	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	46	205	48	566
Head Boat	0	0	0	0
Grand Total	46	205	48	566

Wave 3 2021				
Mode	May		June	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	66	964	55	714
Head Boat	0	0	3	22
Grand Total	66	964	58	736

Item 2: Charter Boat Logbook Reporting Program

Since 1993, all fishermen with for-hire licenses have been required to submit monthly trip level logbook reports to MRD's Fisheries Statistics Section. These logbook reports allow staff to monitor catch and effort of for-hire vessels in the state. Charter boat trip logs are coded and entered into a database. If trip logs are incomplete, staff contacted charter vessel owners/captains to fill in data gaps to ensure accurate

information. This program provides 100% reporting of catch and effort from licensed six passengers or fewer charter boat operators in South Carolina. It can be used to supplement and verify the National Marine Fisheries Service's Marine Recreational Information Program's charter vessel data and has been provided for potential use in fishery stock assessments and regional fisheries management.

During this reporting period (July 1, 2020 – June 30, 2021; aligns values with fiscal year licensing) there were 647 licensed six passenger or fewer charter boat vessels in South Carolina. Trip level data is submitted by licensed vessel owners/operators on a monthly basis. June's charter data was not required to be submitted to the agency until July 10, 2021 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 2020.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 79.76% of all species caught	Accounts for 77.43% of all species landed	Accounts for 82.62% of all species released
Sea Bass, Black (22.40%)	Mackerel, Spanish (24.18%)	Sea Bass, Black (26.82%)
Drum, Red (18.48%)	Snapper, Vermilion (10.06%)	Drum, Red (22.17%)
Seatrout, Spotted (10.17%)	Sea Bass, Black (7.92%)	Seatrout, Spotted (11.09%)
Mackerel, Spanish (7.29%)	Seatrout, Spotted (7.16%)	Shark, Atlantic Sharpnose (5.59%)
Shark, Atlantic Sharpnose (5.45%)	Drum, Red (6.40%)	Snapper, Vermilion (3.83%)
Snapper, Vermilion (5.29%)	Flounder, Unclassified (5.40%)	Flounder, Unclassified (3.58%)
Flounder, Unclassified (4.01%)	Shark, Atlantic Sharpnose (5.00%)	Drum, Black (2.79%)
Drum, Black (2.80%)	Mackerel, King (3.90%)	Shark, Black Tip (2.37%)
Whiting (Kingfish) (2.04%)	Grunt, White (3.74%)	Shark, Bonnethead (2.24%)
Shark, Black Tip (1.83%)	Whiting (Kingfish) (3.68%)	Mackerel, Spanish (2.14%)

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	2020
Trips	13,702	15,610	14,381	15,620	15,660	16,649	15,984
Boat Hours	56,952	63,697	58,627	63,196	62,696	66,578	60,534
Anglers	48,305	55,779	50,794	54,385	55,462	60,358	58,491
Angler Hours	199,622	226,311	206,317	219,674	217,697	235,659	213,608
Estuarine Trips (%)	50.74	48.35	49.92	55.12	54.07	52.99	51.63
Nearshore Trips (%)	32.42	31.19	31.12	27.34	28.79	27.70	30.41
Offshore Trips (%)	16.84	20.42	18.96	17.54	17.10	19.30	16.77

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

Project PI/Participants: Ben Dyar/Stephen Czwartacki, Ann Clark Little, Michael Hodges, Barry Sturmer, Gary Sundin

Reporting Period: July 1, 2020 – June 30, 2021

Scope of Work:

1. Recycle oyster shells from caterers, restaurants and the general public. Maintain drop-off sites, dump trailers, and shell-moving equipment. Disseminate material to educate public on the necessity and benefits of recycling oyster shell with DNR. Recycling goal for FY2021 is 32,000 bushels of shell.
2. Build and maintain at least 1 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 DNR equipment we will plant 17,000 bushels of shell in Charleston County to create 1.5-1.75 acres of new or enhanced oyster habitat.
6. Using Water Rec and/or Game and Fish Funds, plant 17,000 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 PSG's 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.

Summary of Activities/Accomplishments

The unprecedented circumstance caused by COVID-19 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 shell.

1. In FY 2021, **28,736** bushels of shell were recycled. This puts DNR as one of the top programs in the nation for quantity of shell and the largest state funded program. Twenty-five public drop-off sites were serviced in eleven counties. Recycled shell collected from these public drop-off facilities, individual oyster roasts, oyster roast caterers and local restaurants resulted in a savings of over **$100,576** by not having to purchase an equivalent quantity of out of state shell. We saw a 15% decrease in the total amount of bushels

recycled this year from last directly due to the impacts of COVID 19. Oyster roasts and caterers were heavily impacted and restaurant numbers were down slightly as well however, we did see a 12% increase in shell recycled at public drop off locations.

Sub-Category Totals for 2020-2021 Recycling (bushels)					
Permanent Bins	Restaurants	Events	Caterers	Public Trailers	Grand Total
11,610.65	9896.5	3484	1136.25	2609	28,736.40
Percent Contribution to Total					
40.40	34.44	12.12	3.95	9.08	100

2. One new oyster shell recycling public drop-off location was constructed at Live Oak within Edisto Beach State Park. The new constructed bin (fig 2) was a relocation of the bin previously located in a less publicly accessible location at the State Park. The recycle bin at Jessen Landing was closed due to a park redesign by the Town of Summerville and Dorchester County. There is a planned relocation of that bin to the Oakbrook Convenience Site in Ladson, SC (Dorchester County). Another bin is in the early stages of planning at the South Island Ferry Public Boat Landing owned by Springsteen Plantation and operated by Georgetown County.

(Fig 2) A new oyster shell drop-off location at Edisto Beach

3. Due to impacts from COVID 19 there was a reduction in participation with our shell recycling program from many of our partnered events and caterers as well as some restaurants.

Six new restaurants joined the program in Charleston, including: Pier 41, The Basement, Cuda Co. Seafood House, Tempest, The Deli, and Alchemist Beverage Company. Six new restaurants in the Greenville area joined the recycling program, including: Fish Camp on 11th, Gilligan's, Madison's, Saltus, Captain Woody's and Johnson Creek Tavern. Four new restaurants in the Beaufort County area joined the recycling program, including: Jianna, Larkin's, Golden Brown and Delicious and Hall's Chophouse.. The Shell Recycling and Replanting program now collects shell from over 50 restaurants, 32 of which are active weekly contributors in the Charleston area. Educational presentations and a partner recognition are continually being offered to partner restaurants to raise awareness within the restaurant community and increase recycling totals.

The restaurant can lift trailer, donated by CCA, has been a critical upgrade to the program and gives DNR the ability to recycle shell from restaurants and smaller venues with increased efficiency.

The volunteer recycling programs in Charleston, Beaufort and Greenville have recycled a total of 1657 bushels of oyster shells, involving 111 volunteers which accounted for 558 volunteer hours, valued at over $13,777. The volunteer recycling in Greenville, SC is still servicing 2 restaurants and 1 catering company as well as multiple seasonal roasts. The Greenville Oyster Recycling volunteers in the upstate collected over 761 bushels, with an additional 573 bushels donated by the public to the area drop-off bins. All recycled shell from restaurants in the Greenville area is collected by a volunteer group from the SC Master Naturalist. Shell is stored and unloaded from volunteer-collected bins by partner organization Renewable Water Resources (REWA) facility who is partnering with DNR. A presentation is planned for REWA to outline the impact of shell recycled from the Greenville area.

SCDNR staff developed a virtual volunteer training for those involved in oyster shell recycling. This training was developed with staff from SCDNR's Coastal Reserves and Outreach section. The purpose of the training is to educate volunteers on their responsibilities when participating in this program. A presentation was given to the South Carolina Wildlife Federation on the value of oyster shell recycling and to solicit volunteers to participate in recycling efforts.

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 is at the end of their funding period from PEW Charitable Trust, another program partner, which aided in continued ability to collect shell via contractor and then dump the shells at the public shell drop off site at Coastal Discovery Museum. Other funding oportunities are being persued by Outside Foundation to continue this work.

An Oyster Shell Recycling Co-op headed by Dead dog saloon in Murrels Inlet continues to maintain their partnerships with 8 local restaurants including Bovine's, Bubbas Dockside, Claw House, Creek Rats, Dead Dog Saloon, Jumping Jacks, Wicked Tuna, and Wahoo's Fish House. The Co-op is taking their shells to the Murrells Inlet drop off location at Clambank Landing.

4. Staff conducted several media interviews including, an NPR interview with Tut Underwood, two South Carolina news stations and two printed media outlets.

The shell recycling program continues its collaboration with the Coastal Reserves and Outreach section at MRD on a 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 DNR licensing offices were utilized to inform the public on where and how to recycle shell and its importance. Social media platforms managed by DNR were also utilized to notify public.

Restaurant partners were given framed certificates of appreciation to further engage restaurants and to show appreciation. The certificates outlined bushel count totals recycled from each restaurant from FY20 and their equated square foot of contribution of habitat created from shells recycled.

The shell recycling and planting program continues its partnership with PEW Foundation and The Coastal Conservation League (CCL) and The Outside Foundation for their assistance in increase shell recycling. Educational video shorts for shell recycling outreach were created for use in varying applications for the education and promotion of shell recycling for oyster roasts/caterer, restaurants and the public. Internet traffic on the shell recycling website dramatically increased following the release of these videos, proving that the addition of these two organizations as a partnership has greatly expand the outreach footprint to the public for our recycling program. Office of Coastal Reserves and Outreach with MRD is also part of the collaboration.

DNR Shellfish Management was able to create and conduct a recreational oyster harvesting survey in May-June of this year, through state contracted survey company, Southwick Associates. The survey was sent out to 80,000 saltwater recreational license holders to gain a clearer understanding of recreational oyster harvest pressure. In this effort DNR partnered with The Nature Conservancy (TNC) with funding from Toadfish Conservation Coalition (TCC), a local NGO, to conduct the survey. Results and final reports are still being analyzed.

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

5&6. A total of **32,403** bushels of oyster shells were planted on State and Public Shellfish Grounds between July 1, 2020 and June 30, 2021, creating **159,865** square feet (**3.67 acres**) of shellfish habitat along approximately **1.04 miles** of shoreline.

Charleston County – 1.58 acres

- Adams Creek (S187) - **4,918 bushels**
- Folly East (S206E) - **2,880 bushels**
- Folly West (S206W) - **1,920 bushels**
- Lower Hamlin Creek (S255) - **4,884 bushels**

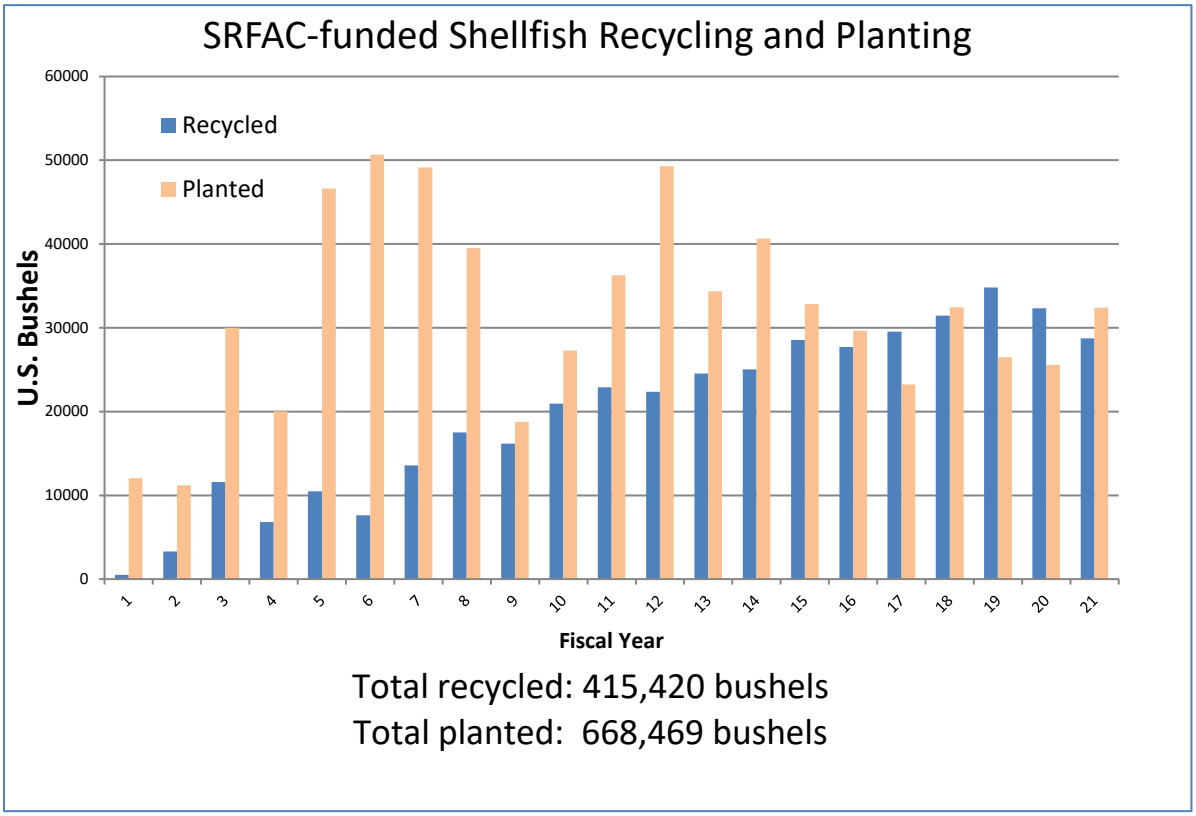
Georgetown County – 0.45 acres

- Murrells Inlet (S358) – **2,263 bushels**
- Drunken Jack Island (S357) - **2,438 bushels**

Beaufort County – 1.64 acres

- Pinckney Island (R036) - **2,000 bushels**
- Skull Creek (S038) - **2,775 bushels**
- Story River (S101) - **3,275 bushels**
- Distant Island (S117) - **3,275 bushels**
- Wallace Creek (S118) - **1,775 bushels**

Charleston County was planted by DNR's oyster barge, *The Indigo Princess*, with SRFAC funds using recycled shell. Georgetown and Beaufort Counties were planted with recycled shell and shell purchased from North Carolina and Florida. Planting was done by contractor and monitored by DNR using SRFAC & WREC funds.



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

8 **Three-Year Assessment:** Fifteen beds originally planted in 2017 were assessed to determine reef development success. Seven of the fifteen planting sites had average success, four were above average and two were below average. One site had a total loss of footprint due to heavy sedimentation. Overall oyster bed success is determined using a composite scale which rates grounds based on density, size, quantity and quality of oysters and on footprint retention.

Mud bank in 2017 just before planting in Sewee Bay just south of Bulls Bay.

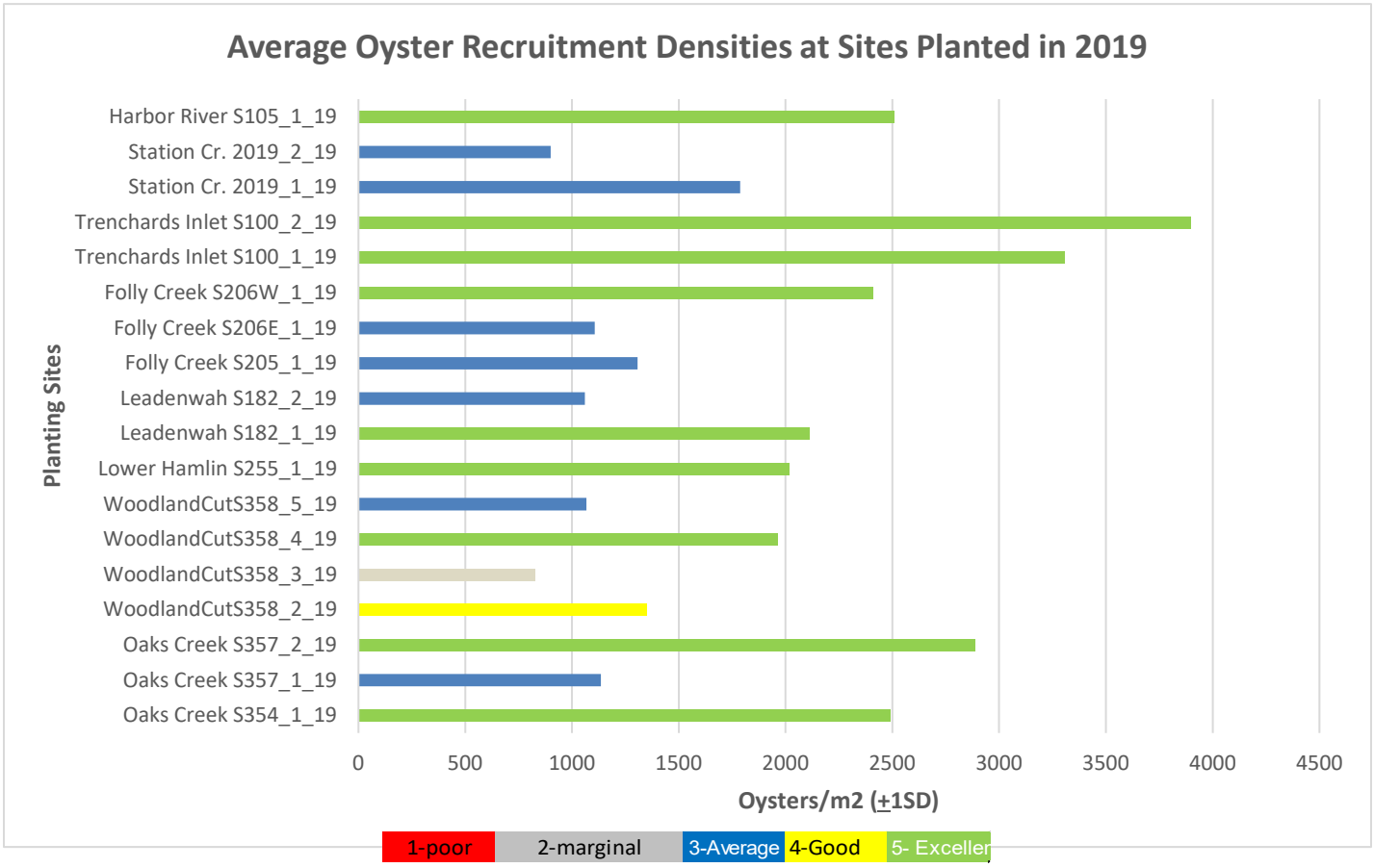
The same bank taken in 2020, three years after planting.

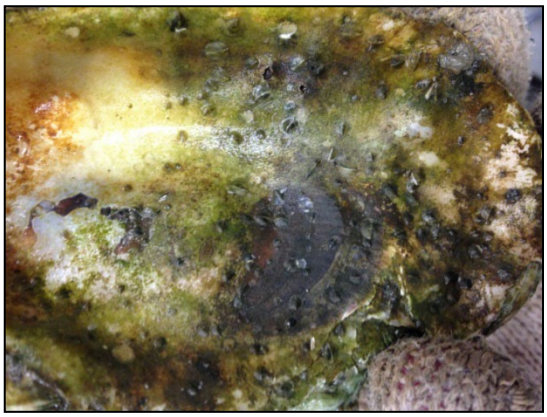
2020 Assessment of beds planted in 2017

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															
North Bulls Bay/Long Creek															
R292_1_17	5/4/17	2100	SC/G	869	108	-761	1137	9/17/2020	2	4	3.5	2	C	2.875	35
R292_2_17	5/3/17	2100	SC/G	625	151.5	-473.5	2061	9/17/2020	3	3.5	3	4	C	3.375	80
Sewee Bay/Anderson Creek															
S272_1_17	5/18/17	1575	SC/G	370	396.1	26.1	1169	10/15/2020	2.5	2.5	3	2.5	F1	2.75	65
S272_2_17	5/30/17	945	SC/G	459	335.2	-123.8	1567	10/15/2020	3	2.5	2.5	3	C	2.75	65
S272_3_17	5/19/17	525	SC/G	769											
R274_1_17	5/19/17	2363	SC/G	1344	983.79	-360.21	2476	10/15/2020	3.5	4	3.5	4	C/F1	3.75	70
R274_2_17	5/18/17	787	SC/G	314	333.2	19.2	1355	10/15/2020	3.5	3.5	3	4	C	3.5	65
Leadenwah Creek															
R175_1_17	6/29/17	1015	SC/G	410	0	-410.0		10/16/2020					N/A		0
R175_2_17	6/29/17	2065	SC/G	820	242	-578	1220	10/16/2020	2	2	2	2.5	M	2.15	20
R174_1_17	6/28/17	2100	SC/G	630	193	-437	1220	10/16/2020	3.5	3.5	3.5		C	3.375	80
Georgetown															
Oaks Creek															
R351_1_17	8/10/17	1392	SC/G	699	462.1	-236.9	3833	11/16/2020	3	3.5	3.5	3	C	3.25	90
R351_2_17	8/16/17	2135	SC/G	612	240.8	-371.2	N/A	11/16/2020	2	3	3	2	C	2.5	90
Woodland Cut															
S358_1_17	8/11/17	1392	SC/G	407	502.1	95.1	1845	11/12/2020	4	4	4	4.5	F	4.125	100
S358_2_17	8/16/17	2134	SC/G	492	159.9	-332.1	1508	11/12/2020	2	2	3	2.5	C	2.375	50
Beaufort															
Harbor River															
S105_1_17	08/01/17	9577	SC/G	3240	1534.69	-1705.31	5328	12/11/2020	4	4	3.5	5	F1	4.125	75

Slope-in Degrees			SC- Local Shell				*Qualitative Rating from 1-5: 1 Poorest, 5 Best								
Creek Width-in meters			G-Gulf				1-poor		2-marginal	3-Average	4-Good	5- Exceller			
			W-Whelk			Recruitment	Less than 450		450-900	900-1400	1400-1700	> 1700			

One-Year Recruitment Rates: Eighteen beds planted in 2019 were sampled and spat measured with digital calipers to determine juvenile recruitment rates. One site had marginal recruitment, seven had average and the remaining ten sites had above average to excellent recruitment.





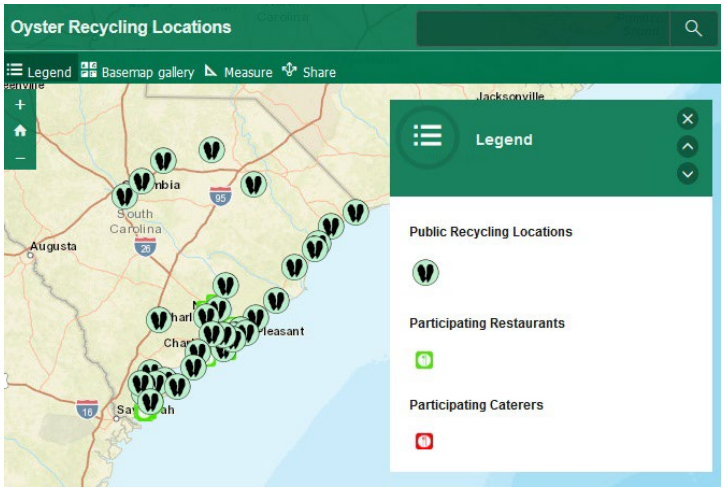
A single planted shell attracts many juvenile oysters. For monitoring purposes every live oyster, including those <1 mm is measured with digital calipers. Average density on SC oyster reefs exceeds 1000 oysters/m^2.

9&10. In FY2021 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 FY2021, public access to recreational shellfish maps was also maintained via a web-based interactive image service, increasing the accessibility of these materials to recreational anglers and shellfish harvesters (see Figure 2). This application allows users to interactively view the boundaries of the recreational shellfish harvesting grounds from any internet-enabled computer or device. Users can view their own geographic location within shellfish areas from GPS-enabled devices. The application also provides links to SCDNR online licensing websites, shellfish harvesting regulations, and to annually produced recreational shellfish maps. Maintaining these GIS products and updating them annually for public access is an important part of the mission to encourage recreational use of South Carolina's shellfish resources.

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



12 Currently we are reassessing areas that need 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 to create a GIS map layer of all the collective shellfish boundary signs in the state.

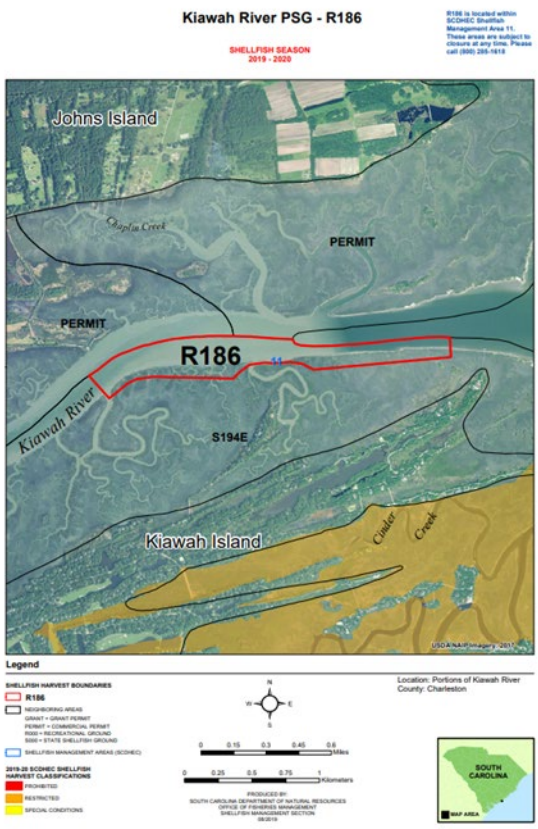
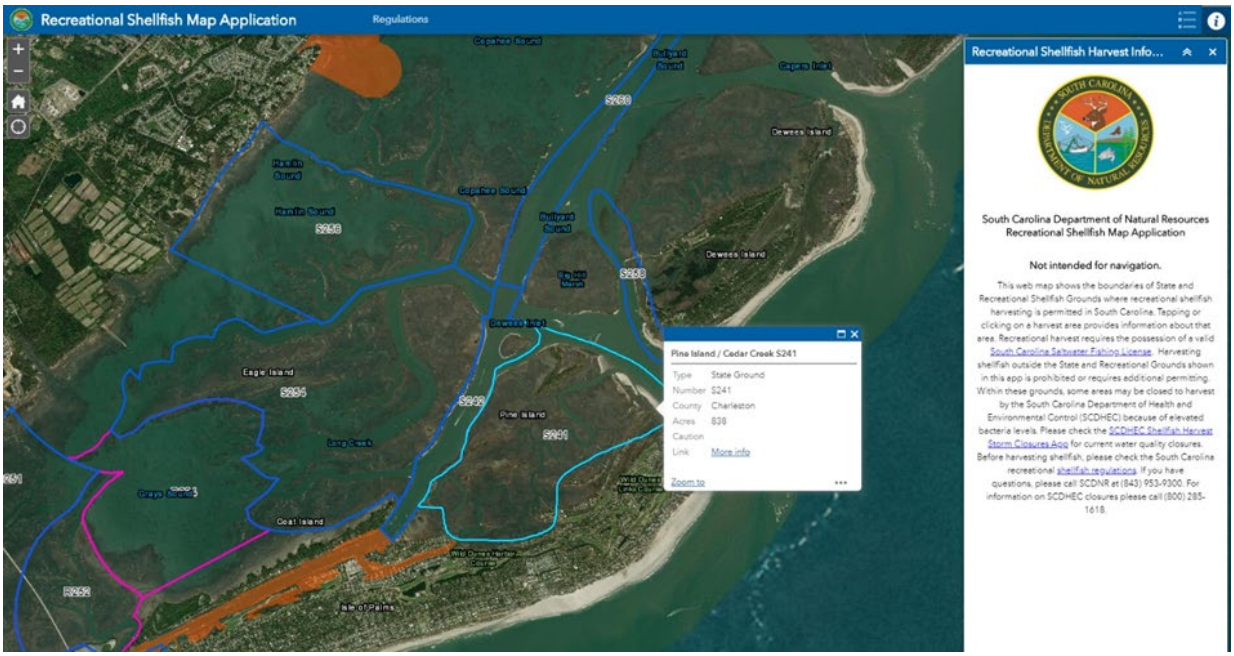


Figure 1. An example of an SCDNR recreational-only shellfish harvesting ground.

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



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

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

Reporting Period: July 1, 2020 – June 30, 2021

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

During FY2021, staff of the South Carolina Department of Natural Resources (SCDNR)'s Marine Resources Research Institute (MRRI)'s Shellfish Research Section (SRS) continued their use of a small, unoccupied aerial system (sUAS) to map and monitor 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 data that are being explored for their utility for the following objectives: 1) to assess the extent and condition of the oyster resources; 2) to determine the effectiveness of resource management; and 3) to explore changes in habitats and resources attributable to both natural and anthropogenic factors.

In November 2020, a flight was completed in Sewee Bay that mapped oyster reef habitat across 78 acres in the heavily harvested Sewee Bay State Shellfish Ground (S272) (Table 1). This effort surveyed an area that was previously mapped in December 2018 and produced a dataset suitable for exploring changes in oyster coverage over a 2-year period. Over 370 individual reefs were digitized (Figure 1) and will be used to update the SCDNR's intertidal oyster reef GIS layer.

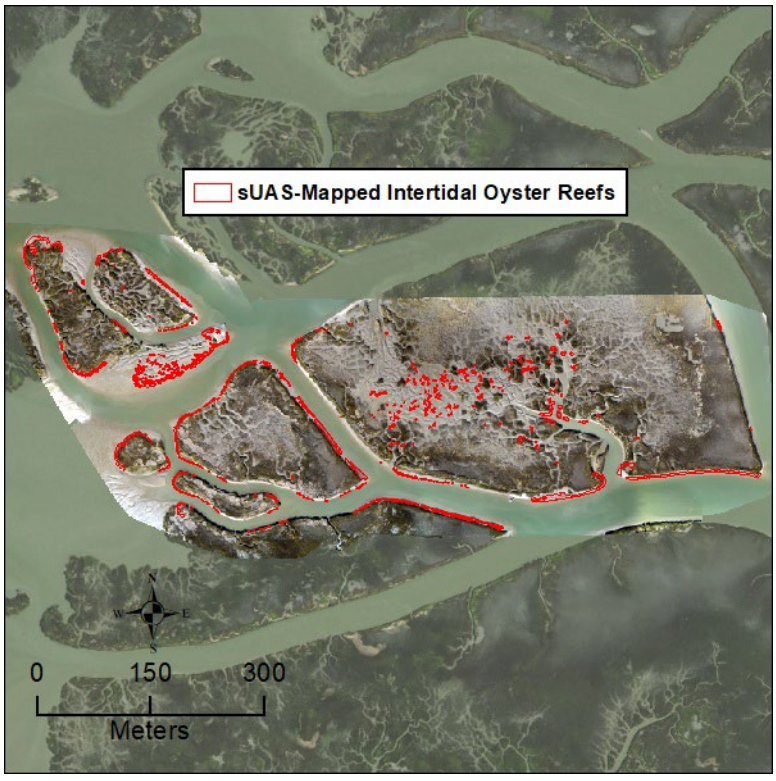


Figure 1 (*right*). Intertidal oyster reefs mapped using sUAS in Sewee Bay (S272).

A flight was also completed in Murrells Inlet in January 2021 at a site previously flown in 2018. Data from these flights was used in an analysis to assess the efficacy of loose shell planting for creating habitat. At this site, the planted shell was successful at increasing reef habitat and at capturing sediment to protect marsh habitat (Figure 2). These results were presented at the 2021 Annual Meeting of the National Shellfisheries Association in March 2021.

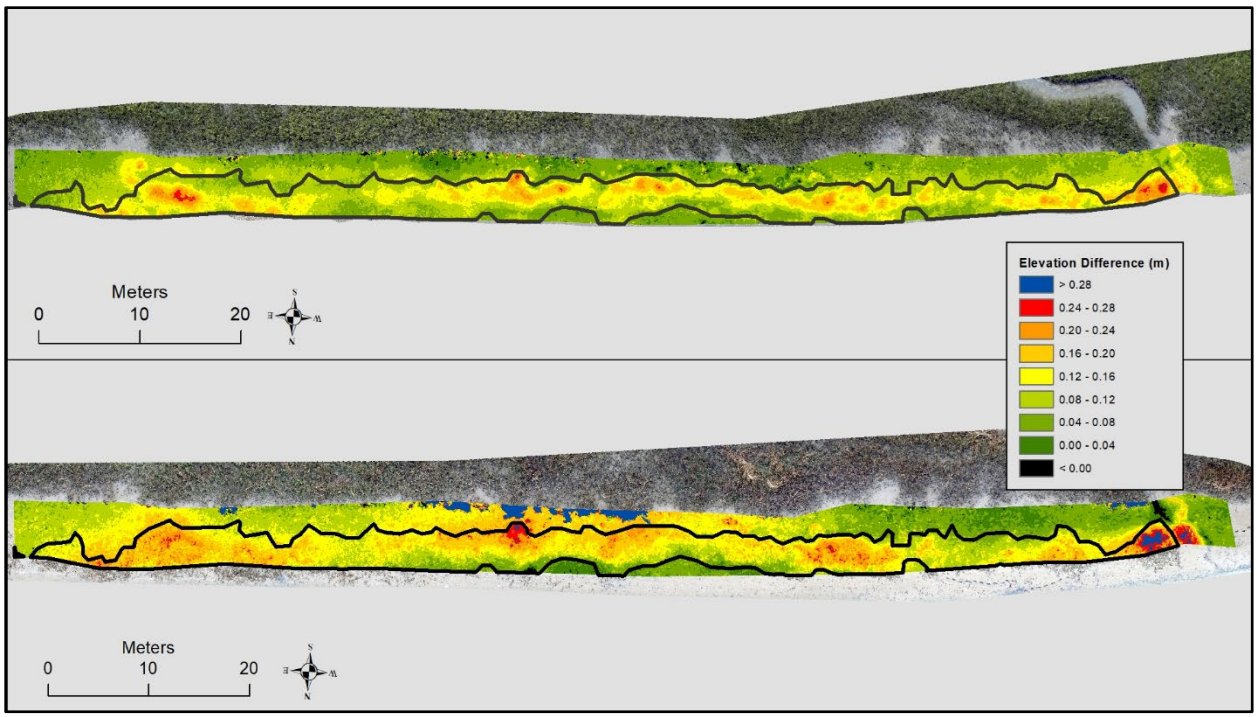


Figure 2 (*above*). A GIS map showing elevation changes over time resulting from the placement of loose oyster shell at State Shellfish Ground S357 in Murrells Inlet. Warm colors indicate greater positive elevation change. The black border indicates the border of the new oyster reef found at the site in 2021, resulting from the loose shell deposition. *Top figure* shows changes directly after shell placement, indicating that initial placement increased the elevation at the site, as shell remained in place following planting. *Bottom figure* shows the elevation change 2.5 years later, indicating that oyster growth and sediment accretion occurred.

During FY2021, staff also mapped a restoration site at Fenwick Island containing multiple habitat-creating reefs dating back to 2017 that have been built using derelict crab traps (DCTs), as well as a site on the Ashepoo-Coosaw Cutoff containing a DCT-reef built in 2018. The goal of these flights was to track the performance of these structures in creating and protecting intertidal marsh (*Spartina alterniflora*) habitat. Using Analyzing Moving Boundaries Using R (AMBUR) software analyses, the primary derelict crab trap reef at Fenwick Island was found to be promoting the expansion of new marsh behind the reef, relative to unrestored areas nearby. [In FY2021, two planned oyster mapping days were canceled due to poor weather conditions.]

Table 1. Flights conducted in FY2021 using sUAS to map intertidal oysters and oyster-based habitat restoration installations in coastal South Carolina.

Location	**State Shellfish Ground Management**	**Flight Dates**
Sewee Bay	2-year post planting	11/13/2020
Murrells Inlet	2.5-year post planting	1/11/2021
Location	**Restoration Site Monitoring**	**Flight Dates**
Fenwick Island (2 flights)	Monitoring reefs from 2017 to 2021	4/9/2021 & 5/27/21
Ashepoo-Coosaw Cutoff	Monitoring reef built in 2018	6/25/2021

Project Title:	Assessing natural mortality of South Carolina intertidal oyster reefs
Reporting Period:	July 1, 2020 – June 30, 2021
Project PI/Participants:	Peter Kingsley-Smith/Gary Sundin & Graham Wagner

In FY2021, SRS staff continued annual monitoring of wild intertidal oysters to explore patterns of oyster mortality and recruitment (and other demographic parameters). During the winter (October 2020 – February 2021), staff visited 34 index sites across the coast of South Carolina and collected triplicate samples of representative oyster clusters (Figure 3).

Figure 3. Location of sites sampled for natural oyster mortality during FY2021. Site codes for locations sampled are explained in Table 2.

All samples were brought back to the shellfish laboratory at the MRRI, where each oyster was assessed as living or dead and measured with digital calipers. In total, 21,434 oysters were collected and measured in FY2021, and 150,579 oysters have been collected and measured since

2015 when monitoring efforts began (Table 2). Following processing, all oyster shells were recycled to be used as new intertidal oyster habitat substrate by SCDNR's South Carolina Oyster Recycling and Enhancement (SCORE) Program. During the first year of the oyster natural mortality survey in 2015-2016, the statewide natural mortality rate was nearly 11% (Table 3, Figure 4).

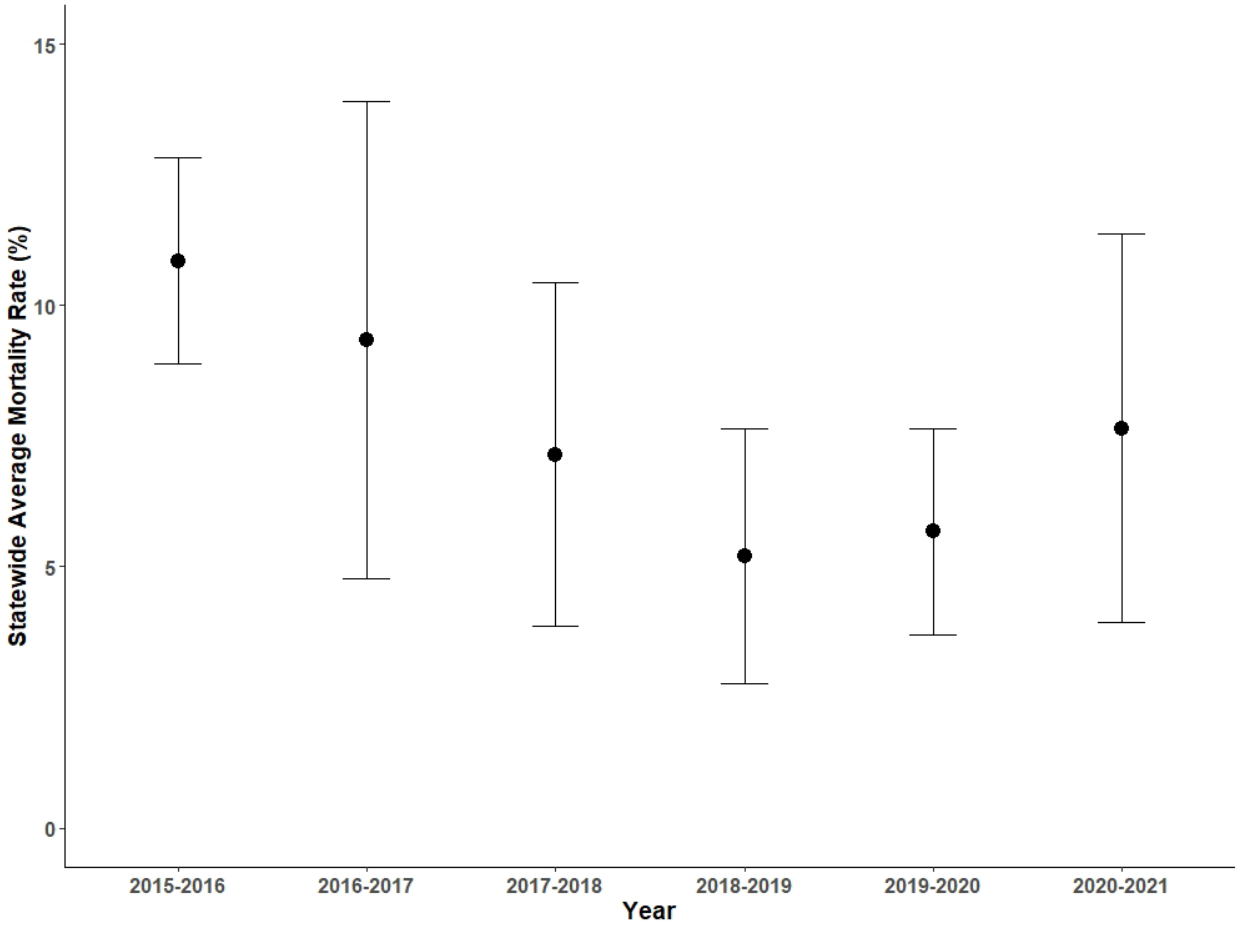


Figure 4. Statewide average natural mortality rates for wild intertidal oysters. Error bars denote standard deviations. The highest natural mortality (11%) was recorded during the first year of the survey, which coincided with an anomalous storm event. The large influx of freshwater into coastal systems is thought to have caused the high mortality rates in 2015-2016. The next three years were characterized by a gradual decrease in natural mortality, perhaps demonstrating a slow and steady return to "normal" natural mortality rates. The last three years have shown more stable natural mortality rates fluctuation around 5%-6% with a slight increase in 2020-2021.

This first year of the survey coincided with extensive flooding from Tropical Storm Joaquin, which likely caused the high natural mortality rates due to the influx of fresh water into coastal systems. The following years were characterized by gradually decreasing natural mortality rates, dropping down to a project low of around 5% in 2018-2019 (Table 3, Figure 4). This decrease over several years may be indicative of a gradual recovery of the oyster population following the high mortality in 2015-2016. Since 2018-2019, natural mortality rates have fluctuated around 5-7% (Table 3, Figure 4), which may be characteristic of more baseline natural mortality rates.

Natural mortality rates of oysters were found to be significantly related to both salinity and latitude, with higher salinities and lower latitudes resulting in lower mortality rates (Figure 5).

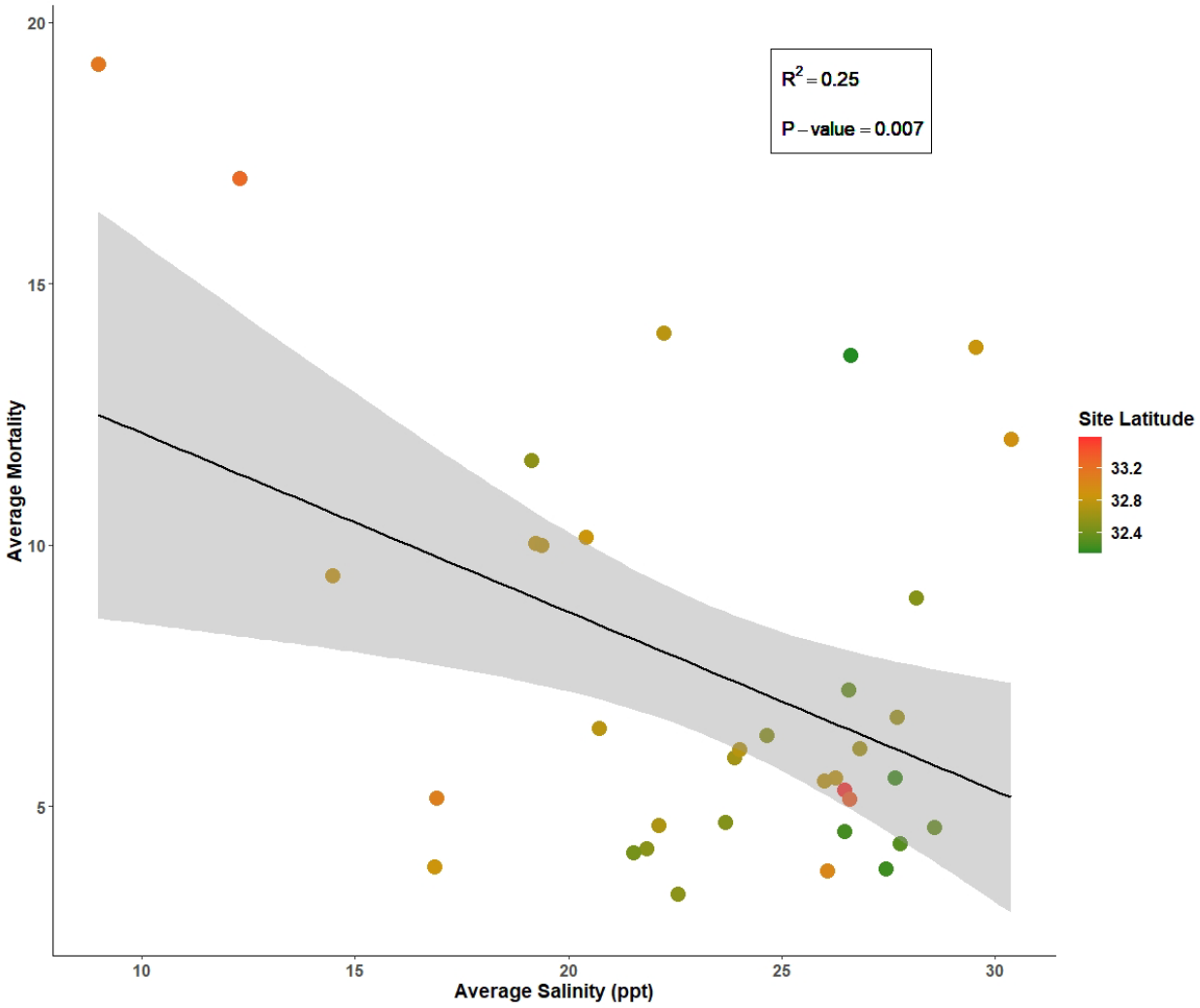


Figure 5. Relationship between average natural mortality rates and site latitude and salinity. Note that as salinity increases, average natural mortality tends to decrease. The sampling sites in the southern portion of the state are denoted by more green colors, and are characterized by lower mortality rates and higher salinities. In contrast, the redder colors represent more northern and central sampling sites, which tend to have higher average natural mortality rates and lower salinities. These trends correspond with the patterns of watershed size driving the salinity regime in a location, which in turn influences natural mortality rates.

In general, this suggests that average natural mortality rates of wild oysters across the six years of data from this survey tend to display a north-south pattern, with higher mortality rates occurring in the northern and middle portion of the South Carolina coast, while the southern regions have lower average natural mortality rates (Figures 5 & 6). This north-south gradient of high to low mortality rates is mirrored by a similar gradient of large to small coastal watersheds (Figure 6). The larger watersheds in the northern portion of South Carolina tend to deliver more freshwater to coastal systems, which in turn drives the salinity regimes in these areas. A salinity regime affected by increased freshwater input, causing local salinities to decrease below the salinity tolerance threshold of oysters, likely contributes to the higher mortality rates generally

seen in the northern parts of the state. In contrast, the southern portions of South Carolina are characterized by smaller watersheds and coastal areas that are influenced more by the ocean than by upland freshwater input, and tend to have lower mortality rates (Figure 6).

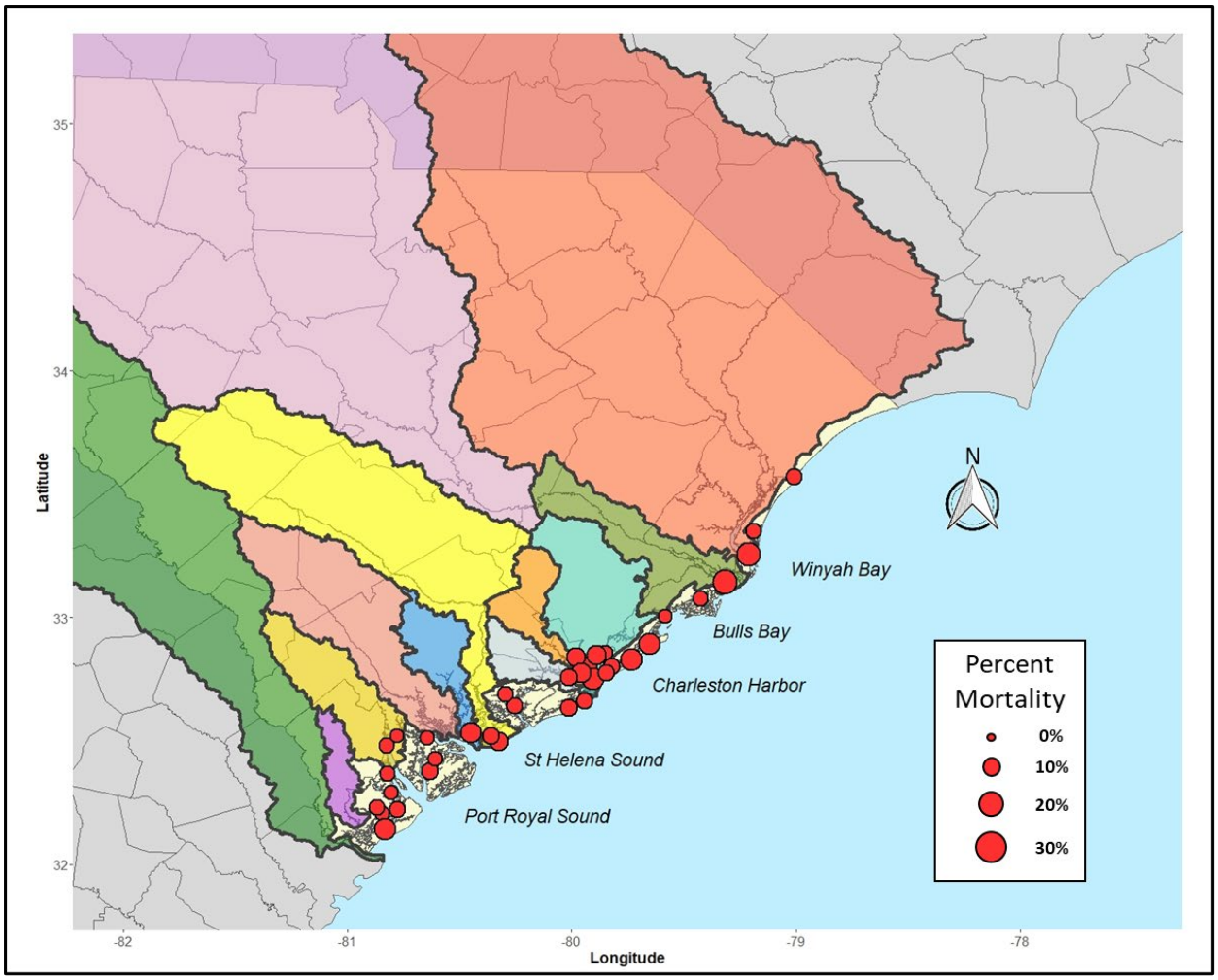


Figure 6. Average natural mortality rates of oysters for each index site across all sampling seasons, with the coastal watersheds of South Carolina denoted by colored regions. Note that, in general, index sites located in larger watersheds tend to have higher natural mortality rates, while index sites in smaller watersheds or in more coastally influenced areas (i.e., not within a colored region on the map) have lower natural mortality rates. This suggests that the amount of freshwater entering a system, and therefore its salinity regime, influences the mortality rates of oysters within that system. This is consistent with the significant relationship between natural mortality rates and salinity and site latitude shown in Figure 5.

The length-frequency data obtained by measuring each oyster collected has allowed staff to assess relative recruitment success based on the proportion of small (less than ~1") individuals in each sample. The proportion of recruits from each sample in each year was calculated, and the resulting distribution was used to categorize the relative recruitment success of each sample as below average, average, or above average. Using this method of assessing recruitment, the 2015-2016 season, which exhibited the highest statewide natural mortality rates during the project to date, was followed in 2016-2017 by a season of relatively low recruitment, which may be explained by a reduction in the size of the reproductive population during the 2015-2016 season (Figure 7). This demonstrates the potential effect that episodic die-offs may have in subsequent

years and contextualizes the recovery period following high mortality events. Identifying changes in relative recruitment success both spatially and temporally is useful directing where restoration efforts may need to be directed.

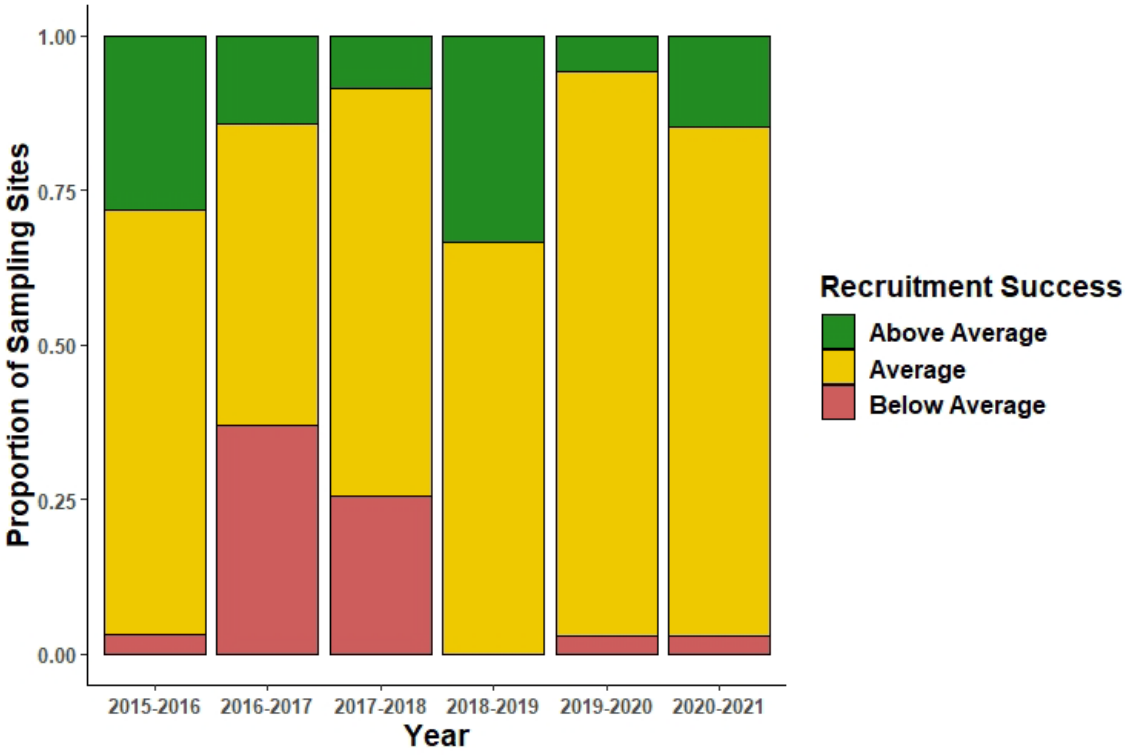


Figure 7. Proportion of sampling sites with relative recruitment categorized as “above average”, “average”, and “below average” in each sampling year. Note the large proportion of sites with below average recruitment in the 2016-2017 sampling season. This season followed a year with the highest mortality rates in the survey, believed to be caused by severe flooding from Tropical Storm Juaquin. A reduction in the reproductive population from a year with high natural mortality would explain the overall below average recruitment seen in the following year

The length-frequency data collected through this survey has also supported estimates of growth rates for wild intertidal oysters. The lengths of oysters collected across all years at a single site are pooled, and distinct cohorts can be identified. Assuming each identifiable cohort corresponds to a single year class, the growth rates of oysters from year to year can be estimated. These growth rates have not been confirmed with in situ measurements, but provide insights for identifying areas with slower rates of oyster growth. Relating physical and environmental conditions to growth rates of oysters in different locations could allow managers to identify the causes of poor growth and to make informed decisions regarding harvest to prevent the wild oyster resource from being overharvested. Together, the length-frequency and mortality data from six years of monitoring is improving our understanding of the spatial and temporal patterns in oyster mortality, growth, and recruitment, and these data will become more valuable as more years of monitoring are completed.

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

	2015-2016			2016-2017			2017-2018			2018-2019			2019-2020			2020-2021		
Site	**Range**	**Mean**	**SD**	**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	1.85 – 95.28	23.25	15.70
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	0.93 – 114.20	17.64	15.17
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	2.01 – 118.81	25.10	19.37
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	2.40 – 130.31	32.87	25.67
BLB	3.77 – 98.42	24.72	16.93	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	2.98 – 99.27	26.48	21.42
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	1.43 – 114.63	22.30	21.94
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	2.19 – 104.65	30.38	20.14
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	1.61 – 88.02	16.75	12.94
CCH	2.48 - 74.74	18.86	16.13	2.57 – 105.97	26.92	18.48	0.93 - 95.72	20.84	15.49	2.18 - 106.06	19.91	16.08	1.45 – 90.14	22.20	18.92	1.81 – 107.24	26.58	22.23
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	1.89 – 111.02	30.98	23.04
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	1.98 – 71.13	19.17	14.01
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	3.78 – 114.82	37.65	24.20
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	2.72 – 80.76	22.86	15.07
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	1.80 – 135.01	29.67	25.74
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	0.78 – 95.91	21.75	19.82
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	1.49 – 83.53	18.65	14.53
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	2.05 – 132.30	32.62	26.38
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	1.94 – 101.83	22.70	18.24
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	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	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	2.14 – 114.28	26.18	20.03
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	1.41 – 100.03	25.96	19.55
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	0.13 – 98.92	20.42	15.02
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	0.23 – 130.07	30.71	29.24
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	2.99 – 105.22	30.78	21.21
NHI	4.04 – 140.55	37.49	30.86	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	2.99 – 146.17	38.06	31.83
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	2.98 – 103.44	29.98	21.60
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	0.86 – 117.19	28.11	23.33
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	1.79 – 79.17	18.58	15.24
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	1.48 – 95.98	24.96	19.15
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	1.67 – 136.04	30.13	23.05
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	2.15 – 101.92	30.62	19.42
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	1.62 – 112.39	27.51	24.60
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	NA	NA	NA
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	3.11 – 139.82	32.36	27.99
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	3.13 – 67.14	21.20	12.00

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

Site Name	Site Code	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	Mean
Ashepoo River	ASP	9.7	19.9	9.7	11.5	12.3	6.7	**11.6**
Big Bay Creek	BBC	10.7	9.9	4.9	3.1	6.1	19.2	**9.0**
Bears Bluff	BBF	3.7	8.6	4.6	3.5	4.8	10.2	**5.9**
Beaufort River	BFT	6.7	11.5	10.0	4.7	2.5	8.0	**7.2**
Bulls Bay	BLB	2.9	4.2	5.5	2.9	2.9	3.5	**3.7**
Broad River	BRD	9.8	1.6	3.1	5.4	2.2	6.0	**4.7**
Bull Creek	BUL	2.5	2.8	4.8	2.6	3.4	6.8	**3.8**
Calibogue Sound	CBG	7.7	17.2	10.0	9.8	7.6	29.4	**13.6**
Chechessee River	CCH	4.3	4.8	6.4	1.8	3.2	7.2	**4.6**
Colleton River	CLT	2.5	4.3	6.2	1.9	7.0	3.9	**4.3**
Cooper River	CPR	10.4	7.9	29.5	4.3	3.7	4.5	**10.1**
Cape Romain	CRM	4.7	5.8	3.4	4.3	5.2	7.6	**5.2**
Cosgrove Bridge	CSG	20.3	11.8	7.3	2.8	7.9	6.4	**9.4**
Coosaw River	CSW	6.2	3.3	3.6	3.1	2.2	6.6	**4.2**
Dewees Inlet	DWE	7.1	2.8	13.0	16.8	10.0	8.0	**9.6**
Edisto River	EDR	7.9	4.9	2.1	6.0	3.7	13.6	**6.4**
Folly River	FLR	4.8	4.1	8.2	3.4	9.8	6.4	**6.1**
Foster Creek	FOS	-	-	-	2.4	3.3	5.8	**3.8**
Fish Creek	FSC	-	6.8	3.7	-	-	-	**5.3**
Grice Cove	GRC	-	-	-	6.4	5.4	6.6	**6.1**
Charleston Harbor	HAR	15.5	27.2	6.9	6.8	-	-	**14.1**
Hog Island	HOG	3.5	7.5	6.3	2.2	6.9	6.9	**5.6**
Inlet Creek	INL	6.4	9.3	6.8	2.7	3.5	4.7	**5.6**
James Island Connector	JIC	19.4	8.9	9.2	5.5	9.6	7.3	**10.0**
May River	MAY	2.1	3.1	6.6	4.8	6.3	4.3	**4.5**
Murrells Inlet	MRI	-	3.6	5.0	3.8	9.7	4.4	**5.3**
North Inlet	NHI	4.4	5.1	6.6	0.4	7.4	6.9	**5.1**
South Santee	SST	77.3	3.9	9.8	12.0	7.1	5.1	**19.2**
Stono Inlet	STI	6.0	8.8	5.0	6.7	6.5	7.2	**6.7**
Stono River	STR	13.2	7.8	6.2	3.4	3.3	5.1	**6.5**
Sewee Bay	SWE	19.0	15.8	11.0	3.0	10.8	12.5	**12.0**
Toogoodoo Creek	TGD	5.3	6.0	4.0	3.4	3.3	5.7	**4.6**
Tolers Cove	TOL	7.1	5.6	9.9	2.1	2.8	5.4	**5.5**
Whale Branch	WBR	-	0.9	4.0	4.5	1.8	5.4	**3.3**
Wando River	WND	9.7	26.9	5.6	4.2	4.3	-	**10.1**
Warsaw Flats	WSW	3.3	4.9	5.5	2.9	2.7	5.3	**4.1**
Winyah Bay	WYB	33.3	24.1	5.8	22.0	9.4	7.5	**17.0**
Mean		**10.9**	**8.6**	**7.1**	**5.2**	**5.7**	**7.7**	**7.5**

Crustacean Research and Fishery-Independent Monitoring

Program PI: Peter Kingsley-Smith

Program Co-PIs: Michael Kendrick, Jeff Brunson

Reporting Period: July 1, 20120- June 30, 2021

Sampling by Crustacean Research and Monitoring Section (CRMS) staff focuses on the collection of recreationally-important crustacean species at critical life stages within estuarine waters. Focal species are white shrimp (*Penaeus* (*Litopenaeus*) *setiferus*), brown shrimp (*Penaeus* (*Farfantepenaeus*) *aztecus*), and blue crabs (*Callinectes sapidus*). Sampling efforts and subsequent analyses facilitate the timely analysis of the development of crustacean species and are regularly used by the SCDNR Office of Fisheries Management to inform management decisions. Over the course of the past year, staff have recorded abundance trends in these focal species, with fall and spring white shrimp and summer brown shrimp abundance values at or above the long-term averages, summer white shrimp abundance values similar to recent years and blue crab abundance values lower-than average.

Sampling by the CRMS consists of the following fisheries-independent surveys:

1) Estuarine trawl survey: This survey is conducted aboard the R/V *Silver Crescent* using a 20-foot trawl net with 1" stretch mesh, towed for 15 minutes at each station. Monthly sampling occurs at four stations within the Charleston Harbor/Ashley River and at 20 additional stations along the ICW from Charleston to Hilton Head in March, April, August, and December (*Figure 1*). Sampling provides information on the status of crustacean populations at important times in their life cycle (e.g., spring reproductive status, availability for fall harvest, overwintering abundance). which is critical for the effective management of these resources. Although July 2020 sampling was not completed due to COVID-19 restrictions, all other estuarine trawl survey dates were successfully completed during the July 1, 2020 to June 30, 2021 reporting period.

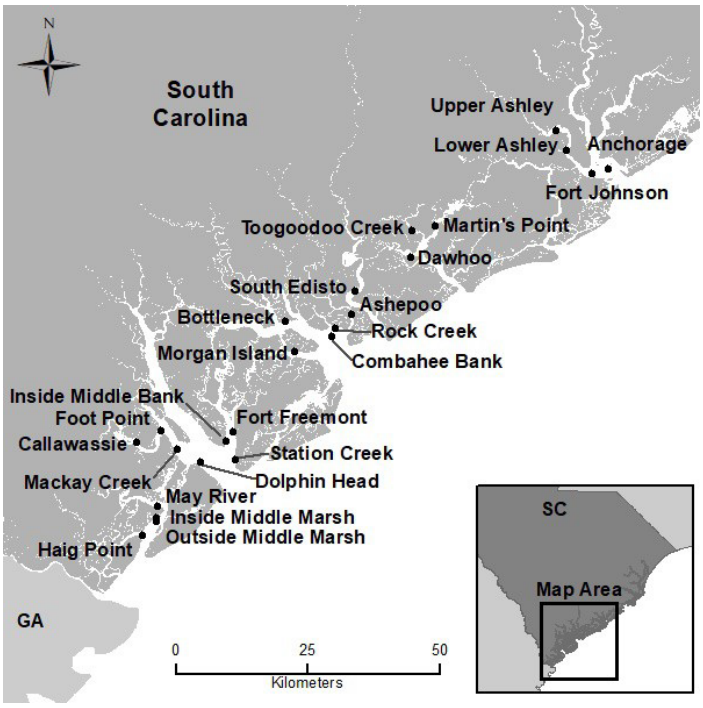


Figure 1. Estuarine trawl survey sampling stations.

2) Creek trawl survey: This survey is conducted from a small (<20') research vessel using a 10-foot, ¼-inch mesh flat otter trawl towed for 5 minutes at each station around low tide when target animals are concentrated in creek bottoms. Creek trawl sampling historically occurred from May to September, but has recently been expanded to include year-round sampling at fixed stations in the Charleston area (Figure 2). Juvenile shrimp, in particular, remain in tidal creeks before migrating into larger water bodies with juvenile brown typically found in tidal creeks from early May to late July and juvenile white shrimp found from mid-June to mid-September. These data allow CRMS staff to track the timing of shrimp migration into and out of tidal creeks, and to track the use of tidal creeks by juvenile, sub-adult, and adult blue crabs. During the current reporting period, sampling was completed for all months.

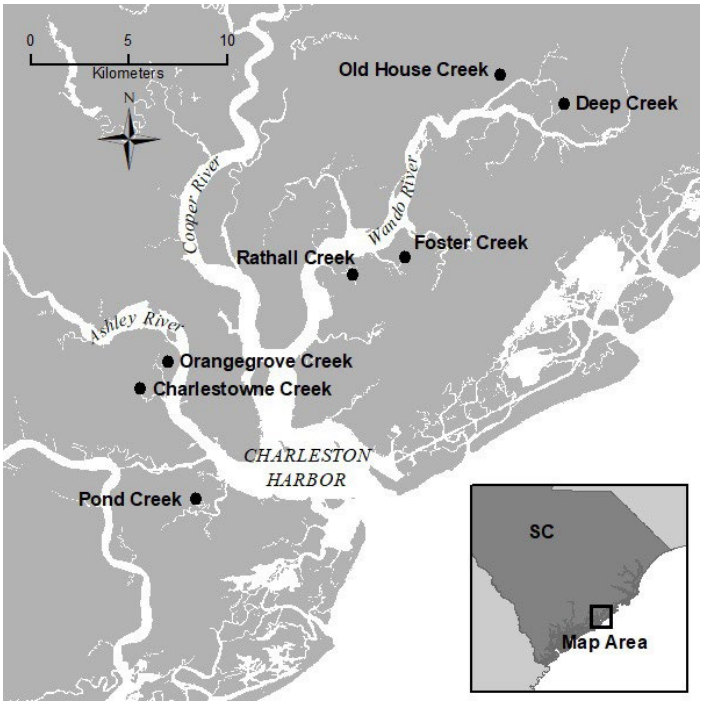


Figure 2. Creek trawl survey sampling stations.

3) Crab pot survey: This survey is conducted using standard wire crab traps deployed for 4 to 6 hour soak times in October and November at six stations from Winyah Bay to Port Royal Sound (Figure 3). This survey targets blue crabs beginning their seaward fall migration, cued by decreasing seawater temperatures, and provides an index of crab abundance during this time of year.

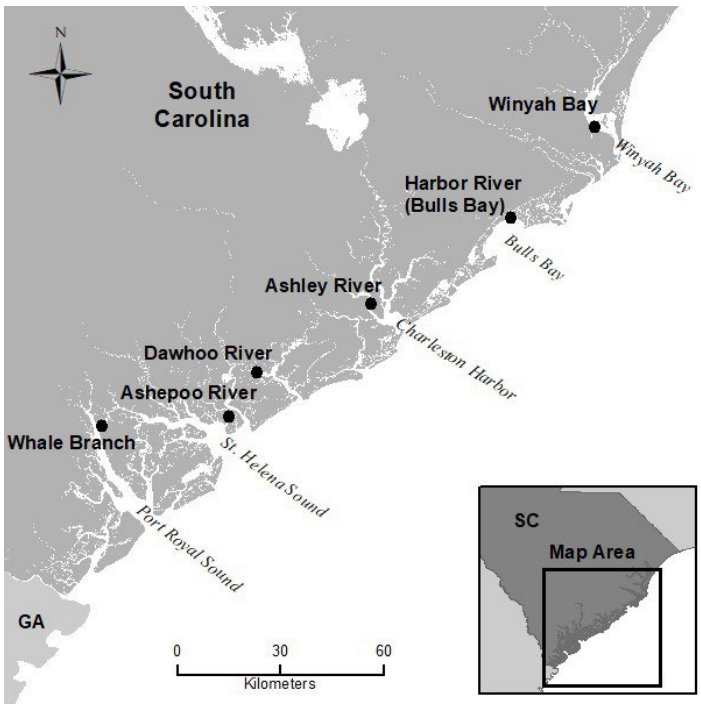


Figure 3. Statewide fall crab pot survey sampling stations.

PROGRAM FINDINGS FOR FY21

White shrimp (*Penaeus* (*Litopenaeus*) *setiferus*).

Overview of white shrimp abundance: White shrimp abundance generally followed a seasonal pattern, with relatively high abundance of smaller shrimp

collected during the late summer and fall prior to their migration offshore in the spring. Abundances were generally higher than the long-term mean and readily available for recreational harvest, particularly in the fall of 2020 (Figure 4).

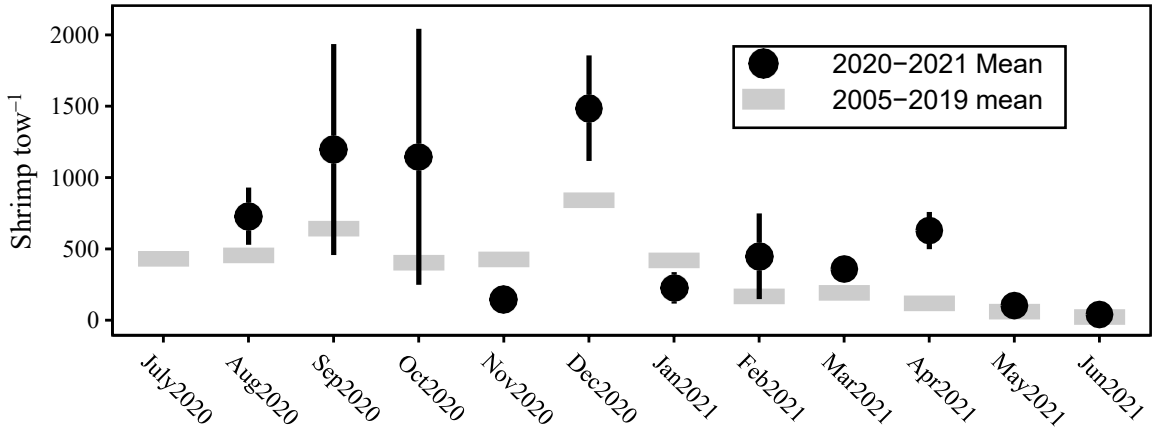


Figure 4. Monthly white shrimp abundance (mean ± S.E.) from the estuarine trawl survey.

Seasonal patterns in white shrimp abundance: White shrimp catches in the summer (May-July) for the creek trawl survey were below the long-term mean (Figure 5A), but juvenile white shrimp were at levels similar to recent years. White shrimp abundance in fall (August to December) 2020 was well above the long-term mean (2005-2020; Figure 5B). White shrimp abundance in spring (Feb-Apr) 2021 was well above the long-term mean (2005-2020; Figure 5C).

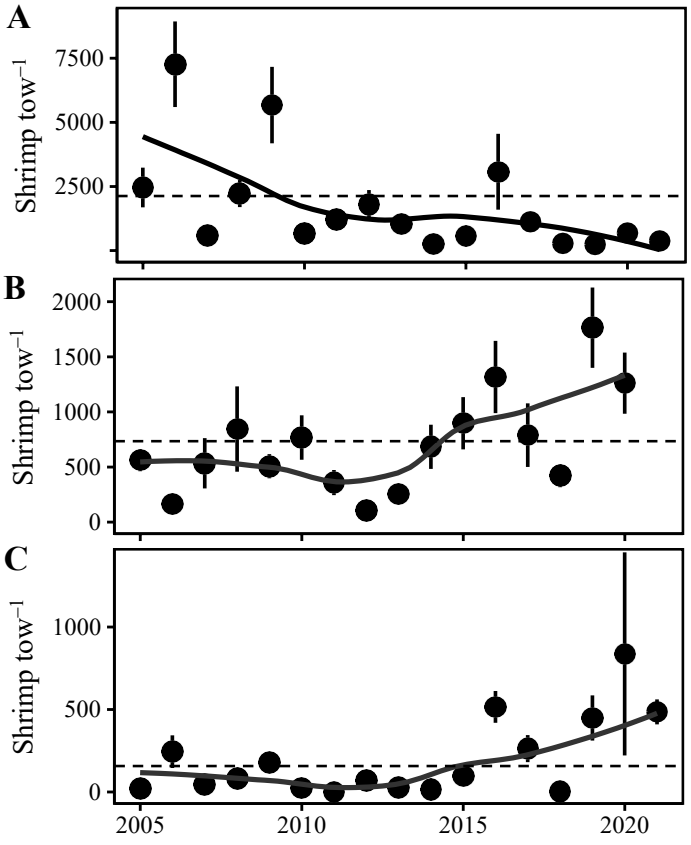


Figure 5. White shrimp abundance (mean ± standard error) from summer (A), fall (B), and spring (C) surveys. Fall and spring samples are from estuarine trawls while summer samples are from creek trawls. Lines represent long-term means (dashed) and smoothed trends (solid).

Brown Shrimp (*Penaeus* (*Farfantepenaeus*) *aztecus*).

Brown shrimp are an important component of the recreational shrimp fishery, as they are typically available for use as bait and for human consumption during the summer. In 2021, brown shrimp catches in the creek trawl survey (Figure 6A) were similar to the long-term mean while catches from the estuarine trawl survey (Figure 6B) were above the long-term mean.

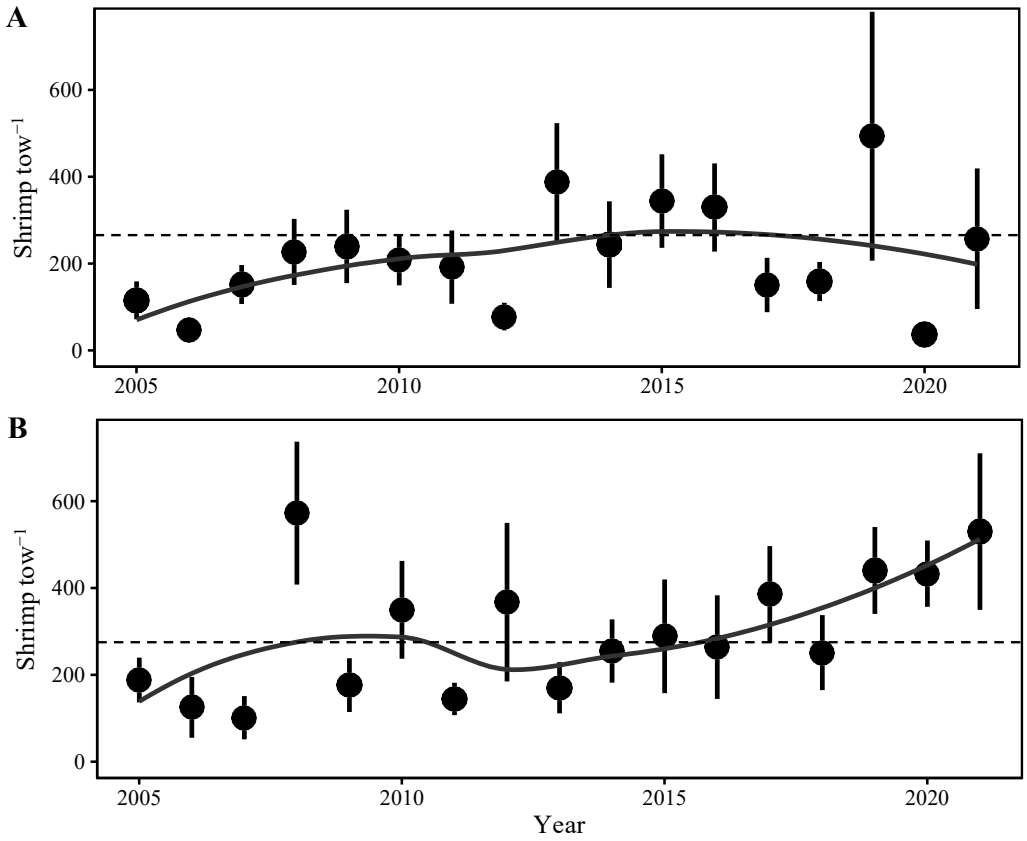


Figure 6. Trends in summer (May-July) brown shrimp abundance (mean ± S.E.) from creek trawl (A) and estuarine trawl (B) surveys. Lines represent long-term means (dashed) and smoothed trends (solid).

Black gill

Black gill, a condition in which the gills become melanized as part of the shrimp immune response, has not been documented to negatively impact shrimp population abundances, but shrimp with melanized gills may be more susceptible to predation due to impacts on respiratory function. Black gill prevalence in fall 2020 was similar to the long-term mean for brown shrimp, and slightly above the long-term mean for white shrimp (Figure 7).

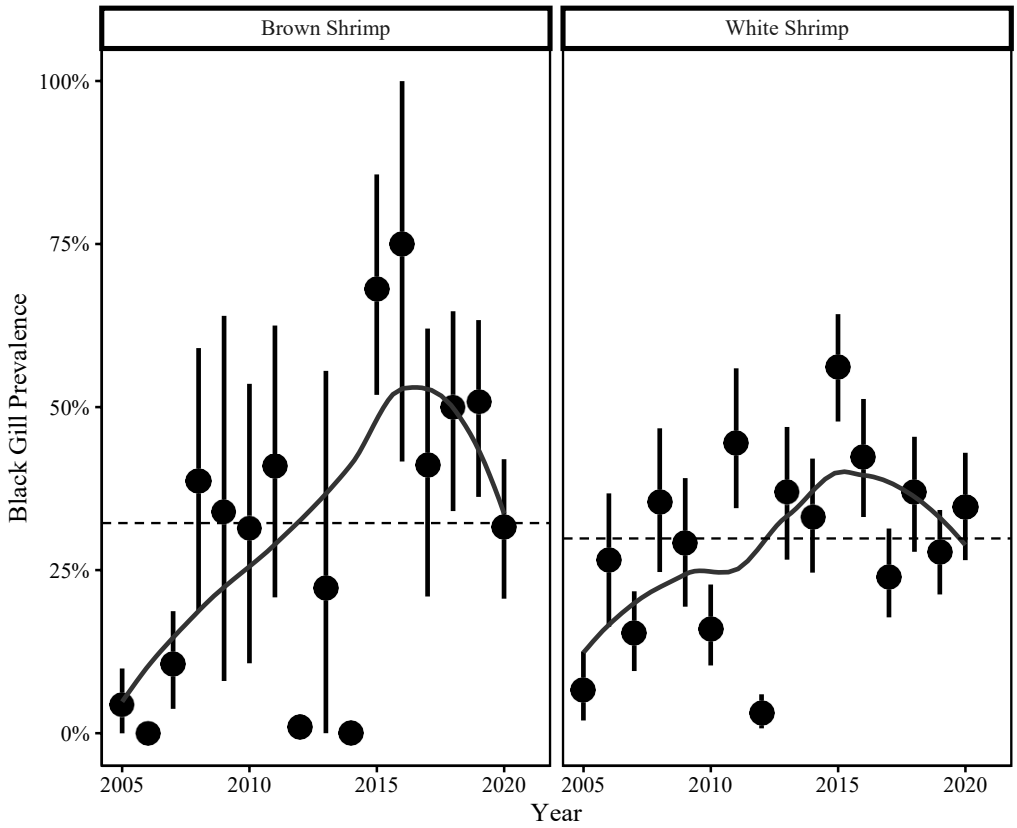


Figure 7. Trends in fall (Aug-Dec) 2020 black gill (mean ± S.E.) in brown shrimp and white shrimp collected from the estuarine trawl survey. Lines represent long-term means (dashed) and smoothed trends (solid).

Blue crab (*Callinectes sapidus*)

Estuarine trawl survey: Blue crab abundance was above the long-term mean in early fall, but has remained near or below the long-term mean since January 2021 (Figure 8). Legal-sized blue crab (≥5“ carapace width, CW) abundance was similar to the long-term mean, while catches of sublegal crabs (<5” CW) were below the long-term mean (Figure 9).

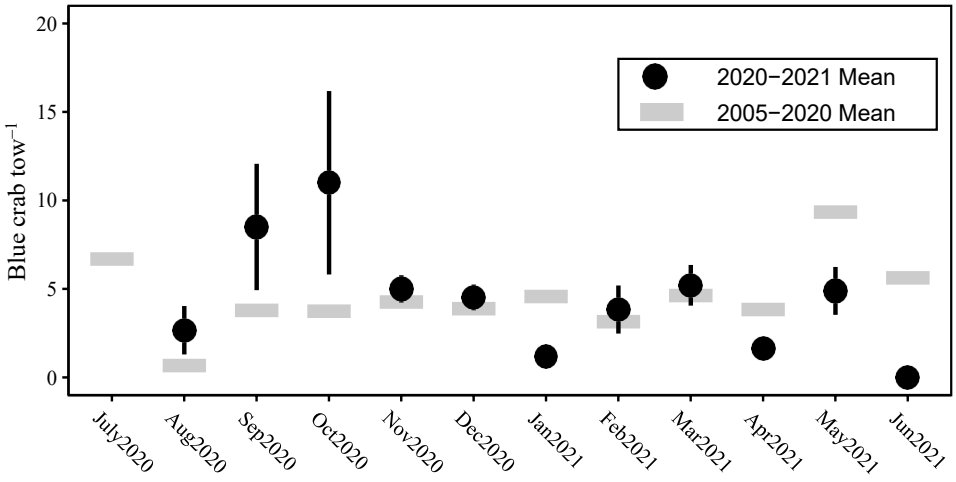


Figure 8. Monthly blue crab abundance (mean ± S.E.) from the estuarine trawl survey.

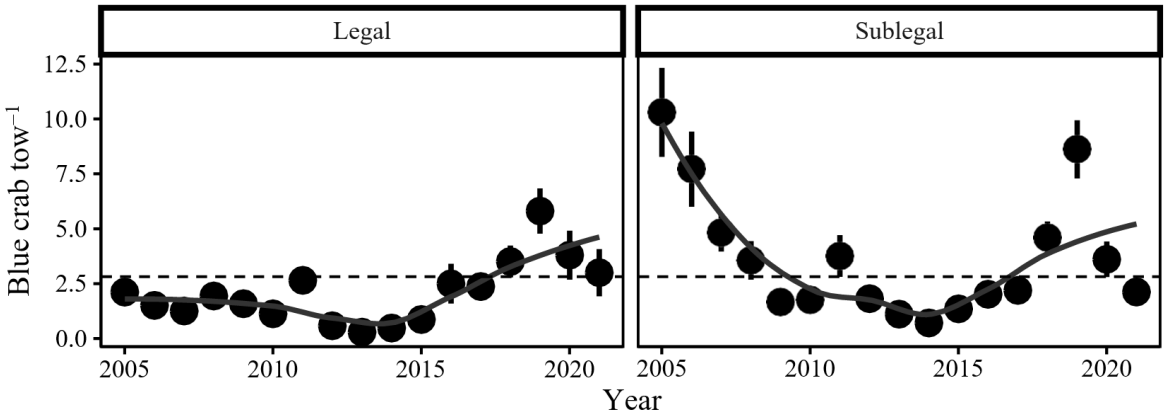


Figure 9. Blue crab abundance (mean ± S.E.) for legal- (≥5" CW) and sublegal- (<5" CW) sized blue crabs. Lines represent long-term means (dashed) and smoothed trends (solid).

Creek trawl survey: Blue crab abundance in the creek trawl survey was below the long-term mean (1995-2020; Figure 10).

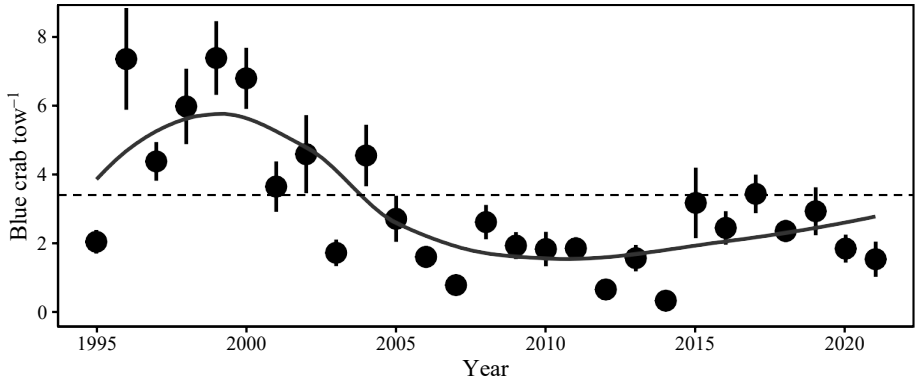


Figure 10. Blue crab abundance (mean ± standard error) from creek trawl survey in the Charleston Harbor watershed (May-July). Lines represent long-term means (dashed) and smoothed trends (solid).

Crab pot survey: Blue crab abundance in the 2020 fall crab port survey was below the long-term mean (1995-2020) and comparable to abundances in 2017 and 2019 (Figure 11)

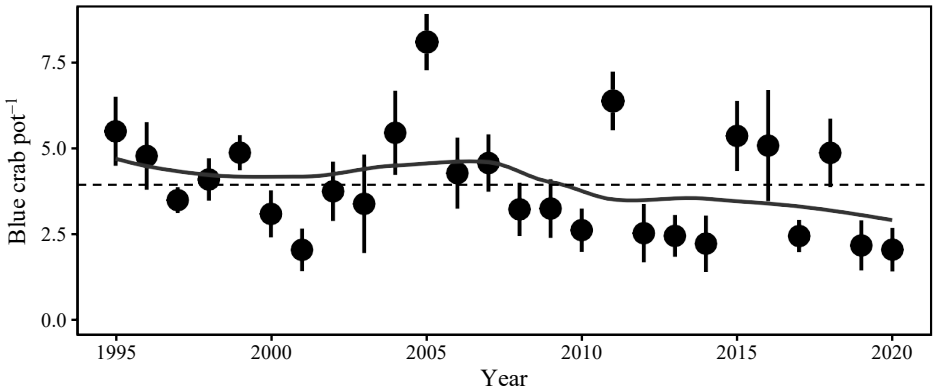


Figure 11. Fall blue crab abundance (mean ± standard error) from the statewide crab pot survey. Lines represent long-term means (dashed) and smoothed trends (solid).

Marine Outreach and Education Program

Program PIs: Matt Perkinson and Olivia Bueno

Reporting Period: July 1, 2020 through June 30, 2021

Program Objectives:

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

Summary of Activities:

- Through the Carolina Coastal Discovery Marine Education program, staff completed 44 vessel-based education programs and 162 land-based programs to 2,746 students from grades K-12. Staff spent 5,314 contact hours with students and teachers. Six teacher workshops were held with a total of 105 teachers attending.

- Due to social distancing guidelines, in-person events were limited during the project period. To supplement traditional activities, saltwater fishing outreach staff offered a variety of virtual saltwater fishing education-based programs and digital resources this year. Three webinars covered saltwater fishing subjects, including basic rigging, surf fishing, and fish handling 101. These webinars were attended live by 444 participants and had a total of 1,083 registrants. Those that were unable to view the webinars in real time were emailed a link of a recorded version to watch at their pleasure. Staff also offered four virtual Family Fishing Clinics reaching a total of 66 participants.
- Staff produced 10 saltwater fishing education videos for the SCDNR saltwater fishing YouTube playlist, focusing on basic skills like casting, knot tying, and properly measuring a fish. The playlist can be found here.

- Staff created the SCDNR Saltwater Fishing page to help people easily access SCDNR's saltwater fishing online resources and programs (Fig. 1). Resources found on this page include the Fish Rules app, basic saltwater fishing YouTube videos, saltwater fishing

event calendar, and more. This link is found on the Saltwater Fishing Resource business card that is passed out during fishing outreach opportunities.

- Staff continued the saltwater family fishing clinic program (Fig. 2) through the SCDNR Certified Fishing Instructor Course and offered virtual clinics as well. This year's instructor training took place virtually, which lead to training sixty-six new volunteers, bringing the total number of certified fishing instructors to ninety-two. The increase of volunteers in different coastal regions allowed the program to expand fishing outreach programs including the "Pier and Dock Outreach Program" and surf fishing clinics. The "Pier and Dock Outreach Program" allows volunteers to work a 2.5 hour shift at a designated pier/dock (Fig. 3) and teach basic fishing skills, emphasize marine resource stewardship, and pass out SCDNR publications. Volunteers have worked at the following piers/docks: Cherry Gove Pier, Second Avenue Pier, Springmaid Pier, Myrtle Beach State Park, Garden City Pier, Jason's Lake at Botany Bay WMA, and the James Island County Park fishing dock. Below is the SCDNR Certified Fishing Instructor program breakdown:

FISHING OUTREACH PROGRAM	# OF CLINICS/ EVENTS	# OF ATTENDEES	# OF VOLUNTEER HOURS
FAMILY FISHING CLINIC PROGRAM	24	262	226
PIER/DOCK OUTREACH PROGRAM	22	763	255.50
TOTAL # OF ATTENDEES	1,036		
TOTAL # OF VOL. HOURS	484.50		

- Staff led and assisted with three fishing tournaments, including a new "live release" format tournament with the Murrells Inlet Rotary Club. During that tournament, staff measured, tagged, and released 71 southern flounder. They also held one youth/family crabbing clinic and their first surf fishing clinic at Huntington Beach State Park.

- Staff continued to engage with the public regarding the noted population declines in the southern flounder fishery. Information on population status and potential recovery solutions were presented at four fishing club meetings during the project period. Additionally, staff produced a live webinar to virtually provide an update on southern flounder and another recorded webinar to answer the most frequently asked questions related to the fishery. Updates on southern flounder were also included in the Marine Gamefish tagging program newsletter and staff responded to 22 questions/requests for additional information.

- Public information material was distributed through the Coastal Information Distribution System (CIDS). Seven days were spent delivering approximately 194,120 copies of printed material to 121 vendors located throughout the coastal counties of South Carolina. Materials included rules and regulations books, fish rulers, crab rulers, fish identification charts, guides to saltwater fishes, and beginner guides to saltwater fishing.

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

ITEM	NUMBER PRODUCED AND DISTRIBUTED
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 100 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 978 recreational anglers participated in the Marine Game Fish Tagging Program (MGFTP) through tagging and/or reporting the recovery of tagged fish. Program volunteers tagged and released 4,062 fish from a variety of species. Information was received from 1,151 recaptured fish and of those, 82 percent were released with the tag intact. In lieu of in-person training, two virtual training events were held with MGFTP participants, reaching 44 active taggers. Information on the program and other important topics were provided via the MGFTP newsletter, with a distribution to over 1,000 anglers.

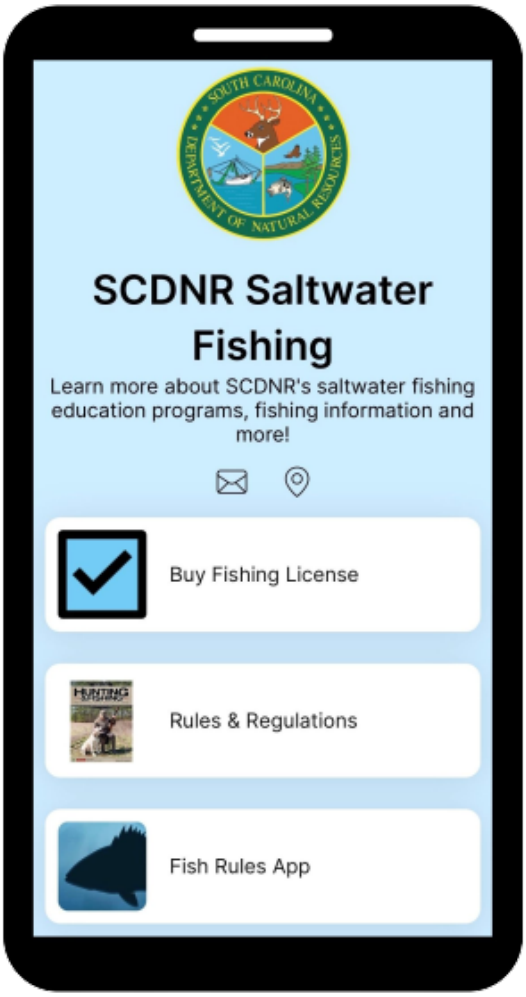


Figure 1. Screenshot of SCDNR Saltwater Fishing resource page. Visit https://flow.page/scdnr to view page.

Figure 2. Participant during one of the Saltwater Family Fishing Clinics down in the Ace Basin.

Figure 3. A Certified SCDNR Fishing Instructor helps young anglers fish at the Second Avenue Pier in Myrtle Beach

Figure 4. Screenshot of an educational YouTube video on casting.

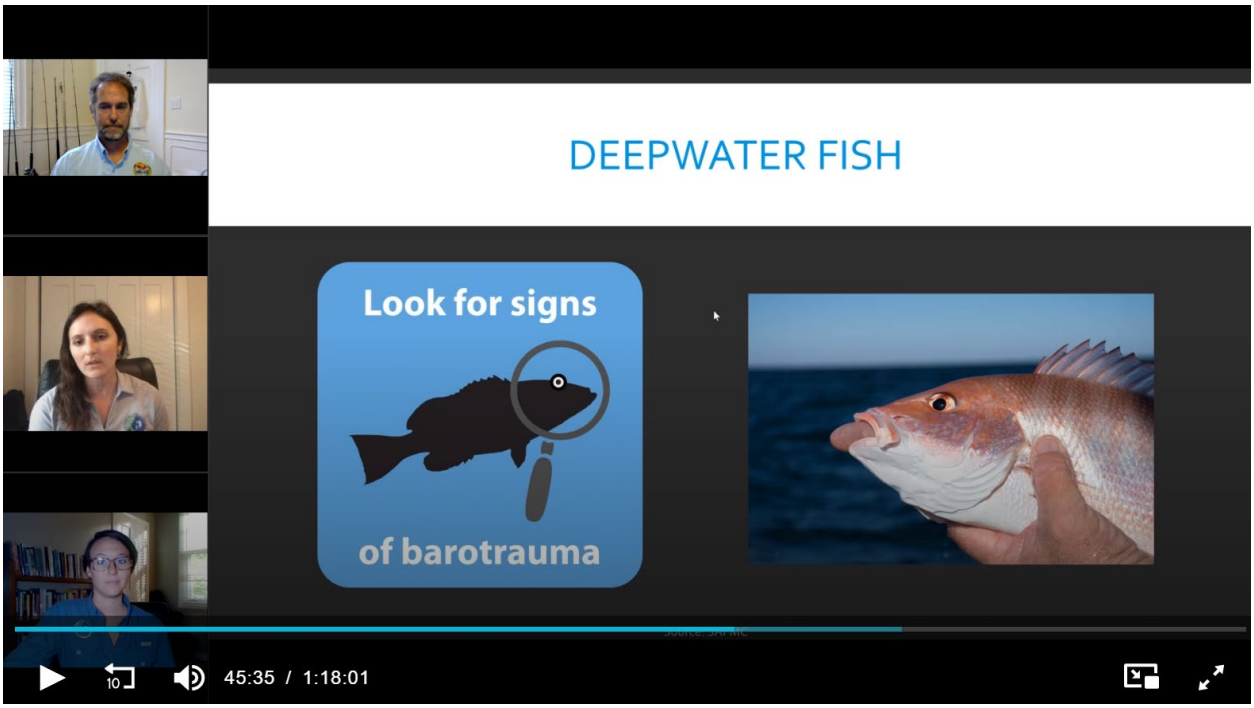


Figure 5. Screenshot of the "Fish Handling 101" webinar held in partnership with staff from the South Atlantic Fisheries Management Council.