SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2022

Inshore Fisheries Monitoring and Research

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Reporting Period: July 1, 2021 - June 30, 2022

Summary of Activities / Accomplishments to Date:

The Inshore Fisheries Section conducts long-term monitoring and research on the inshore fish species in South Carolina. SRFAC funding supports four long-term, fishery-independent surveys, including: (I) a trammel net survey of lower estuarine shoreline habitats, (ii) an electrofishing survey of upper estuarine shoreline habitats, (iii) a coastal bottom long-line survey, and (iv) a trawl survey of estuarine benthic habitats. We also take biological samples from angler-caught fish via a freezer drop-off program and a fishing tournament sampling program. SCDNR and other management agencies (e.g., ASMFC and NOAA Fisheries Service) use the data to make science-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, 2021 – June 30, 2022), Inshore Fisheries staff made 600 trammel sets in nine survey areas ('strata') found in five broad geographic areas along the South Carolina coast (Table 1). The survey caught 9,711 specimens belonging to 66 taxa (Table 2). We enumerated and measured all fish, releasing most alive at the site of capture. From the 9,711 specimens, we collected 3,603 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 use catch rates of American Eel as an index of abundance in their US stock assessment models. The survey, which began in May 2001, uses a specially designed electrofishing boat that temporarily stuns fish, enabling staff to collect, measure, and enumerate individual fish before releasing them alive.

During the reporting period, Inshore Fisheries staff made 275 electrofishing sets in five strata along the South Carolina coastline (Table 4). The survey caught 4,657 specimens belonging to

58 taxa (Table 5). From those 4,657 specimens, staff collected 864 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 sub-adults (< 5 years old) which we sample through the trammel net and electrofishing surveys. The survey also supplies information on regionally managed coastal shark species.

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

During the reporting period we made 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 2,037 specimens belonging to 31 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 51 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). We present long-term population trends for a sub-set of species as observed in the electrofishing survey in Figure 3 (Atlantic Sharpnose Shark, Blacknose Shark, Blacktip Shark, Finetooth Shark, Red Drum, and Sandbar Shark). Note there was a bait change in this survey, with Atlantic Mackerel used from 2007-2009 and Striped Mullet used from 2010-2017. The effect of this bait change on relative abundance has not been accounted for herein.

Estuarine Trawl Survey
Staff assessed the finfish catch in 132 trawls performed by the Estuarine Trawl Survey. Seventy of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). The remaining 62 trawls were performed in the southern part of the state (August and December 2021; March and April 2022; Table 8).

The 132 trawls yielded 93,777 fish belonging to 76 species (Table 9), of which at least 13 falls under federal/regional management plans. From these specimens, staff collected 1,152 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 4 (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 time frame 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 5th most numerous species captured in the trawl survey; we captured 3,645 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 181 fish carcasses belonging to five 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 104 fish belonging to six species, of which Sheepshead were the most numerous, followed by Southern Flounder (Table 10).

Tagging Program

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

The trammel and electrofishing surveys tagged 796 fish belonging to five species between July 1, 2021 and June 30, 2022, with the majority being Red Drum (Table 11). Over the same period, individuals recaptured 285 tagged fish, of which recreational anglers caught 254 and SCDNR survey staff caught 31 (Table 12). Anglers released alive 93% (236/254) of the angler-caught fish (mostly Red Drum), while they harvested the remaining 7% (18/254).

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 2 years is below:

Knotek, R. J., **B. S. Frazier**, T. S. Daly-Engel, C. F. White, S. N. Barry, E. J. Cave, & N. M. Whitney. 2022. Post-release mortality, recovery, and stress physiology of blacknose sharks, *Carcharhinus acronotus*, in the Southeast U.S. recreational shark fishery. Fisheries Research 254: 106406 (https://doi.org/10.1016/j.fishres.2022.106406). (October 2022)

Branham, C. C., **B. S. Frazier**, J. B. Strange, **A. S. Galloway**, D. H. Adams, J. M. Drymon, R. D. Grubbs, D. S. Portnoy, R. J. D. Wells, & G. Sancho. 2022. Diet of the bonnethead (*Sphyrna tiburo*) along the northern Gulf of Mexico and southeastern Atlantic coast of the United States. Animal Biodiversity and Conservation 45(2): 257-267. (August 2022)

Dalrymple, K. M., I. de Buron, K. M. Hill-Spanik, **A. S. Galloway**, A. Barker, D. S. Portnoy, **B. S. Frazier**, & W. A. Boeger. 2022. Hexabothriidae and Monocotylidae (Monogenoidea) from the gills of neonate hammerhead sharks (Sphyrnidae) *Sphyrna gilberti*, *Sphyrna lewini*, and their hybrids from the western North Atlantic ocean. Parasitology, 1-48 (https://doi.org/10.1017/S0031182022001007). (August 2022)

Guttride, T. L., L. Muller, B. A. Keller, M. E. Bond, R. D. Grubbs, W. Winram, L. A. Howey, **B. S. Frazier**, & S. H. Gruber. 2022. Vertical space use and thermal range of the great hammerhead (*Sphyrna mokarran*), (Ruppell, 1837) in the western North Atlantic. J. Fish Biol. 2022: 1-14 (https://doi.org/10.1111/jfb.15185). (August 2022)

McClain, M. N., N. Hammerschlag, A. J. Gallagher, J. M. Drymon, R. D. Grubbs, T. L. Guttride, M. J. Smukall, **B. S. Frazier**, & T. S. Daly-Engel. 2022. Age-dependent dispersal and relatedness in Tiger Sharks (*Galeocerdo cuvier*). Frontiers in Marine Science 9: https://doi.org/10.3389/fmars.2022.900107. (March 2022)

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)

Anstead, K. A., K. Drew, D. Chagaris, A. M. Schueller, J. E. McNamee, A. Buchheister, G. Nesslage, J. H. Uphoff Jr., M. J. Wilberg, A. Sharov, M. J. Dean, J. Brust, M. Celestino, S. Madsen, S. Murray, M. Appelman, **J. C. Ballenger**, J. Brito, E. Crosby, C. Craig, C. Flora, K. Gottschall, R. J. Latour, E. Leonard, R. Mroch, J. Newhard, D. Orner, C. Swanson, J. Tinsman, E. D. Houde, T. J. Miller, & H. Townsend. 2021. The path to an ecosystem approach for forage fish management: A case study of Atlantic menhaden. Frontiers in Marine Science 8: 607657 (https://doi.org/10.3389/fmars.2021.607657). (May 2021)

Erickson, K. A., J. West, M. A. Dance, T. M. Farmer, **J. C. Ballenger**, & S. R. Midway. 2021. Changing climate associated with the range-wide decline of an estuarine finfish. Global Change Biology 27(11): 2520-2536 (https://doi.org/10.1111/gcb.15568). (March 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)

Tables:

Table 1: Number of trammel net sets in each sampling stratum during July 1, 2021 - June 30, 2022.

	2021						2022						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Port Royal Sound	11			11		12		12	12	11	10		**79**
ACE Basin		11	12		11	12		12	12	9		11	**90**
Charleston Harbor	25	16	19	24	22	22	23	24	23	17	18	22	**255**
Cape Romain	12	9		12		10	12		12	9		12	**88**
Winyah Bay		8	11	12	11		12	12			10	12	**88**
Total	**48**	**44**	**42**	**59**	**44**	**56**	**47**	**60**	**59**	**46**	**38**	**57**	**600**

Table 2: Catch of species encountered by the trammel net survey during July 1, 2021 - June 30, 2022.

	Common Name	Scientific Name	Family	Abundance
1	Striped Mullet	*Mugil cephalus*	Mugilidae	1,896
2	Spotted Seatrout	*Cynoscion nebulosus*	Sciaenidae	1,564
3	Spot	*Leiostomus xanthurus*	Sciaenidae	1,178
4	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	839
5	Red Drum	*Sciaenops ocellatus*	Sciaenidae	835
6	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	690
7	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	389
8	Blue Crab	*Callinectes sapidus*	Portunidae	377
9	Diamondback Terrapin	*Malaclemys terrapin centrata*	Emydidae	280
10	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	267
11	Southern Kingfish	*Menticirrhus americanus*	Sciaenidae	143
12	Bonnethead	*Sphyrna tiburo*	Sphyrnidae	119
13	Ladyfish	*Elops saurus*	Elopidae	116
14	Pinfish	*Lagodon rhomboides*	Sparidae	114
15	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	112
16	Permit	*Trachinotus falcatus*	Carangidae	112
17	Sheepshead	*Archosargus probatocephalus*	Sparidae	51
18	Striped Burrfish	*Chilomycterus schoepfi*	Diodontidae	44
19	American Harvestfish	*Peprilus paru*	Stromateidae	43
20	Horseshoe Crab	*Limulus polyphemus*	Limulidae	42
21	White Mullet	*Mugil curema*	Mugilidae	40
22	Bluntnose Stingray	*Dasyatis say*	Dasyatidae	38
23	Pigfish	*Orthopristis chrysoptera*	Haemulidae	36
24	Finetooth Shark	*Carcharhinus isodon*	Carcharhinidae	35
25	Gizzard Shad	*Dorosoma cepedianum*	Clupeidae	34
26	Banded Drum	*Larimus fasciatus*	Sciaenidae	30
27	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	Carcharhinidae	26
28	Hogchoker	*Trinectes maculatus*	Achiridae	26
29	Bluefish	*Pomatomus saltatrix*	Pomatomidae	25
30	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	25
31	Black Drum	*Pogonias cromis*	Sciaenidae	24
32	Cownose Ray	*Rhinoptera bonasus*	Rhinopteridae	21

Table 2: cont.

	Common Name	Scientific Name	Family	Abundance
33	Green Sea Turtle	*Chelonia mydas*	Cheloniidae	14
34	White Catfish	*Ameiurus catus*	Ictaluridae	14
35	Northern Puffer	*Sphoeroides maculatus*	Tetraodontidae	12
36	Blacktip Shark	*Carcharhinus limbatus*	Carcharhinidae	8
37	Crevalle Jack	*Caranx hippos*	Carangidae	8
38	Atlantic Tripletail	*Lobotes surinamensis*	Lobotidae	7
39	Butterfish	*Peprilus triacanthus*	Stromateidae	7
40	Lemon Shark	*Negaprion brevirostris*	Carcharhinidae	7
41	Spanish Mackerel	*Scomberomorus maculatus*	Scombridae	6
42	Atlantic Spadefish	*Chaetodipterus faber*	Ephippidae	5
43	Gafftopsail Catfish	*Bagre marinus*	Ariidae	5
44	Blueback Herring	*Alosa aestivalis*	Clupeidae	4
45	Hickory Shad	*Alosa mediocris*	Clupeidae	4
46	Leatherjack	*Oligoplites saurus*	Carangidae	4
47	Smooth Butterfly Ray	*Gymnura micrura*	Gymnuridae	4
48	Bull Shark	*Carcharhinus leucas*	Carcharhinidae	3
49	Sandbar Shark	*Carcharhinus plumbeus*	Carcharhinidae	3
50	Atlantic Sturgeon	*Acipenser oxyrinchus*	Acipenseridae	2
51	Gulf Flounder	*Paralichthys albigutta*	Paralichthyidae	2
52	Gulf Kingfish	*Menticirrhus littoralis*	Sciaenidae	2
53	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	Paralichthyidae	2
54	Lookdown	*Selene vomer*	Carangidae	2
55	Family (Pipefishes and Seahorses)	*Syngnathidae* sp.	Syngnathidae	2
56	Striped Bass	*Morone saxatilis*	Moronidae	2
57	Weakfish	*Cynoscion regalis*	Sciaenidae	2
58	Atlantic Bumper	*Chloroscombrus chrysurus*	Carangidae	1
59	Atlantic Needlefish	*Strongylura marina*	Belonidae	1
60	Bighead Searobin	*Prionotus tribulus*	Triglidae	1
61	Chain Pipefish	*Syngnathus louisianae*	Syngnathidae	1
62	Loggerhead Turtle	*Caretta caretta*	Cheloniidae	1
63	Northern Searobin	*Prionotus carolinus*	Triglidae	1
64	Roughtail Stingray	*Dasyatis centroura*	Dasyatidae	1
65	Spotfin Killifish	*Fundulus luciae*	Fundulidae	1
66	Striped Anchovy	*Anchoa hepsetus*	Engraulidae	1
			Total	**9,711**

Table 3: Number of biological samples collected during July 1, 2021 - June 30, 2022.

		Gear					
Sample	**Purpose**	**Electrofishing**	**Hook and Line**	**Longline**	**Trammel**	**Trawl**	**Total**
Digestive Tract	Microplastic Studies	84	7		71		**162**
Fillet	SCDHEC Mercury analysis	11	31		64		**88**
Fin Clip	Genetics	567	293	477	2,203	1,152	**4,692**
Otoliths	Ageing	69	247	56	649		**1,021**
Reproductive Tissue	Sex and maturity	64	109	56	435		**664**
Whole Specimen	Educational programs	11			90		**101**
Whole Specimen	Diamondback Terrapin Studies						**0**
Whole Specimen	Stock Enhancement Program Brood Stock	7		10	91		**108**
Whole Specimen	Parasite Study						**0**
Whole specimen	Largemouth Bass and Bowfin Evolution Study	51					**51**
Total		**864**	**669**	**599**	**3,603**	**1,641**	**6,887**

Table 4: Number of electrofishing sets made in each stratum during July 1, 2021 - June 30, 2022.

	2021						2022						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**[a]	**Total**
Combahee River	6	6	6	6	6		6		6	6	6	6	**60**
Edisto River	6		6	6	6	6	6	6	6		6	6	**60**
Ashley River	6	6		6	6	6		6	6	3	4		**49**
Cooper River		6	6	6	6	1	6	6	6	6			**49**
Winyah Bay	6	5	6		5	6	6	5	6	6	6		**57**
Total	**24**	**23**	**24**	**24**	**29**	**19**	**24**	**23**	**30**	**21**	**22**	**12**	**275**

[a] – Electrofishing boat was unavailable the second half of June due to necessary mechanical repairs.

Table 5: Catch of species encountered by the electrofishing survey during July 1, 2021 - June 30, 2022.

	Common Name	**Scientific Name**	**Family**	**Abundance**
1	Striped Mullet	*Mugil cephalus*	Mugilidae	1,250
2	Spot	*Leiostomus xanthurus*	Sciaenidae	572
3	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	417
4	Inland Silverside	*Menidia beryllina*	Atherinopsidae	387
5	Bay Anchovy	*Anchoa mitchilli*	Engraulidae	333
6	Red Drum	*Sciaenops ocellatus*	Sciaenidae	280
7	Blue Catfish	*Ictalurus furcatus*	Ictaluridae	197
8	Largemouth Bass	*Micropterus salmoides*	Centrarchidae	141
9	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	123
10	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	117
11	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	100
12	American Eel	*Anguilla rostrata*	Anguillidae	86
13	White Catfish	*Ameiurus catus*	Ictaluridae	86
14	Redbreast Sunfish	*Lepomis auritus*	Centrarchidae	65
15	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	50
16	Redear Sunfish	*Lepomis microlophus*	Centrarchidae	46
17	Bluegill	*Lepomis macrochirus*	Centrarchidae	44
18	Western Mosquitofish	*Gambusia holbrooki*	Poeciliidae	43
19	Pinfish	*Lagodon rhomboides*	Sparidae	42
20	Freshwater Goby	*Ctenogobius shufeldti*	Gobiidae	33
21	Mummichog	*Fundulus heteroclitus*	Fundulidae	27
22	Spotted Sucker	*Minytrema melanops*	Catostomidae	24
23	Flathead Catfish	*Pylodictis olivaris*	Ictaluridae	23
24	Bowfin	*Amiidae*	Amiidae	22
25	Striped Bass	*Morone saxatilis*	Moronidae	19
26	American Shad	*Alosa sapidissima*	Clupeidae	12
27	Channel Catfish	*Ictalurus punctatus*	Ictaluridae	10
28	Speckled Worm Eel	*Myrophis punctatus*	Ophichthidae	10
29	Sheepshead	*Archosargus probatocephalus*	Sparidae	9
30	Threadfin Shad	*Dorosoma petenense*	Clupeidae	8
31	Gizzard Shad	*Dorosoma cepedianum*	Clupeidae	6
32	Hogchoker	*Trinectes maculatus*	Achiridae	6

Table 5: cont.

	Common Name	Scientific Name	Family	Abundance
33	Sailfin Molly	*Poecilia latipinna*	Poeciliidae	6
34	Spotted Seatrout	*Cynoscion nebulosus*	Sciaenidae	6
35	Black Crappie	*Pomoxis nigromaculatus*	Centrarchidae	5
36	Common Carp	*Cyprinus carpio*	Cyprinidae	5
37	Tidewater Mojarra	*Eucinostomus harengulus*	Gerreidae	5
38	Spotted Sunfish	*Lepomis punctatus*	Centrarchidae	4
39	Atlantic Needlefish	*Strongylura marina*	Belonidae	3
40	Bay Whiff	*Citharichthys spilopterus*	Paralichthyidae	3
41	Black Drum	*Pogonias cromis*	Sciaenidae	3
42	Golden Shiner	*Notomigonus crysoleucas*	Cyprinidae	3
43	Highfin Goby	*Gobionellus oceanicus*	Gobiidae	3
44	Spinycheek Sleeper	*Eleotris pisonis*	Eleotridae	3
45	White Mullet	*Mugil curema*	Mugilidae	3
46	Fringed Flounder	*Etropus crossotus*	Paralichthyidae	2
47	Minnow - Species TBI	*Minnow - Species TBI*	Cyprinidate	2
48	Naked Goby	*Gobiosoma bosc*	Gobiidae	2
49	Warmouth	*Lepomis gulosus*	Centrarchidae	2
50	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	1
51	Bluefish	*Pomatomus saltatrix*	Pomatomidae	1
52	Chain Pickerel	*Esox niger*	Esocidae	1
53	Eucinostomus species	*Eucinostomus sp.*	Gerreidae	1
54	Gambusia species	*Gambusia sp.*	Poeciliidae	1
55	Gray Snapper	*Lutjanus griseus*	Lutjanidae	1
56	Pumpkinseed	*Lepomis gibbosus*	Centrarchidae	1
57	Spotted Whiff	*Citharichthys macrops*	Paralichthyidae	1
58	Tiger shrimp	*Penaeus monodon*	Penaeidae	1
			Total	**4,657**

Table 6: Number of one-third mile longline sets made during July 1, 2021 - June 30, 2022.

Stratum		**Month**					
Area	**Depth**	**August**	**September**	**October**	**November**	**December**	**Total**
Winyah Bay	Inner		10	12	5		**27**
	Outer		20	18	25		**63**
Charleston Harbor	Inner		10	11	9		**30**
	Outer		20	19	21		**60**
St. Helena Sound	Inner	11		10	9		**30**
	Outer	19		20	21		**60**
Port Royal Sound	Inner	10		13	7		**30**
	Outer	20		17	23		**60**
TOTAL		**60**	**60**	**120**	**120**		**360**

Table 7: Catch of species encountered by the SCDNR longline survey during July 1, 2021 - June 30, 2022.

	Common Name	Scientific Name	Abundance
1	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	880
2	Red Drum	*Sciaenops ocellatus*	484
3	Blacknose Shark	*Carcharhinus acronotus*	161
4	Sandbar Shark	*Carcharhinus plumbeus*	121
5	Blacktip Shark	*Carcharhinus limbatus*	109
6	Southern Stingray	*Hypanus americanus*	70
7	Finetooth Shark	*Carcharhinus isodon*	62
8	Bonnethead	*Sphyrna tiburo*	42
9	Black Sea Bass	*Centropristis striata*	24
10	Oyster Toadfish	*Opsanus tau*	19
11	Scalloped Hammerhead	*Sphyrna lewini*	11
12	Spinner Shark	*Carcharhinus brevipinna*	10
13	Nurse Shark	*Ginglymostoma cirratum*	9
14	Whiting	*Menticirrhus americanus*	7
15	Bull Shark	*Carcharhinus leucas*	4
16	Smooth Butterfly Ray	*Gymnura micrura*	4
17	Lemon Shark	*Negaprion brevirostris*	3
18	Atlantic Croaker	*Micropogonias undulatus*	2
19	Cownose Ray	*Rhinoptera bonasus*	2
20	Gafftopsail Catfish	*Bagre marinus*	2
21	Bluefish	*Pomatomus saltatrix*	1
22	Dusky Shark	*Carcharhinus obscurus*	1
23	Great Barracuda	*Sphyraena barracuda*	1
24	Inshore lizardfish	*Synodus foetens*	1
25	Red Snapper	*Lutjanus campechanus*	1
26	Pigfish	*Orthopristis chrysoptera*	1
27	Pinfish	*Lagodon rhomboides*	1
28	Sand Tiger Shark	*Carcharias taurus*	1
29	Spiny Butterfly Ray	*Gymnura altavela*	1
30	Tarpon	*Megalops atlanticus*	1
31	Weakfish	*Cynoscion regalis*	1
Total			**2,037**

Table 8: Number of Estuarine Trawl Survey trawls monitored for finfish from July 1, 2021 - June 30, 2022.

	2021						**2022**						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Charleston Harbor	2	4	4	4	4	4	4	4	4	4	4	4	**46**
Ashley River	2	2	2	2	2	2	2	2	2	2	2	2	**24**
Stono River/Kiawah River		3				3			3	3			**12**
ACE Basin		5				5			5	5			**20**
Port Royal Sound		3				2			3	3			**11**
Calibogue Sound		4				5			5	5			**19**
Total	**4**	**21**	**6**	**6**	**6**	**21**	**6**	**6**	**22**	**22**	**6**	**6**	**132**

Table 9: Catch of finfish species encountered by the SCDNR estuarine trawl survey during July 1, 2021 - June 30, 2022.

	Common Name	**Scientific Name**	**Family**	**Abundance**
1	Bay Anchovy	*Anchoa mitchilli*	Engraulidae	26,761
2	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	24,835
3	Star Drum	*Stellifer lanceolatus*	Sciaenidae	22,891
4	Spot	*Leiostomus xanthurus*	Sciaenidae	5,388
5	Weakfish	*Cynoscion regalis*	Sciaenidae	3,645
6	Blackcheek Tonguefish	*Symphurus plagiusa*	Cynoglossidae	1,888
7	Silver Seatrout	*Cynoscion nothus*	Sciaenidae	1,048
8	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	1,000
9	Hogchoker	*Trinectes maculatus*	Achiridae	966
10	Butterfish	*Peprilus triacanthus*	Stromateidae	904
11	Spotted Hake	*Urophycis regia*	Phycidae	732
12	Northern Searobin	*Prionotus carolinus*	Triglidae	714
13	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	666
14	Southern Kingfish	*Menticirrhus americanus*	Sciaenidae	527
15	Fringed Flounder	*Etropus crossotus*	Paralichthyidae	288
16	Striped Anchovy	*Anchoa hepsetus*	Engraulidae	244
17	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	138
18	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	136
19	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	Paralichthyidae	127
20	Bighead Searobin	*Prionotus tribulus*	Triglidae	91
21	Banded Drum	*Larimus fasciatus*	Sciaenidae	84
22	Bay Whiff	*Citharichthys spilopterus*	Paralichthyidae	74
23	Lookdown	*Selene vomer*	Carangidae	74
24	White Catfish	*Ameiurus catus*	Ictaluridae	54
25	Leopard Searobin	*Prionotus scitulus*	Triglidae	36
26	Smooth Butterfly Ray	*Gymnura micrura*	Gymnuridae	33
27	American Harvestfish	*Peprilus paru*	Stromateidae	31
28	Atlantic Silverside	*Menidia*	Atherinopsidae	31
29	Pinfish	*Lagodon rhomboides*	Sparidae	31
30	Northern Pipefish	*Syngnathus fuscus*	Syngnathidae	28
31	Atlantic Thread Herring	*Opisthonema oglinum*	Clupeidae	26
32	Northern Puffer	*Sphoeroides maculatus*	Tetraodontidae	23
33	Blueback Herring	*Alosa aestivalis*	Clupeidae	21
34	Spotted Seatrout	*Cynoscion nebulosus*	Sciaenidae	18
35	Inshore Lizardfish	*Synodus foetens*	Synodontidae	17
36	Atlantic Bumper	*Chloroscombrus chrysurus*	Carangidae	15
37	Atlantic Spadefish	*Chaetodipterus faber*	Ephippidae	13
38	Striped Mullet	*Mugil cephalus*	Mugilidae	13
39	Threadfin Shad	*Dorosoma petenense*	Clupeidae	13
40	Oyster Toadfish	*Opsanus tau*	Batrachoididae	12
41	Atlantic Cutlassfish	*Trichiurus lepturus*	Trichiuridae	10

Table 9: cont.

	Common Name	Scientific Name	Family	Abundance
42	Feather Blenny	*Hypsoblennius hentz*	Blenniidae	9
43	Striped Burrfish	*Chilomycterus schoepfi*	Diodontidae	9
44	Highfin Goby	*Gobionellus oceanicus*	Gobiidae	8
45	Planehead Filefish	*Stephanolepis hispidus*	Monacanthidae	8
46	Shrimp Eel	*Ophichthus gomesii*	Ophichthidae	8
47	Black Sea Bass	*Centropristis striata*	Serranidae	7
48	Naked Goby	*Gobiosoma bosc*	Gobiidae	7
49	Gafftopsail Catfish	*Bagre marinus*	Ariidae	6
50	Bluefish	*Pomatomus saltatrix*	Pomatomidae	5
51	Fat Sleeper	*Dormitator maculatus*	Eleotridae	5
52	Skilletfish	*Gobiesox strumosus*	Gobiesocidae	5
53	Blue Catfish	*Ictalurus furcatus*	Ictaluridae	4
54	Cownose Ray	*Rhinoptera bonasus*	Rhinopteridae	4
55	Southern Stargazer	*Astroscopus y-graecum*	Uranoscopidae	4
56	Striped Cusk-Eel	*Ophidion marginatum*	Ophidiidae	4
57	Bluntnose Stingray	*Dasyatis say*	Dasyatidae	3
58	Bonnethead	*Sphyrna tiburo*	Sphyrnidae	3
59	Freshwater Goby	*Ctenogobius shufeldti*	Gobiidae	3
60	Gray Snapper	*Lutjanus griseus*	Lutjanidae	3
61	Gulf Kingfish	*Menticirrhus littoralis*	Sciaenidae	3
62	Pigfish	*Orthopristis chrysoptera*	Haemulidae	3
63	Southern Hake	*Urophycis floridana*	Phycidae	3
64	Atlantic Sturgeon	*Acipenser oxyrinchus*	Acipenseridae	2
65	Bank Sea Bass	*Centropristis ocyurus*	Serranidae	2
66	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	2
67	Striped Searobin	*Prionotus evolans*	Triglidae	2
68	Astroscopus species	*Astroscopus* sp.	Uranoscopidae	1
69	Blackwing Searobin	*Prionotus rubio*	Triglidae	1
70	Bullnose Eagle Ray	*Myliobatis freminvillei*	Myliobatidae	1
71	Crevalle Jack	*Caranx hippos*	Carangidae	1
72	Scup	*Stenotomus chrysops*	Sparidae	1
73	Silver Jenny	*Eucinostomus gula*	Gerreidae	1
74	Spanish Mackerel	*Scomberomorus maculatus*	Scombridae	1
75	Striped Blenny	*Chasmodes bosquianus*	Blenniidae	1
76	Tidewater Mojarra	*Eucinostomus harengulus*	Gerreidae	1
			Total	**93,777**

Table 10: Fish acquired from the freezer and tournament monitoring programs during July 1, 2021 - June 30, 2022.

Species	Freezer	Tournament	Total
Black Drum	13		13
Bluefish		2	2
Gulf Flounder	3		3
Red Drum		2	2
Sheepshead	160	46	206
Southern Flounder	3	43[a]	46
Southern Kingfish		4	4
Spotted Seatrout	2	7	9
Total	**181**	**104**	**285**

a – Southern Flounder noted in the tournament column were tagged and released after measuring and collecting biological samples.

Table 11: Fish tagged by the trammel net and electrofishing surveys during July 1, 2021 - June 30, 2022.

Species	Electrofishing	Trammel	Total
Atlantic Tripletail	0	1	1
Black Drum	1	8	9
Red Drum	155	488	643
Sheepshead	3	31	34
Southern Flounder	17	92	109
Total	**176**	**620**	**796**

Table 12: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2021 - June 30, 2022.

Capture Method	Disposition	Atlantic Tripletail	Black Drum	Red Drum	Southern Flounder	Total
Anglers	Harvested	1	4	12	1	**18**
	Released		6	229	1	**236**
	Anglers: sub-total	**1**	**10**	**241**	**2**	**254**
SCDNR Surveys	Harvested					**0**
	Released		1	29	1	**31**
	Survey: sub-total	**0**	**1**	**29**	**1**	**31**
Total		**1**	**11**	**270**	**3**	**285**

Figures

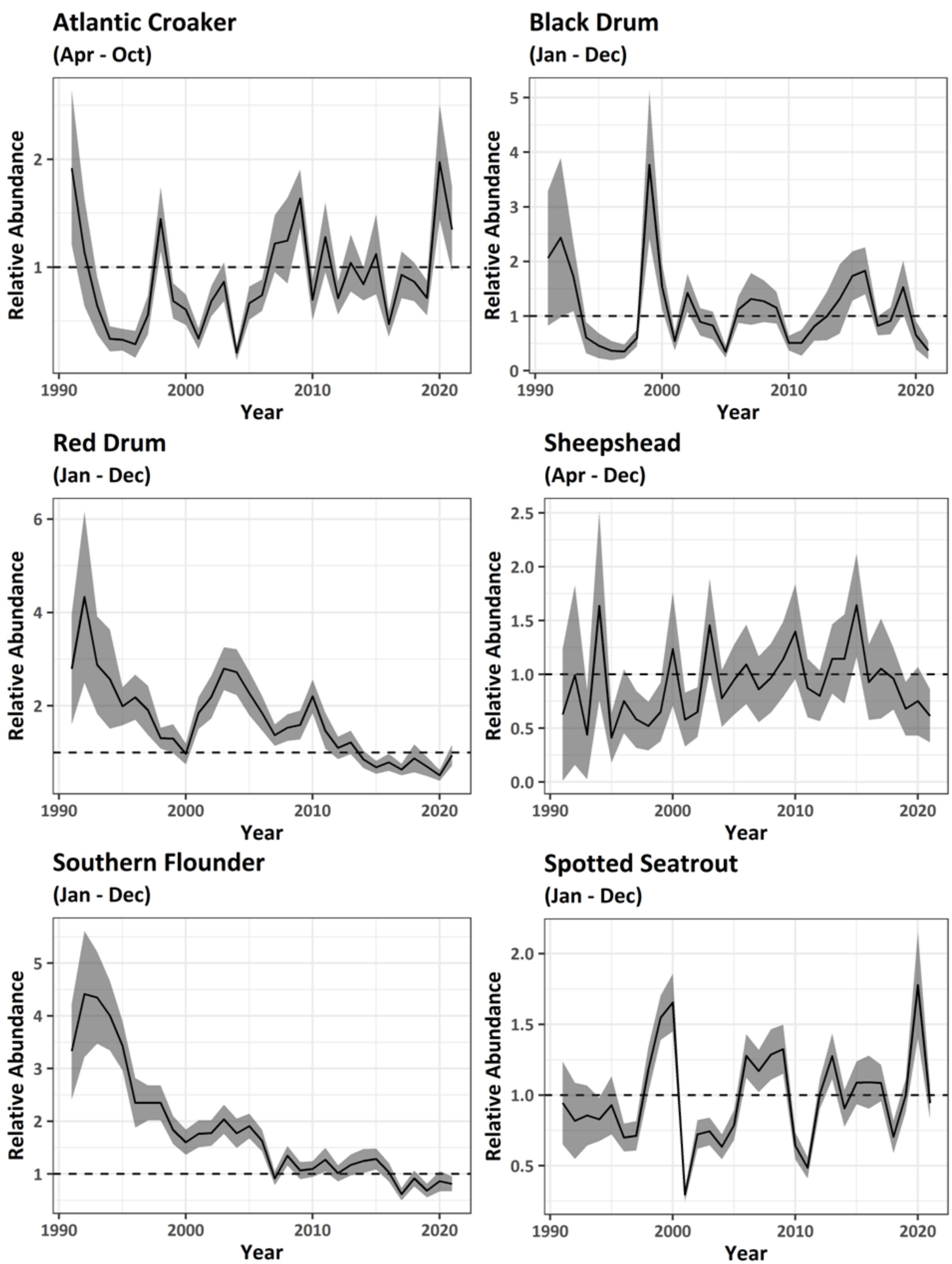


Figure 1: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR trammel net survey. Vertical axis is a relative index of fish abundance, with annual average catch shown relative to 2010-2021 average catch (dashed black line).

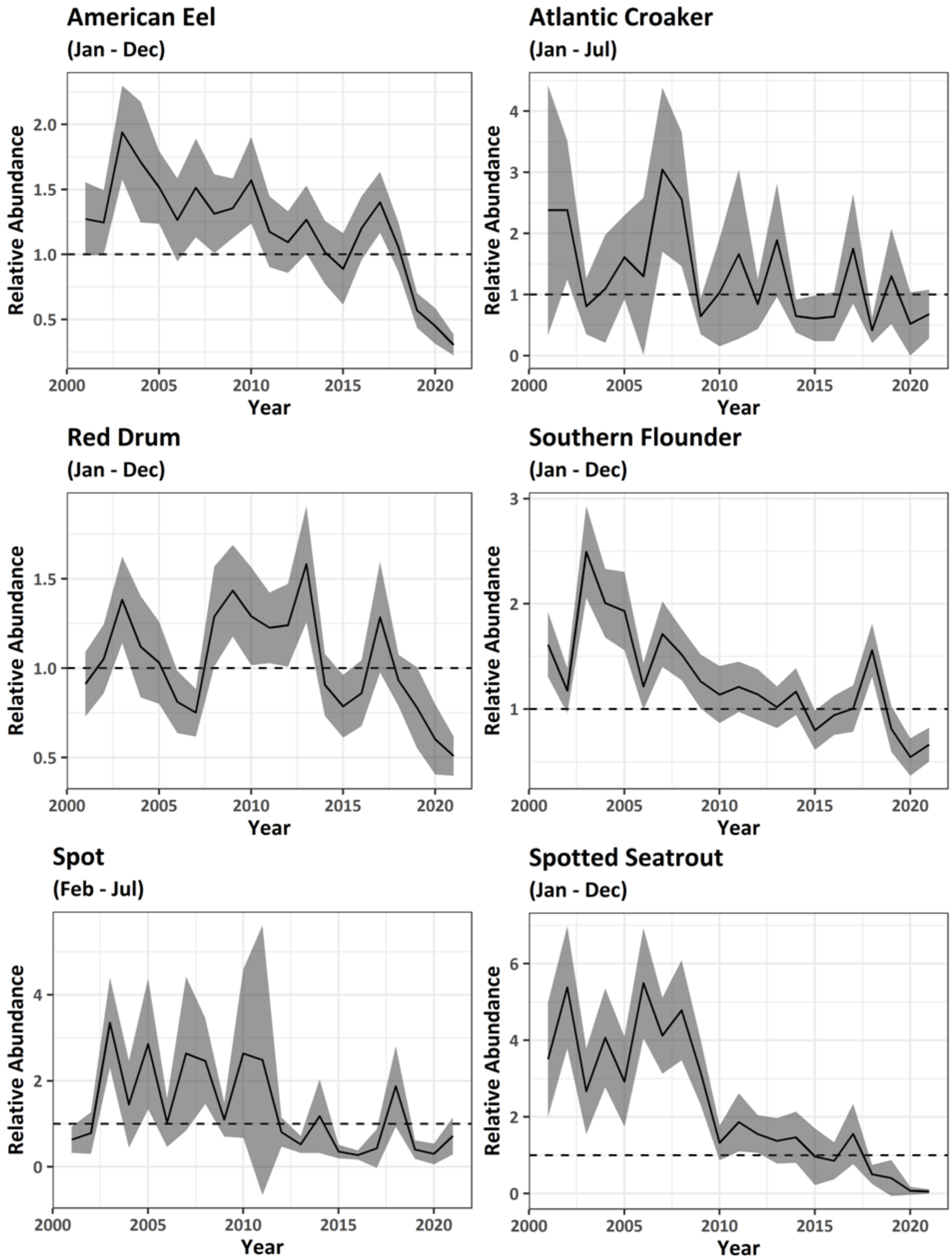


Figure 2: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR electrofishing survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes electrofishing shown relative to 2010-2021 average catch per 15 minutes electrofishing (dashed black line).

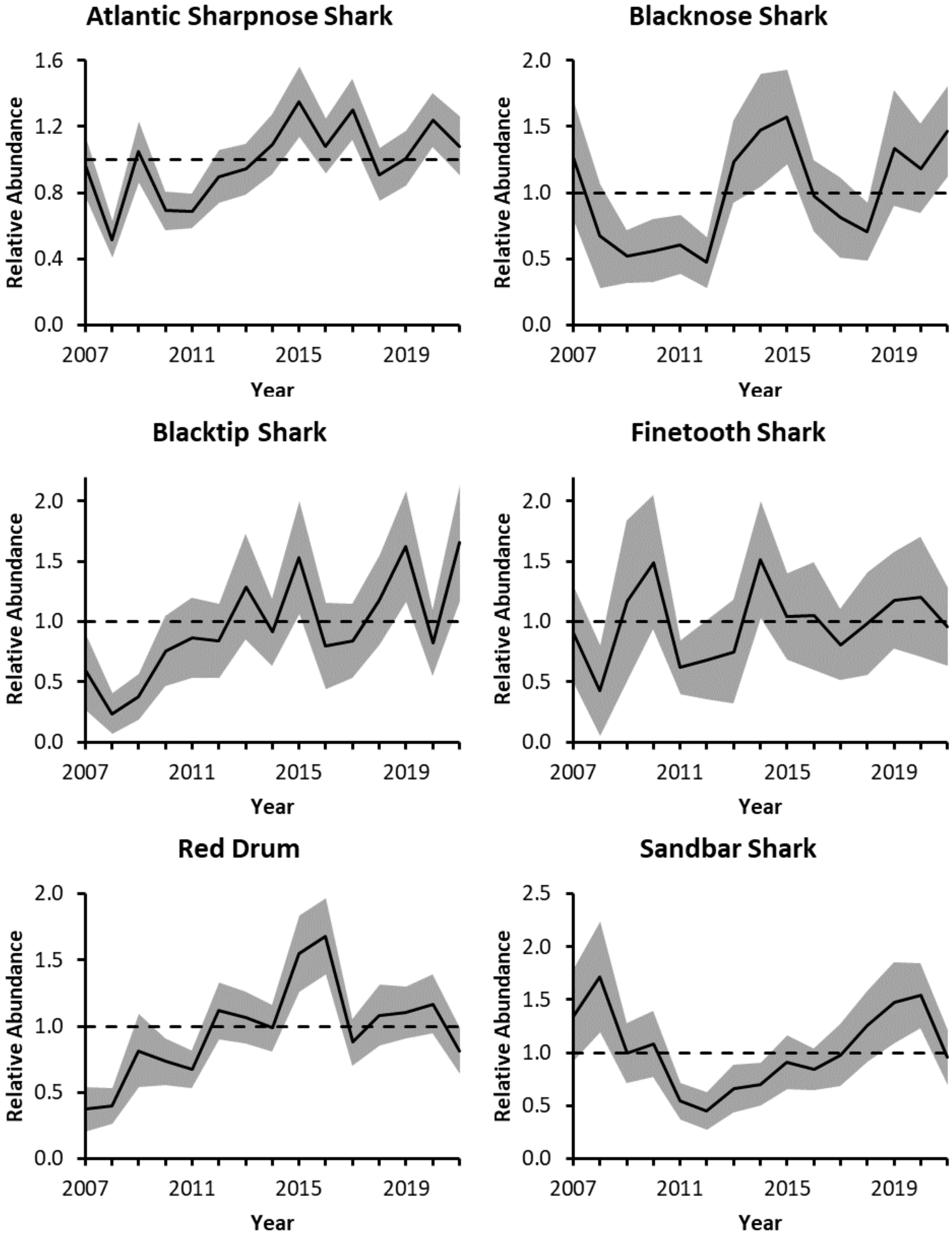


Figure 3: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR adult red drum and shark longline survey. Vertical axis is a relative index of fish abundance, with annual average catch shown relative to 2007-2021 average catch (dashed black line). Note, a bait change between 2007-2009 and 2010-2017 has not been accounted for in this index.

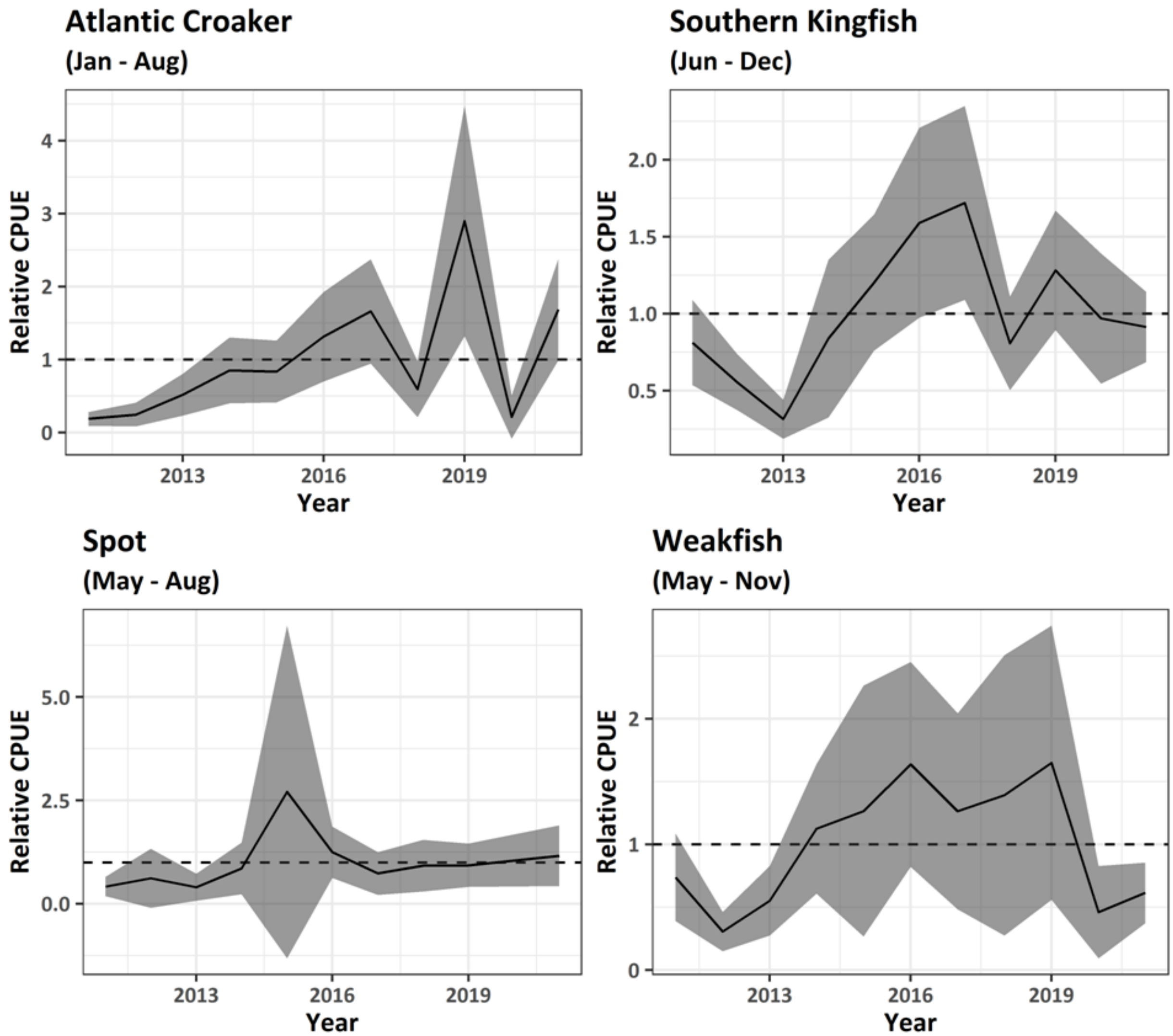


Figure 4: Long-term population trends (black lines, 95% CI shaded region) for selected species, as assessed by the SCDNR estuarine trawl survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes trawling shown relative to time series average catch per 15 minutes 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.

Stock Enhancement & Genetic Fisheries Research

Project PIs: Aaron Watson, Tanya Darden,

Project Title: Stock Enhancement & Genetic Fisheries Research

Reporting Period: July 1, 2021 - June 30, 2022

Introduction:

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

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

Project Objectives:

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

Summary of Accomplishments/Activities:

Red Drum:

2021 Production: Four unique genetic families (HML118, HML119, NWL1, and OWL 3) contributed to the 2021 YC stock enhancement releases. Four estuaries were stocked including Port Royal Sound, Charleston Harbor (Ashley River), ACE Basin, and North Edisto River. Small juvenile fish were produced for YC 2021 (27.8- 62.3 avg. TL) with stocking occurring from 9/2/2021-12/7/2021 and the medium fish released on 2/18/2021.

The red drum stocking strategy for 2021 was to evaluate contribution of small juvenile red drum (~30-50 mm TL) to the wild population from two release treatments located within the Ashley River (brackish water <8 g/L and saltwater >25 g/L) as well as their movement patterns following release. During previous years where brackish versus saltwater releases were evaluated, releases occurred in one location within the desired salinity range. During 2019, the release methods were modified to distribute fish in multiple locations within the desired salinity range. We believe this allows us to answer the primary question of salinity effects on survival rather than the single release location per salinity range from previous years which likely is answering a release location question rather than salinity. One family was stocked into the Port Royal Sound, but no design was employed.

The other three estuaries only had one genetic family stocked so no comparative questions can be addressed. Movement and contribution, however, will be evaluated.

<u>Ashley River:</u> A total of 288,510 small juvenile red drum (mean TL 35.9 mm) from HML 118 were released by boat near the mouth of the Ashley River as part of the saltwater release treatment. Releases occurred on 9/16/2021 (79,438 fish), and 9/24/2021 (209,072 fish). A total of 278,981 juvenile red drum (mean TL 31.4 mm) from NWL 1 were released by boat near Magnolia Plantation for the brackish water release treatment. Releases occurred on 9/23/2021 (173,502 fish), 9/29/2021 (58,957 fish), and 9/30/2021 (46,522 fish). Due to excessive rainfall around the time of stocking, the salinities at our saltwater and brackish water release locations were much lower than normal, 15.7 ppt and 4.3 ppt respectively.

<u>ACE Basin:</u> One unique genetic family (OWL 3) totaling 212,296 juveniles was released directly from the hauling trailer (mean TL 40.1 mm) at the Bennett's Point and Live Oak Boat Landings. A total of 36,928 small red drum (mean TL 51.7 mm) were released on 9/14/2021 at Bennett's Point Boat Landing. A total of 175,368 juvenile red drum (mean TL 37.7 mm) were released on 9/2/2021 at Live Oak Boat Landing.

<u>North Edisto</u>: One genetic family (HML 119) 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 183,812 small juvenile red drum (mean TL 36.9 mm) were released on five separate days from boat by staff at BBNFH in two different creeks within the

North Edisto. Leadenwah Creek received 107,216 small juvenile red drum (mean TL 32.4 mm) on 9/17/2021 and 9/27/2021. Bohicket Creek received a total of 76,596 small red drum (mean TL 43.1 mm) on 9/20/2021, 9/21/2021, and 9/22/2021.

Port Royal Sound: One unique genetic family (OWL 3) totaling 12,040 was released directly from the hauling trailer (mean TL 27.8 mm) at the Alljoy Boat Landing into the May River on 12/7/2021.

Table 1. Stocking information for the 2021 YC juvenile hatchery red drum.

Avg. TL	Number Released	Release Location	Treatment
40.1	212,296	ACE Basin	Trailer
35.9	288,510	Ashley River	Boat/Saltwater
31.4	278,981	Ashley River	Boat/Brackish
36.9	183,812	North Edisto	Boat
27.8	12,040	Port Royal Sound	Trailer

Contribution:

Out of a total of 375 red drum tissue samples from 2020YC individuals collected during July-December 2021, 366 samples were included in the analysis of contribution to the Ashley River, Charleston Harbor, Cooper River, North Edisto River, Port Royal Sound, and Wando River. Six samples were removed after being determined to be a recapture of an earlier fish, two were removed because contamination prevented genotyping, and one was removed after it failed to amplify. This last sample appeared to be an empty vial that was collected by a cooperating angler. A total of 105 cultured fish were collected and sampled for an overall hatchery contribution of 28.7% from stocking effort in 2020.

In the Ashley River, 124 tissue samples were included in the analysis and 53 cultured were fish captured for a stocked contribution of 42.7%. In the Charleston Harbor, 15 tissue samples were included in the analysis and 2 cultured fish were captured, with 13.3% hatchery contribution. In the Wando River, 69 tissue samples were included in the analysis and 32 hatchery fish were captured for a hatchery contribution of 46.4%. Contribution to the entire Charleston Harbor System was 41.8%. In the North Edisto River, 111 tissue samples were included in the analysis and 18 cultured fish were captured for hatchery contribution of 16.2%. In the Port Royal Sound, 43 tissue samples were included in the analysis and no hatchery fish were captured for a hatchery contribution of 0%.

Charleston Harbor

In the Charleston Harbor System, 208 2020YC Red Drum were captured (Figure 1). Of those, 87 were hatchery fish, for a total system contribution of 41.8%. Charleston Harbor had 2 hatchery fish out of 15 captures, for a contribution of 13.3%. The Cooper had no hatchery captures with 4 fish and no contribution and was removed from contribution analysis due to its distance from release sites.

The Wando River had 32 hatchery fish out of 69 captures for a contribution of 46.4% making this the largest contribution of small juveniles to date when stocking occurred in this estuary. A 50.4% contribution was seen in the Wando when stocking medium (160 mm TL) fish. In previous release years, fish were either much smaller (~22 mm) or a much lower total number stocked compared to 2020. This may explain the highest contribution numbers seen within the river from the 2020 YC, however water quality and precipitation may also be a factor. Genetic family OWL 3 was released early in the Wando River and had 2 captured individuals in the Wando River, showing no signs of movement. Genetic Family NWL 1 was released late in the Wando River and 28 were captured by our Inshore Fisheries Group within the Wando River.

The Ashley River had 53 hatchery fish out of 124 captures, for a contribution of 42.7%. This contribution is similar to previous years (21-76%) when similar size and number of fish have been stocked. Genetic Family NWL 1 was released early in the Ashley River. 7 fish were captured from the early release in the Ashley River and 1 was captured in Charleston Harbor. Due to this family being released in both the Wando and Ashley Rivers, it's not possible to determine which river the one fish in the harbor originated from. Genetic Family HML 118 was released late in the Ashley River and had 46 captures. Hatchery fish from HML 118 were also captured in Charleston Harbor (1) and the Wando River (2), demonstrating some movement across the system. Also, half of this family's captures were caught upstream of the release site similar to previous years indicating some preference to move into lower salinity water.

In each case, the late release family had significantly more hatchery captures in their respective systems compared to the earlier stocked fish. A similar release strategy was conducted in 2005 and 2006 within the Colleton River and North Edisto River respectively with the late released fish making a larger contribution than the early released fish. However, the design of the experiment was not robust with different sized fish and different release numbers being released in the same estuary. In addition, our three-year comparison of stocking fish before and after a tropical rain event revealed that the later stocked fish made a much higher contribution compared to the early season releases. This leads to the question, are later releases more effective compared to earlier releases and/or do rain events decrease the survivability of hatchery released fish and potentially wild recruitment. Looking at precipitation information from the weather station on top of MRRI, the beginning of the production season in 2020 saw higher rain totals with 2 days seeing over 3" of rain compared to the later part of the season (Fig. 2). In addition, salinity from water quality monitors maintained by the USGS on the Ashley River near I-526 show much lower salinities early in the season (0-16 ppt) compared to later in the season (12-22 ppt) (Fig. 3). It's possible that the rainfall in August and September had a negative impact on the early released fish and potentially the wild young of year which provided more available habitat for the later stocked fish to inhabit. Another factor that may be contributing to the later stocked fish's success is water temperature and its relationship with dissolved oxygen (DO). Later released fish would experience lower temperatures and higher DO which may lead to high survival rates. Figures 4 and 5 show the temperature and DO of the Ashley River throughout the stocking season with stars representing release dates. Temperature ranged from 25-29 °C for the early releases and 13-16 °C for the late releases. Dissolved oxygen ranged from 3-5 mg/L for the early releases and 7-9 mg/L for the late releases. The lower temperatures and higher DO seen during the late releases likely decrease the stress from harvest, transportation, and releases. Determining the optimal temperature and DO to release red drum in could increase productivity within our stock enhancement program and will be evaluated over the coming stocking years (2022-2024).

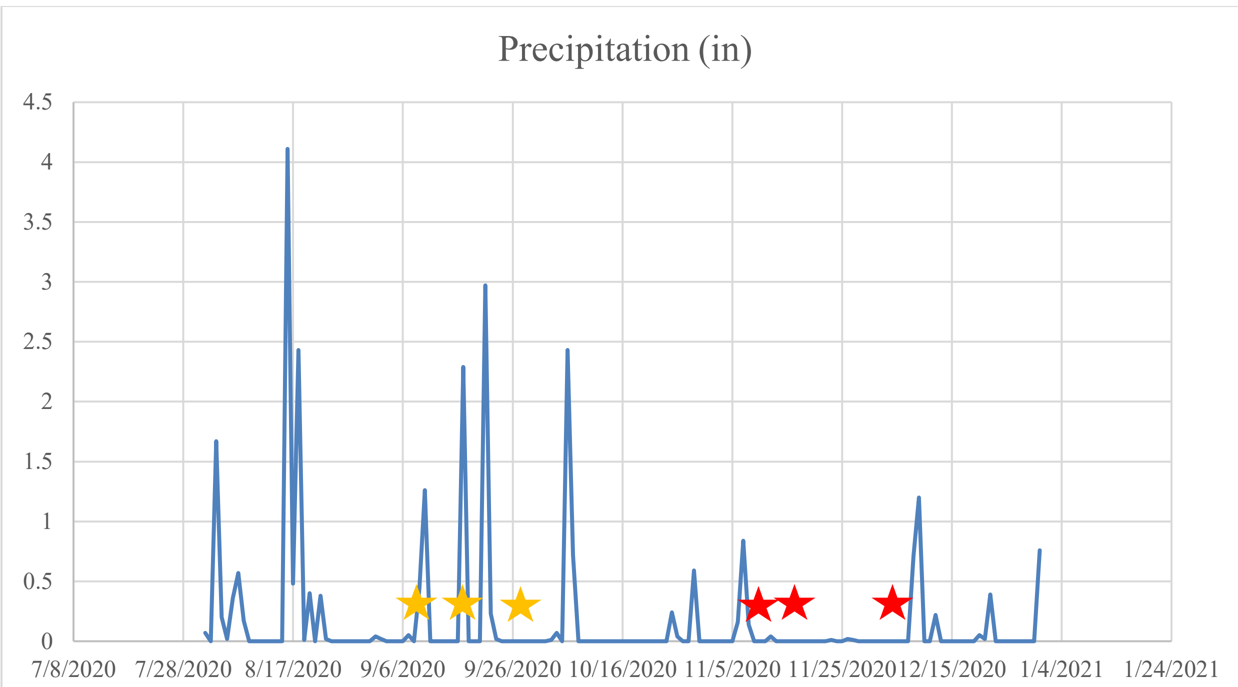


Figure 2: Precipitation in inches from the weather station located on top of MRRI during the 2020 red drum production season. Yellow stars represent early stocking and red stars indicate late stocking.

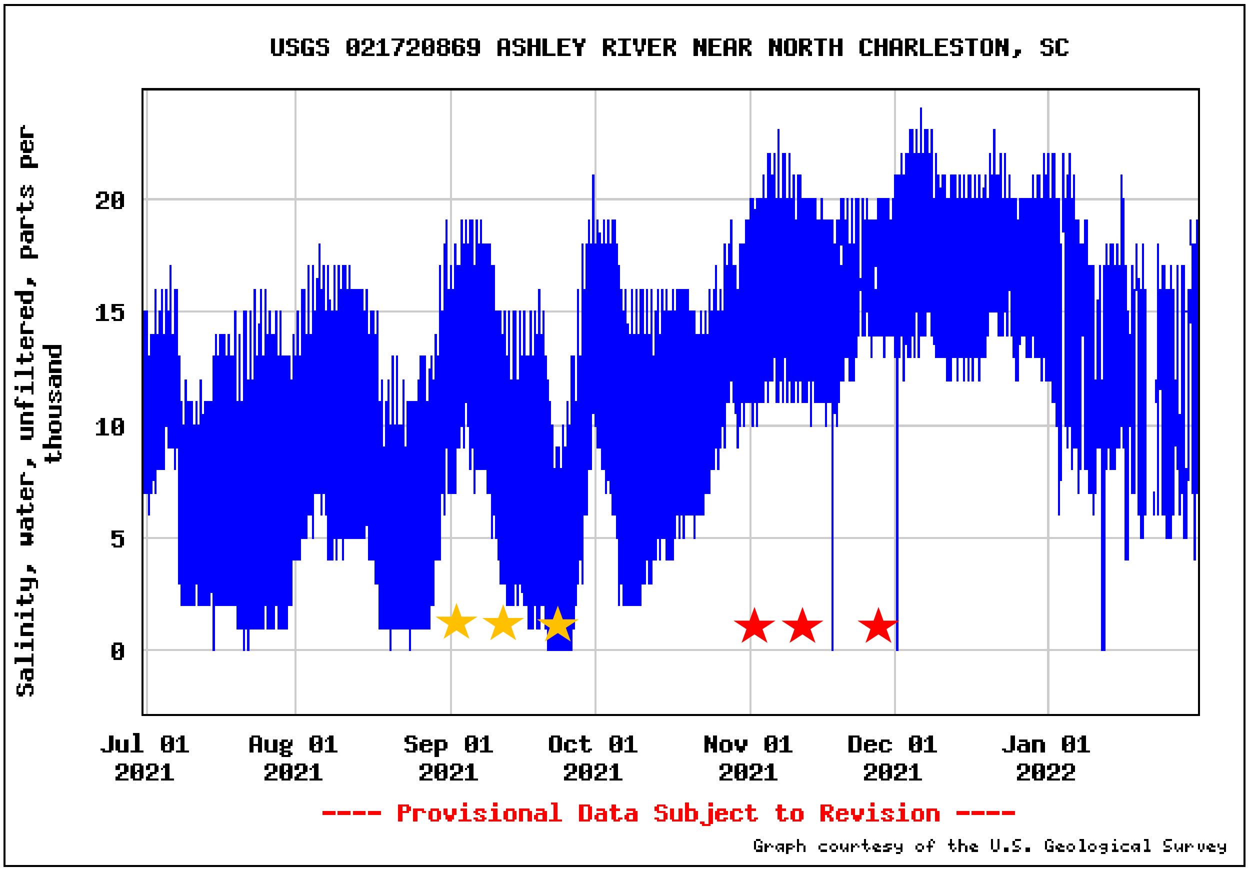


Figure 3: Salinity data from a USGS water quality sonde located around the I-526 bridge going over the Ashley River. Yellow stars represent early stocking and red stars indicate late stocking.

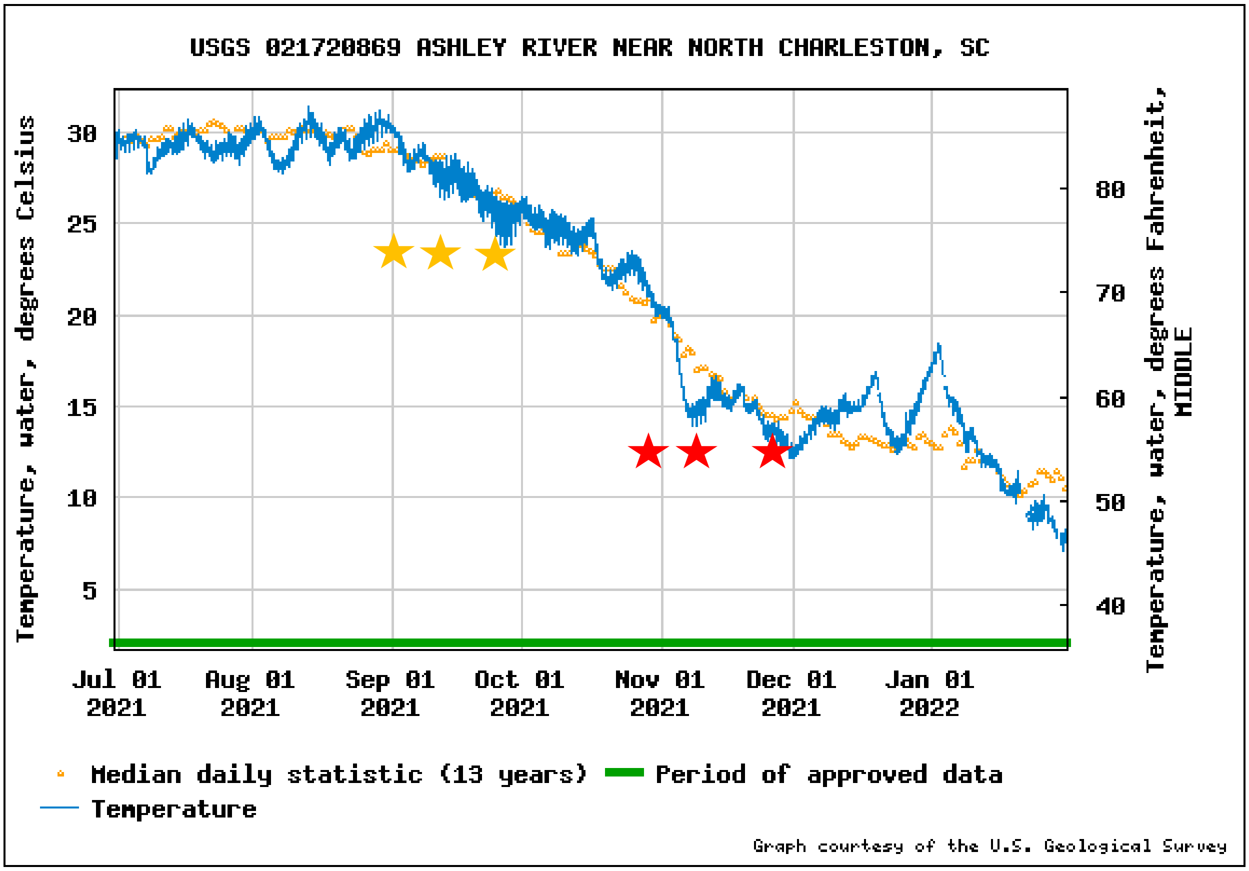


Figure 4: Temperature measurements (°C) from a USGS water quality sonde for the Ashley River near the I-526 bridge adjacent to our stocking location. Yellow stars represent early stocking and red stars indicate late stocking.

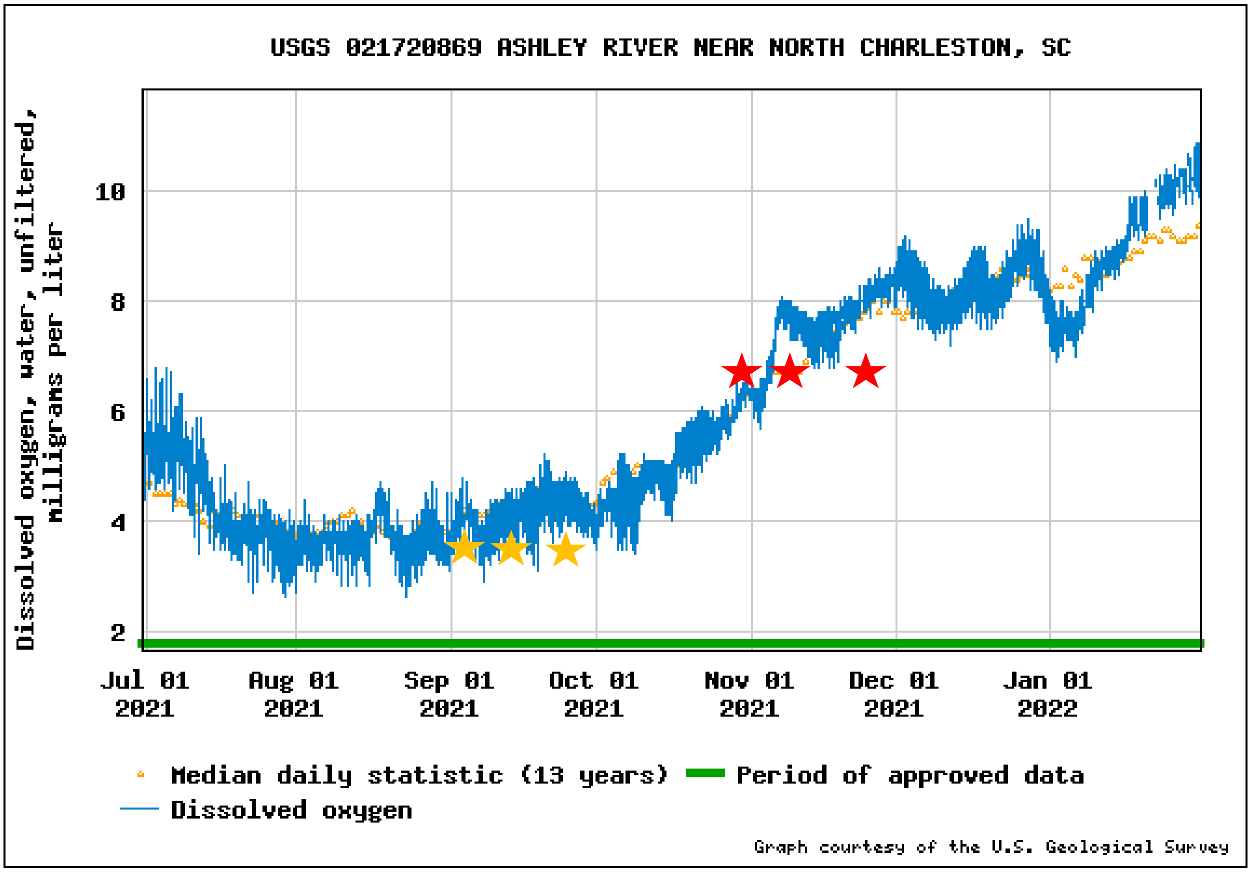


Figure 5: Dissolved oxygen (mg/L) from a USGS water quality sonde for the Ashley River near the I-526 bridge adjacent to our stocking location. Yellow stars represent early stocking and red stars indicate late stocking.

North Edisto River

In the North Edisto River, there were 18 hatchery fish captured from the 2020YC; 13 in Bohicket Creek, and 5 in Leadenwah Creek (Figure 6). Hatchery contribution in the North Edisto was 16.2%, with 23.2% contribution in Bohicket Creek and 9.1% in Leadenwah Creek. Contribution in Leadenwah Creek was higher than in 2019 (2.2%), but still lower than Bohicket Creek. All captures originated from the small juvenile releases from family HML118 (447,682). 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 2020YC in a moderate range 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.

Port Royal Sound

In Port Royal Sound, no hatchery fish were captured for a hatchery contribution of 0% (Figure 7). There were only 2,803 fish released from the Trask Boat Landing late in the season and the release location was far from most of the Inshore Fisheries collection sites, which most likely lead to a lack of hatchery captures.

CONCLUSIONS

Release Strategies, Contribution and Movement

In the Charleston Harbor system, the families that were released late in the Ashley and Wando Rivers both had higher contribution than the early release families. The relationship between early and late water quality will be examined further in the coming stocking years to determine the optimal time to stock juvenile red drum. Family HML 118 also showed movement from the Ashley River into Charleston Harbor and to the Wando River. Hatchery contribution was higher at electrofishing sites (61.7%) than trammel net sites (36.0%), despite twice as many hatchery fish being caught in trammel nets (n=58) than by electrofishing (n=29). In the North Edisto River, 18 hatchery fish were captured with more caught in Bohicket Creek (n=13) than Leadenwah Creek (n=5). The release location within Bohicket Creek is in close proximity to the dock where anglers collect samples, likely increasing contribution numbers. The stocking of a single genetic family and limited sampling coverage does not allow for examination of movement throughout the estuary.

Spotted Seatrout:

2021 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 2019 YC Stocking:

To evaluate the contribution of stocked juvenile spotted seatrout, a total of 265 fin clip tissue samples were processed from spotted seatrout collected in the Charleston Harbor system from September-December during monthly independent random sampling in 2021.

Overall, six hatchery spotted seatrout representing one year class were collected in 2021. Movements from the Ashley River or Charleston Harbor into the Wando or Cooper Rivers have been very rare over time (n=1). In 2021, there was one hatchery fish collected in the Wando River that was from a family that was released in both the Ashley River and Wando River. Since movement from stocking locations within the Ashley River or Charleston Harbor to the Wando River is rare, this hatchery fish most likely came from the Wando River release. This is the first year that a hatchery fish has been collected in the Wando River since 2015. Before stocking in the Wando River in July 2019, there had been no stocking in the Wando River since 2013. All hatchery fish collected from the Charleston Harbor stocking treatments were collected on the southern shore of the Charleston Harbor. 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 release for the Charleston Harbor, the trailer release did have a slightly higher contribution, but there were too few hatchery fish collected to statistically evaluate a difference in treatments. Total release numbers also appeared to influence contribution with the greatest release number yielding the highest return rate (Charleston Harbor trailer release).

The 4.5% hatchery contribution from the 2019YC in 2021 is much lower than its contribution in 2020 (9.0%), which is similar to other stocking years where fish make up a higher contribution during their first recruitment year compared to their second year. In both 2020 and 2021, the highest contribution came from fish released in the Charleston Harbor by trailer. However, in 2020 we did see a small contribution from fish released in the Ashley River by both boat and trailer, but we saw no contribution from those families in 2021. The lack of hatchery fish from the 2018YC was likely due to the fact that there were far fewer individuals collected from this YC compared to the 2019YC (18 vs. 132, respectively).

Cobia:

2021/2022 Production: Three families of cobia were produced during this reporting period. In 2021, 544 small juveniles (avg TL 76.5 mm) were released from family WMC 20 at Trask Landing on the Colleton River. In 2022, a total of 24,352 small juveniles (avg TL 46.9 mm) were released from 2 unique genetic families. WMC12S had 7,146 (avg TL 55.0 mm) and WMC20L had 17,206 (avg 43.5 mm TL) juveniles released during the months of May and June. All releases were by trailer at Trask Landing.

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 been limited.

The federal government reopened 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 12 samples from 2021 and 62 samples were collected from inshore and offshore fish through a cooler program which works cooperatively with local charter boat captains to obtain fish racks, genetic samples, and catch information. Our cooperative fin clip program provided an additional 63 samples from 2021 collect from offshore Charleston south into upper Georgia waters. The 2022 genetic samples have not been returned to date. An additional 50 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 July 2021 - June 2022 to collect cobia broodstock from the Broad River annual inshore aggregation for hatchery production of fingerlings for stock enhancement research. Seven wild cobia were captured by cooperating recreational anglers and SCNDR staff in the Broad River, but only one individual was large enough and sexually mature, 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. Only one tank of cobia broodstock at both MRRI and WMC were injected on a single occasion with LH-RHa spawning hormone during the project period but induced spawning was unsuccessful. Fortunately, two tanks at WMC spawned volitionally 12 different times throughout the period from 4/19/22-6/24/22 resulting in the production of 36 million eggs produced from two genetically distinct families. This allowed multiple stockings of fertilized production ponds at WMC with larvae from the 10 million viable eggs that were available. Five releases totaling 24,896 juvenile cobia occurred during this reporting period. One release came from a unique family organized for 2021 production in the 20-ft maturation tank at WMC (20-ft-WMC-21), two releases came from the WMC family housed in the 20-ft maturation tank for 2022 production (20-ft-WMC-22) and two from a WMC family housed in a 12-ft maturation tank for 2022 production (12-ft-WMC-22). Juveniles from the 20-ft-WMC-21 family were 76.54 mm (TL) on average at release with 544 released at Trask Landing on the Colleton River in Port Royal Sound on 7/1/2021. Juveniles from the 20-ft-WMC-22 family were 43.7 mm (TL) on average at release with 17,206 released at Edgar Glenn Landing on the Chechessee River in Port Royal Sound on 6/7/2022. Juveniles from the 12-ft-WMC-22 family were 54.9 mm (TL) on average at release with 7,146 released at Trask Landing on the Colleton River in Port Royal Sound during releases on 5/24/22 and 6/15/22.

Contribution*:* A total of 357 cobia genetic samples were processed this year from all collection sources. Overall, two cultured fish were captured in the 2021 collections (all fish sampled in all locations) for a total hatchery contribution of 0.6%. However, samples used for calculating contribution must meet collection criteria, including a collection date from April- July. When including only these samples in the calculations, the total hatchery contribution was 0.7%. 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 0.7%. As expected, there was no contribution to the Gulf of Mexico stock.

For the South Carolina collections, the total contribution was 0.9%. Hatchery contribution was only seen from the inshore samples within the Broad River (where stocking occurred) at 4.3% (n=2), with no hatchery contribution from offshore. Due to the no harvest 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 lower inshore contribution in 2021 compared to 2020 or 2019 (4.3% vs. 19.7% and 12.9%, respectively). There has been no hatchery contribution from offshore by the 2017YC in 2019, 2020, or 2021.

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. This was the first year that cultured fish were not captured from the 2012YC since they were first captured in 2015. However, there was only one cultured fish collected from the 2012YC in both 2019 and 2020. 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. As expected, no fish were captured from the 2020YC since these fish typically don't enter the fishery until at least age 2.

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. During this funding cycle, we continued our evaluation of plausibility of relating eDNA detections to biomass.

We have continued the processing of the eDNA filters from the controlled experiments to investigate how cobia DNA accumulates and degrades in water sample over time with varying densities of fish. The remaining sample processing will be completed during the upcoming year and final compiled results will be evaluated and presented together.

We also completed a second round of field collections in PRS during the winter and spring of 2022 to build on our testing dataset. Winter samples represented collections outside of the spawning season when detections are not anticipated and spring sampling occurred during cobia's spawning season at standardized tide and moon cycles to represent our first baseline field collection with our optimized collection protocols. A total of 249 filtered water samples were collected and are being stored at -20 °C. Processing of those field samples has begun and will continue during the upcoming year.

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 repeat the 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.

Based on results from last year's pilot scale study, additional testing was needed during ideal, calm conditions to determine if cobia can be identified compared to the many shark species within the river. In the spring of 2022, research focused on repeating side scan transects during a calm day in hopes of improving image quality. We utilized the same field and analysis methods from the first year of the study. Four transects were performed around the Broad River bridge during a calm morning over a two-hour period. The boat made approximately three-knot headway, which is ideal for image quality, however no evidence of cobia was seen. Based on the two years of conducting these scans, this method of identifying and enumerating cobia within the Broad River does not appear to be effective and will not be part of our monitoring program in the future.

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, 2021 - June 30, 2022

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:

Objective 1: State Recreational Survey (SRS) and Marine Recreational Information Program (MRIP)

Recreational fishing surveys allow MRD staff to monitor recreational catch and fishing effort as well as provide an opportunity for staff to interact with the anglers. These interactions also 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 of local fisheries. MRD staff interview recreational anglers at public and selected private access sites throughout SC's coastal counties. Data collected during interviews include mode fished, body of water fished, angler's county of residence, species targeted, time spent fishing, fishing trips taken previous year, catch/disposition by species, length/weight measurements of retained fish, and otoliths from selected species when permissible. The survey provides data to help determine the components of finfish stocks that are being targeted by recreational anglers as well as recreational fishing effort and behavior. This information is used for decision making by managers on a state level, to supplement and verify recreational fishing data collected by SCDNR's Charter Boat Logbook Program, and by NOAA Fisheries to produce estimates for stock assessments and management of species on a regional basis.

SRS: During the reporting period from January 1, 2022, to February 28, 2022; 179 fishing parties were interviewed in private boat and shore mode representing contact with 295 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 251 fish belonging to 13 species (**Table 2**).

MRIP: During the reporting period from July 1, 2021, to December 31, 2021, and March 1, 2022, to June 30, 2022; 564 assignments were completed resulting in 4,988 angler interviews in all modes (**Table 3**). Head boat assignments did not resume until April of 2022 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 2022 - February 2022.

SRS TOTALS	
Site Visits	207
Intercepts	179
Anglers Interviewed	295
Fish Measured	26

Table 2. Fish and shellfish caught by fishing parties interviewed by SRS staff during January 2022 - February 2022.

Species Name	# Kept (bushels for oysters)	# Released (bushels for oysters)	# Caught (bushels for oysters)
Clams	2075	0	2075
Oysters	135	0	135
Drum, Red	16	128	144
Mussel, Ribbed	134	0	134
Seatrout, Spotted	31	26	57
Sheepshead	10	19	29
Whiting, Southern	5	0	5
Catfish, Blue	5	0	5
Flounder, Unclassified	0	4	4
Drum, Black	3	1	4
Mullet	0	1	1
Bass, Striped	0	1	1
Wahoo	0	1	1

Table 3. MRIP assignments and interviews obtained by mode in FY2022.

Wave 4 2021				
Mode	July		August	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	53	601	58	527
Head Boat	0	0	0	0
Total	53	601	58	527

Wave 5 2021				
Mode	September		October	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	57	573	58	658
Head Boat	0	0	0	0
Total	57	573	58	658

Wave 6 2021				
Mode	November		December	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	57	353	53	306
Head Boat	0	0	0	0
Total	57	353	53	306

Wave 2 2022				
Mode	March		April	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	56	234	47	412
Head Boat	0	0	1	6
Total	56	234	48	418

Wave 3 2022				
Mode	May		June	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	69	690	56	564
Head Boat	4	32	3	32
Total	73	722	59	596

Objective 2: Charter Boat Logbook Reporting Program

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

During this reporting period (July 1, 2021 - June 30, 2022; aligns values with fiscal year licensing) there were 675 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, 2022, 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 2021 calendar year charter boat data (**Tables 4 and 5**).

Table 4. "Top 10 Species" caught, landed, and released during reported charter vessel trips in 2021.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 78.64% of all species caught	Accounts for 76.18% of all species landed	Accounts for 82.04% of all species released
Sea Bass, Black (24.03%)	Mackerel, Spanish (25.64%)	Sea Bass, Black (28.00%)
Drum, Red (18.34%)	Snapper, Vermilion (10.68%)	Drum, Red (22.41%)
Seatrout, Spotted (8.52%)	Sea Bass, Black (10.36%)	Seatrout, Spotted (9.20%)
Mackerel, Spanish (7.21%)	Seatrout, Spotted (6.20%)	Shark, Atlantic Sharpnose (5.48%)
Snapper, Vermilion (5.71%)	Shark, Atlantic Sharpnose (4.49%)	Snapper, Vermilion (4.27%)
Shark, Atlantic Sharpnose (5.26%)	Drum, Red (4.30%)	Flounder, Unclassified (3.42%)
Flounder, Unclassified (3.34%)	Whiting (Kingfish) (4.10%)	Shark, Black Tip (2.61%)
Whiting (Kingfish) (2.15%)	Mackerel, King (3.83%)	Croaker, Atlantic (2.43%)
Shark, Black Tip (2.05%)	Grunt, White (3.49%)	Shark, Bonnethead (2.14%)
Croaker, Atlantic (2.03%)	Flounder, Unclassified (3.09%)	Snapper, Red (2.08%)

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

Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Trips	15,610	14,381	15,620	15,661	16,682	16,085	21,910
Boat Hours	63,697	58,626	63,216	62,700	66,722	61,011	80,863
Anglers	55,778	50,792	54,390	55,466	60,469	58,845	80,872
Angler Hours	226,308	206,307	219,783	217,711	236,156	215,298	289,422
Estuarine Trips (%)	48.36	49.92	55.11	54.07	52.98	52.06	51.25

Nearshore Trips (%)	31.19	31.12	27.35	28.79	27.74	30.66	26.92
Offshore Trips (%)	20.42	18.96	17.54	17.11	19.27	17.28	21.73

Southern Flounder Stock Enhancement

Project PIs: Aaron Watson, Tanya Darden, Joey Ballenger

Reporting Period: July 1, 2021 - June 30, 2022

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. 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. This past year we have used our extensive experience in stock enhancement to begin developing a new program for southern flounder.

Focus on Southern Flounder:

Southern flounder have seen a dramatic decline in population abundance not only in South Carolina (Figure 1), but throughout their range from North Carolina through Texas. This decline prompted concern from every state within their range and varying degrees of management options considered. In response to this decline in South Carolina, along with regulation changes, the initiation of a stock enhancement program was initiated. Researchers at the Marine Resources Research Institute (MRRI) developed an aggressive ten-year plan to rapidly build upon in-house knowledge of stock enhancement as well as species-specific knowledge. Flounder present multiple unique challenges for stock enhancement that requires novel solutions and infrastructure at both the MRRI and the Waddell Mariculture Center (WMC). The first two years of the development plan are highly focused on these infrastructure needs as well as developing the population genetics tools required to assess the wild population, manage broodstock, and track hatchery reared fish in the wild in subsequent years.

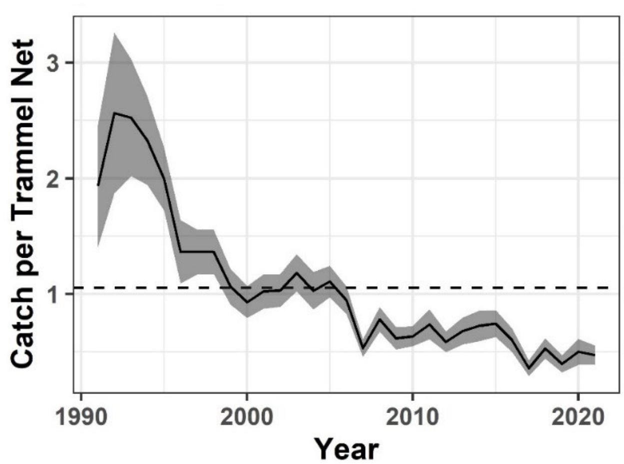


Figure 1. Annual catch of southern flounder in the SCDNR Inshore Fisheries standardized trammel net survey showing significant statewide decline.

During this project year, we began the first year of the development of a stocking program for southern flounder in South Carolina. The program is being developed to follow the "responsible approach" guidelines and to adhere 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, and one of the primary objectives in the first year of the program for southern flounder is to develop a similar genetic tool prior to the production and release of juvenile flounder into state waters.

Year 1 Project Objectives:

- Development and optimization of a genetic marker panel
- Implement needed infrastructure renovations specific for southern flounder husbandry
- Field survey design and implementation
- Initial broodstock collection and optimization of husbandry protocols
- Coordination of genetic sample collection along the southeastern US coast

Summary of Accomplishments/Activities:

Development and optimization of a genetic marker panel

The development of a genetic marker panel for southern flounder started with collecting muscle tissue in quadruplicate from a suspected immature female (waiting on histology) southern flounder on August 11, 2021 and immediately storing it at -80 °C. The tissue was shipped frozen to GENEWIZ on September 15, 2021. DNA extraction, isolation, and whole genome sequencing was conducted by GENEWIZ. Sequencing was performed on an Illumina MiSeq using the V2 500 cycle sequencing kit with library preparation for 2 x 250 base pair paired-end sequencing. Data was received on November 9, 2021. This sequencing resulted in 21,053,763 forward and reverse reads. Forward and reverse sequences were merged using default parameters in FLASH resulting in 17,500,952 reads ranging from 35 - 490 base pairs. MSATCOMMANDER was used to search for tri to hexa nucleotide repeat microsatellites and design primers, resulting in 10,905 microsatellites with primer pairs for PCR amplification. From this list of primers, 130 markers were ordered in early January 2022, including 35 trinucleotide, 33 tetranucleotide, 35 pentanucleotide, and 27 hexanucleotide microsatellite primers.

The initial screening of markers began in mid-January 2022 using M13 tails to visualize PCR products on a CEQ 8000 automated sequencer allowing accurate estimations of allele size ranges and polymorphism. For the initial screening, seven samples were tested, including six from South Carolina and one from North Carolina. Any markers that did not amplify, had spurious peaks that made scoring difficult, or had less than five alleles across the seven samples were removed from further screening. The remaining 47 markers were then tested with an additional 60 samples, including 18 samples from South Carolina, 24 samples from North Carolina, and 18 samples from Georgia. Of these, 25 markers amplified consistently across all 67 samples and were highly polymorphic. Allele binning analyses were then completed for the 25 markers to allow for consistent genotyping of the 67 samples.

To evaluate the effectiveness of the 25 markers for further analyses, they were tested for deviations from Hardy-Weinberg equilibrium (HWE), linkage disequilibrium, and frequency of null alleles using Genepop 4.7.2. Three markers were found to be out of HWE. These three markers, along with three others, were also found to have a high frequency of null alleles. Therefore, six markers were removed from the panel. Three sets of markers were found to be linked, but were not consistent across states, so they were retained in the panel. Marker testing was completed in mid-June 2022, with 19 markers selected for inclusion in the final microsatellite panel. All 19 markers have been multiplexed into three optimized PCR panels using fluorescently labeled forward primers (Table 1) and are ready for use in the stock enhancement program.

Table 1. Multiplex panel, locus, repeat motif, fluorescent dye, number of alleles, allelic size range, and primer concentration (µM) for 19 microsatellite loci for southern flounder.

Multiplex Panel	Locus	Repeat Motif	WellRed Dye	Number of alleles	Allelic size range (base pairs)	Primer concentration (µM)
1	Ple101	AGC	D3	13	139-187	0.032
	Ple109	AGC	D2	10	147-174	0.050
	Ple77	AAGAT	D4	9	152-192	0.029
	Ple44	AACCTG	D2	9	193-247	0.050
	Ple58	AAT	D3	10	195-222	0.047
	Ple70	AACT	D4	14	232-296	0.044
	Ple74	ACAG	D2	8	271-303	0.050
2	Ple04	AAT	D4	12	100-142	0.032
	Ple01	AAG	D2	26	158-287	0.071
	Ple47	ACCAGG	D3	8	165-207	0.063
	Ple104	ACT	D4	19	170-233	0.039
	Ple102	ATC	D3	8	246-267	0.059
	Ple37	ACTAT	D4	13	269-364	0.036
3	Ple81	AACTT	D3	15	97-192	0.030
	Ple60	AGC	D2	13	179-215	0.057
	Ple120	AATAT	D4	8	185-225	0.061
	Ple73	AATC	D3	20	200-288	0.042
	Ple62	ATC	D2	10	269-302	0.057
	Ple30	ACACT	D4	11	265-315	0.053

Implement needed infrastructure renovations specific for southern flounder husbandry

As flatfish with a protracted larval period and strict temperature sensitivities, southern flounder present a different set of husbandry challenges compared to the more pelagic species that have been reared in the past by SCDNR for marine stock enhancement. Flounder will have to be reared intensively from fertilized egg through metamorphosis and their temperature-dependent sex determination phase. This unique life history requires multiple infrastructure changes and additions at both MRRI and WMC over the first few years of the program. To facilitate the initiation and advancement of the southern flounder stocking program, three SCDNR staff visited both of Texas Parks and Wildlife Department's flounder production facilities. Staff were able to observe all broodstock and larviculture systems and develop collaborations with biologists at each facility to learn about what has and has not worked in their facilities. In addition, one SCDNR staff member was also able to visit the University of Texas at Austin's Marine Science Institute in Port Aransas, TX and was able to attend a flounder symposium in Baton Rouge, LA in March 2022 to discuss ongoing population trends and aquaculture program successes and challenges throughout the region. Based on observations, conversations, and past experiences, the SCDNR mariculture staff were able to develop a plan of system upgrades and installations. Thus far at MRRI, we have designed and ordered a water polishing system to replace the labs current chlorination and de-chlorination method of sterilizing water for introduction to indoor recirculating systems. This polishing system will not only reduce time in prepping water and redundant checks of water quality prior to bringing water into the building, but will also allow for on-demand, sterilized water access for rapid water changes and systems updates. New water quality monitoring systems for broodstock, quarantine, and larval rearing systems have been ordered, with some components delivered and awaiting the remainder for installation. These systems are a significant upgrade to the current monitoring systems and will also allow for real-time notification to staff of water temperature, water level, or critical dissolved oxygen level changes. These upgrades and real-time notifications are a must for flounder and larval culture as temperature and dissolved oxygen levels must be addressed immediately when changes occur. Larviculture will require the production of live feeds in-house through the maintenance of rotifer and artemia cultures. The WMC facility and staff have been maintaining these cultures for several years for other funded research projects and will scale up production as needed for flounder. MRRI staff have designed and ordered the needed components for live feeds culture and expect to establish a space designated for that activity during the fall of 2022. Two wet-lab spaces have been identified to establish larviculture systems at the MRRI and staff have begun designing and moving tanks and components into place for these systems. Finally, at MRRI, a set of six tanks that were isolated, stand-alone systems for intermittent animal housing has been plumbed together with other recirculating aquaculture system components (biofilter, pump, UV sterilizer, temperature control) in order to establish a short-term housing system with full environmental control to quarantine new flounder as they arrive from collection in the wild. In addition, WMC staff, SCDNR facilities staff, and state engineers have been working on planning, re-designing, and bidding out projects to rebuild significant portions of the ponds and water control structures at WMC. Significant progress is expected through 2023 on the pump house which supplies water to the water control structure and the hatchery where broodstock flounder and larviculture will occur.

Field survey design and implementation

The Inshore Fisheries Section conducts long-term monitoring and research on the estuarine finfish, including southern flounder, in South Carolina. Annually, the section conducts five fishery-independent, long-term monitoring programs across South Carolina's estuarine and coastal waters, namely 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, iv) a trawl survey of estuarine benthic habitats, and v) a multi-gear survey of high saline areas of estuaries. Three of these surveys, namely the trammel net survey, the electrofishing survey, and the estuarine trawl survey routinely encounter southern flounder. Data on southern flounder from these surveys was included in the recent regional stock assessment. As such, during the current performance period staff evaluated the use of these surveys to characterize southern flounder relative abundance across coastal South Carolina to determine if a dedicated southern flounder survey is needed to monitor southern flounder across the state or to aid in the collection of brood stock for the stock enhancement program.

The trammel net survey operates in lower estuary (high salinity) salt-marsh edge habitats frequented by recreationally important 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. 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 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. Finfish monitoring of the Estuarine Trawl Survey began in 2011 and samples 4-6 Charleston Harbor and Ashley River sites monthly and additional sites in the Stono and Kiawah Rivers, St. Helena Sound, Port Royal Sound, and Calibogue Sound in March, April, August, and December. The survey targets deeper estuarine benthic habitats, often encountering a different suite of species and/or different life stage of a species than is encountered by either the trammel net or electrofishing surveys.

The trammel net survey has encountered 22,786 southern flounder across 24,830 collections since 1991, the electrofishing survey recorded 5,923 southern flounder from 6,207 collections, and 565 southern flounder in 273 estuarine trawl survey collections. The combined surveys represent southern flounder from 0 to 6 years old (Figure 2). Each of the surveys differ somewhat in their modal size distribution, but collectively complement each other to continuously cover a size range from 10 to 696 mm TL (Figure 3). Through time, the catches of southern flounder in both the trammel net and electrofishing surveys have declined such that catches in recent years are at all time low levels (Figure 4). During the relatively short time series of estuarine trawl survey, the relative abundance of southern flounder has remained relatively stable; however, that much of the declines in southern flounder relative abundance observed in the other surveys occurred prior that start of this survey (2011). Importantly, the uncertainty in annual relative abundance estimates from all three of SCDNR's survey datasets were low with an average proportional standard error ranging from 0.085 for the trammel survey to 0.128 for the estuarine trawl survey (Figure 5), suggesting the each of them track annual changes in relative abundance of southern flounder well.

Based on the review of data available from contemporary surveys, SCDNR staff do not recommend the need for any new monitoring programs to be established to expressly monitor the status of southern flounder in South Carolina. The only additional sampling suggested was the potential for specific targeting of habitats and areas where larger, adult southern flounder have historically occurred based on our current survey gears, hook-and-line sampling, and night-time bully net sampling for the collection of broodstock for the stock enhancement program.

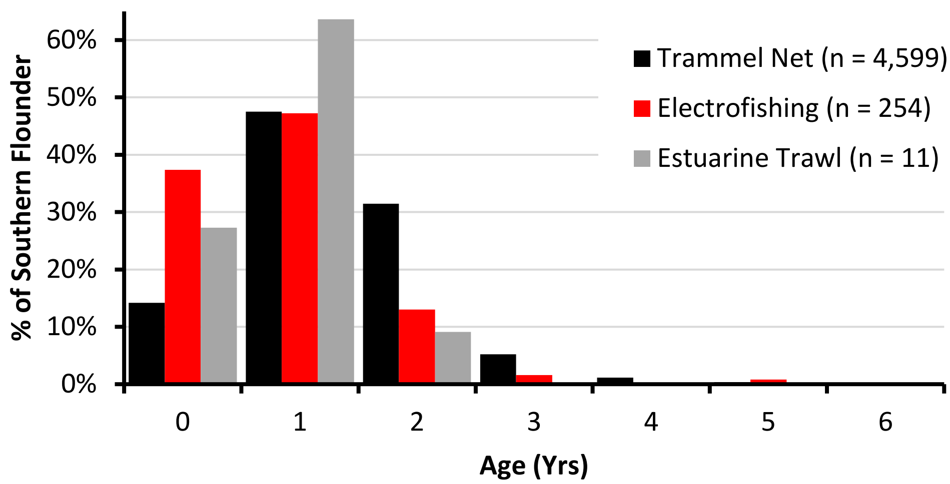


Figure 2: Percent of southern flounder within each survey by age; trammel net (black bars), electrofishing (red bars), and estuarine trawl (gray bars) surveys.

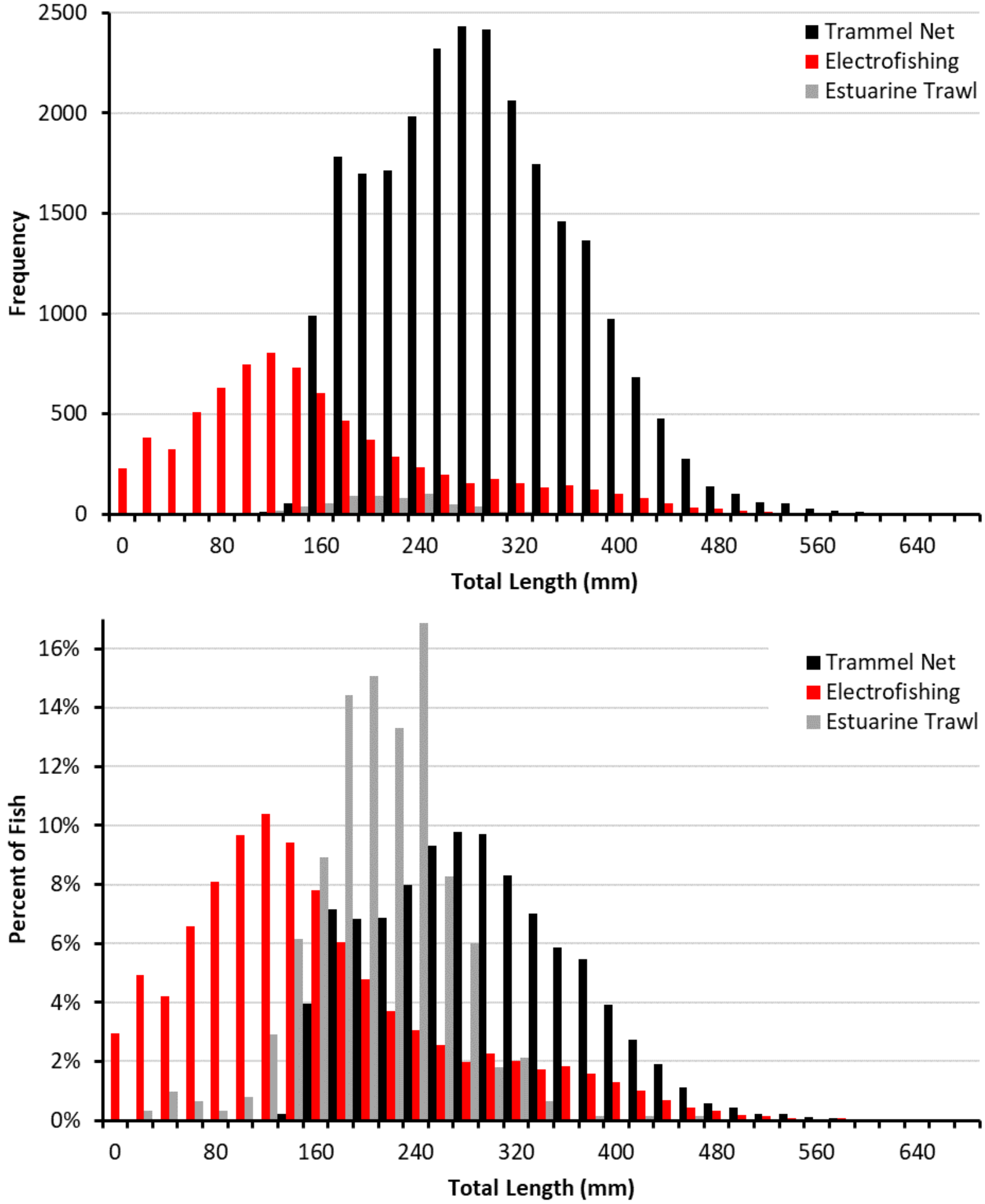


Figure 2: Frequency (top panel) of southern flounder by size class (20 mm total length bins) encountered by the trammel net (black bars), electrofishing (red bars), and estuarine trawl (gray bars) surveys. Using same color scheme, percentage of southern flounder within each survey by size class (bottom panel).

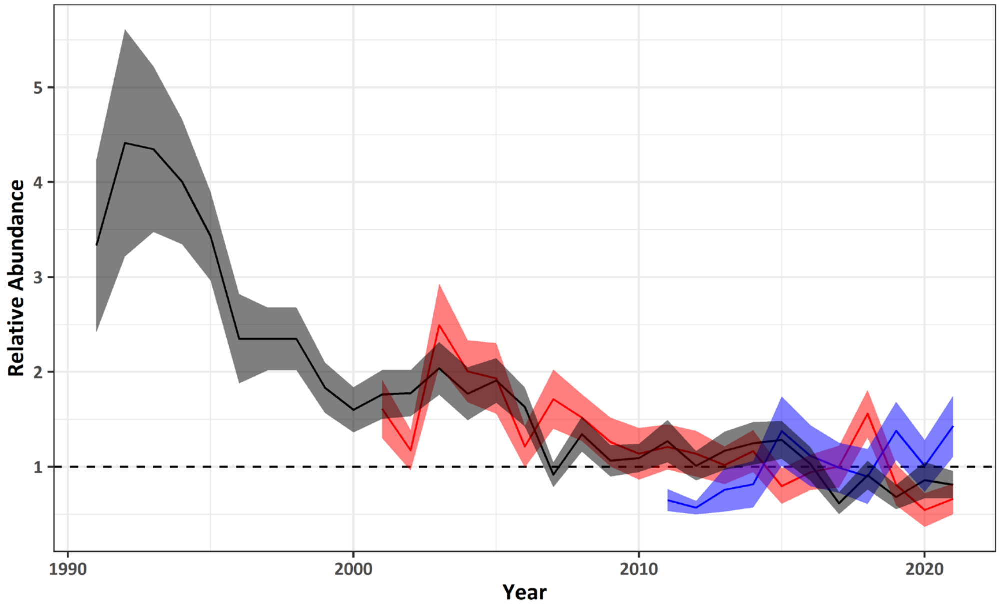


Figure 4: Southern flounder relative abundance as observed by the SCDNR trammel net (black line and gray shaded region), electrofishing (red line and shaded region), and estuarine trawl (blue line and shaded region) surveys. Data are presented relative to the average catch in the survey from 2010-2021, such that below average annual catches are less than one. The shaded regions represent 95% confidence intervals about annual relative abundance.

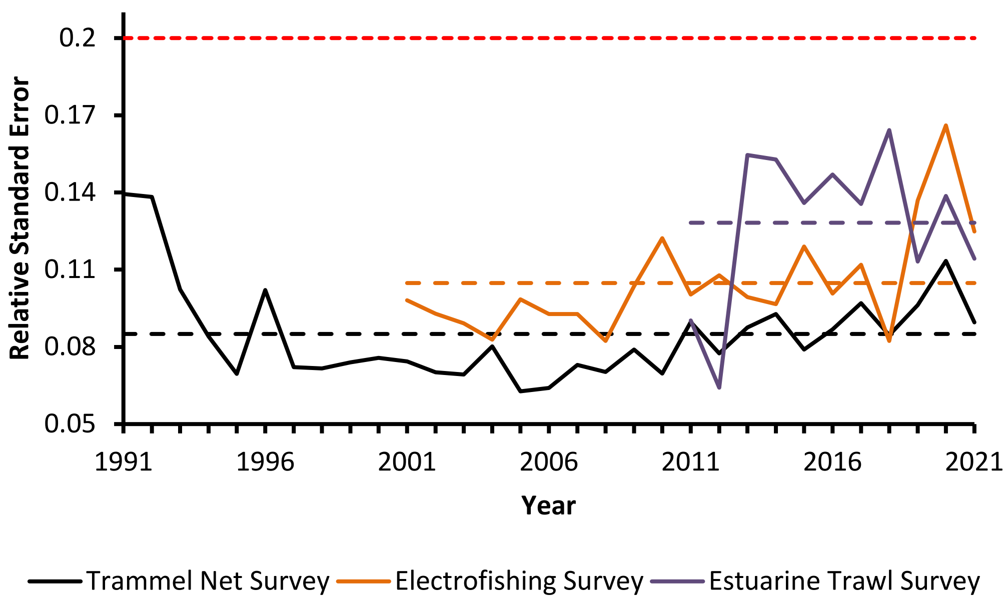


Figure 5: Annual proportional standard error estimates of southern flounder relative abundance from the SCDNR trammel net (black), electrofishing (green), and estuarine trawl (yellow) surveys. Shown are the annual estimates (solid lines) and mean estimates throughout the time series (long-dash). Note, provided is a reference line at a proportional standard error of 0.2 (red short-dashed line) which for stock assessment purposes is considered a threshold in that indices with proportional standard errors <0.2 are generally considered to accurately track annual changes in relative abundance.

Initial broodstock collection and optimization of husbandry protocols

Broodstock collection began in late August 2021 and has been ongoing to provide animals at both MRRI and WMC. Flounder have been collected via multiple methods and by multiple SCDNR research groups and transferred to the mariculture team. Daytime collections have occurred by mariculture staff through hook and line fishing, collaboration with charter boat captains, SCDNR inshore fisheries section's various survey programs, and the SCDNR crustacean research sections trawl survey. Mariculture staff have also experimented with nighttime collections via a "bully net" design to target specific sized fish without the harm of gigging. During the first year, over 150 broodstock were collected and transitioned into various systems at MRRI and WMC and staff have been utilizing a combination of methods learned from past experience with other species as well as advice from regional collaborators on the best protocols for transitioning flounder to a cut-feed diet. This process and prophylactic treatment of potential parasites and diseases before animals are introduced into recirculating systems are proving challenging but are issues that other stock enhancement programs also grapple with. Through communication and collaboration with these other facilities, mariculture staff are developing an intense initial treatment protocol to put into effect in the fall of 2022 to help mitigate broodstock loses after capture. All collected broodstock have, and in the future will be, PIT tagged for unique identification and had a fin clip taken and transferred to the population genetics group for broodstock management. Staff have also consulted with researchers at Hubbs SeaWorld Research Institute and the University of Miami on broodstock management protocols for various flatfish species. SCDNR staff have adopted the use of a vitamin supplement utilized successfully by TPWD and will be implementing a photothermal conditioning schedule for broodstock that was developed by facilities in Texas and North Carolina. In addition to spawning induction hormones currently utilized by SCDNR for cobia and spotted seatrout, additional hormones utilized by University of Texas researchers will be included in spawning trials in year two of the SCDNR program.

While no spawning or larviculture occurred during the first year of the program, as expected with animals being newly transitioned to recirculating systems from the wild and new diets, SCDNR staff have developed spawning protocols and larviculture protocols to implement moving forward. Based on conversations and shared information from researchers at TPWD, UT, UM, and others, SCDNR staff are well prepared to identify female flounder that can be induced, as well as to conduct the required strip spawning procedures and begin intensive larviculture in the coming year.

Coordination of genetic sample collection along the southeastern US coast

Points of contact for fin clip collection were established in each partner state (North Carolina, Georgia, and Florida) during August 2021. With input from state partners during a regional team meeting, sampling designs were completed in September 2021. Sampling designs include the collection of adults during the spawning season (November-February) and young-of-the-year (YOY) fish during the summer. Sampling kits were then sent to regional collectors in late September 2021 containing vials with a sarcosyl-urea preservation solution, which is a non-hazardous solution and simultaneously stabilizes sample DNA and serves as a preliminary cell lysis solution which allows for easier sample collection in the field and subsequent shipping of samples. All fin clips received have been archived into the SCDNR Population Genetics Tissue Collection. In mid-January 2022, we received 690 fin clips from North Carolina and 120 fin clips from Georgia. Another 200 fin clips were received from Georgia in late April 2022. About 450 individuals have been captured and fin clipped through SCDNR monitoring programs during year 1. An additional 46 fin clips were collected from a tournament held in Murrell's Inlet, South Carolina in late April 2022. With the completed development of the new genetic marker panel for southern flounder, these samples will soon be processed to evaluate patterns of gene flow and genetic health of the wild southern flounder population(s) to guide future broodstock management and stocking protocols.

Construction and Maintenance of Marine Artificial Reefs

Program PI\Participants: Ryan Yaden, Brent Merritt, Joe Alston

Reporting Period: July 2, 2021 - July 1, 2022

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
14 Sept 21	260-ft. deck barge	Edisto 60' Reef
19 Oct 21	48-ft. tugboat	Cape Romain Reef
19 Oct 21	4 designed concrete structures	Area 51 SSMZ
17 Nov 21	60-ft. steel-hulled trawler	Ten Mile Reef
17 Nov 21	26 pieces concrete culvert	Ten Mile Reef
13 April 22	26 Concrete Junction Boxes	Georgetown Nearshore
1 June 22	245' Cargo Ship "Coastal Venture"	Charleston Deep Reef
2 June 22	1 Reef Box 12 Concrete culvert	Paradise Reef

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

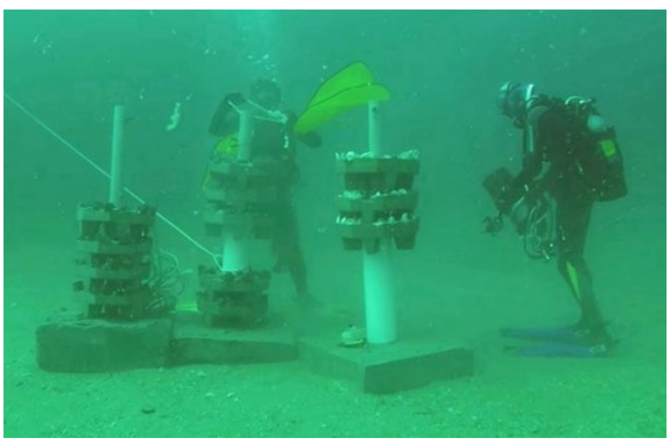
- Twenty-one scuba dives were made to conduct video surveys, arrange placement of new reef structures, document colonization, and service acoustic receivers.

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

- Three missing reef buoys were replaced.

- Presentations to fishing clubs, diving clubs, and virtual presentations on artificial reefs and their function; as well as press releases and media events.

Sinking of *Coastal Venture*



Stackable reef structures

Edisto 60’ barge with life-sized great white sculpture on bow.

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

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

Reporting Period: July 1, 2021 - June 30, 2022

Project Title: Assessing the spatial extent and condition of State-managed shellfish grounds using small, unmanned aerial systems (sUASs)

During FY2022, South Carolina Department of Natural Resources (SCDNR) Marine Resources Research Institute (MRRI) Shellfish Research Section (SRS) staff continued their use of a small, unmanned 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.

The goal of such flights is to establish workflows for monitoring loose shell planting sites with sUAS and to test the capabilities of UAV methods for detecting and estimating change. In March of 2022, a flight was completed at a small (1.2-acre) site in Murrells Inlet within State Shellfish Ground S357, one of the most popular recreational grounds along the coast. This site has been flown annually since it was originally planted with loose shell in August 2018. Figure 1 graphically illustrates changes over this period within a portion of the planted area. The planting has been successful, establishing a new oyster reef with harvest size oysters. Elevation has increased at the site and the marsh has expanded behind the planting. Elevation data were used to estimate volumetric changes at the site. Immediately after planting in 2018, the site increased by 48.7 m^3 relative to the pre-planting volume. In 2022, the cumulative increase was 78.1 m^3, relative to pre-planting, indicating a net increase in volume of 29.4 m^3 since the initial planting. This increase in overall volume is attributable to increases in both shell volume and sediment volume within the planted footprint and is a quantifiable positive indicator of planting success.

Similar flights exploring sUAS methods for monitoring loose shell management were conducted in June 2022 at two sites within State Ground S206W, a popular recreational shellfish harvesting ground near Folly Beach. Ground truth data, including chain-rugosity, and oyster presence/absence data were collected in association with these flights. UAV data, including near infrared reflectance (NIR) data, from the 2022 flights were used to develop a new workflow to automatically delineate oyster reefs using supervised classification with GIS software. The resulting products were useful for monitoring the performance of these sites four years post-planting. Figure 2 illustrates an area of relative success, in which planted footprints resulted in an established reef footprint after 4 years. Figure 3 illustrates an area of unsuccessful planting in which the footprint did not result in the significant establishment of new reef habitat after 4 years. The successful development of these workflows and approaches has resulted from several years of dedicated data collection and experimentation with multiple methods. Going forward, these methods will be used to detect changes in extent and potentially to assess the quality of natural reefs.

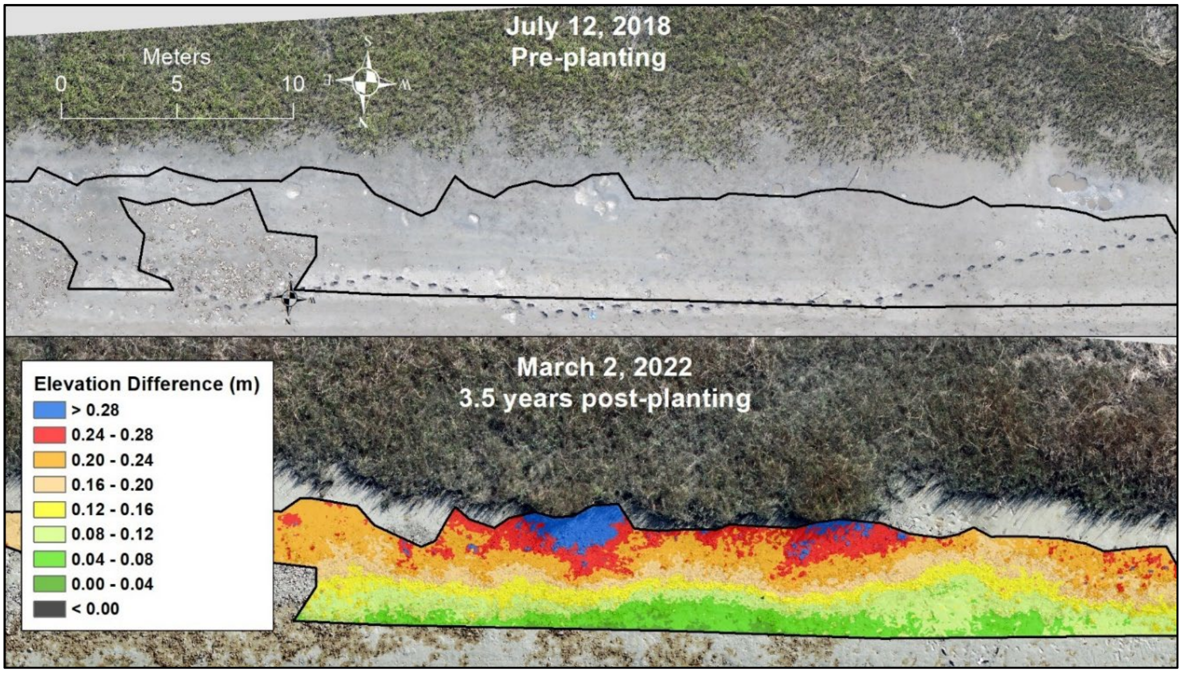


Figure 1 (*above*). A GIS map showing elevation changes over time resulting from the placement of loose oyster shell within State Shellfish Ground S357 in Murrells Inlet. Warm colors indicate greater positive elevation change. The black border indicates the border of the analysis area, which excludes areas where established reefs existed prior to the 2018 planting. *Top panel*: Site immediately pre-planting. *Bottom panel:* Elevation change 3.5 years post-planting, with oyster growth, sediment accretion, and marsh accretion all occurring following shell planting.

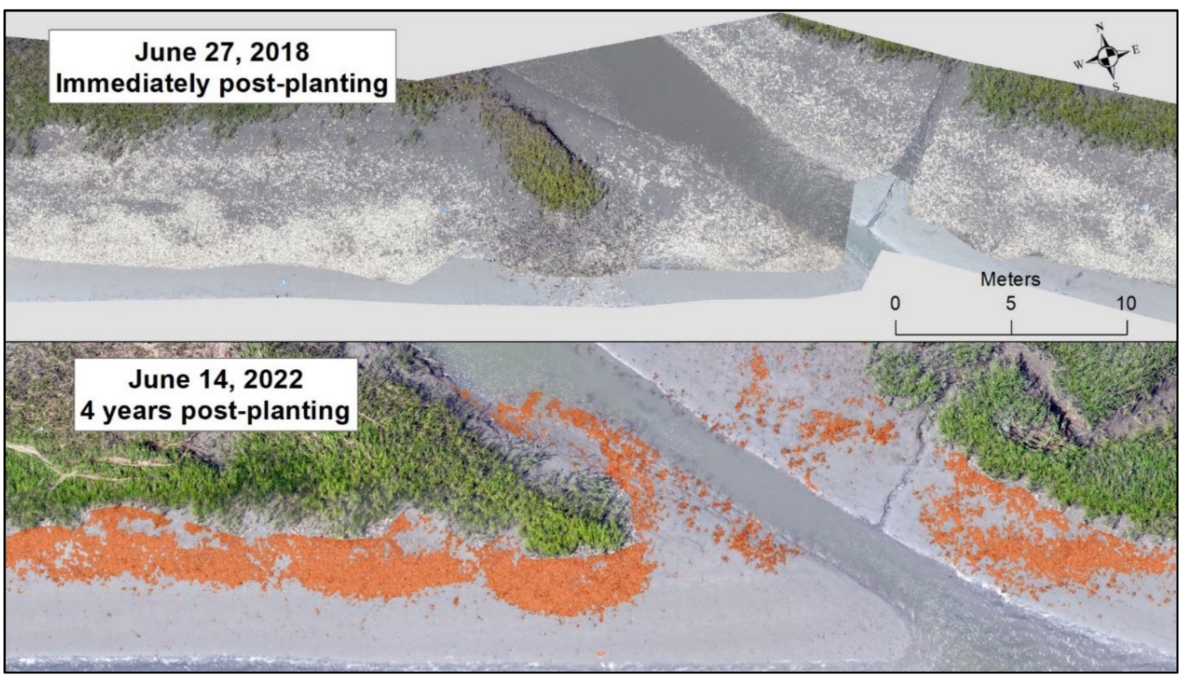


Figure 2 *(above)*. A GIS map from S206W showing a loose shell planting site immediately post planting in June 2018 (*top panel*) and same view in June 2022 (*bottom panel*) showing oyster reefs delineated using UAV imagery and supervised automated classification (*orange overlay*). Final oyster reefs were classified using a newly developed workflow. The planting at this site was successful in creating an established reef.

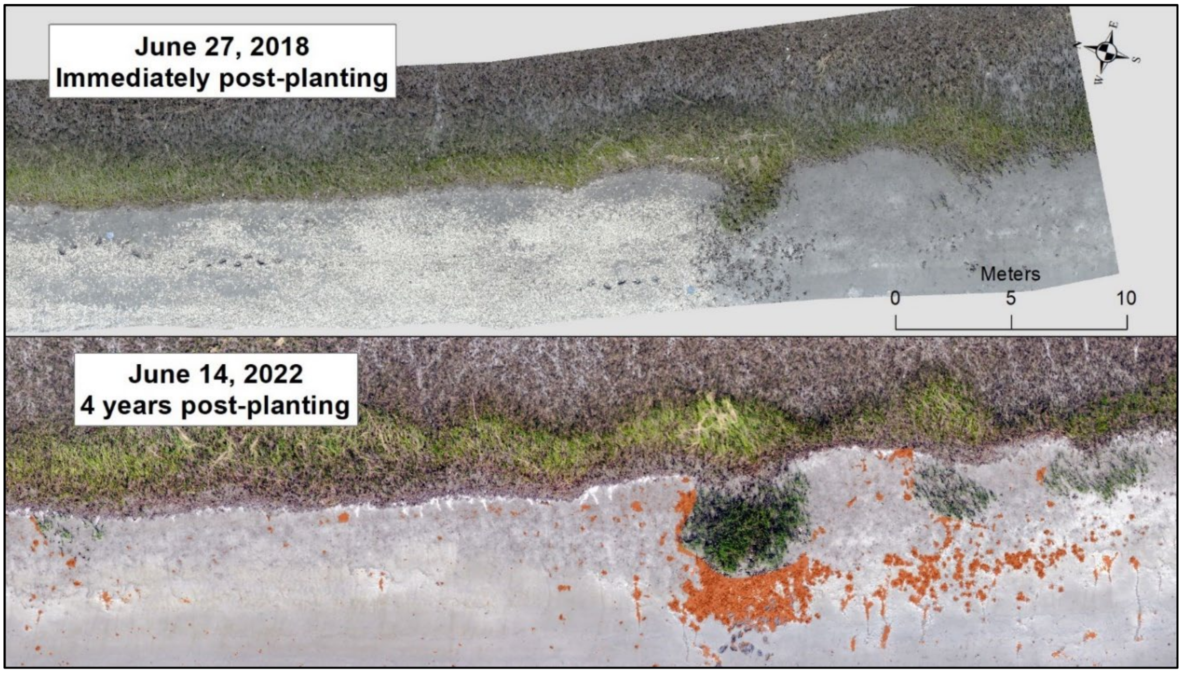


Figure 3 *(above)*. A GIS map from S206W showing a loose shell planting site immediately post planting in June 2018 (*top figure*) and same view in June 2022 (*bottom figure*) showing oyster reefs delineated using UAV imagery and supervised automated classification (*orange overlay*). Final oyster reefs were delineated using a newly developed workflow. The planting at the site was unsuccessful as most of the footprint did not have established reefs in 2022.

In addition, on May 16, 2022 a flight was conducted in S206W near Folly Beach that successfully mapped 59.1 acres of intertidal oyster habitat including natural patch and fringing reefs. On June 13, 2022, a flight was conducted in S272 in Sewee Bay that successfully mapped 25.3 acres of intertidal oyster habitat. A further flight in S272 originally planned for June 2022 was cancelled due to weather in June, but was completed in July 2022, and will be reported in future progress reports. The data from these flights and the imagery and elevation map products are stored on secure SCDNR servers for future analyses. During the reporting period digitized oyster reefs from flights in Sewee Bay in November 2020 were integrated into the statewide oyster GIS layer.

Project Title: Assessing natural mortality patterns of South Carolina intertidal oyster reefs to inform restoration and resource management.

During FY2022, staff in the Shellfish Research Section (SRS) continued annual monitoring of wild intertidal oysters to explore patterns of mortality, recruitment, and other demographic parameters. During the winter (October 2021 – March 2022), staff collected triplicate oyster samples from 34 index sites along the South Carolina coast (Figure 4). Samples were collected by placing quadrats on oyster reefs in representative locations and removing oyster clusters from within the quadrat. Upon collection, oyster samples were taken back to the shellfish laboratory at the Marine Resources Research Institute (MRRI), where each oyster was assessed as living or recently dead, and shell heights were measured using digital calipers. All data were entered into a relational Microsoft Access database on SCDNR servers.

During FY2022, a total of 19,963 individual oysters were collected and measured. Since 2015 when this survey started, 170,590 oysters have been collected and measured. Once oysters were processed in the lab, all shells were recycled to be used to create intertidal oyster reef habitat through the South Carolina Oyster Recycling and Enhancement (SCORE) program. Oyster natural mortality rates were calculated as the proportion of dead oysters in each sample (Table 1). In FY2022, the statewide natural mortality rate was 6.5%, which is down from 7.7% in the previous year. In the first year of this project (2015), an anomalous rainfall event in the form of tropical storm Joaquin contributed to a statewide natural mortality rate of almost 11% (Figure 5). The large input of freshwater into coastal systems in 2015 is thought to have caused the high mortality in that year. Since 2015, natural mortality rates have decreased, indicating a gradual recovery of the population. The past five years have been characterized by mortality rates between 5% and 8%, which appears to be a baseline for wild intertidal oysters in South Carolina (Table 1, Figure 5).

The length-frequency data generated by measuring oysters collected through the winter is also used to assess relative recruitment success. The proportion of small oysters (less than 1 inch, assumed to be recruits) was calculated in each sample from each year of the oyster demographic survey. The distribution of proportions of recruits was then used to assign each sample in each year into one of three categories based on the proportion of recruits: “below average”, “average”, and “above average.” This recruitment index can be useful in identifying times and places where recruitment is weak, and may inform management by allowing for certain places to be closed to harvest prior to a weak year class recruiting to the fishery. In the 2016-2017 season, there was a high proportion of index sites categorized with below average recruitment success (Figure 6). This may be explained by the high mortality rates (>10%) in the previous year, thought to be caused by freshwater input from tropical storm Juaquin. A high mortality year could lead to a weak year class the following year, as there would be less individuals reproducing. In FY22, there were six sites with below average recruitment. These sites were located in the northern portion of the state and around the Charleston area. Generally, these locations are influenced by freshwater input from upland watersheds, which may relate to higher mortality and lower recruitment success. However, none of these sites had abnormally high mortality rates in the previous year that would explain the below average recruitment success. Therefore, the below average recruitment success at these sites is not of concern. The combination of natural mortality rates and length-frequency data from sites widely distributed across the South Carolina coast is a powerful tool for monitoring changes in the wild oyster population, and will continue becoming more useful as further years of data are added to the time series.

Table 13. Summary of natural morality rates of oysters tabulated by year and sampling site.

Site	Site Name	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	Mean
ASP	**Ashepoo River**	9.7	19.9	9.7	11.5	12.3	6.7	4.4	**10.6**
BBC	**Big Bay Creek**	10.7	9.9	4.9	3.1	6.1	19.2	9.4	**9.0**
BBF	**Bears Bluff**	3.7	8.6	4.6	3.5	4.8	10.2	4.3	**5.7**
BFT	**Beaufort River**	6.7	11.5	10.0	4.7	2.5	8.0	5.7	**7.0**
BLB	**Bulls Bay**	2.9	4.2	5.5	2.9	2.9	3.5	4.4	**3.8**
BRD	**Broad River**	9.8	1.6	3.1	5.4	2.2	6.0	3.6	**4.5**
BUL	**Bull Creek**	2.5	2.8	4.8	2.6	3.4	6.8	2.5	**3.6**
CBG	**Calibogue Sound**	7.7	17.2	10.0	9.8	7.6	29.4	21.9	**14.8**
CCH	**Chechessee River**	4.3	4.8	6.4	1.8	3.2	7.2	7.5	**5.0**
CLT	**Colleton River**	2.5	4.3	6.2	1.9	7.0	3.9	12.5	**5.5**
CPR	**Cooper River**	10.4	7.9	29.5	4.3	3.7	4.5	5.5	**9.4**
CRM	**Cape Romain**	4.7	5.8	3.4	4.3	5.2	7.6	6.2	**5.3**
CSG	**Cosgrove Bridge**	20.3	11.8	7.3	2.8	7.9	6.4	5.4	**8.8**
CSW	**Coosaw River**	6.2	3.3	3.6	3.1	2.2	6.6	4.4	**4.2**
DWE	**Dewees Inlet**	7.1	2.8	13.0	16.8	10.0	8.0	16.6	**14.2**
EDR	**Edisto River**	7.9	4.9	2.1	6.0	3.7	13.6	5.1	**6.2**
FLR	**Folly River**	4.8	4.1	8.2	3.4	9.8	6.4	4.8	**5.9**
FOS	**Foster Creek**	-	-	-	2.4	3.3	5.8	3.8	**3.8**
FSC	**Fish Creek**	-	6.8	3.7	-	-	-	-	**5.2**
GRC	**Grice Cove**	-	-	-	6.4	5.4	6.6	4.2	**5.6**
HAR	**Charleston Harbor**	15.5	27.2	6.9	6.8	-	-	-	**14.1**
HOG	**Hog Island**	3.5	7.5	6.3	2.2	6.9	6.9	4.6	**5.4**
INL	**Inlet Creek**	6.4	9.3	6.8	2.7	3.5	4.7	5.2	**5.5**
JIC	**James Island Connector**	19.4	8.9	9.2	5.5	9.6	7.3	5.1	**9.3**
MAY	**May River**	2.1	3.1	6.6	4.8	6.3	4.3	5.0	**4.6**
MRI	**Murrells Inlet**	-	3.6	5.0	3.8	9.7	4.4	2.5	**4.9**
NHI	**North Inlet**	4.4	5.1	6.6	0.4	7.4	6.9	7.0	**5.4**
SST	**South Santee**	77.3	3.9	9.8	12.0	7.1	5.1	5.1	**17.2**
STI	**Stono Inlet**	6.0	8.8	5.0	6.7	6.5	7.2	8.9	**7.0**
STR	**Stono River**	13.2	7.8	6.2	3.4	3.3	5.1	6.8	**6.5**
SWE	**Sewee Bay**	19.0	15.8	11.0	3.0	10.8	12.5	10.3	**11.8**
TGD	**Toogoodoo Creek**	5.3	6.0	4.0	3.4	3.3	5.7	6.3	**4.9**
TOL	**Tolers Cove**	7.1	5.6	9.9	2.1	2.8	5.4	9.8	**6.1**
WBR	**Whale Branch**	-	0.9	4.0	4.5	1.8	5.4	4.0	**3.4**
WND	**Wando River**	9.7	26.9	5.6	4.2	4.3	-	-	**10.1**
WSW	**Warsaw Flats**	3.3	4.9	5.5	2.9	2.7	5.3	3.8	**4.1**
WYB	**Winyah Bay**	33.3	24.1	5.8	22.0	9.4	7.5	5.2	**15.3**
Mean		**10.9**	**9.2**	**7.1**	**5.2**	**5.7**	**7.7**	**6.5**	**7.5**

Figure 4. Location of sites sampled for natural oyster mortality during FY2022. Site codes for locations sampled are explained in Table 1.

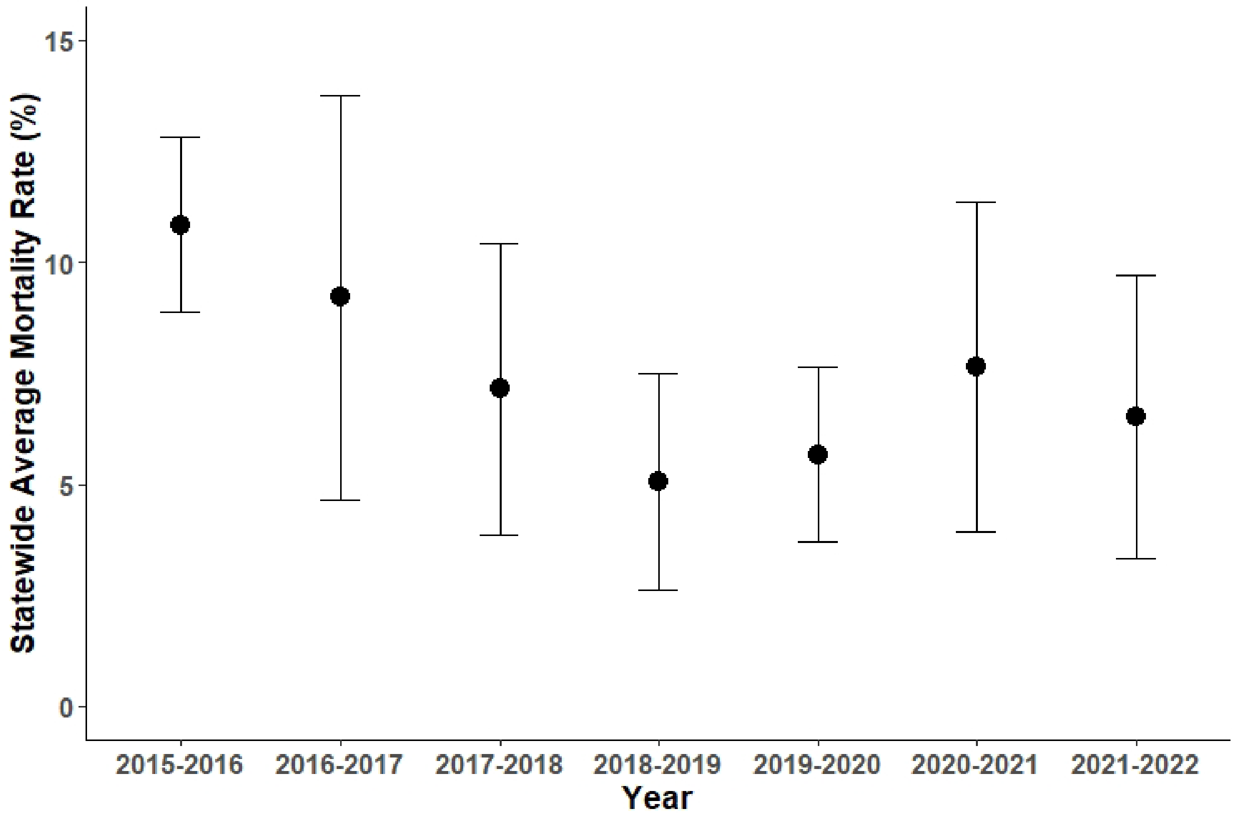


Figure 5. Statewide average natural mortality rates for wild intertidal oysters. Error bars denote standard deviations. The highest natural mortality was recorded during the first year of the survey, which coincided with an anomalous storm event. The large influx of freshwater into coastal systems is thought to have caused the high mortality rates in 2015-2016. The next two years were characterized by a gradual decrease in natural mortality, perhaps demonstrating a slow and steady return to "normal" natural mortality rates. The last four years have shown more stable natural mortality rates fluctuation around 5-8% with a slight increase in 2020-2021 before falling again in 2021-2022.

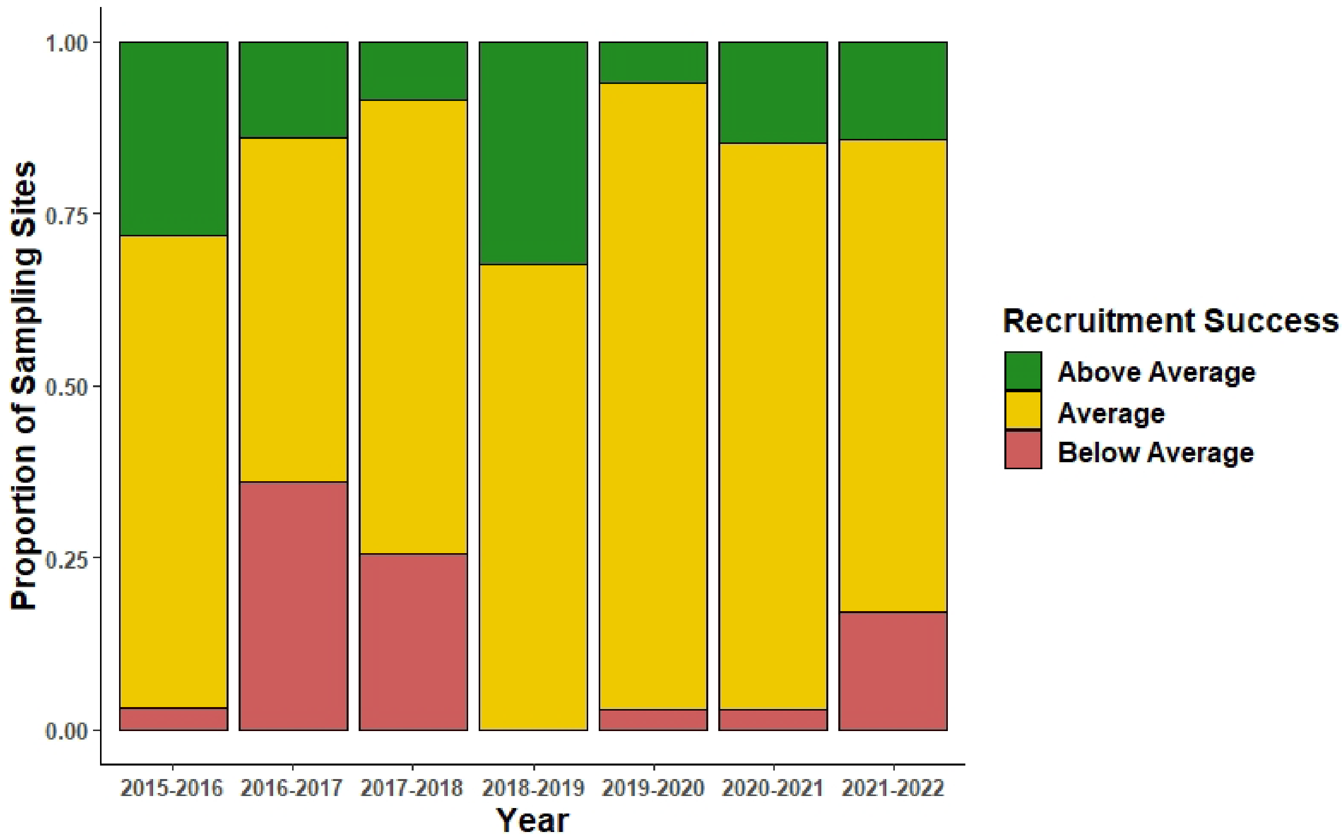


Figure 6. Proportions of index sites characterized by various levels of recruitment success for each year of demographic sampling. Relative recruitment success was determined based on the proportion of small (<1”) oysters in each sample that were assumed to be recruits. The distribution of proportions of recruits for all sites and years was then divided into three categories: above average, average, and below average. The larger proportions of index sites with below average recruitment success in 2016-2018 may be related to the high mortality experienced statewide in 2015-2016.

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

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

Reporting Period: July 1, 2021 - June 30, 2022

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 FY2022 was 30,000 bushels of shell.
2. Site, build and maintain at least one new oyster shell recycling bin 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 area(s).
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

1. In FY 2021, **33,991** bushels (bu.) of shell were recycled. This is the <u>second largest</u> amount of shell recycled in program history since its inception in 1999 and continues SCDNR's role as one of the top programs in the nation for quantity of shell and the largest state-funded program. Eighteen public drop-off sites were serviced in 11 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 **$167,235** by not having to purchase an equivalent quantity of out of state shell.

   We saw an 18% increase in the total amount of bushels recycled from FY21 to FY22. Increases were recorded for every shell source (Table 1) except public drop-off bins. Shell recycled from restaurants increased by a third, owing to the implementation of a volunteer-led recycling initiative in Beaufort County, recycling can-cleaning measures in Charleston and the overall waning of impacts of COVID-19. A "clean can plan" was initiated for several restaurants who are large producers of recycled shell that traditionally had to shut down recycling operations during the hottest months of the year due to pests. This was mitigated by can-cleaning events and can switch-outs.

Several caterers were contacted to start directly recycling through trailer and can drop-offs in lieu of them using the public drop-off bins. This leads to more detailed recognition for participating caterers and less frequent public drop-off bin servicing leading to a decreased number in amount of shells reported from public drop-offs for this season.

The program saw the purchase of three new hydraulic dump trailers, overhauls of aging hydraulic dump trailers, and the donation of one hydraulic dump trailer from the Coastal Conservation Association (CCA).

Table 14: Sources of recycled shell in bushels and percent change from FY21 to FY22

Shell Source	2021-2022	2020-2021	Difference
Restaurants	13228	9897	33.7%
Public Drop-off Bins	11195	11611	-3.6%
Events	4011	3484	15.1%
Public Trailers	2881	2609	10.4%
Caterers	2676	1136	135.5%
Total	**33991**	**28736**	**18.3%**

2. One new oyster shell recycling public drop-off location was constructed at the Dorchester County Oakbrook Convenience Center in Ladson, SC. The new constructed bin (Fig. 1) was a relocation of the bin previously located at Jessen Landing which closed due to a park redesign by the Town of Summerville and Dorchester County. Materials for this bin were purchased by partner organization CCA.

   Reconstruction/upgrade of bins are currently planned at: 1) 6-Mile Road in the Town of Mt. Pleasant, and 2) at the Marine Resources Division campus at Ft. Johnson. New construction of a public drop-off bin is planned for Cross Island Boat Landing within the Town of Hilton Head Island. The CCA has agreed to purchase materials for the construction of these planned new bins.

Figure 5: New public drop-off bin installed at Dorchester County Oakbrook Convenience Site, Ladson, SC

3. Twelve new restaurants and one new caterer joined the program in Charleston, including: Bexley Fish & Raw Bar, Locals Raw, Blu Oyster, Bailey's Raw Bar, Fatty's Beer Works, Herd Provision, LoLA, Three Sirens, Port of Call, Pelican's Nest, Shuckin' Shack – West Ashley, Sullivan's Fish Camp, and Top Shelf Catering. One new restaurant in the Greenville area joined the recycling program, Mr. Crisp. Five new restaurants in the Beaufort County area joined the recycling program, including: Hogshead Kitchen, May River Grill, Morgan River Grill, Octagon at Palmetto Bluff, and The Bluffton Room. The Shell Recycling and Planting program now collects shell from 67 restaurants, 47 of which are active weekly contributors in the Charleston area. A hydraulic can lift attached to a recycling trailer is used to service Charleston area restaurants (Fig. 2). Educational presentations and a partner recognition are continually being offered to partner restaurants to raise awareness within the restaurant community and increase recycling totals.

Figure 6: A CCA donated can lift used for the bi-weekly Charleston area restaurant route and smaller oyster roast events

The volunteer recycling programs in Charleston, Beaufort and Greenville have recycled a total of 4,242.25 bushels of oyster shells which accounted for 1,280.75 volunteer hours, valued at over $32,620.70. The volunteer recycling in Charleston, SC is still servicing eight restaurants as well as multiple seasonal roasts. The Charleston Oyster Recycling Volunteers collected 778.75 bushels. The volunteer recycling in Beaufort, SC is still servicing nine restaurants. The Beaufort Oyster Recycling Volunteers collected 1,523.25 bushels of oysters. The volunteer recycling in Greenville, SC is still servicing three restaurants and one catering company as well as multiple seasonal roasts. The Greenville Oyster Recycling volunteers in the upstate collected 1,053.25 bushels. 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.

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. The Murrells Inlet area will be a focus of volunteer-led shell recycling efforts in the coming year, based-on the output of the previously mentioned workshop

4. Staff conducted several news and media interviews, including interviews with The State (Columbia, SC), the Charleston Post and Courier (Charleston, SC), and several other news print and television news media outlets. Staff participated in a podcast with journalists from "Good Beer Hunting (dot) com" about conservation, sustainability and the role of oysters the coastal ecosystem and beyond.

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 (Fig. 3) 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 SCDNR, and program partners were also used to notify the public, targeted towards seasons of high shell production.

Figure 7: Informational placard placed at seafood retail markets and oyster roast events

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.

The South Carolina Oyster Recycling and Enhancement (SCORE) program held a workshop to organize a volunteer-led shell recycling initiative in the Grand Strand region. This workshop, facilitated by staff from the North Inlet-Winyah Bay National Estuarine Research Reserve, focused on identifying infrastructure (volunteer groups, locations for public drop-offs, potential government and non-government organization partnerships. Information and partnerships gained from the 26 regionwide participants who attended this workshop will be crucial to implementation of community-led volunteer shell recycling efforts in several communities of the Grand Strand.

SCDNR 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 email survey was sent out to 100,000 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 **34,542** bushels of oyster shells were planted on State and Public Shellfish Grounds during the 2021-2022 planting season, creating **11,574 m^2 (2.86 acres)** of shellfish habitat along approximately **1.12 miles** of shoreline (Table 2 & Fig. 4).

Charleston County was planted by DNR's oyster barge, *The Indigo Princess*, with SRFAC funds using recycled shell. A contracted barge planted one site on the Kiawah River. Georgetown and Beaufort Counties were planted with recycled shell as well as shell purchased from North Carolina. Planting was done by contractor using SRFAC & WREC funds and monitored by SCDNR.

Table 15: 2022 State and Public Shellfish Ground planting tallies and acreages by county

	Waterbody	Bushels	Acres	Miles
Georgetown County				
R355_1_22	Murrells Inlet	850	0.09	0.04
S354_1_22	Oaks Creek	2,000	0.08	0.03
S358_1_22	Oaks Creek	1,500	0.15	0.09
S358_2_22	Oaks Creek	500	0.05	0.04
Total		**4,850**	**0.37**	**0.19**
Charleston County				
R193_1_22	Green Creek	4,960	0.36	0.13
R274_1m_22	Sewee Bay	2,016	0.08	0.12
R274_2_22	Sewee Bay	1,920	0.17	0.09
S194E_1_22	Kiawah River	3,136	0.22	0.06
S194E_2_22	Kiawah River	2,016	0.17	0.06
S272_1_22	Anderson Creek	832	0.13	0.04
S272_2_22	Anderson Creek	960	0.08	0.04
S272_3_22	Anderson Creek	2,860	0.12	0.04
R272_4_22	Anderson Creek	992	0.10	0.05
Total		**19,692**	**1.49**	**0.63**
Beaufort County				
S100_1_22	Trenchards Inlet	5,125	0.50	0.08
S105_1_22	Harbor River	4,875	0.50	0.22
Total		**10,000**	**1.00**	**0.30**
2022 Totals		**34,542**	**2.86**	**1.12**

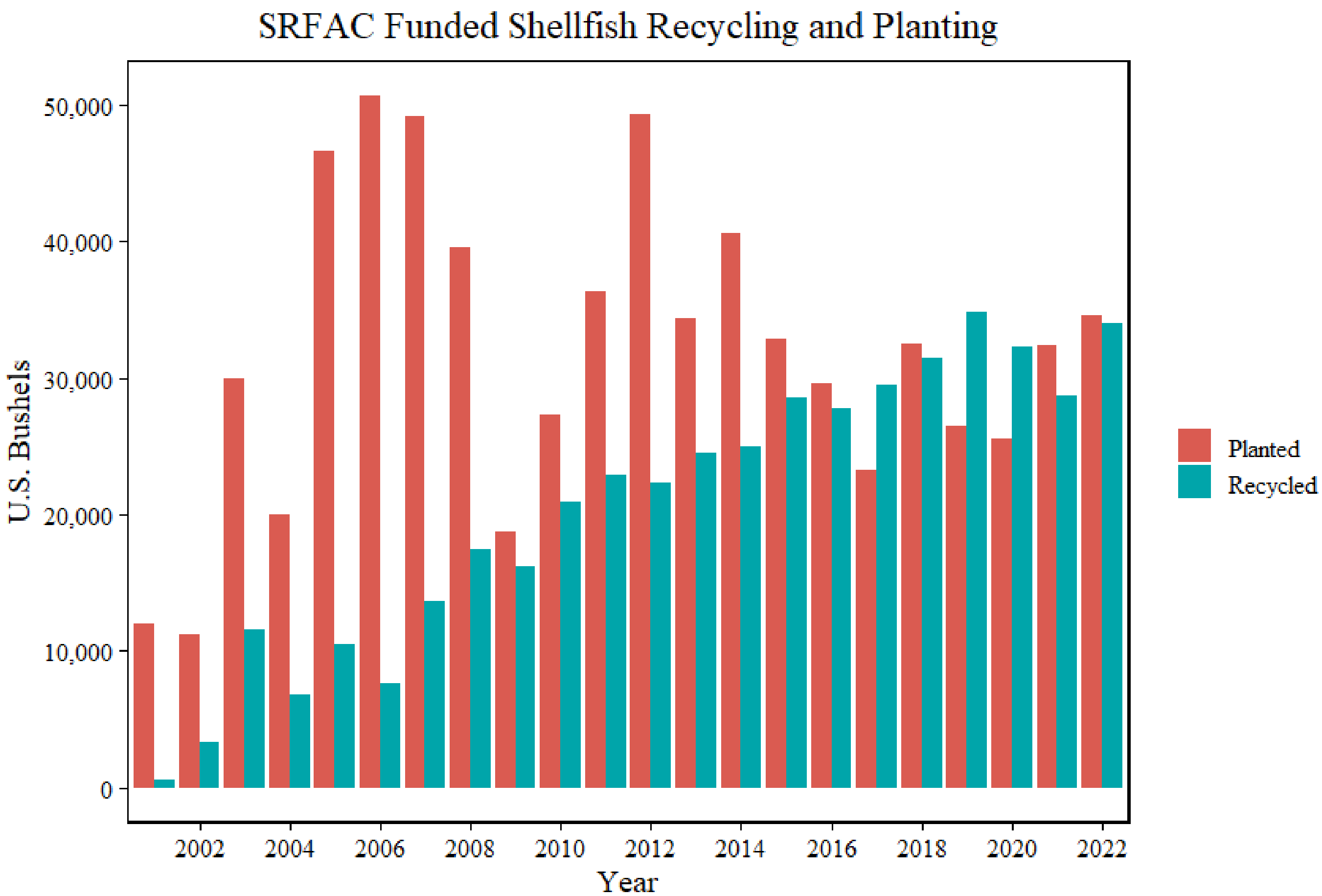


Figure 8: Histogram showing amounts of shell in bushels recycled and planted during FY22

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

8 **Three-Year Assessment (2021 assessments of sites planted in 2018):** Seventeen beds originally planted in 2018 were assessed to determine reef development success. However, all data from the four 2018 sites planted in the Folly River system (S206E n=1; S206W n=3) were corrupted and are not included in this report. These sites will be added to FY23 monitoring of 2019 sites. One site (S161_3_18 Steamboat Creek) had a 95% loss of footprint from the initial planting. The remaining twelve 3-yr sites planted in 2018 were assessed for footprint retention and several standardized qualitative metrics, including quality, quantity and size of oysters; and coverage of the oyster bed within the

footprint measured. Pre-planting, post-planting, 1-yr and 3-yr photographs were taken to document growth over time (Fig. 5).

Expected footprint retention on three-year-old large-scale planting sites on shellfish grounds is 70% based-on historical data. Sites planted in 2018 were found to have a mean 3-yr footprint retention of 69.1%. Two sites (S251_1-18 Hamlin Creek; S357_1_18 Oaks Creek) were found to have gained in footprint. Nine of twelve sites assessed had an overall "Average" success rating, using a composite scale including all qualitative metrics listed previously, while the remaining three sites were scored "Good" (Fig. 6). Mean vertical growth was found to be 75% ($\tilde{x}$=80%) for all twelve sites assessed.

Figure 9: Before (June 2018) and after (October 2021) photos of planting in (Oaks Creek) in Murrells Inlet planted July 2018

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															
Upper/Lower Hamlin, Swinton Creek															
S251_1_18	5/23/2018	**980**	SC/G	297.5	440.23535	142.7		10/18/2021	3.125	3.375	3.75	2.25	G		50
S251_2_18	5/23/2018	**630**	SC/G	175	109.17397	-65.8		10/18/2021	3.875	3.625	3.875	3.125	C		80
S255_1_18	5/21/2018	**2100**	SC/G	1210	170.918042	-1039.1	1160	10/18/2021	3.875	3.75	4	3.75	C		60
R252_1_18	5/23/2018	**1347.5**	SC/G	300	226.804995	-73.2		9/22/2021	3	3.75	4	4	C		60
R252_2_18	5/22/2018	**262.5**	SC/G	300	220.447928	-79.6		9/22/2021	3.5	4	4	3	F1		90
Steamboat Creek															
S161_1_18	6/1/2018	**2100**	SC/G	575	325.193767	-249.8	2045	9/17/2021	3.5	3.5	3	3.5	C		
S161_2_18	6/5/2018	**542.5**	SC/G	215	194.179031	-20.8	800	9/17/2021	4	3	3	3	F1		70
S161_3_18	6/6/2018	**2135**	SC/G	690	33.45	-656.6	501	9/17/2021	N/A	N/A	N/A	N/A	M		
S161_4_18	6/5/2018	**542.5**	SC/G	220.5	97.402508	-123.1	1493	9/17/2021	4	3.5	3	3.5	C		80
Robbins Creek, Second Sisters, Cuttoff Reach															
S206E_1_18	6/20/2017	**1575**	SC/G	420	N/A		872	9/1/2021	N/A	N/A	N/A	N/A			
S206W_1_18	6/21/2017	**1435**	SC/G	600	N/A			9/1/2021	N/A	N/A	N/A	N/A			
S206W_2_18	6/18/2017	**1645**	SC/G	467.5	N/A			9/1/2021	N/A	N/A	N/A	N/A			
S206W_3_18	6/18/2017	**525**	SC/G	210	N/A		2579	9/1/2021	N/A	N/A	N/A	N/A			
Georgetown															
Oaks Creek															
S357_1_18	7/20/18	**3813**	SC/G	1100	1498.072413	398.1		10/5/2021	4.25	4.25	4.5	4.375	F		80
S357_2_18	7/17/18	**1929**	SC/G	763	429	-334.0	1484	10/5/2021	3.375	3.5	4	3	C		80
Woodland Cut															
S358_1_18	7/19/18	**1450**	SC/G	600	316.050867	-283.9	1640	10/5/2021	4.25	4.5	4	4.25	G		90
Beaufort															
Beaufort River, Distant Island Creek															
S090_1_18	8/31/18	**9020**	SC/G	3349	2818	-531.0	3377	10/4/2021	3.875	4.125	3.625	4.5	F		90
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				Less than 450		450-900	900-1400	1400-1700	> 1700			

Figure 10: Site information, planting details and qualitative assessment data taken in 2021of 3-yr sites planted in 2018

1-Year Assessment (2021 assessments of sites planted in 2020): Seven beds planted in 2020 were sampled and spat measured with digital calipers to determine juvenile (Fig. 7) recruitment rates. One site had “Poor” recruitment, two had “Marginal” and the remaining four sites sampled “Average” recruitment (Fig. 8). Three sites on Adams Creek were not sampled as they were incorporated into a new (2021) Kings Grant. One site on Cowen Creek was not sampled due to almost no footprint retention; one management sites on Hamlin Creek was not monitored due to new growth being indistinguishable the original planting; and one site on Wallace Creek was not sampled due to inaccessibility at time of monitoring.

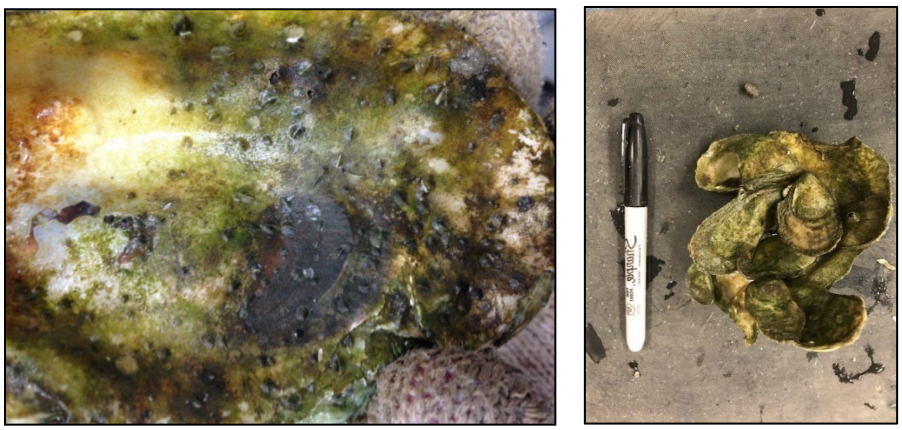


Figure 11: Juvenile oysters, or "spat" after settlement on recycled shell within hours (A) and 1 year post planting

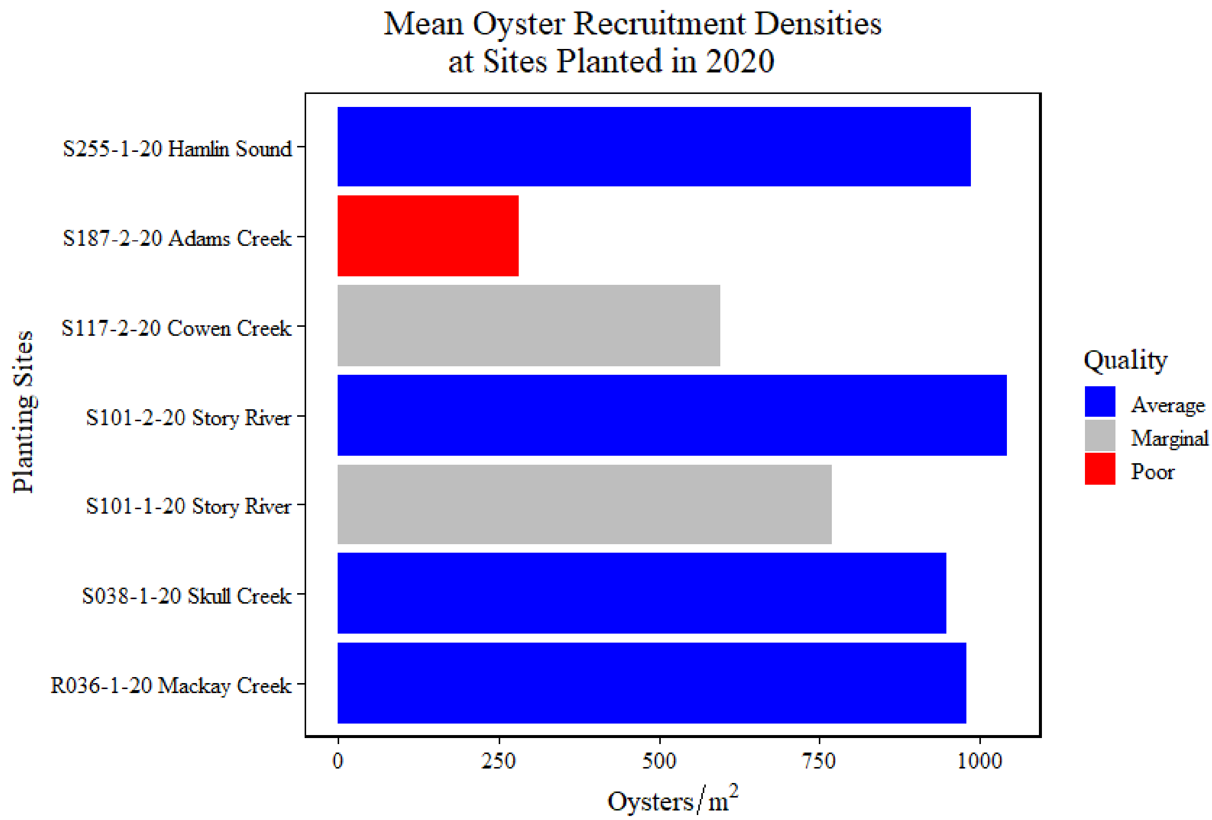


Figure 12: Recruitment densities for seven 1-yr sites planted in 2020 and measured in 2021

9&10. In FY22, maps of recreational shellfish harvesting grounds were made available on the Internet. These maps are updated annually. Recreational shellfish maps (Fig. 9) 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 FY22, 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 (Fig. 10). This interactive application allows users to 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.

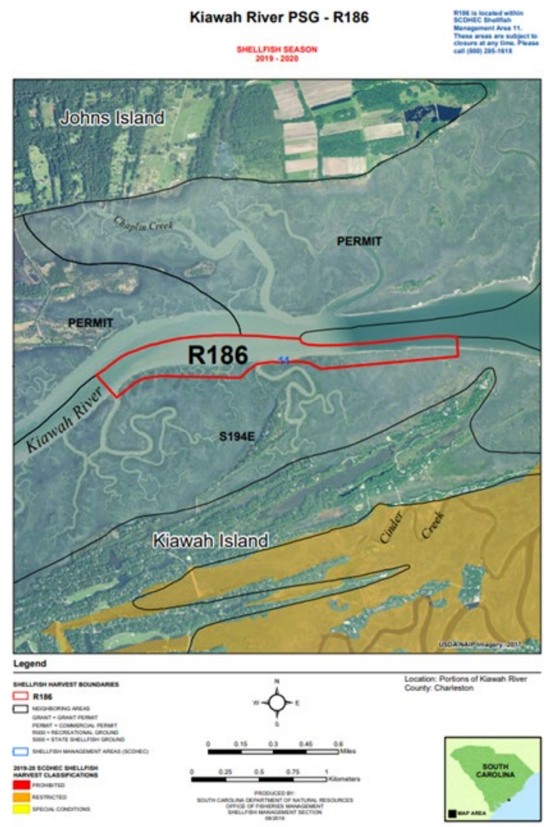


Figure 9: Example of PDF and paper maps of recreational shellfish grounds available upon online or by mail upon request

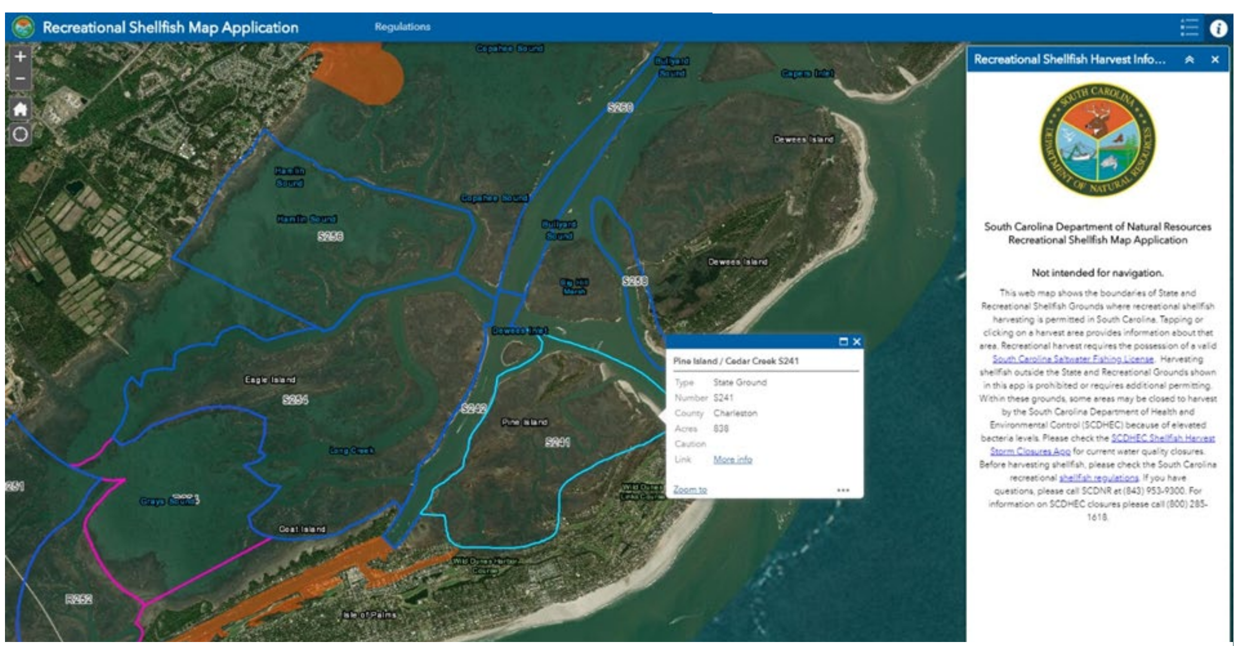


Figure 130: Interactive map available for viewing from any internet-enabled device

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 (Fig 11). 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.

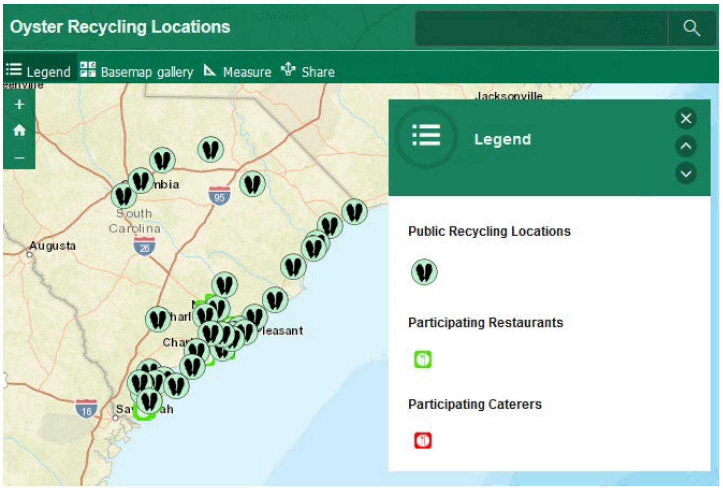


Figure 14: Interactive map showing locations of all public-drop off bins and participating restaurants

12 Currently, we are reassessing areas that are in need of sign replacement and/or repair due to lost or damaged signs. We are continually collecting GPS points for all new signs as well as existing signs in order to create a GIS map layer of all the collective shellfish boundary signs in the state.

Crustacean Research and Fishery-Independent Monitoring

Program PI: Peter Kingsley-Smith

Program Co-PIs: Michael Kendrick, Jeff Brunson

Reporting Period: July 1, 2021 - June 30, 2022

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 SCDNR's 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 values above the long-term averages, while summer white shrimp abundance values were lower than average but similar to recent years. Summer brown shrimp abundance values were above average in the estuarine trawl survey but below average in the creek trawl survey. Blue crab abundances were lower than average in the creek trawl and fall crab pot surveys, but similar to or above the long-term average in the estuarine trawl survey.

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. 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 Island 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. All planned Estuarine Trawl Survey dates were successfully completed during the July 1, 2021 to June 30, 2022 reporting period.

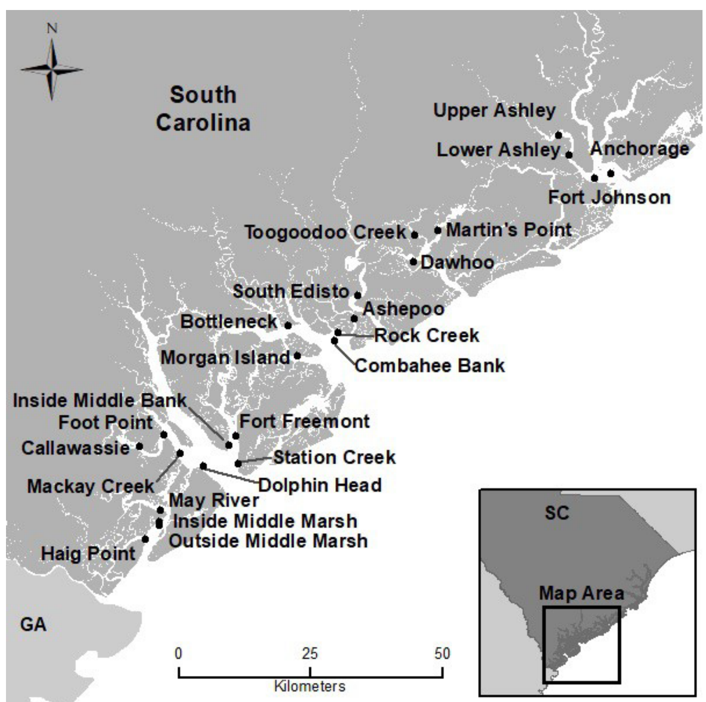


Figure 1. Estuarine trawl survey sampling stations.

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.

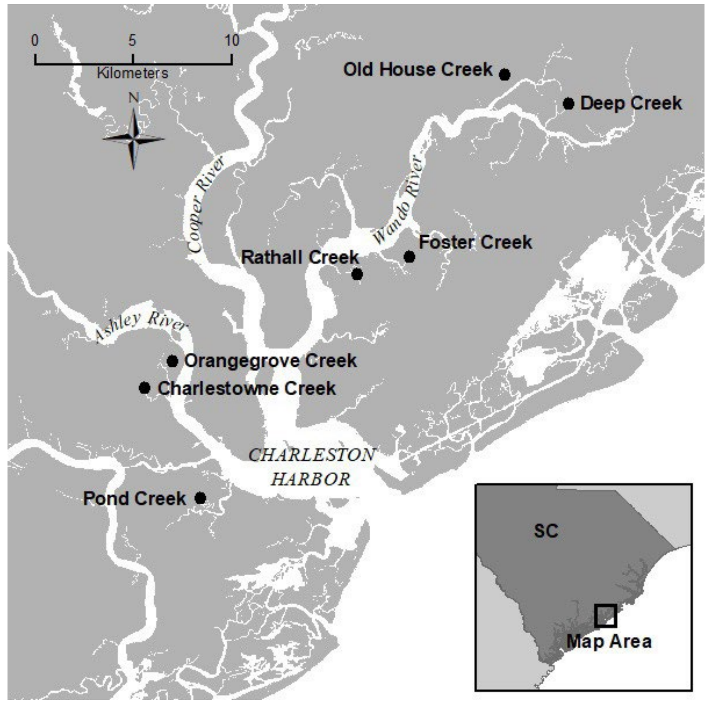


Figure 2. Creek trawl survey sampling stations.

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.

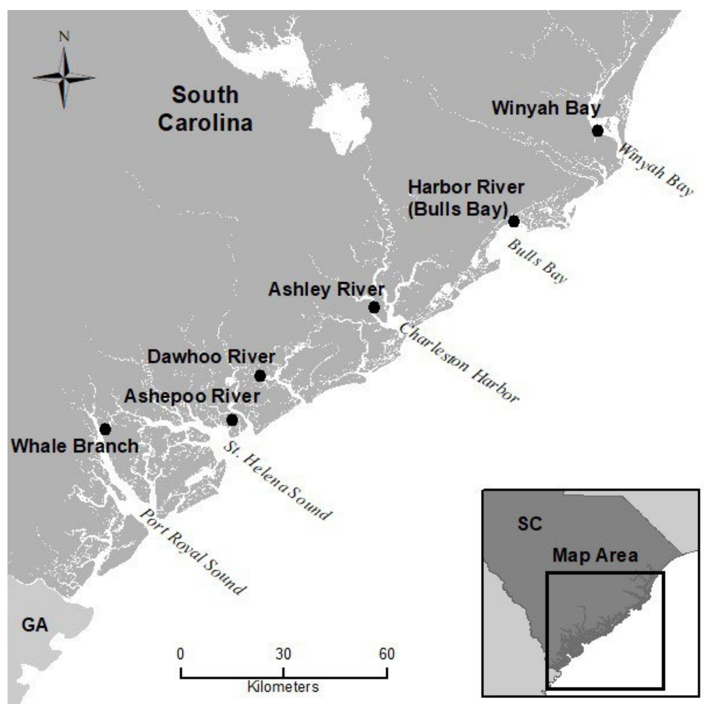


Figure 3. Statewide fall crab pot survey sampling stations.

PROGRAM FINDINGS FOR FY22

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, indicating that shrimp should have been readily available for recreational harvest. White shrimp abundance was much higher than the long-term mean in April 2022. White shrimp in April generally compose a portion of the spawning stock for the shrimp harvested in the late summer and fall.

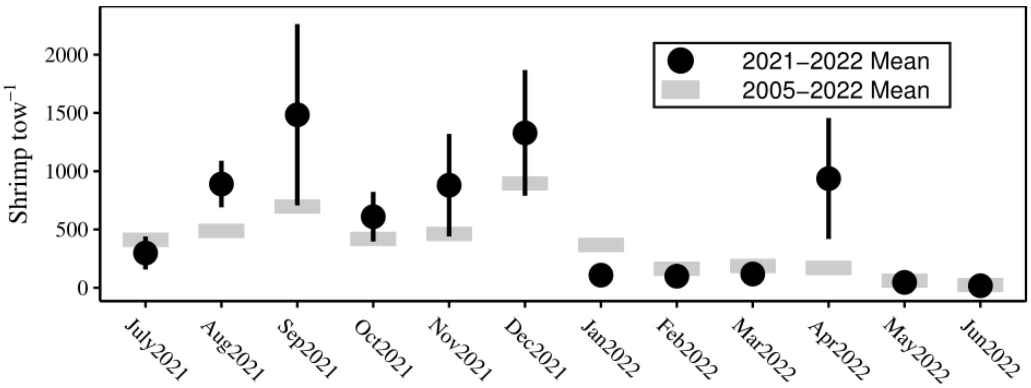


Figure 4: Monthly white shrimp abundance (mean ± standard error) from the Estuarine Trawl Survey

***Seasonal patterns in white shrimp abundance*:**
White shrimp abundance in fall (September to December) and spring (February - April) 2021 was well above the long-term mean (2005-2022; *Figure 5B* and *5C*). Although the catch of white shrimp in the summer (May - August) creek trawl survey was below the long-term mean, the presence of juvenile white shrimp in the samples at levels similar to recent years demonstrates successful spawning activity and recruitment of shrimp throughout the spring and summer of 2021 (Figure 5).

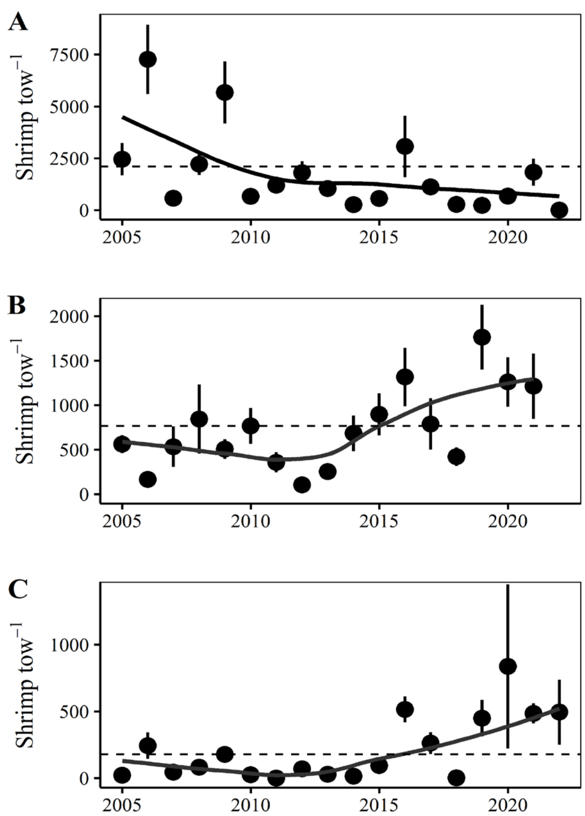


Figure 5: White shrimp abundance (mean ± standard error) from summer (A), fall (B), and spring (C) surveys. Fall and spring samples are from estuarine trawl survey while summer samples are from creek trawls. Lines represent long-term means (dashed) and smoothed trends (solid).

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 below the long-term mean while catches from the estuarine trawl survey (*Figure 6B*) were above the long-term mean and similar to catches in recent years.

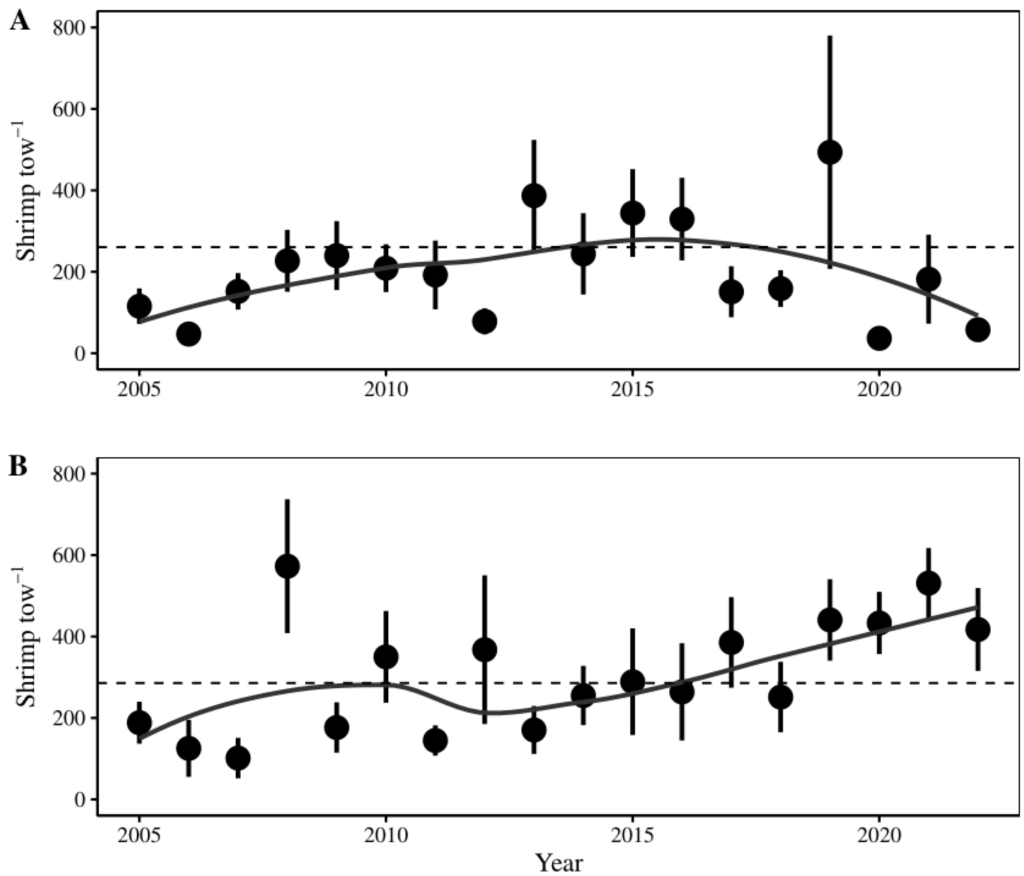


Figure 6: Trends in summer (May-July) brown shrimp abundance (mean ± standard error) from creek trawl (A) and estuarine trawl (B) surveys. Lines represent long-term means (dashed) and smoothed trends (solid).

Black Gill

Black gill has not been documented to negatively impact shrimp population abundances, but shrimp with melanized gills may be more susceptible to predation. Black gill prevalence in fall 2021 was similar to the long-term mean for both brown shrimp and white shrimp (*Figure 7*).

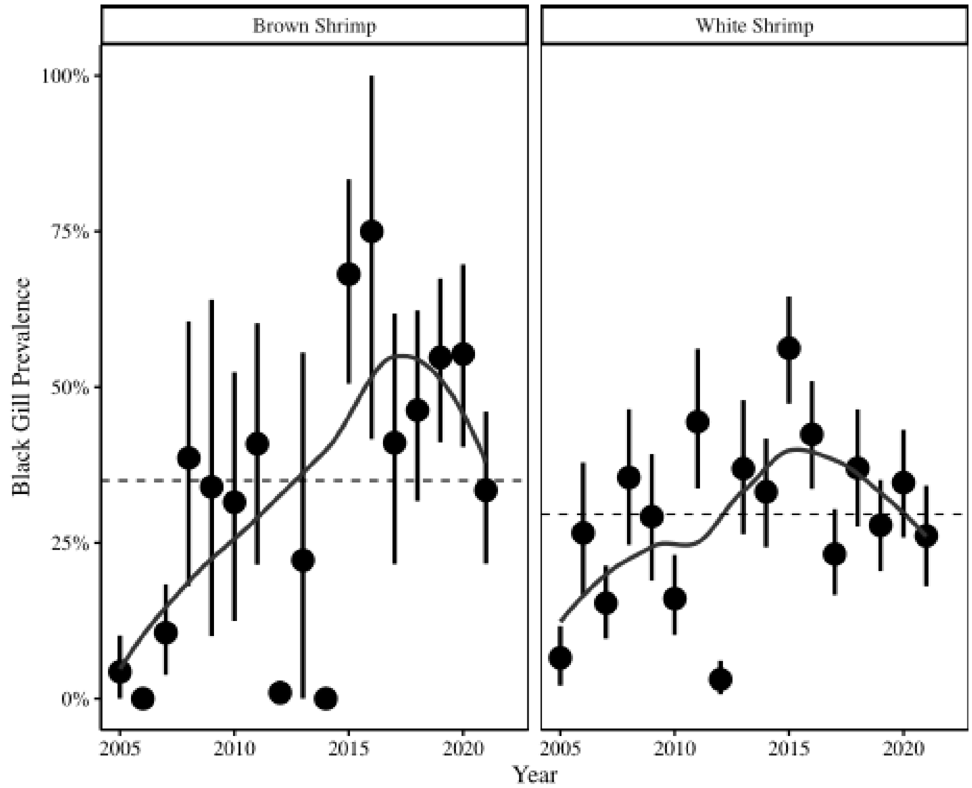


Figure 7: Trends in fall (Aug-Dec) 2021 black gill (mean ± standard error) in brown shrimp and white shrimp collected from the estuarine trawl survey. Lines represent long-term means (dashed) and smoothed trends (solid).

Blue crab (*Callinectes sapidus*)

1) Estuarine trawl survey: Blue crab abundance was at or below the long-term mean from July 2021 through January 2022. Abundance has remained near or above the long-term mean since (*Figure 8*), with especially high abundances in May 2022. When separated by size, legal-sized blue crab (>5”) abundance was similar to the long-term mean, while catches of sublegal crabs (<5”) were well above the long-term mean (*Figure 9*).

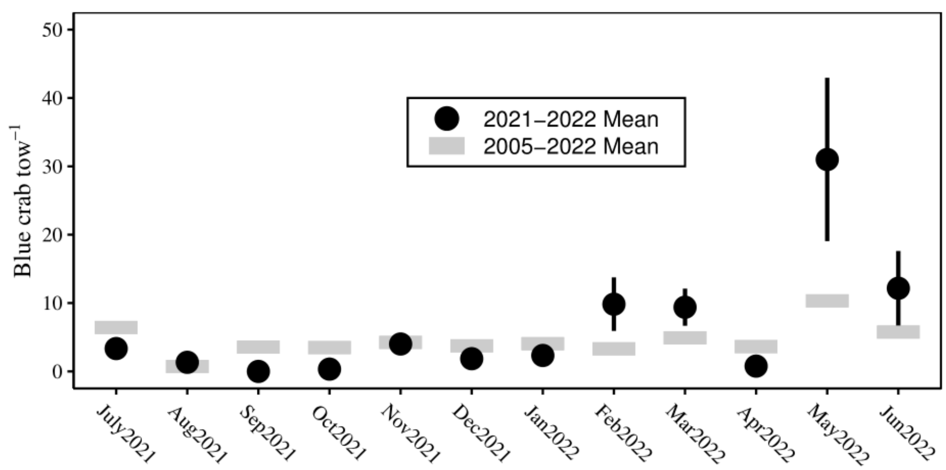


Figure 8. Monthly blue crab abundance (mean ± S.E.) from the estuarine trawl survey.

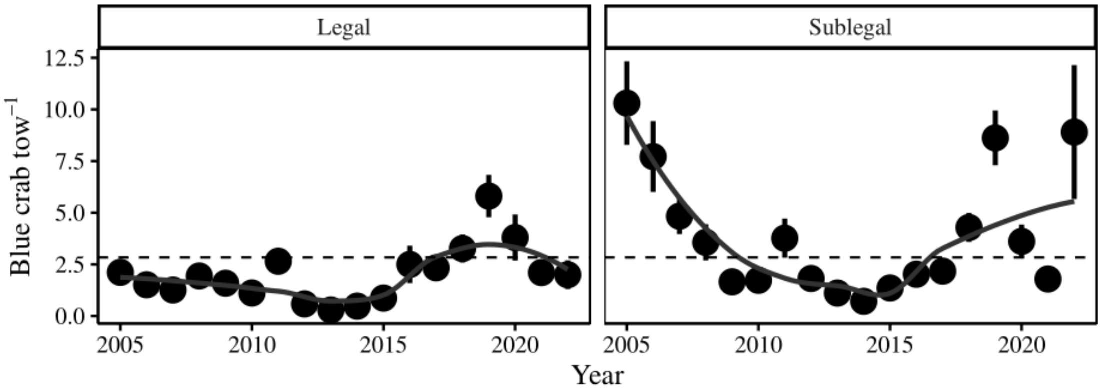


Figure 9. Blue crab abundance (mean ± S.E.) for legal- (≥5" CW) and sublegal- (<5" CW) sized blue crabs collected from the estuarine trawl survey. Lines represent long-term means (dashed) and smoothed trends (solid).

2) Creek trawl survey: Blue crab abundance in the creek trawl survey was below the long-term mean (1995-2022; *Figure 10*).

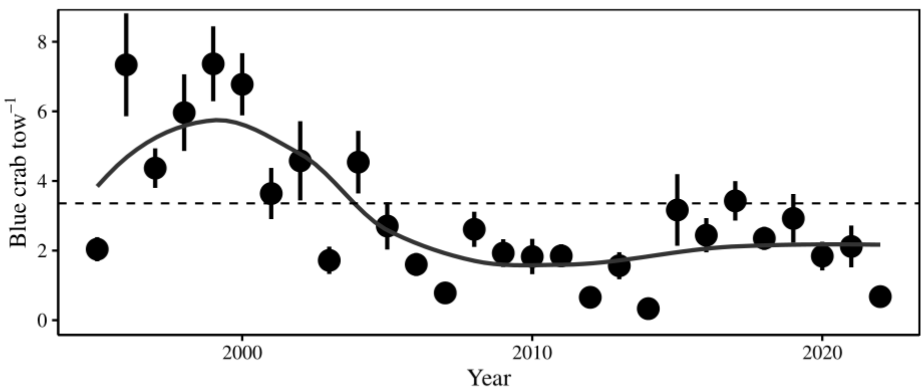


Figure 10. Blue crab abundance (mean ± standard error) from creek trawl survey in the Charleston Harbor watershed (May-July). Lines represent long-term means (dashed) and smoothed trends (solid).

***3) Crab pot survey*:** Blue crab abundance in the 2021 fall crab pot survey was well below the long-term mean (1995-2021; *Figure 11*).

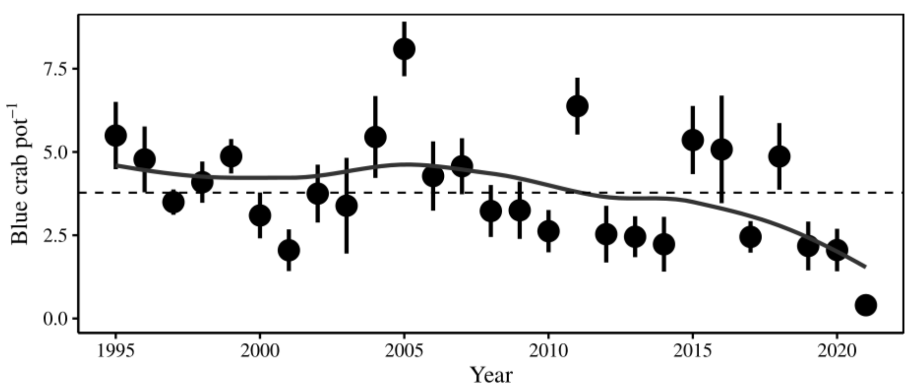


Figure 11. Fall blue crab abundance (mean ± standard error) from the statewide crab pot survey. Lines represent long-term means (dashed) and smoothed trends (solid).

Marine Recreational Angler Conservation and Education Project

Program PIs: Matt Perkinson and Olivia Bueno

Reporting Period: July 1, 2021 through June 30, 2022

Program Objectives:

- The Educational Vessel *Discovery* will be utilized as an educational tool to teach students, teachers, and public audiences about the complexity and importance of marine resources in coastal South Carolina.
- Saltwater Fishing Outreach Programs will promote saltwater fishing participation and marine resource stewardship through representation at public events, fishing education programs, and through presentations to fishing and civic organizations.
- Information will be disseminated through printed and online materials, including resources for educating anglers on fishing rules and regulations, population trends, proper fish handling, and sustainable fishing techniques.
- The Marine Game Fish Tagging Program will be used as a tool for communicating with recreational anglers, demonstrating the value of catch and release, 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 68 vessel-based education programs and 136 land-based programs to 5,954 students from grades K-12. Staff spent 15,290 contact hours with students and teachers. Nine teacher workshops were held with a total of 213 teachers attending.
- Staff began a public outreach campaign aimed at addressing long term declines in the red drum population in South Carolina as observed by long-term sampling data. Initial efforts in this campaign include creating information products (presentations, fact sheets) to inform anglers of the decline in the population and information gathering from the fishing community. Outreach opportunities in 2022-2023 will focus on the importance of proper fish handling methods in reducing the amount of discard mortality and potential spawning disruption that occurs as fishing pressure continues to increase.
- With the hiring of additional staff, the scope of programs and number of anglers reached saw a significant increase during 2021-2022. These programs include:

  Fishing Clinics: Educational programs led by a combination of SCDNR staff and trained certified family fishing instructors designed to provide anglers with a baseline of saltwater fishing skills while also promoting sustainable fishing practices and stewardship of marine resources. These clinics are targeted toward anglers of all ages and include opportunities for pier, dock, and surf fishing.

  Pier/Dock Outreach Program: Informal outreach led by certified fishing instructors designed to answer questions and provide fishing instruction for those who need it.

Fishing Tournaments/Rodeos: Partnerships with state/city/county and private organizations to promote fishing participation, provide instruction, and educate youth and adult anglers on sustainable fishing practices.

Fishing Events: All other outreach events attended including the Palmetto Sportsman's Classic, ICAST, SEWE, Cast It Forward, etc.

Fishing Outreach Program	**# Programs**	**# Attendees/Encounters**	**# Volunteer Hours**
Fishing Clinic Program	25	352	428.25
Pier/Dock Outreach Program	77	1628	265.00
fishing Tournaments/rodeos	5	404	92.00
Large Events	8	2000+ (est.)	136.50
Total # of Attendees		4,384	
Total # of Vol. Hours			921.75

- Virtual and in-person training events for Certified Fishing Instructors were held in coastal South Carolina, resulting in an additional 22 instructors and increasing the overall number of instructors in the program to 114. Greater volunteer participation has allowed the program to expand into new areas and develop partnerships with Hunting Island State Park, Myrtle Beach State Park, the Mt. Pleasant Pier, and various private organizations. To reach additional audiences, specialty clinics were developed for women, military/veterans, and bilingual/Spanish-speaking anglers.
- A total of 687 recreational anglers participated in the Marine Game Fish Tagging Program through tagging and/or reporting the recovery of tagged fish. Program volunteers tagged and released 2,953 fish from a variety of species. Information was received from 731 recaptured fish and of those, 86 percent were released. The program hosted three tagger training events along the coast of SC. Through these events, 33 new taggers were added to the program. Topics of interest to the recreational angling community were provided via the MGFTP newsletter, with a distribution to over 1,600 individuals.
- Fishing outreach staff aided tournament organizers from the Murrells Inlet Rotary Club and the Grand Strand Saltwater Anglers Association as they transitioned their flounder tournaments to a live-release format. Over 100 flounder were measured, weighed, tagged, and released during the two events.
- Public information material was distributed through the Coastal Information Distribution System (CIDS). Seven days were spent delivering approximately 150,500 copies of printed material to 131 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 beginners guides to saltwater fishing.

Publications

S. Lowerre-Barbieri, C. Friess, L. Griffin, D. Morley, G. Skomal, J. Bickford, N. Hammerschlag,

Item	Number Produced and Distributed
SW Fish Ruler Stickers	50,000
Fish ID Chart	20,000
Guide to SW Fishes	2,500
Beginner Guides to SW Fishing	3,000
Total	75,500

M. Rider, M. Smukall, M. Bergmann, T. Guttridge, A. Kroetz, R. Grubbs, C. Gervasi, J. Rehage, G. Poulakis, K. Bassos-Hull, J. Gardiner, G. Casselberry, J. Young, **M. Perkinson**, D. Abercrombie, D. Addis, B. Block, A. Acosta, A. Adams, A. Danylchuk, S. Cooke, F. Whoriskey, J. Brownscombe. 2021. Movescapes and eco-evolutionary movement strategies in marine fish: Assessing a connectivity hotspot. Fish and Fisheries. 2021;22:1321-1344.

Figure 1. Students inspect a blue crab during a program aboard the E/V Discovery.

Figure 2. Red drum presentation designed to educate anglers on recent population trends and best fishing practices to support a sustainable population.


Figure 3. Young angler participating in a pier fishing clinic.

Figure 4. Volunteer instructor extraordinaire Brad Shenk helps a young angler with their first catch, a spot.

Figure 5. The classroom portion of a women's fishing clinic is held at Fort Johnson.


Figure 6. Participating in a kid’s fishing tournament at the Mt. Pleasant Pier


Figure 7. Staff participate in the Post and Courier’s Cast It Forward event at Firefly Distillery


Figure 8. Anglers practice tagging techniques on a blackfin tuna.

Figure 9. Marine Game Fish Tagging Program coordinator Joey Coz tags and releases a flounder during the Murrells Inlet Rotary Club live release flounder tournament.