SALTWATER RECREATIONAL FISHERIES LICENSE PROGRAM

Annual Report for Fiscal Year 2023

#1: Fishery-Independent and Fishery-Dependent Sampling of Estuarine Finfish

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Reporting Period: July 1, 2022 to June 30, 2023

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 longline 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 (moderate to 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, 2022 – June 30, 2023), Inshore Fisheries staff made 707 trammel sets, approximately an 18% increase from previous reporting period, in nine survey areas ('strata') found in five broad geographic areas along the South Carolina coast (Table 1). The survey caught 12,003 specimens, approximately a 24% increase from previous reporting period, belonging to 63 taxa (Table 2). We enumerated and measured all fish, releasing most alive at the site of capture. From the 12,003 specimens, we collected 4,943 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 251 electrofishing sets, an approximate 9% decrease relative to the previous reporting period, in five strata along the South Carolina coastline (Table 4). The decrease in effort was primarily driven due to vessel repairs leading to the loss of 6 sampling days throughout the reporting period that were unable to be made up within the original sampling month. The survey caught 14,823 specimens belonging to 58 taxa (Table 5). From those 14,823 specimens, staff collected 1,951 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. Since the expansion, the survey has been conducted during three time periods (8/1 – 9/15, 9/16 – 10/31, and 11/1-12/15) across four South Carolina estuaries (Winyah Bay, Charleston Habor, Saint Helena Sound, and Port Royal Sound) 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 298 longline sets (each longline is one-third of a mile long) in four survey strata along the South Carolina coast (Table 6). This represents a 17% reduction in effort relative to the previous reporting period due to the damage sustained by the primary research vessel, the *R/V Silver Crescent*, during Hurricane Ian. Sampling effort (normally split into 3 time periods, 30 sets in 4 strata per period for a total of 120 sets per period) was reduced in periods 2 and 3 due to extensive damage to the primary research vessel, the *R/V Silver Crescent*, at the beginning of period 2. To salvage sampling, an electric drive longline reel was used on a 23 ft center console (in lieu of hydraulic reels). Only 69 out of the target of 120 set were sampled in Period 2 (and no sampling took place in Port Royal Sound) as it took time to purchase, assemble and train on the new reel. Period 3 had a more similar sampling effort to normal with 109 sets completed out of 120.

These 298 sets caught 1,581 specimens belonging to 23 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 58 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 68 trawls performed by the Estuarine Trawl Survey. Thirty-six of these trawls were in the Charleston Harbor system (Ashley River and Charleston Harbor; monthly trips). The remaining 32 trawls were performed in the southern part of the state (August and December 2021; March and April 2022; Table 8). Similar to the longline survey, this survey relies upon the availability of the *R/V Silver Crescent*, with the vessel being unavailable to the survey from October 2021 thru March 2022 due to damage suffered during Hurricane Ian. This led to a decrease in sampling effort during the reporting period, including the loss of 6 months of sampling in Charleston Habor and 2 sampling trips (December 2021 and March 2022) to the southern part of the state.

The 68 trawls yielded 61,946 fish belonging to 58 species (Table 9), of which at least 13 falls under federal/regional management plans. From these specimens, staff collected 584 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 Kingfish, 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 4th most numerous species captured in the trawl survey; we captured 3,388 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 163 fish carcasses belonging to four 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 of a cooperating angler's harvested fish, rather than just trophy fish.

During the reporting period, the SCDNR Inshore Fisheries Section took measurements and biological samples from 314 fish belonging to six species, of which Southern Flounder were the most numerous, followed by Sheespehad (Table 10). The large number of flounder encountered was the result of our participation in several live release tournaments in the Murrells Inlet area where lengths and genetic information were obtained.

Tagging Program

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

The trammel and electrofishing surveys tagged 1,721 belonging to six species between July 1, 2022 and June 30, 2023, with the majority being Red Drum (Table 11). Over the same period, individuals recaptured 410 tagged fish, of which recreational anglers caught 348 and SCDNR survey staff caught 63 (Table 12). Anglers released alive 82% (286/348) of the angler-caught fish (mostly Red Drum), while they harvested the remaining 18% (62/348).

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:

Swift, D. G., S. J. O'Leary, R. D. Grubbs, **B. S. Frazier**, A. T. Fields, J. M. Gardiner, J. M. Drymon, D. M. Bethea, T. R. Wiley, & D. S. Portnoy. 2023. Philopatry influences the genetic population structure of the blacktip shark (*Carcharhinus limbatus*) at multiple spatial scales. Molecular Ecology 32(18): 4953-4970. https://doi.org/10.1111/mec.17096. (August 2023)

Frazier, B. S., **E. A. Vinyard**, A. T. Fields, W. B. Driggers, R. D. Grubbs, D. H. Adams, J. M. Drymon, J. M. Gardiner, J. M. Hendon, E. Hoffmayer, R. E. Hueter, R. J. D. Wells, T. R. Wiley, & D. S. Portnoy. 2023. Age, growth and maturity of the bonnethead *Sphyrna tiburo* in the U.S. Gulf of Mexico. Environmental Biology of Fishes 106: 1597-1617. https://doi.org/10.1007/s10641-023-01439-5. (June 2023)

Heim, V., R. D. Grubbs, M. J. Smukall, **B. S. Frazier**, J. K. Carlson, & T. L. Guttridge. 2023. Observations of fin injury closure in great hammerheads and implications for the use of fin-mounted geolocators. Journal of Aquatic Animal Health 35(2): 53-63. https://doi.org/10.1002/aah.10178. (June 2023)

Guttridge, 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. Journal of Fish Biology 101(4): 797-810. https://doi.org/10.1111/jfb.15185. (October 2022)

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 weastern North Atlantic ocean. Parasitology, 1-48 (https://doi.org/10.1017/S0031182022001007). (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. (July 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)

Tables:

Table 1: Number of trammel net sets in each sampling stratum during July 1, 2022 – June 30, 2023.

	2022						2023						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Port Royal Sound	9		11	13		12	14	12	23	22	12	9	**137**
Saint Helena Sound	7	11				12	12	13			12	10	**77**
Charleston Harbor	19	32	11	23	20	25	26	22	24	19	25	22	**268**
Cape Romain	11	6		10		12	11	12	24	11	19	12	**128**
Winyah Bay		11	12	12		13	14	10		12		13	**97**
Total	**46**	**60**	**34**	**58**	**20**	**74**	**77**	**69**	**71**	**64**	**68**	**66**	**707**

Table 2: Catch of species encountered by the trammel net survey during July 1, 2022 – June 30, 2023

	Common Name	**Scientific Name**	**Family**	**Abundance**	**Rank**
1	Striped Mullet	*Mugil cephalus*	Mugilidae	2,488	1
2	Spotted Seatrout	*Cynoscion nebulosus*	Sciaenidae	1,890	2
3	Red Drum	*Sciaenops ocellatus*	Sciaenidae	1,436	3
4	Spot	*Leiostomus xanthurus*	Sciaenidae	1,148	4
5	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	683	5
6	Blue Crab	*Callinectes sapidus*	Portunidae	613	6
7	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	445	7
8	Pinfish	*Lagodon rhomboides*	Sparidae	440	8
9	Diamondback Terrapin	*Malaclemys terrapin centrata*	Emydidae	385	9
10	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	375	10
11	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	362	11
12	Bonnethead	*Sphyrna tiburo*	Sphyrnidae	170	12
13	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	163	13
14	Southern Kingfish	*Menticirrhus americanus*	Sciaenidae	129	14
15	Ladyfish	*Elops saurus*	Elopidae	127	15
16	Black Drum	*Pogonias cromis*	Sciaenidae	104	16
17	Sheepshead	*Archosargus probatocephalus*	Sparidae	94	17

Table 2: cont.

	Common Name	**Scientific Name**	**Family**	**Abundance**	**Rank**

18	Gizzard Shad	*Dorosoma cepedianum*	Clupeidae	89	18
19	Pigfish	*Orthopristis chrysoptera*	Haemulidae	83	19
20	Striped Burrfish	*Chilomycterus schoepfi*	Diodontidae	68	20
21	Bluefish	*Pomatomus saltatrix*	Pomatomidae	66	21
22	American Harvestfish	*Peprilus paru*	Stromateidae	65	22
23	Bluntnose Stingray	*Dasyatis say*	Dasyatidae	62	23
24	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	59	24
25	Northern Puffer	*Sphoeroides maculatus*	Tetraodontidae	53	25
26	Green Sea Turtle	*Chelonia mydas*	Cheloniidae	49	26
27	Horseshoe Crab	*Limulus polyphemus*	Limulidae	45	27
28	Hogchoker	*Trinectes maculatus*	Achiridae	43	28
29	Weakfish	*Cynoscion regalis*	Sciaenidae	37	29
30	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	Carcharhinidae	35	30
31	Atlantic Spadefish	*Chaetodipterus faber*	Ephippidae	24	31
32	Crevalle Jack	*Caranx hippos*	Carangidae	22	32
33	Cownose Ray	*Rhinoptera bonasus*	Rhinopteridae	21	33
34	Atlantic Tripletail	*Lobotes surinamensis*	Lobotidae	14	34
35	Gafftopsail Catfish	*Bagre marinus*	Ariidae	11	35
36	White Mullet	*Mugil curema*	Mugilidae	11	35
37	Blacktip Shark	*Carcharhinus limbatus*	Carcharhinidae	10	37
38	Finetooth Shark	*Carcharhinus isodon*	Carcharhinidae	10	37
39	Lemon Shark	*Negaprion brevirostris*	Carcharhinidae	8	39
40	Summer Flounder	*Paralichthys dentatus*	Paralichthyidae	8	39
41	Sandbar Shark	*Carcharhinus plumbeus*	Carcharhinidae	7	41
42	Permit	*Trachinotus falcatus*	Carangidae	6	42
43	Atlantic Needlefish	*Strongylura marina*	Belonidae	4	43
44	Florida Pompano	*Trachinotus carolinus*	Carangidae	4	43
45	Smooth Butterfly Ray	*Gymnura micrura*	Gymnuridae	4	43
46	Spanish Mackerel	*Scomberomorus maculatus*	Scombridae	4	43
47	Lookdown	*Selene vomer*	Carangidae	3	47
48	White Catfish	*Ameiurus catus*	Ictaluridae	3	47
49	Bay Whiff	*Citharichthys spilopterus*	Paralichthyidae	2	49

Table 2: cont.

	Common Name	Scientific Name	Family	Abundance	Rank
50	Butterfish	*Peprilus triacanthus*	Stromateidae	2	49
51	Gulf Flounder	*Paralichthys albigutta*	Paralichthyidae	2	49
52	Gulf of Mexico Ocellated Flounder	*Paralichthys ommatus*	Paralichthyidae	2	49
53	Leatherjack	*Oligoplites saurus*	Carangidae	2	49
54	Scalloped Hammerhead	*Sphyrna lewini*	Sphyrnidae	2	49
55	Southern Stingray	*Dasyatis americana*	Dasyatidae	2	49
56	Tarpon	*Megalops atlanticus*	Megalopidae	2	49
57	American Shad	*Alosa sapidissima*	Clupeidae	1	57
58	Atlantic herring	*Clupea harengus*	Clupeidae	1	57
59	Atlantic Ridley Turtle	*Lepidochelys kempii*	Cheloniidae	1	57
60	Blacknose Shark	*Carcharhinus acronotus*	Carcharhinidae	1	57
61	Naked Goby	*Gobiosoma bosc*	Gobiidae	1	57
62	Northern Searobin	*Prionotus carolinus*	Triglidae	1	57
66	Striped Anchovy	*Anchoa hepsetus*	Engraulidae	1	57
			Total	**12,003**	

Table 3: Number of biological samples collected during July 1, 2022 – June 30, 2023.

		Gear					
Sample	**Purpose**	**Electrofishing**	**Hook-&-Line**	**Longline**	**Trammel**	**Trawl**	**Total**
Digestive Tract	Microplastic Studies	74	4		83	40	**201**
Fillet	SCDHEC Mercury analysis	30	6		102		**138**
Fin Clip	Genetics	1400	481	2	3,111	538	**5,532**
Otoliths	Ageing	235	311	58	920		**1,524**
Reproductive Tissue	Sex and maturity	157	54	58	572		**841**
Scales	Ageing	2			5		**7**
Scale and Muscle Biopsy	Gar scale and muscle biopsy for mercury study	1			15		**16**
Whole Specimen	Blue Crab Studies				16		**16**
Whole Specimen	Educational programs	49			93	5	**147**
Whole Specimen	Invasive Species	3					**3**
Whole Specimen	SCDHEC Mercury analysis				1		**1**
Whole Specimen	Stock Enhancement Program Broodstock				25	1	**26**
Total		**1,951**	**856**	**118**	**4,943**	**584**	**8,452**

Table 4: Number of electrofishing sets made in each stratum during July 1, 2022 – June 30, 2023.

	2022						2023						
Stratum	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
Combahee River	*	-	6	7	5	5	6	-	6	6	6	6	**53**
Edisto River	*	6	-	6	5	6	6	6	6	-	6	6	**53**
Ashley River	-	*	6	6	5	5	-	5	6	*	6	6	**45**
Cooper River	*	6	6	4	-	6	6	6	6	6	-	5	**51**
Winyah Bay	*	6	6	4	5	-	6	6	4	6	6	-	**49**
Total	**-**	**18**	**24**	**27**	**20**	**22**	**24**	**23**	**28**	**18**	**24**	**23**	**251**

* – Electrofishing boat was unavailable due to necessary mechanical repairs.

Table 5: Catch of species encountered by the electrofishing survey during July 1, 2022 – June 30, 2023.

	Common Name	Scientific Name	Family	Abundance	Rank
1	Striped Mullet	*Mugil cephalus*	Mugilidae	6,282	1
2	Bay Anchovy	*Anchoa mitchilli*	Engraulidae	2,709	2
3	Spot	*Leiostomus xanthurus*	Sciaenidae	689	3
4	Red Drum	*Sciaenops ocellatus*	Sciaenidae	670	4
5	Inland Silverside	*Menidia beryllina*	Atherinopsidae	634	5
6	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	505	6
7	Largemouth Bass	*Micropterus salmoides*	Centrarchidae	464	7
8	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	435	8
9	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	374	9
10	Blue Catfish	*Ictalurus furcatus*	Ictaluridae	221	10
11	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	156	11
12	Redear Sunfish	*Lepomis microlophus*	Centrarchidae	146	12
13	American Eel	*Anguilla rostrata*	Anguillidae	139	13
14	Pinfish	*Lagodon rhomboides*	Sparidae	136	14
15	Bluegill	*Lepomis macrochirus*	Centrarchidae	121	15
16	Bowfin	*Amia calva*	Amiidae	121	15
17	Redbreast Sunfish	*Lepomis auritus*	Centrarchidae	109	17

Table 5: cont.

	Common Name	Scientific Name	Family	Abundance	Rank
18	Spotted Seatrout	*Cynoscion nebulosus*	Sciaenidae	80	18
19	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	77	19
20	Threadfin Shad	*Dorosoma petenense*	Clupeidae	75	20
21	Tidewater Mojarra	*Eucinostomus harengulus*	Gerreidae	65	21
22	American Shad	*Alosa sapidissima*	Clupeidae	63	22
23	Golden Shiner	*Notemigonus crysoleucas*	Cyprinidae	51	23
24	Striped Bass	*Morone saxatilis*	Moronidae	49	24
25	Sheepshead	*Archosargus probatocephalus*	Sparidae	48	25
26	Gizzard Shad	*Dorosoma cepedianum*	Clupeidae	38	26
27	Blueback Herring	*Alosa aestivalis*	Clupeidae	31	27
28	Spotted Sunfish	*Lepomis punctatus*	Centrarchidae	30	28
29	Spotted Sucker	*Minytrema melanops*	Catostomidae	26	29
30	White Catfish	*Ameiurus catus*	Ictaluridae	24	30
31	Flathead Catfish	*Pylodictis olivaris*	Ictaluridae	21	31
32	Mummichog	*Fundulus heteroclitus*	Fundulidae	19	32
33	Black Drum	*Pogonias cromis*	Sciaenidae	17	33
34	Speckled Worm Eel	*Myrophis punctatus*	Ophichthidae	14	34
35	Bay Whiff	*Citharichthys spilopterus*	Paralichthyidae	13	35
36	Channel Catfish	*Ictalurus punctatus*	Ictaluridae	12	36
37	Common Carp	*Cyprinus carpio*	Cyprinidae	12	36
38	Hogchoker	*Trinectes maculatus*	Achiridae	12	36
39	Chain Pickerel	*Esox niger*	Esocidae	11	39
40	Pumpkinseed	*Lepomis gibbosus*	Centrarchidae	10	40
41	White Mullet	*Mugil curema*	Mugilidae	9	41
42	Atlantic Needlefish	*Strongylura marina*	Belonidae	8	42
43	Black Crappie	*Pomoxis nigromaculatus*	Centrarchidae	8	42
44	Southern Kingfish	*Menticirrhus americanus*	Sciaenidae	8	42
45	Warmouth	*Lepomis gulosus*	Centrarchidae	8	42
46	Highfin Goby	*Gobionellus oceanicus*	Gobiidae	7	46
47	Horse-Eye Jack	*Caranx latus*	Carangidae	7	46
48	TBI Minnow		Cyprinidate	7	46
49	Atlantic Silverside	*Menidia menidia*	Atherinopsidae	6	49

Table 5: cont.

	Common Name	Scientific Name	Family	Abundance	Rank
50	Freshwater Goby	*Ctenogobius shufeldti*	Gobiidae	6	49
51	Naked Goby	*Gobiosoma bosc*	Gobiidae	6	49
52	Brook Silverside	*Labidesthes sicculus*	Atherinopsidae	5	52
53	Crevalle Jack	*Caranx hippos*	Carangidae	5	52
54	Ladyfish	*Elops saurus*	Elopidae	4	54
55	Flier	*Centrarchus marcropterus*	Centrarchidae	3	55
56	Leatherjack	*Oligoplites saurus*	Carangidae	3	55
57	Atlantic Tripletail	*Lobotes surinamensis*	Lobotidae	2	57
58	Brown Bullhead	*Ameiurus nebulosus*	Ictaluridae	2	57
59	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	1	59
60	Bluefish	*Pomatomus saltatrix*	Pomatomidae	1	59
61	Fat Sleeper	*Dormitator maculatus*	Eleotridae	1	59
62	Flat Bullhead	*Ameiurus platycephalus*	Ictaluridae	1	59
63	Gray Snapper	*Lutjanus griseus*	Lutjanidae	1	59
64	Lyre Goby	*Evorthodus lyricus*	Gobiidae	1	59
65	Permit	*Trachinotus falcatus*	Carangidae	1	59
66	Smallmouth Buffalo	*Ictiobus bubalus*	Catostomidae	1	59
67	Violet Goby	*Gobioides broussonetii*	Gobiidae	1	59
68	Western Mosquitofish	*Gambusia holbrooki*	Poeciliidae	1	59
Total				**14,823**	

Table 6: Number of one-third mile longline sets made during July 1, 2022 – June 30, 2023

Stratum		**Month**					
Estuary	**Location**	**August**	**September**	**October[a]**	**November**	**December**	**Total**
Winyah Bay	Inner		10	9	7		**26**
Winyah Bay	Outer		20	15	20		**55**
Charleston Harbor	Inner	6	7	11	7		**31**
Charleston Harbor	Outer	9	8	9	3	16	**45**
Saint Helena Sound	Inner	3	10	10	12		**35**
Saint Helena Sound	Outer	16	1	15	18		**50**
Port Royal Sound	Inner	11			9		**20**
Port Royal Sound	Outer	19			17		**36**
TOTAL		**64**	**56**	**69**	**93**	**16**	**298**

[a] – The primary research vessel was damaged during Hurricane Ian on September 30, 2022, resulting in the loss of the vessel for the remainder of the 2022 longline season. Staff bought supplies and retrofitted a smaller, non-ideal research platform, and resumed sampling on October 18, 2022.

Table 7: Catch of species encountered by the SCDNR longline survey during July 1, 2022 – June 30, 2023.

	Common Name	Scientific Name	Abundance	Rank
1	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	616	1
2	Red Drum	*Sciaenops ocellatus*	422	2
3	Sandbar Shark	*Carcharhinus plumbeus*	154	3
4	Blacknose Shark	*Carcharhinus acronotus*	104	4
5	Blacktip Shark	*Carcharhinus limbatus*	102	5
6	Finetooth Shark	*Carcharhinus isodon*	58	6
7	Southern Stingray	*Hypanus americanus*	32	7
8	Bonnethead	*Sphyrna tiburo*	23	8
9	Black Sea Bass	*Centropristis striata*	18	9
10	Scalloped Hammerhead	*Sphyrna lewini*	13	10
11	Oyster Toadfish	*Opsanus tau*	9	11
12	Whiting	*Menticirrhus americanus*	6	12
13	Lemon Shark	*Negaprion brevirostris*	5	13
14	Nurse Shark	*Ginglymostoma cirratum*	5	13
15	Bull Shark	*Carcharhinus leucas*	4	15
16	Bullnose Ray	*Myliobatis freminvillii*	2	16
17	Spinner Shark	*Carcharhinus brevipinna*	2	16
18	Atlantic Croaker	*Micropogonias undulatus*	1	18
19	Bluefish	*Pomatomus saltatrix*	1	18
20	Cownose Ray	*Rhinoptera bonasus*	1	18
21	Great Hammerhead	*Sphyrna mokarran*	1	18
22	Smooth Butterfly Ray	*Gymnura micrura*	1	18
23	Tiger Shark	*Galeocerdo cuvier*	1	18
Total			**1,581**	

Table 8: Number of Estuarine Trawl Survey trawls monitored for finfish from July 1, 2022 – June 30, 2023.

	2022						2023						
Stratum	**Jul**	**Aug**	**Sep**	**Oct[a]**	**Nov[a]**	**Dec[a]**	**Jan[a]**	**Feb[a]**	**Mar[a]**	**Apr**	**May**	**Jun**	**Total**
Charleston Harbor	4	4	4							4	4	4	**24**
Ashley River	2	2	2							2	2	2	**12**
Stono River/Kiawah River		3								3			**6**
ACE Basin		5								5			**10**
Port Royal Sound		3								3			**6**
Calibogue Sound		5								5			**10**
Total	**6**	**22**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**22**	**6**	**6**	**68**

[a] – The primary research vessel was damaged during Hurricane Ian on September 30, 2022, resulting in the loss of the vessel from October 2022 thru March 2023 for the survey.

Table 9: Catch of finfish species encountered by the SCDNR estuarine trawl survey during July 1, 2022 – June 30, 2023.

	Common Name	Scientific Name	Family	Abundance	Rank
1	Star Drum	*Stellifer lanceolatus*	Sciaenidae	24,393	1
2	Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae	16,894	2
3	Bay Anchovy	*Anchoa mitchilli*	Engraulidae	7,966	3
4	Spot	*Leiostomus xanthurus*	Sciaenidae	4,065	4
5	Weakfish	*Cynoscion regalis*	Sciaenidae	3,388	5
6	Silver Perch	*Bairdiella chrysoura*	Sciaenidae	1,271	6
7	Striped Searobin	*Prionotus evolans*	Triglidae	634	7
8	Striped Anchovy	*Anchoa hepsetus*	Engraulidae	481	8
9	Blackcheek Tonguefish	*Symphurus plagiusa*	Cynoglossidae	445	9
10	Hogchoker	*Trinectes maculatus*	Achiridae	322	10
11	Silver Seatrout	*Cynoscion nothus*	Sciaenidae	299	11
12	Southern Kingfish	*Menticirrhus americanus*	Sciaenidae	254	12
13	Summer Flounder	*Paralichthys dentatus*	Paralichthyidae	222	13
14	Atlantic Cutlassfish	*Trichiurus lepturus*	Trichiuridae	212	14
15	Lookdown	*Selene vomer*	Carangidae	151	15
16	Atlantic Menhaden	*Brevoortia tyrannus*	Clupeidae	128	16
17	Banded Drum	*Larimus fasciatus*	Sciaenidae	79	17
18	Butterfish	*Peprilus triacanthus*	Stromateidae	79	17
19	Bay Whiff	*Citharichthys spilopterus*	Paralichthyidae	61	19
20	Atlantic Bumper	*Chloroscombrus chrysurus*	Carangidae	57	20
21	Atlantic Thread Herring	*Opisthonema oglinum*	Clupeidae	56	21
22	Pinfish	*Lagodon rhomboides*	Sparidae	54	22
23	Spotted Hake	*Urophycis regia*	Phycidae	54	22
24	Fringed Flounder	*Etropus crossotus*	Paralichthyidae	42	24
25	Pigfish	*Orthopristis chrysoptera*	Haemulidae	42	24
26	Atlantic Stingray	*Dasyatis sabina*	Dasyatidae	40	26
27	Southern Flounder	*Paralichthys lethostigma*	Paralichthyidae	34	27
28	Smooth Butterfly Ray	*Gymnura micrura*	Gymnuridae	33	28
29	Atlantic Spadefish	*Chaetodipterus faber*	Ephippidae	25	29
30	Gafftopsail Catfish	*Bagre marinus*	Ariidae	21	30
31	Guaguanche	*Sphyraena guachancho*	Sphyrnidae	20	31

32	Bluefish	*Pomatomus saltatrix*	Pomatomidae	14	32

Table 9: cont.

	Common Name	Scientific Name	Family	Abundance	Rank
33	Crevalle Jack	*Caranx hippos*	Carangidae	14	32
34	White Catfish	*Ameiurus catus*	Ictaluridae	14	32
35	American Harvestfish	*Peprilus paru*	Stromateidae	8	35
36	Bluntnose Stingray	*Dasyatis say*	Dasyatidae	8	35
37	Fourspot Flounder	*Hippoglossina oblonga*	Paralichthyidae	8	35
38	Inshore Lizardfish	*Synodus foetens*	Synodontidae	8	35
39	Cownose Ray	*Rhinoptera bonasus*	Rhinopteridae	7	39
40	Feather Blenny	*Hypsoblennius hentz*	Blenniidae	5	40
41	Leopard Searobin	*Prionotus scitulus*	Triglidae	5	40
42	Planehead Filefish	*Stephanolepis hispidus*	Monacanthidae	5	40
43	Bonnethead	*Sphyrna tiburo*	Sphyrnidae	4	43
44	Florida Pompano	*Trachinotus carolinus*	Carangidae	4	43
45	Oyster Toadfish	*Opsanus tau*	Batrachoididae	3	45
46	Highfin Goby	*Gobionellus oceanicus*	Gobiidae	2	46
47	Longnose Gar	*Lepisosteus osseus*	Lepisosteidae	2	46
48	Northern Pipefish	*Syngnathus fuscus*	Syngnathidae	2	46
49	Northern Searobin	*Prionotus carolinus*	Triglidae	2	46
50	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	Carcharhinidae	1	50
51	Black Sea Bass	*Centropristis striata*	Serranidae	1	50
52	Naked Goby	*Gobiosoma bosc*	Gobiidae	1	50
53	Northern Puffer	*Sphoeroides maculatus*	Tetraodontidae	1	50
54	Sand Perch	*Diplectrum formosum*	Serranidae	1	50
55	Sandbar Shark	*Carcharhinus plumbeus*	Carcharhinidae	1	50
56	Smooth Puffer	*Lagocephalus laevigatus*	Tetraodontidae	1	50
57	Speckled Worm Eel	*Myrophis punctatus*	Ophichthidae	1	50
58	Striped Burrfish	*Chilomycterus schoepfi*	Diodontidae	1	50
			Total	**61,946**	

Table 10: Fish acquired from the freezer and tournament monitoring programs during July 1, 2022 – June 30, 2023.

Species	Freezer	Tournament	Total
Atlantic Croaker		1	1
Black Drum	3	3	6
Bluefish		7	7
Red Drum	18	22	40
Sheepshead	125	55	180
Southern Flounder		184	184
Spotted Seatrout	17	42	59
Total	**163**	**314**	**477**

Table 11: Fish tagged by the trammel net and electrofishing surveys during July 1, 2022 – June 30, 2023.

Species	Electrofishing	Trammel	Total
Atlantic Tripletail		1	1
Black Drum	6	18	24
Red Drum	464	996	1,460
Sheepshead	7	57	64
Southern Flounder	21	151	172
Total	**498**	**1,223**	**1,721**

Table 12: Recaptures of fish tagged by the SCDNR trammel net and electrofishing surveys during the period July 1, 2022 – June 30, 2023.

Capture Method	**Disposition**	**Atlantic Tripletail**	**Black Drum**	**Red Drum**	**Sheepshead**	**Southern Flounder**	**Total**
Anglers	Harvested		2	53		7	**62**
	Released	1	2	276	2	5	**286**
	Anglers: sub-total	**1**	**4**	**329**	**2**	**12**	**348**
SCDNR Surveys	Harvested			1			**1**
	Released			60		2	**62**
	Survey: sub-total		**0**	**61**	**0**	**2**	**63**
Total			**4**	**390**	**2**	**14**	**410**

Figures

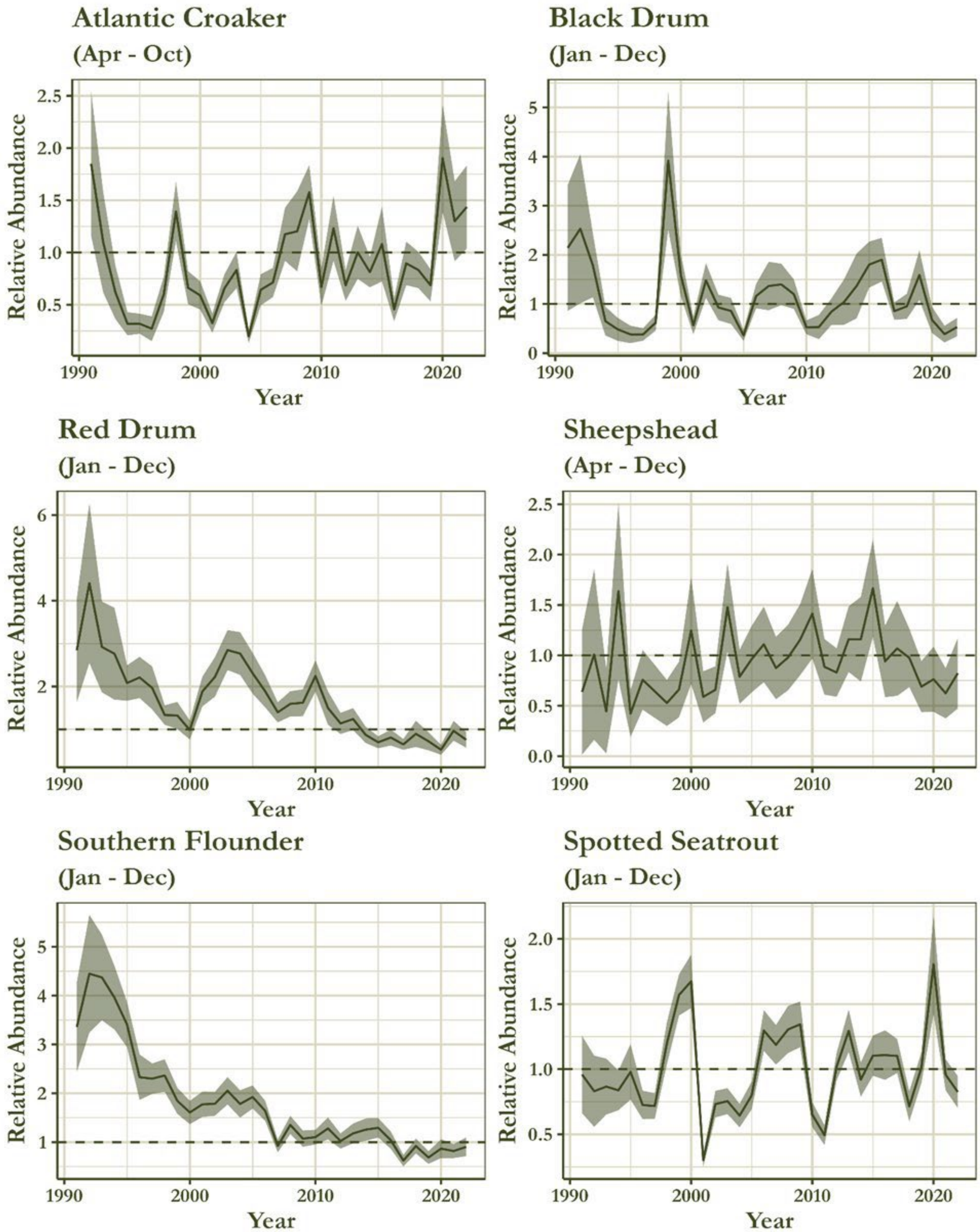

Figure 1: Long-term population trends (green lines, 95% CI shaded region) for selected species, as assessed by the SCDNR trammel net survey. Vertical axis is a relative index of fish abundance, with annual average catch shown relative to 2010-2022 average catch (dashed green line).

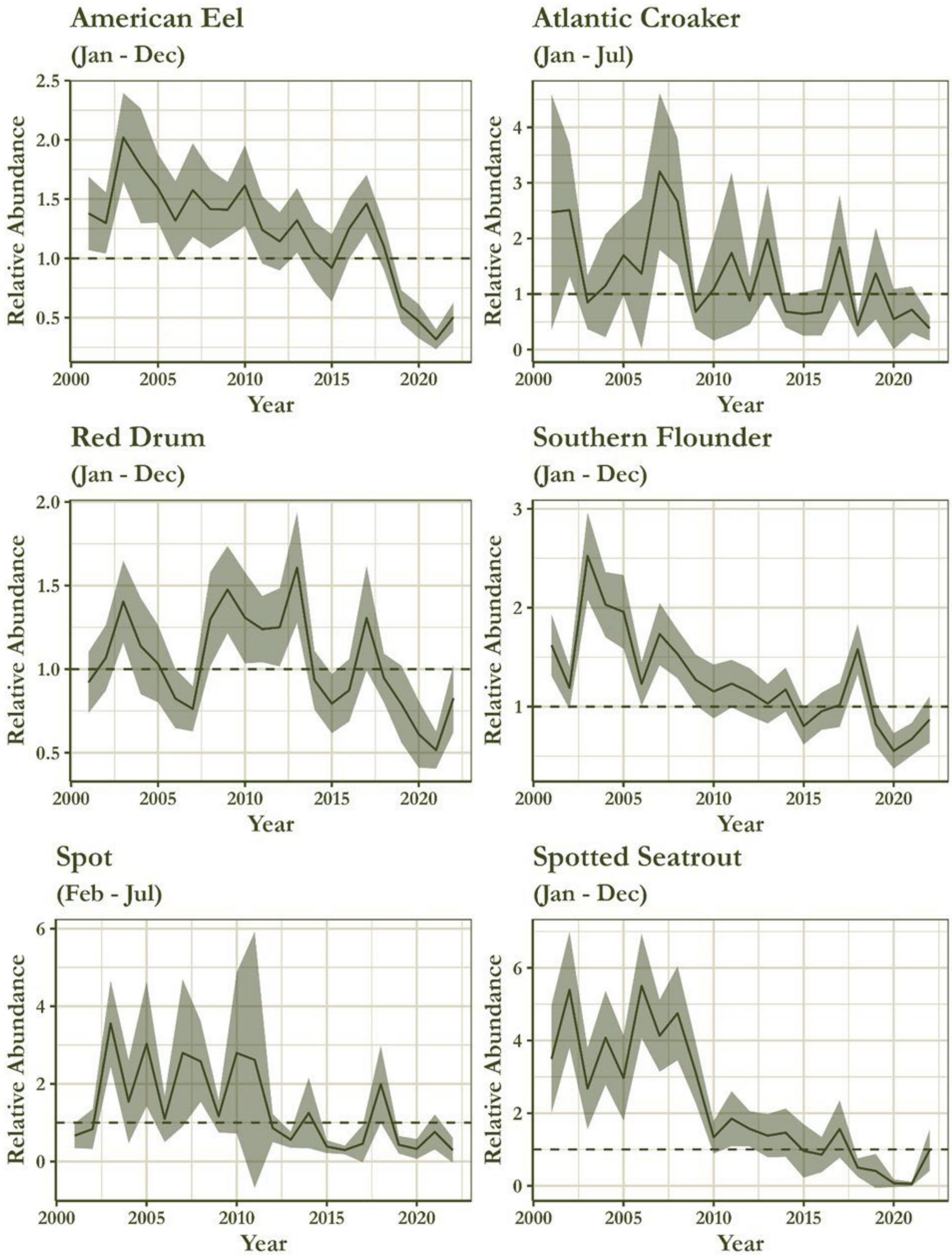

Figure 2: Long-term population trends (green lines, 95% CI shaded region) for selected species, as assessed by the SCDNR electrofishing survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes electrofishing shown relative to 2010-2022 average catch per 15 minutes electrofishing (dashed green line).

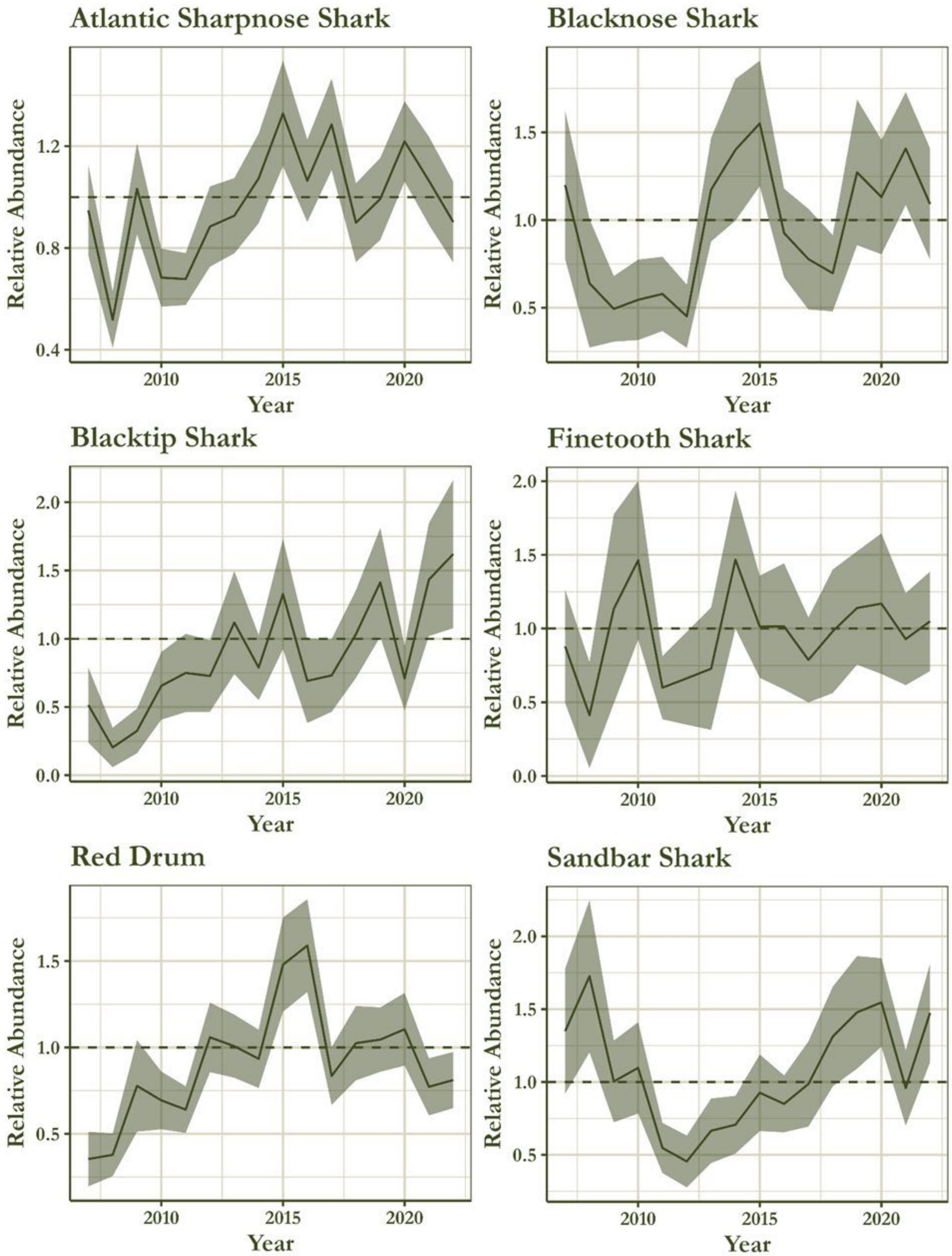

Figure 3: Long-term population trends (green lines, 95% CI shaded region) for selected species, as assessed by the SCDNR adult red drum and shark longline survey. Vertical axis is a relative index of fish abundance, with annual average catch shown relative to 2010-2022 average catch (dashed black line). Note, a bait change between 2007-2009 and 2010-2022 has not been accounted for in this index.

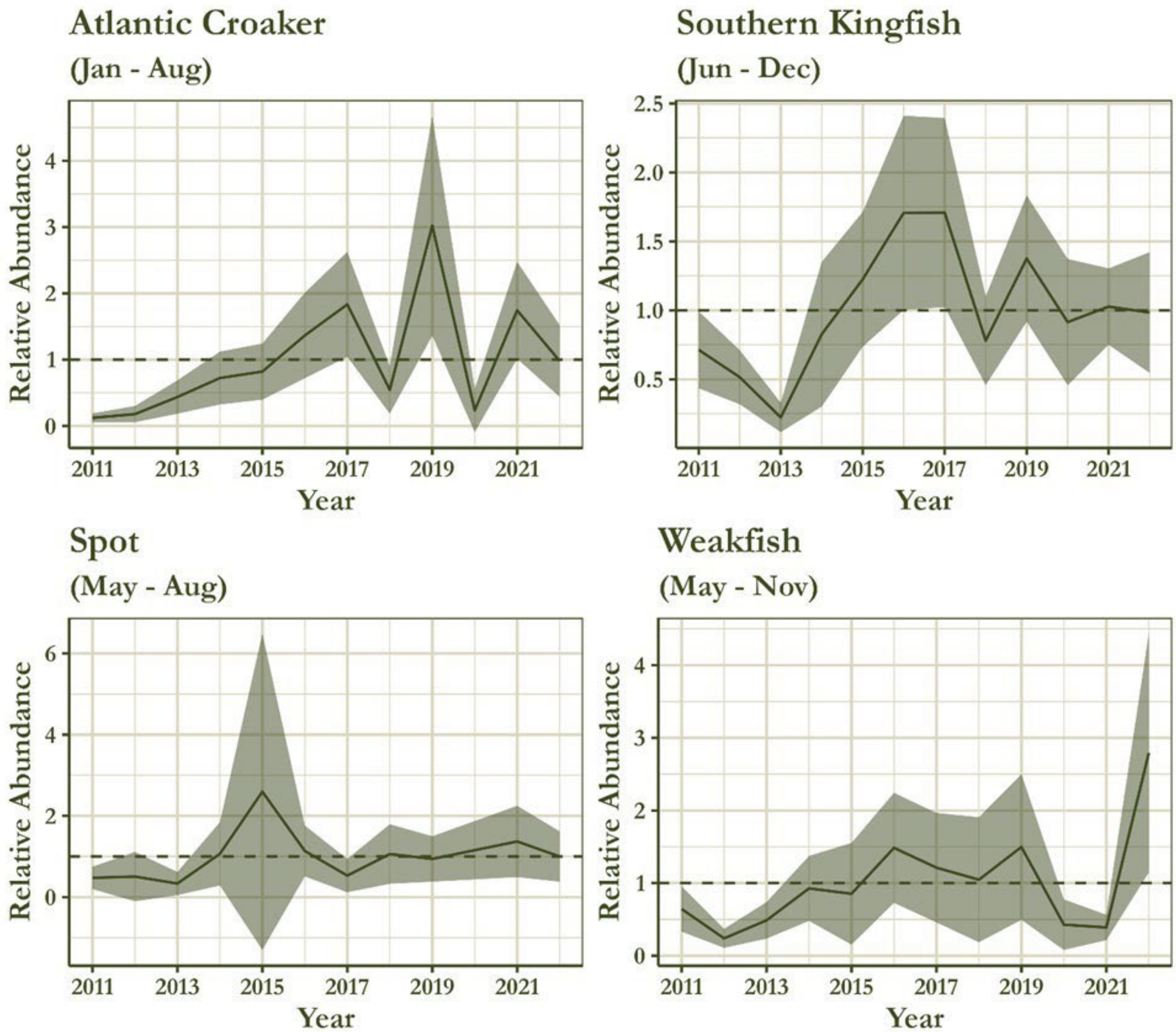

Figure 4: Long-term population trends (green lines, 95% CI shaded region) for selected species, as assessed by the SCDNR estuarine trawl survey. Vertical axis is a relative index of fish abundance, with annual average catch per 15 minutes trawling shown relative to time series average catch per 15 minutes trawling (dashed green line). Note, estuarine trawl efforts in 2020 and 2022 severely affected by vessel availability and COVID-19 social distancing protocols so we advise interpreting 2020 and 2022 trends with caution.

2: Stock Enhancement and Genetic Fisheries Research

Project PIs: Aaron Watson, Tanya Darden

Reporting Period: July 1, 2022 to June 30, 2023

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 the Charleston Harbor system 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

2022 Production: Four unique genetic families (HML119, NWL1, NWL 2, and OWL 3) contributed to the 2022 YC stock enhancement releases. Four estuaries were stocked including Port Royal Sound, Charleston Harbor (Ashley and Wando Rivers), ACE Basin, and North Edisto

River. Small juvenile fish were produced from the 2022 YC (30.8- 38.09 avg. TL) with stocking occurring from 8/16/2022-12/13/2022.

The red drum stocking strategy for 2022 was to evaluate contribution of small juvenile red drum (~30-50 mm TL) to the wild population from two release treatments (Early vs Late) located within the Ashley River, ACE Basin, Wando River, and North Edisto River as well as their movement patterns following release (Table 1). This release strategy should help clarify our results from stocking before and after tropical events, where the fish released after the events contributed significantly more than the fish stocked before these events. It is unclear if the fish stocked after the tropical events did better because they had more available habitat due to mortality or displacement of the wild recruits and fish stocked before the event or if stocking later in the fall when water temperatures were lower contributed to the higher success.

In addition, one family was stocked into the upper reaches of Port Royal Sound. The goal of this release was to see if stocking success would increase from releasing fish into brackish water. In previous stocking years within the Ashley River and Winyah Bay, fish stocked into the higher saline portions of the system were recaptured at a higher percentage in the brackish water. In Murrell's Inlet, fish stocked at one month old did not contribute to the wild population compared to fish stocked at six months old. Both examples suggest that during early life stages of red drum, fish rely on brackish water potentially for food or habitat availability. All age-classes of fish from this system will be monitored over a 4-year period as they move down into more saline waters were our Inshore Fisheries group sample.

<u>Ashley River:</u> A total of 320,346 small juvenile red drum (mean TL 35.7 mm) from OWL 3 were released by trailer at W.O. Thomas Jr. Boat Landing in Ashley River as part of the early release treatment. Releases occurred on 8/24/2022 (138,924 fish), 9/1/2022 (96,504 fish), and 9/14/2022 (84,918). A total of 379,327 juvenile red drum (mean TL 33.88 mm) from NWL 2 were released by at the same location as the early release for the late treatment. Releases occurred on 10/19/2022 (191,288 fish) and 10/28/2022 (188,039 fish).

<u>ACE Basin:</u> Two unique genetic families (NWL 1 and NWL 2) were released by trailer to evaluate early versus last release success. A total of 126,139 juveniles (NWL 1) were released on 8/16/2022 directly from the hauling trailer (mean TL 35.7 mm) at the Combahee Boat Ramp as part of the early release treatment. A total of 224,219 small red drum (mean TL 36.29 mm) were released on 10/7/2022 at the same landing for the late release from NWL 2.

<u>North Edisto</u>: Two genetic families (NWL 2 and HML 119) were 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. This again was part of a study to examine early versus late release success. A total of 91,133 small juvenile red drum (NWL 2) (mean TL 33.96 mm) were released on three separate days from boat and trailer by staff at BBNFH in three different creeks within the North Edisto. Leadenwah Creek received 5,268 small juvenile red drum (mean TL 33.7 mm) on 9/16/2022. Bohicket Creek received a total of 85,800 small red drum (mean TL 43.1 mm) on 9/20/2022. Finally, Wee Creek received 65 fish (mean TL 39 mm) on 9/27/2022. The late release came from genetic family HML 119 and totaled 89,979 juvenile fish (mean TL 30.8). All fish were released by boat in Leadenwah Creek on 11/18/2022.

Port Royal Sound: One unique genetic family (NWL 2) totaling 255,942 was released directly from the hauling trailer (mean TL 32.53 mm) at the Dawson's Landing on 11/21/2022 and 12/13/2022.

Wando River: Two unique genetic families (NWL 1 and HML 119) were released by trailer to evaluate early versus last release success. A total of 361,064 small juvenile red drum (mean TL 38.09 mm) from NWL 1 were released by trailer at Remley's Point Boat Landing on the Wando River as part of the early release treatment. Releases occurred on 9/7/2022 (19,453 fish), 9/13/2022 (245,138 fish), and 9/16/2022 (96,473). A total of 367,511 juvenile red drum (mean TL 33.13 mm) from HML 119 were released by at the same location as the early release for the late treatment. Releases occurred on 11/8/2022 (216,478 fish) and 11/17/2022 (151,033 fish).

Table 1. Stocking information for the 2022 YC juvenile hatchery red drum.

Avg. TL	Number Released	Release Location	Treatment
35.7	126,139	ACE Basin	Early
36.29	224,219	ACE Basin	Late
37.5	320,346	Ashley River	Early
33.88	379,327	Ashley River	Late
32.39	181,112	North Edisto	NA
38.09	361,064	Wando River	Early
33.13	367,511	Wando River	Late
32.53	255,942	Port Royal Sound	NA
33.96	91,133	North Edisto	Early
30.8	89,979	North Edisto	Late

Contribution: Out of a total of 436 red drum tissue samples from 2021YC individuals collected during July-December 2022, 430 samples were included in the analysis of contribution to the Ace Basin, Ashley River, Charleston Harbor, Calibogue Sound, Cooper River, North Edisto River, Port Royal Sound, and Wando River. Two samples were removed after identifying them to be recaptures of earlier fish, and four were removed because contamination prevented genotyping. A total of 95 cultured fish were collected and sampled for an overall hatchery contribution of 22.1% from stocking efforts in 2021.

In the Ashley River, 95 tissue samples were included in the analysis and 75 cultured fish were captured for a stocked contribution of 78.9%, which is the highest contribution within the Ashley River since the Inshore Fisheries Section implemented a random sampling design. In Charleston Harbor, 18 tissue samples were included in the analysis and 5 cultured fish were captured, with 27.8% hatchery contribution. In the Cooper River, 24 tissue samples were included in the analysis and 1 hatchery fish was captured for a hatchery contribution of 4.2%. In the Wando River, 52 tissue samples were included in the analysis and 0 hatchery fish were captured for a hatchery contribution of 0%. Contribution to the entire Charleston Harbor System was 42.9%. In the Ace Basin, 105 tissue samples were included in the analysis and 7 cultured fish were captured for hatchery contribution of 6.7%. In the North Edisto River, 92 tissue samples were included in the analysis and 7 cultured fish were captured for hatchery contribution of 7.6%. In the Port Royal

Sound, 32 tissue samples were included in the analysis and no hatchery fish were captured for a hatchery contribution of 0%.

Charleston Harbor

Fish were only stocked in the Ashley River, however due to precipitation around the time of stocking (Figure 1), our saltwater release was close to the mouth of the Ashley River. Evaluating the Charleston Harbor System as a whole, 189 2021YC Red Drum were captured. Of those, 81 were hatchery fish for a total system contribution of 42.9%. Charleston Harbor had 5 hatchery fish out of 18 captures for a contribution of 27.8%, however most of these fish were recaptured within 3 to 5 miles of the stocking location within the Ashley River. The Cooper River had one hatchery capture with 24 age 1 fish examined for a contribution of 4.2%. This fish showed significant movement during this period, traveling a minimum of 25 river miles. The Wando River had zero hatchery fish among 52 fish sampled resulting in no hatchery contribution.

The Ashley River was our primary study area in 2021. The experimental design was to evaluate contribution from brackish and saltwater releases, but due to high precipitation during the release period (Figure 1), salinity was significantly reduced compared to normal conditions (Figure 2). The Inshore Fisheries Section collected 95 age-1 red drum of which 75 fish were from the hatchery resulting in a 78.9% contribution. This contribution is higher than last year (42.7%) when similar size and number of fish were stocked. Genetic Family NWL 1 was released in brackish (4.3 ppt) water within the Ashley River. Thirty-five fish from this family were captured upstream from release locations in the Ashley River, 7 were captured downstream, 1 was captured in Charleston Harbor, and 1 was captured in the Cooper River. Genetic Family HML 118 was released in the higher salinity (15.7 ppt) portion of the Ashley River– near the confluence with Charleston Harbor. Thirty-seven hatchery fish were collected by our Inshore Fisheries Section with 9 fish captured upstream of the release sites, 7 captured around the release location, and 4 captured in Charleston Harbor.

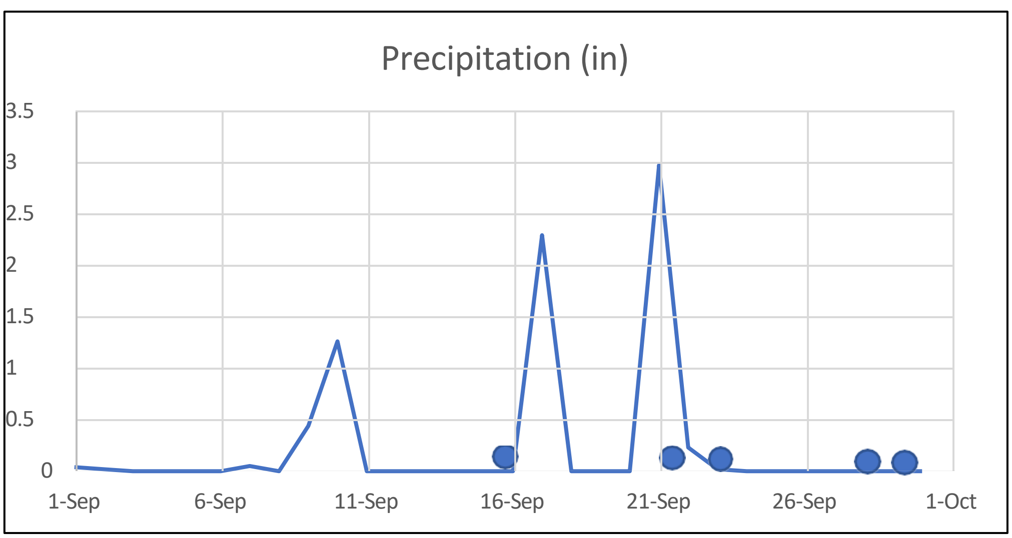

Figure 1: Precipitation in inches from the weather station located on top of MRRI during the 2021 red drum production season. Circles indicate stocking events within the Ashley River.

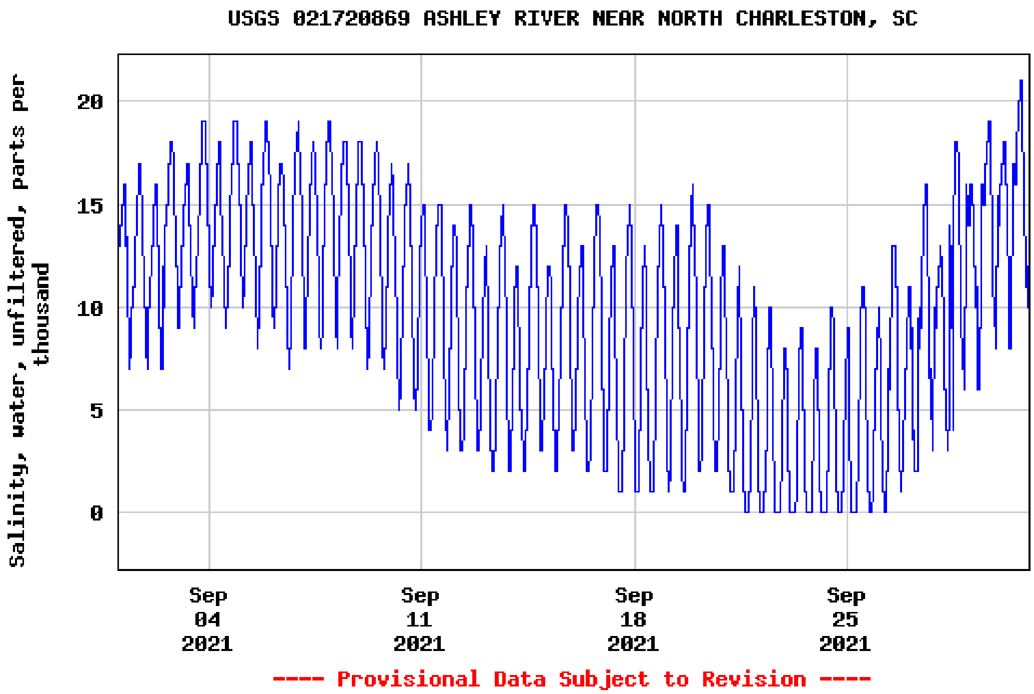

Figure 2: Salinity data from a USGS water quality sonde located around the I-526 bridge going over the Ashley River.

<u>North Edisto River</u>

In the North Edisto River, there were 7 hatchery fish captured from the 2021YC; 3 in Bohicket Creek and 4 in Leadenwah Creek. Hatchery contribution in the North Edisto was 7.6%, with 5.5% contribution in Bohicket Creek and 10.8% in Leadenwah Creek. Contribution in Leadenwah Creek was higher than in 2020 (9.1%) and higher than Bohicket Creek for the first time in 3 years likely due to a higher proportion of fish being stocked into Leadenwah Creek compared to Bohicket Creek. All captures originated from the small juvenile releases from family HML119 (183,812). 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 2021YC on the lower 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.

<u>ACE Basin</u>

In the ACE Basin, 7 hatchery fish were captured for a hatchery contribution of 7.7%. There were 212,296 fish from genetic family OWL 3 released at Live Oak and Bennett's Point Landings resulting in 6 captures for a contribution of 5.7%. One hatchery capture came from HML 119, released in the North Edisto River, for 0.9% contribution and is the first known capture of a fish stocked into the N. Edisto in the ACE Basin.

<u>Port Royal Sound</u>

In December 2021, 12,040 fish from OWL3 were released from Alljoy Boat Landing. No hatchery fish were captured, for a contribution of 0%. This is not surprising since a small number of fish were released in the season at a very small size and fishery dependent sampling does not occur anywhere near the release location.

CONCLUSIONS

Release Strategies, Contribution and Movement

In the Charleston Harbor system, fish released in the brackish waters of the Ashley River (NWL1) had a higher contribution than fish released in the higher salinity portions of the river (HML118). Both families showed movement outside the stocking estuary with NWL1 moving into the Charleston Harbor and the Cooper River and HML 118 into the Charleston Harbor. Hatchery contribution was higher at electrofishing sites (59.2%) than trammel net sites (32.0%), and more hatchery fish were caught by electrofishing (n=45) than in trammel nets (n=36) which is consistent to what we see in most years within the Ashley River.

In the North Edisto River, 7 hatchery fish were captured with fewer caught in Bohicket Creek (n=3) than Leadenwah Creek (n=4). Our Inshore Fisheries Section does not sample this estuary therefore we rely on recreational anglers to provide fin clips to assess contribution. This creates challenges with interpretation of the data due to few anglers participating and these anglers fishing in relatively the same locations year after year. One fish from HML 119 was captured in the ACE Basin, showing the potential for movement between estuaries.

In the ACE Basin, 6 hatchery fish were captured showing some movement up and downstream from release locations in tidal creeks. These captures are encouraging since we typically do not recapture any of our stocked fish in this estuary.

2020 YC Hatchery Captures

There were 17 fish captured in the Ashley River (n=16) and North Edisto River (n=1) that matched to 2020 YC families 20HML118 (n=14) and 20NWL1 (n=3). Family 20HML118 was released in the Ashley River as part of a late release treatment, and in the North Edisto. 20NWL1 was released early in the Ashley River and late in the Wando River. All of these fish were in the larger range of length's considered for Age 1 fish and caught from September to December 2022. Usually, age 1 fish are distinguished from age 2 fish by lengths, but that relationship can break down late in the year. Since there was not a clear separation late in the year for the 2022 collections, the decision was made to include the larger fish.

Spotted Seatrout

2022 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 318 fin clip tissue samples were processed from spotted seatrout collected in the Charleston Harbor system from September-December during monthly independent random sampling in 2022.

Overall, two hatchery spotted seatrout representing one year class were collected in 2022. Both hatchery fish collected were from the Charleston Harbor stocking treatments and 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. The Charleston Harbor trailer release had the highest contribution, with no hatchery fish collected from any other treatment. The trailer-released fish have shown the highest contribution since this family began showing up in the inshore fisheries collections in 2020. This suggests that minimizing handling stress by releasing fish from the hauling box outweighs stocking fish into flooded marsh grass by boat which was believed to provide cover for the fish until they acclimated to their surroundings. However, stocking timing and release numbers may play a role in these findings since the Charleston Harbor releases occurred in two separate months and stocking numbers were almost double for the trailer releases compared to the boat releases. Unfortunately, 2019 was the last year of stocking spotted seatrout so no replication over years was conducted.

The 6.1% hatchery contribution from the 2019YC in 2022 is higher than its contribution in 2021 (4.5%). The lack of hatchery fish from the 2018YC was likely due to having collected many fewer individuals from this YC compared to the 2019YC (3 vs. 33, respectively), and we did not see any hatchery fish from the 2018YC in our 2021 collections either.

Cobia

2022/2023 Production: Two families of cobia were produced during this reporting period. In 2022, 10,159 small juveniles (avg TL 67.39 mm) were released from family WMC12S-22 at Trask Landing on the Colleton River July 6th. In 2023, a total of 13,750 small juveniles (avg TL 48.64 mm) were released from a unique family (WMC12S-23), also Trask Landing on the Colleton River on June 21st.

Sample Collection: Mariculture staff have been collecting cobia carcasses from recreational anglers as well as from tournaments since 2007. Due to cobia fishing closures during peak inshore intercepts in state waters dating back to 2016, collection of cobia in the Port Royal and St. Helena to produce life history information has been limited.

In 2022, 1 sample was collected inshore and 51 samples were collected from offshore fish through our cooler program which works cooperatively with local charter boat captains to obtain fish racks, genetic samples, and catch information. An additional 10 fish were collected from the cooler program but did not have a location provided to researchers. Our cooperative fin clip program provided an additional 36 samples from 2022 taken from offshore Charleston and south into upper Georgia waters. The 2023 genetic samples have not been returned to date. An additional 10 genetic samples were collected in collaboration with our federally funded NOAA CRP project and a grant through ASMFC. Sixteen samples were obtained from the Food and Beverage tournament held on Hilton Head Island in June of 2022. Genetic samples of all cobia are utilized to evaluate population structure as well as identify the contribution of stocked fish to the population.

Broodstock Collection and Production*:* In addition to the collection of life history data, recreational license funds were used to make several trips from July 2022 - June 2023 to collect cobia broodstock from the Broad River annual inshore aggregation for hatchery production of fingerlings for stock enhancement research. Eight wild cobia were captured by cooperating recreational anglers and SCNDR staff in the Broad River, and unfortunately none were large enough and sexually mature to bring back and use as broodstock. 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. No induced spawning attempts at eighter MRRI and WMC were attempted during the reporting period. Fortunately, three tanks, each with unique genetic families, at WMC spawned volitionally 14 different times throughout the reporting period resulting in the production of nearly 48 million eggs. This allowed multiple stockings of fertilized production ponds at WMC with larvae from the 9.4 million viable eggs that were available. Two releases totaling 24,059 juvenile cobia occurred during this reporting period. One release came from a unique family organized for 2022 production in a 12-ft maturation tank at WMC (WMC12S-22), and the other in 2023 from a 12-ft maturation tank also at WMC (WMC12S-23). Juveniles from the WMC12S-22 family were harvested from a single set of 0.25 and 0.5 ha ponds which yielded 3,786 and 19,855 fish, respectively, that were 72.56 and 62.22 mm (TL), respectively. A total of 3,736 juveniles were released from the 0.25 ha pond and 6,423 fish from 0.5 ha pond, all at Trask Landing on the Colleton River in Port Royal on 7/6/2022. The remaining 9,726 from the 0.5 ha were held over at WMC for other studies. Juveniles from the WMC12S-23 family were harvested from two, 0.25 ha ponds which yielded 11,400 and 2,350 juveniles each that were 55.62 and 41.66 mm, respectively, all harvested on 6/21/2023 and released at Trask Landing.

Contribution*:* A total of 548 cobia genetic samples were processed this year from all collection sources. Overall, four cultured fish were captured in the 2022 collections (all fish sampled in all locations) for a total hatchery contribution of 0.8%. However, samples used for calculating contribution must meet collection criteria, including a collection date from April- July. When including only these samples in the calculations, the total hatchery contribution was 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 2.5%. As expected, there was no contribution to the Gulf of Mexico stock.

For the South Carolina collections, the total contribution was 2.1%. The highest hatchery contribution was seen from the inshore samples within the Broad River (where stocking occurred) at 10.0% (n=1), with a smaller contribution from offshore samples at 1.2% (n=1). 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. There was one cultured fish from the 2017YC, but it is unknown if this fish was caught inshore or offshore so it was not included in the SC contribution numbers. This was the first year we saw contribution from the 2021YC.

Genetic data suggest that all cultured fish from the 2017YC to date have been offspring from the parental cross of CB084 and CB085 even though there were two males and two females in the spawning tank. Year class could not be verified for any of the cultured fish due to a lack of otolith data. Hatchery contribution from fish stocked prior to 2012 was unlikely due to the limited occurrence of fish 10 years and older in the fishery. However, it was surprising to see fish from the 2021YC since these fish typically don't enter the fishery until at least age 2.

There was one fin clip that genetically matched to the 2020YC, but according to age estimations from the associated otolith, the fish was from the 2014YC. We reisolated DNA from the fin clip to ensure the correct sample was used, and the sample matched the original genotype. We then attempted to isolate DNA from the other otolith associated with the sample number. We did not get as much DNA from the otolith, so we were only able to genotype the sample at 12 out of the 19 loci. Out of 12 loci, the otolith and fin clip samples mismatched at 3 loci. Since the fin clip and otolith genotypes did not match exactly, we cannot determine if the collection information for this sample is associated with the fin clip. Therefore, this sample was not included in contribution calculations.

Development, Optimization, and laboratory testing of eDNA Tool to investigate DNA accumulation/degradation and biomass: In an effort to incorporate 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 goal of the tool will be relating quantities of cobia eDNA found in water sample to a measure of biomass or abundance. During the current reporting period we continued to evaluate the effectiveness of the tool and proceeded to process field samples to establish a baseline of cobia eDNA in PRS.

Conduct controlled density experiments in laboratory tanks and evaluate DNA accumulation/degradation and biomass: Three replicate tank systems in Hollings Marine Laboratory (HML) were used to conduct an experiment to investigate biomass-based patterns of DNA accumulation and degradation. Each system comprised 4 experimental tanks and 4 non-experimental tanks (no fish and were not sampled). The 4 experimental tanks contained either 0 cobia, 1 cobia, 5 cobia, or 10 cobia (Figure 3). All fish were cultured juveniles from SCDNR's stock enhancement program, average total length ~183 mm and ~29 g. Precautions were taken to avoid cross-contamination of tank water and removal or flushing of cobia eDNA. After fish were added, tanks were maintained with no flow-through water, no water changes, and no filters or cleaning. Tanks were covered with mesh and plastic drop sheets to prevent fish from jumping and splash-over cross-contamination. Feeding occurred ad libitum three days a week and activity in the lab was limited to minimize disturbance effects. Within each system, experimental tanks were separated by non-experimental tanks to the fullest extent possible (Figure 3). Water quality was monitored daily. No equipment (water quality sampling, nets, gloves, etc.) was shared between tanks.

Water sampling for eDNA occurred on day 0 (before fish were added), 1, 2, 3, 4, 7, and 10 to evaluate DNA accumulation. After day 10, ~ 55 L of water from each experimental tank was siphoned into a secondary covered container from which water sampling for eDNA occurred on day 1, 2, 3, 5, 7, and 15 to evaluate DNA degradation. Each sample comprised ~0.50 L (mean=0.50 L ± 0.013 L) and was filtered during collection with a Smith-Root automated eDNA Sampler through Smith-Root 5 µm Self-Preserving filters and stored at -20 °C until DNA extraction. DNA was extracted and purified from each filter using the MO-BIO Power Soil DNA Isolation Kits/Qiagen DNeasy PowerLyzer PowerSoil Kits and qPCRs were run with 8 technical replicates. To date, all 147 filters have been processed.

During the accumulation stage, most technical qPCR replicates for tanks with cobia were positive for cobia DNA while all technical qPCR replicates for tanks without cobia were negative. Only 6 technical replicates for tanks with fish failed to amplify, 4 from day 3 with 1 cobia, 1 from day 4 with 5 cobia and 1 from day 10 with 1 cobia. Given the Cq values of other technical replicates from the same DNA isolations (5 cobia ~ 31.4; 1 cobia ~ 36.1), we presume these failed amplifications were caused by pipetting error. Overall, a general trend of lower Cq (more starting quantity of DNA) values for higher fish densities was observed. During the accumulation period at all three densities, the data show daily fluctuations and an overall stable trend in cobia eDNA (Figure 4). During the degradation period, DNA steadily declined (Figure 4) along with the number of technical replicates (Table 2) from days 1-15. Surprisingly, we were able to detect trace amounts of cobia DNA through day 15 post fish removal in contrast to our results from a broodstock tank at WMC (Figure 5). The persistence of DNA for at least 15 days in the HML experiments is likely due to the indoor controlled environment and high-quality water. The results from our outdoor experiment at the WMC using water from PRS are more representative of what we should expect in the field and suggest cobia eDNA likely fully degrades in natural systems within several days of fish being present. These experiments in closed systems allowed us to demonstrate proof of concept for our eDNA tool and understand the dynamics of cobia eDNA in a controlled environment, which is the first step towards developing a robust eDNA survey program.

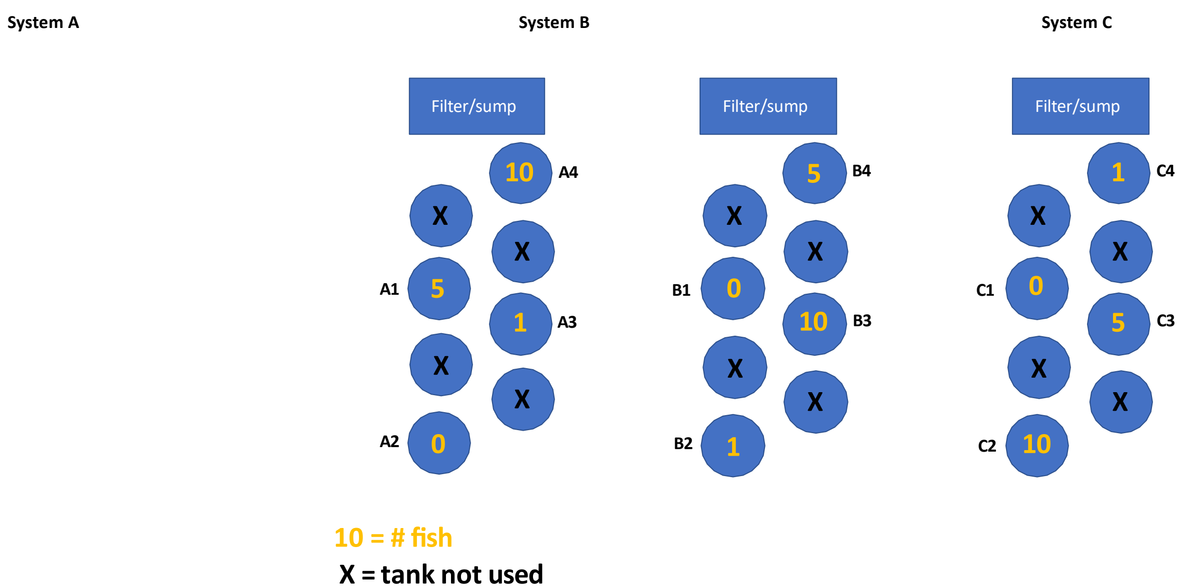

Figure 3. Experimental tank design for cobia eDNA accumulation/degradation patterns and biomass.

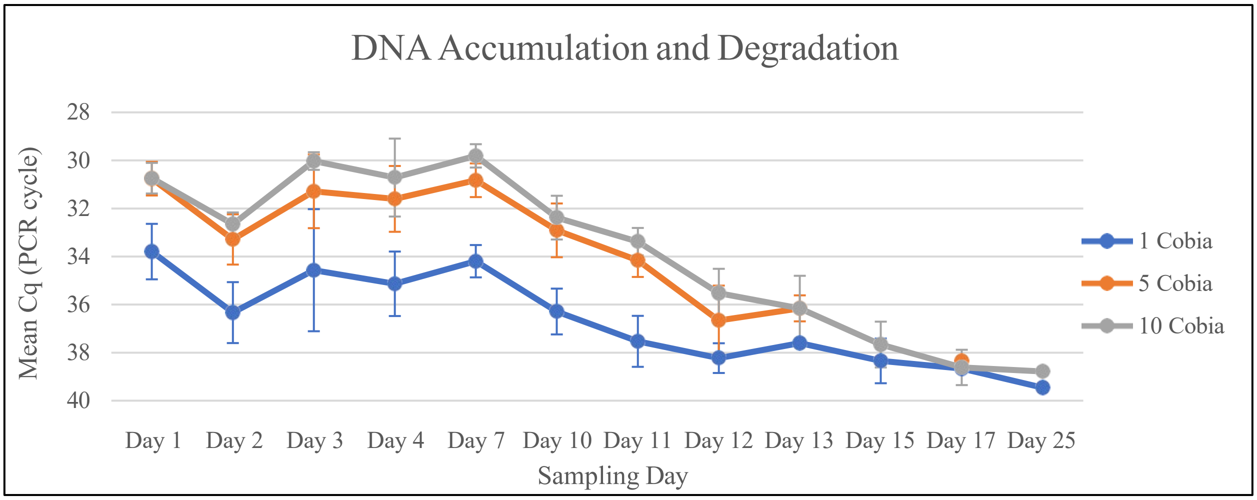

Figure 4. Mean Cq values (lower Cq = higher [DNA]) and one standard deviation for our DNA accumulation/degradation samples from our HML controlled laboratory experiment. Cobia were not present in the water sampled after the Day 10 sampling event (i.e. Day 11 marks the beginning of the DNA degradation period).

Table 2. Positive PCR technical replicates for the DNA degradation period of HML tank experiment

Days after removal	1 cobia	5 cobia	10 cobia
1	18	24	24
2	11	15	24
3	1	3	4
5	6	0	20
7	1	1	5
15	1	0	3

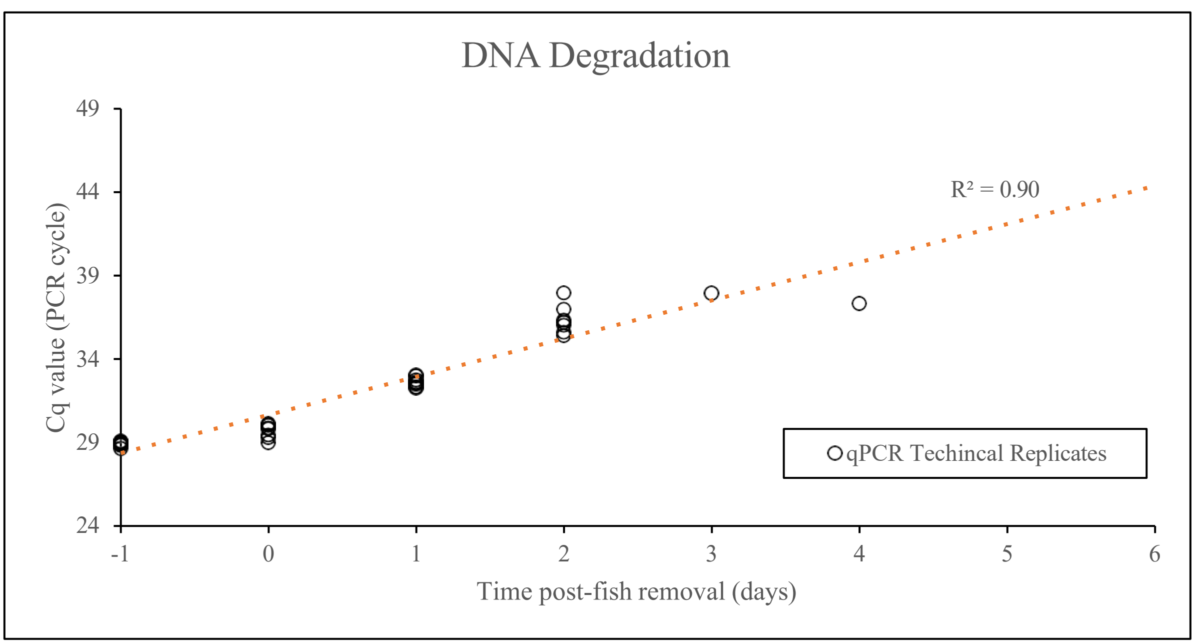

Figure 5. Scatter plot of cobia DNA degradation showing time after cobia broodstock were removed verse the amount of DNA detected (lower Cq = higher [DNA]).

Field surveying using the eDNA tool: Translating our results and conclusion to what we may find cobia's natural environment presents a challenge given the dynamics of coastal and estuarine habitats, specifically Port Royal Sound (PRS) in South Carolina - host of a genetically distinct spawning aggregation. A total of 249 field samples were collected from Feb 2021- June 2022. All sampling events were standardized around slack high tides and comprised 3 sites in the Broad River. Water was filtered in the field using a Smith-Root automated eDNA Sampler through Smith-Root 5 µm Self-Preserving filters. At each site 10 samples were collected (except the first sampling event comprising 5 samples/site) per day and comprised ~2.5 L of water. Equipment controls of DI water were filtered at each site to rule out contamination. Filters were immediately stored on ice while in the field and stored at -20° C in the laboratory. DNA isolations were performed using the methods described above and qPCRs were run with 8 technical replicates.

To date, most of the 2021-2022 field samples have been fully processed. One sample was lost in the isolation process, 3 filters have yet to be isolated, and the PCR for 2 sites from 14 May 2021 are incomplete. Sampling conducted in February 2021 and 2022 was intended to rule out the presence of cobia eDNA outside of the season when they are typically found inshore PRS. All filters from these sampling events were negative suggesting cobia eDNA from oceanic sources should not interfere with the interpretation of our results from the PRS inshore spawning season sampling. Additionally, all equipment controls were negative for cobia DNA.

Results from samples that have been fully processed are promising and will provide baseline data for our current and future cobia eDNA surveys (Table 3). On 30 April 2021 all samples were negative. The following sampling event on 14 May 2021 was our first positive detection of cobia eDNA in the wild. While all of the PCRs from this day are not complete, 2 of 9 filters at the 170 Bridge were positive. On 28 May 2021, our final sampling event of 2021, nearly half of our samples (13/30 or 43%) were positive. On 05 May 2022 17% of our samples were positive followed by sampling on 18 May 2022 when 46% were positive. Our final sampling event of 2022 was 15 June when we found 17% of the filters collected were positive. While these data only represent 2 sampling years and processing is not fully complete, we see a basic trend of more positive detections in mid-late May which coincides with our expectations of cobia's presence in the Broad River. We plan to increase our sampling to standardize around slack high and low tides moving forward to better understand cobia eDNA dynamics in PRS.

Table 3. Positive detections of cobia eDNA by location and date.

Location	04 Feb 21	30 April 21	14 May 21	28 May 21	23 Feb 22	05 May 22	18 May 22	15 June 22	**Total**
Parris	0	0		0	0	2	6	0	8
Turtle	0	0		6	0	3	3	1	13
170 Bridge	0	0	2	7	0	0	4	4	17
Total	0	0	2	13	0	5	13	5	38
Proportion	0/15	0/30	2/9	13/30	0/30	5/30	13/28	5/30	

We have continued to process 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 samples will be processed during the upcoming year and final compiled results will be evaluated and presented together.

We also completed a third round of field collections in PRS during the winter and spring of 2023 to build on our testing dataset. Spring sampling occurred during cobia's spawning season standardized around slack tides. A total of 165 filtered water samples were collected over 5 days 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 stufy. Four transects were performed around the Broad River bridge during a calm morning over a 2-hour period. The boat made approximately 3 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.

3: South Carolina Marine Recreational Fisheries Survey

Principal Investigators: Amy Dukes & Brad Floyd

Period Covered: July 1, 2022 to June 30, 2023

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, 2023, to February 28, 2023; 221 fishing parties were interviewed in private boat, charter and shore mode representing contact with 363 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 1099 fish belonging to 40 species and biologists measured 120 kept fish (**Table 2 & 3**).

MRIP - During the reporting period from July 2, 2022, to December 31, 2022, and March 1, 2023, to June 30, 2023; 556 Access Point Angler Intercept Survey (APAIS) assignments were completed resulting in 3,976 angler interviews in all modes and 18 head boat observer trips were completed resulting in 120 angler interviews (**Table 4**). NOAA Fisheries handles data from the MRIP survey, and these data and the estimates generated are available on NOAA's website as they become finalized. NOAA Fisheries data access site:
https://www.fisheries.noaa.gov/topic/recreational-fishing-data

Table 1. Number of intercepts, anglers interviewed, and fish measured by SRS staff during January 2023 – February 2023.

SRS TOTALS	
Intercepts	221
Anglers Interviewed	363
Fish Measured	120

Table 2. Fish and shellfish kept by fishing parties interviewed by SRS staff during January 2023 – February 2023.

Species Name	Number Kept
Clams, Hard	2,671
Drum, Black	32
Drum, Red	41
Eastern Oyster	126.5
Flounder, Gulf	9
Flounder, Southern	3
Grunt, White	2
Kingfish	1
Menhaden, Atlantic	12
Porgy, Jolthead	2
Porgy, Red	6
Ribbed Mussel	111
Seabass, Black	19
Seatrout, Spotted	22
Sheepshead	25
Snapper, Vermilion	5
Triggerfish, Gray	1
Tuna, Blackfin	5
Tunny, Little	1
Wahoo	1

Table 3. Fish measured by SRS staff during January 2023 – February 2023.

Species Name	Number Measured
Drum, Black	22
Drum, Red	33
Flounder, Gulf	8
Flounder, Southern	2
Porgy, Jolthead	2
Seabass, Black	16
Seatrout, Spotted	22
Sheepshead	11
Tuna, Blackfin	4

Table 4. MRIP assignments and interviews obtained by mode in FY2023.

Wave 4 2022				
Mode	July		August	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	52	402	56	397
Head Boat	5	38	1	4
Total	57	440	57	401
Wave 5 2022				
Mode	September		October	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	51	372	57	374
Head Boat	3	18	2	10
Total	54	390	59	384
Wave 6 2022				
Mode	November		December	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	55	248	47	141
Head Boat	0	0	0	0
Total	55	248	47	141
Wave 2 2023				
Mode	March		April	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	58	297	52	511
Head Boat	0	0	0	0
Total	58	297	52	511
Wave 3 2023				
Mode	May		June	
	Assignments	Intercepts	Assignments	Intercepts
Charter/Shore/Private	65	536	54	698
Head Boat	2	10	5	40
Total	67	546	59	738

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 655 licensed six passenger or fewer charter boat vessels in South Carolina. Trip level data is submitted by licensed vessel owners/operators on a monthly basis. June's charter data was not required to be submitted to the agency until July 10th, 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 2022 calendar year charter boat data (**Tables 5 & 6**).

Table 5. "Top 10 Species" caught, landed, and released during reported charter vessel trips in 2022.

10 Most Caught Species	10 Most Landed Species	10 Most Released Species
Accounts for 80.09% of all species caught	Accounts for 78.32% of all species landed	Accounts for 83.05% of all species released
Sea Bass, Black (27.64%)	Mackerel, Spanish (28.63%)	Sea Bass, Black (32.12%)
Drum, Red (19.24%)	Sea Bass, Black (12.66%)	Drum, Red (23.44%)
Mackerel, Spanish (8.26%)	Snapper, Vermilion (10.81%)	Seatrout, Spotted (7.84%)
Seatrout, Spotted (7.10%)	Drum, Red (5.23%)	Shark, Atlantic Sharpnose (3.90%)
Snapper, Vermilion (5.39%)	Seatrout, Spotted (4.64%)	Flounder, Unclassified (3.79%)
Flounder, Unclassified (3.71%)	Grunt, White (3.62%)	Snapper, Vermilion (3.77%)
Shark, Atlantic Sharpnose (3.55%)	Whiting (Kingfish) (3.48%)	Snapper, Red (2.20%)
Whiting (Kingfish) (1.85%)	Flounder, Unclassified (3.44%)	Mackerel, Spanish (2.16%)
Snapper, Red (1.71%)	Dolphin (3.14%)	Shark, Black Tip (2.12%)
Shark, Black Tip (1.64%)	Bluefish (2.66%)	Shark, Bonnethead (1.70%)

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

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Trips	14,381	15,620	15,661	16,682	16,085	21,910	18,430
Boat Hours	58,626	63,216	62,700	66,722	61,011	80,863	67,260
Anglers	50,792	54,390	55,466	60,469	58,845	80,872	66,063
Angler Hours	206,307	219,783	217,711	236,156	215,298	289,422	230,766
Estuarine Trips (%)	49.92	55.11	54.07	52.98	52.06	51.25	51.66
Nearshore Trips (%)	31.12	27.35	28.79	27.74	30.66	26.92	22.85
Offshore Trips (%)	18.96	17.54	17.11	19.27	17.28	21.73	17.97

4: Southern Flounder Stock Enhancement

Project PIs: Aaron Watson, Tanya Darden, Joey Ballenger, Lengxob Yong

Reporting Period: July 1, 2022 to June 30, 2023

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.

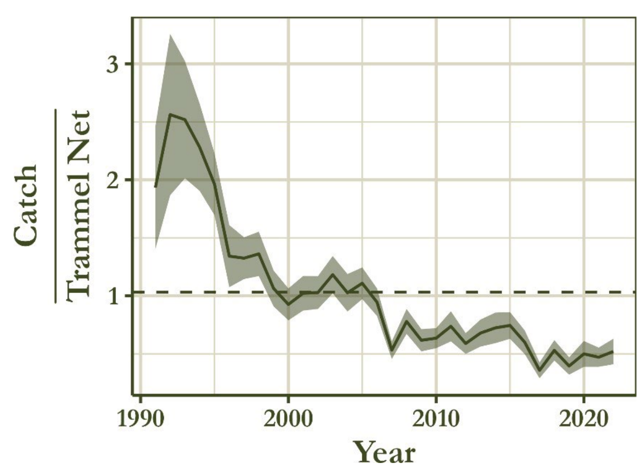

Figure 1. Annual catch of southern flounder in the SCDNR Inshore Fisheries standardized trammel net survey showing significant statewide decline.

During this project year, we have continued the development of our 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 few years of the program for southern flounder is to develop and validate a similar genetic tool prior to the production and release of juvenile flounder into state waters.

Year 2 Project Objectives:

- Complete development and begin optimization of a genetic marker panel
- Conduct initial population genetic health and diversity assessment
- Continued broodstock collection and optimization of husbandry protocols
- Implement needed infrastructure renovations specific for southern flounder husbandry
- Coordination of genetic sample collection along the southeastern US coast

Summary of Accomplishments/Activities:

Development and optimization of a genetic marker panel

We have developed and optimized a genetic marker panel for southern flounder. By using whole genome sequencing, we were able to find microsatellite markers specifically for southern flounder and began testing 130 markers in January 2022. We tested these markers with samples from South Carolina, North Carolina, and Georgia, and found 25 markers that amplified consistently and were highly polymorphic. These markers were tested for deviations from Hardy-Weinberg equilibrium, linkage disequilibrium, and frequency of null alleles. Marker testing was completed in 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).

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

Conduct initial population genetic health and diversity assessment

We used this genetic marker panel to genotype 188 southern flounder samples collected in South Carolina between September 2021 and December 2022. Our analyses of these samples (Table 2) showed that genetic diversity was relatively high ($H_E = 0.840$) and there was no sign of inbreeding ($F_{IS} = 0.011$). The effective population size (N_e) had a negative estimate (95% confidence interval = 2,958 to infinity), which is often obtained when the true effective population size is large ($N_e \geq$ 1,000). These results suggest that there is currently little concern about the genetic health of the wild population of southern flounder in South Carolina. We will continue to monitor the genetic health of the wild population before and after stocking begins.

Table 2. Genetic diversity statistics, averaged across 19 loci, for southern flounder samples collected in South Carolina between September 2021 and October 2022. Sample size (N), allelic richness (R), observed heterozygosity (H_O), expected heterozygosity (H_E), inbreeding coefficient (F_{IS}), and estimate of effective population size (N_e), excluding alleles with frequencies <0.02, are presented. Estimates of infinity are often obtained when the true population N_e is large ($N_e \geq$ 1,000).

N	188
R	14.66
H_O	0.830
H_E	0.840
F_{IS}	0.011
Ne estimate (95% confidence interval)	-17,264 (2,958 – ∞)

We have also started analyzing broodstock and larval samples from fertile spawns at MRRI and WMC during the 2023 spawning season. These samples will be used to better understand inheritance of alleles from parents to offspring which will minimize future genotyping errors, as well as help us better understand spawning contributions within broodstock tanks. Once we have collected enough data, we will then conduct parentage simulation analyses to establish critical thresholds for parent-pair genetic tags. Once we begin stocking southern flounder, this will allow us to identify stocked fish from their wild cohorts to determine contribution.

Continued broodstock collection and optimization of husbandry protocols: Field Survey 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.

The trammel net survey, which began in November 1990, 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 electrofishing survey's, which began in May 2001, main purpose is to monitor upper estuary (low salinity) waters, which are important habitat for many estuarine finfish species (e.g., red drum, spotted seatrout, southern flounder, spot, Atlantic menhaden). Finfish monitoring of the Estuarine Trawl Survey, which began in 2011, targets deeper estuarine benthic habitats, often encountering a different suite of species and/or different life stage of a species than encountered by either the trammel net or electrofishing surveys. The trawl survey operates monthly at sites in Charleston Harbor and Ashley River with additional sites in the Stono and Kiawah Rivers, St. Helena Sound, Port Royal Sound, and Calibogue Sound sampled in March, April, August, and December.

Through 2022, the trammel net, electrofishing and estuarine trawl surveys have encountered 23,341, 6,085, and 639 southern flounder across 25,548, 6,480 and 974 collections, respectively. 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 the estuarine trawl survey, the relative abundance of southern flounder has remained relatively stable; however, much of the declines in southern flounder relative abundance observed in the other surveys occurred prior to the 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 0.086 for the trammel survey to 0.22 for the estuarine trawl survey (Figure 5), suggesting each of them track annual changes in relative abundance of southern flounder well.

SCDNR Inshore Fisheries 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. 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.

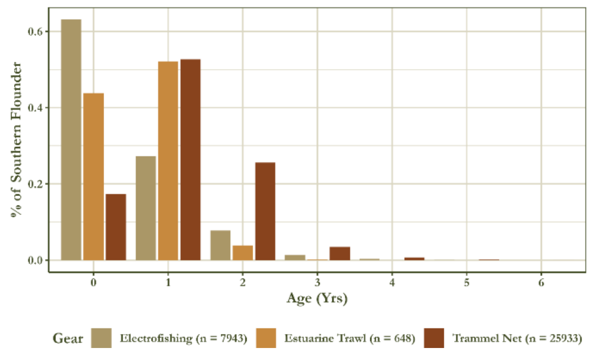

Figure 2. Percent of southern flounder within each survey by ages.

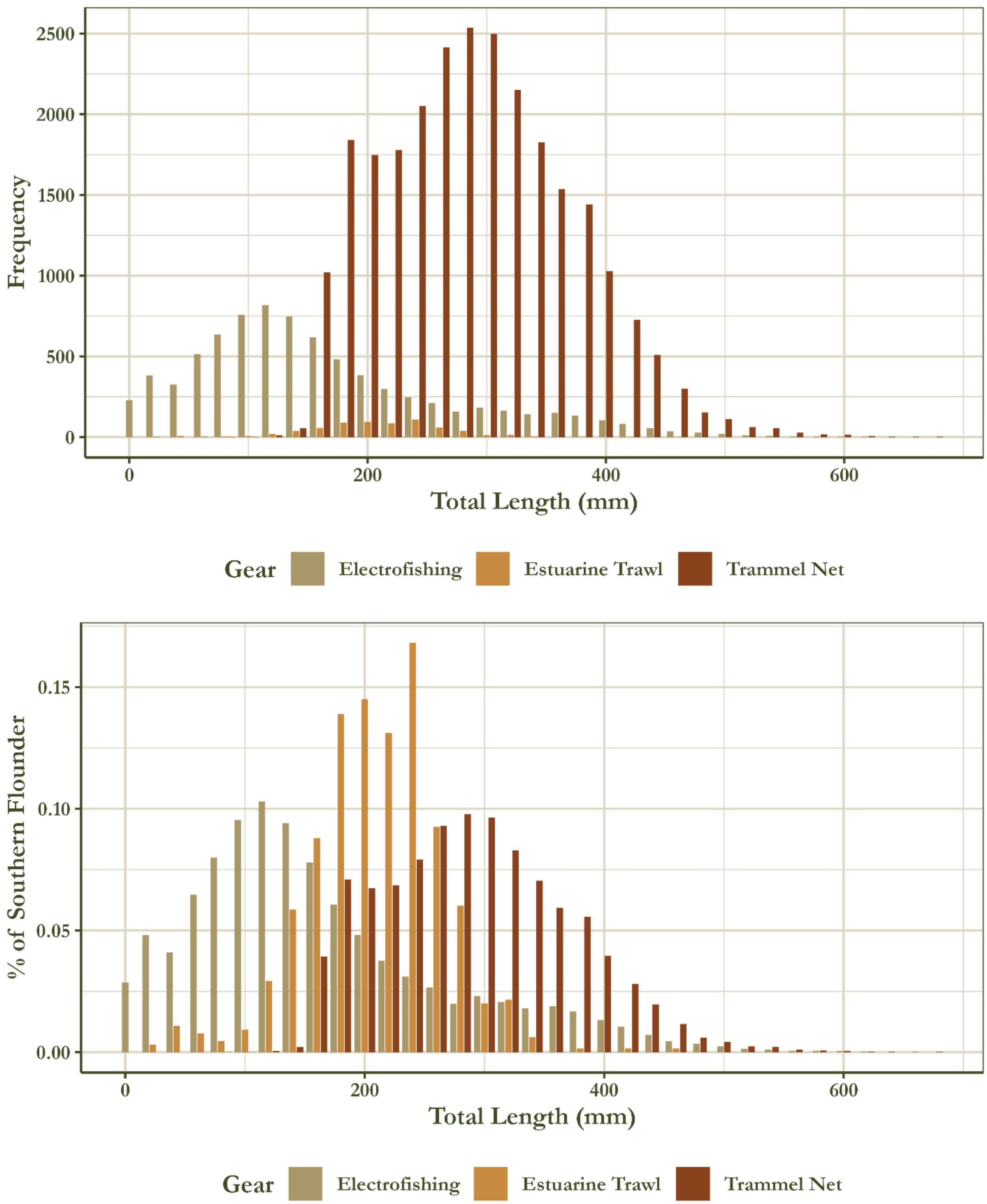

Figure 3. Frequency (top panel) of southern flounder by size class (20 mm total length bins) encountered by the trammel net (rust bars), electrofishing (kaki bars), and estuarine trawl (orange bars) surveys. Using same color scheme, percentage of southern flounder within each survey by size class (bottom panel).

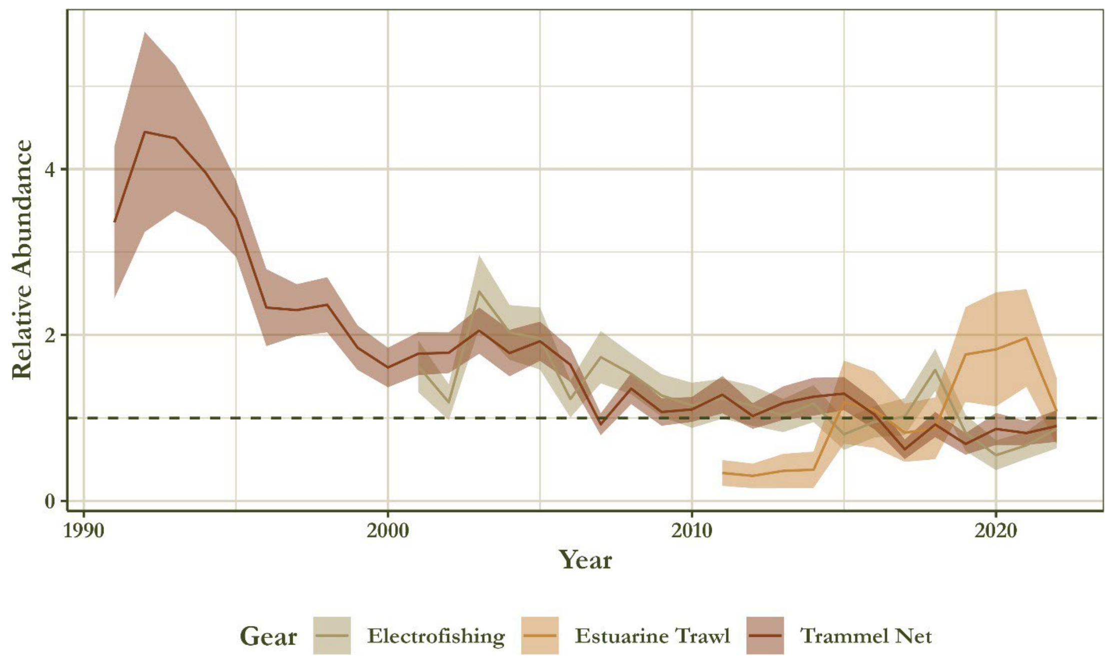

Figure 4. Southern flounder relative abundance as observed by the SCDNR trammel net (black line and gray shaded region), electrofishing (red line and shaded region), and estuarine trawl (blue line and shaded region) surveys. Data are presented relative to the average catch in the survey from 2010-2021,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

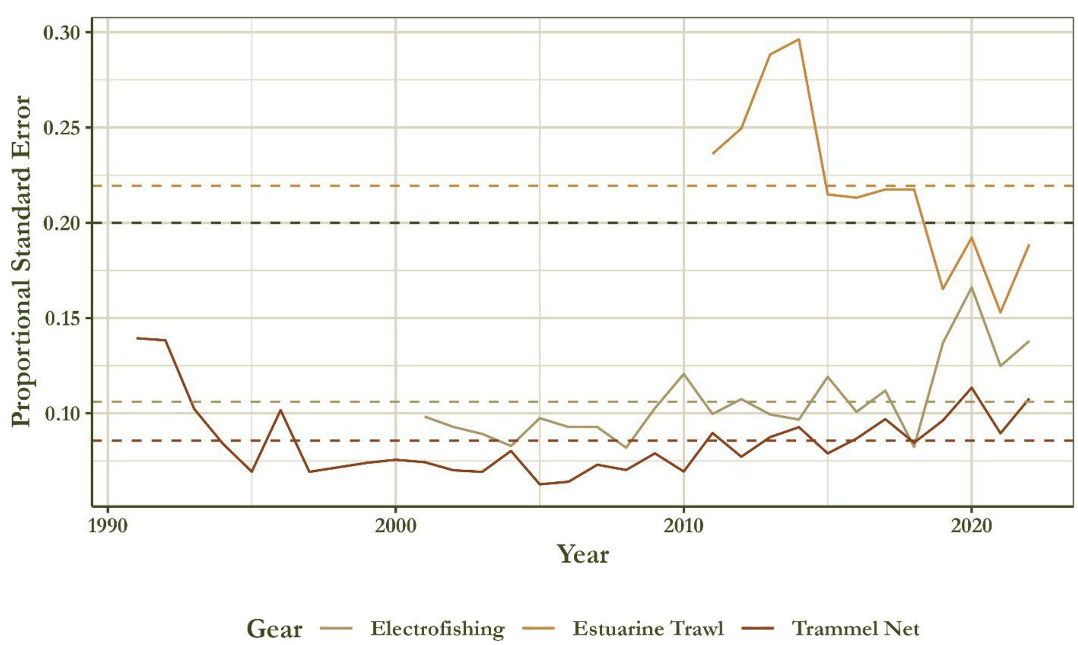

Figure 5. Annual proportional standard error estimates of southern flounder relative abundance from the SCDNR trammel net (rust), electrofishing (kaki), and estuarine trawl (orange) surveys. Shown are the annual estimates (solid lines) and mean estimates throughout the time series (long-dash). Note, provided is a reference line at a proportional standard error of 0.2 (black-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.

Continued broodstock collection and optimization of husbandry protocols

There have been continued collections of broodstock at both MRRI and WMC utilizing hook and line, SCDNR survey programs, and nighttime “bully net” methods. There were 129 healthy and fully transitioned broodfish held during the project period. Inventories were higher during that timeframe, but losses occurred due to issues associated with starvation as well as disease outbreaks caused by sea lice, *Amyloodinium*, and *Cryptocaryon*. Prophylactic treatments with a combination of freshwater dips, formalin treatments, copper treatments, and Dylox® treatment have been relatively effective in preventing further losses and development of an improved quarantine and prophylactic protocol for the introduction of southern flounder into captivity is being developed.

Optimization of husbandry protocols: Captive spawning

Broodstock were dispersed among two, 12-ft diameter tanks with photo-thermal control at MRRI, and nine, 6-ft diameter tanks with thermal control and ambient photoperiod at WMC. Once temperatures were lowered to approximately 17.5°C, volitional spawning occurred at both locations (both MRRI tanks and two, 6-ft tanks at WMC) and began on December 14th, 2022 and continued until March 18th 2023. Densities and sex ratios of each of the WMC tanks were 2 Males:2 Females and an undetermined individual in each, and each MRRI tank contained 32 (12 Females:13 Males:7 unknowns) and 47 (32 Females:11 Males:4 unknowns) individuals each. Forty-five spawns were collected at MRRI and 80 spawns collected at WMC in their respective, actively-spawning tanks. For WMC, volitional spawns contained approximately 61,021 floating eggs and 43,139 sinking eggs on average with the largest spawn containing as many as 302,416 floating eggs and 226,812 sinking eggs (Figure 6). The average hatching success of floating eggs at WMC was 74.89 % and survival to 2 DPH was 69.59% from the most active spawning tank (6A-1) at WMC (Figure 7). A total of 45 volitional spawns were collected at MRRI totaling 1,400 mL of floating eggs and 2,355 mL of sinking eggs. None of those volitional spawns at MRRI yielded viable larvae, however all spawns at WMC which contained at least 2.0 mL or more of floating eggs (71 of the 80 spawns) produced viable larvae that hatched and survived until at least two days after hatching. Overall, more than 4.57 million floating eggs and 3.51 million sinking eggs were produced at WMC and 1.40 million floating eggs and 2.37 million sinking eggs produced at MRRI.

In addition to volitional spawning, induced spawning with hormones was conducted at both locations. Ovaprim® was used at its recommended dosage during two separate trials at MRRI and for 4 of the 7 tanks of broodfish at WMC that were not spawning volitionally. Injections of hormones caused release of eggs from multiple females, and eggs from females at MRRI were also able to be stripped and successfully fertilized with milt that was collected from males 0-24 hours prior. Viable larvae were obtained at MRRI from one of these trials. Broodfish assessments during hormone induction attempts at WMC revealed that of the 39 broodfish not in the volitionally spawning tanks, only three males with nearly negligible milt production were observed. The skewness of the sex ratio was therefore thought to be a factor in those tanks not spawning volitionally and prompted the necessity for continued collections for WMC to focus on obtaining more male broodfish.

Spawning results observed during the project period were overall positive and help provide background data that can be substantiated by replication in the future and even improved upon by utilizing newer technologies such as other spawning aids, tank sizes, sex ratios, etc.

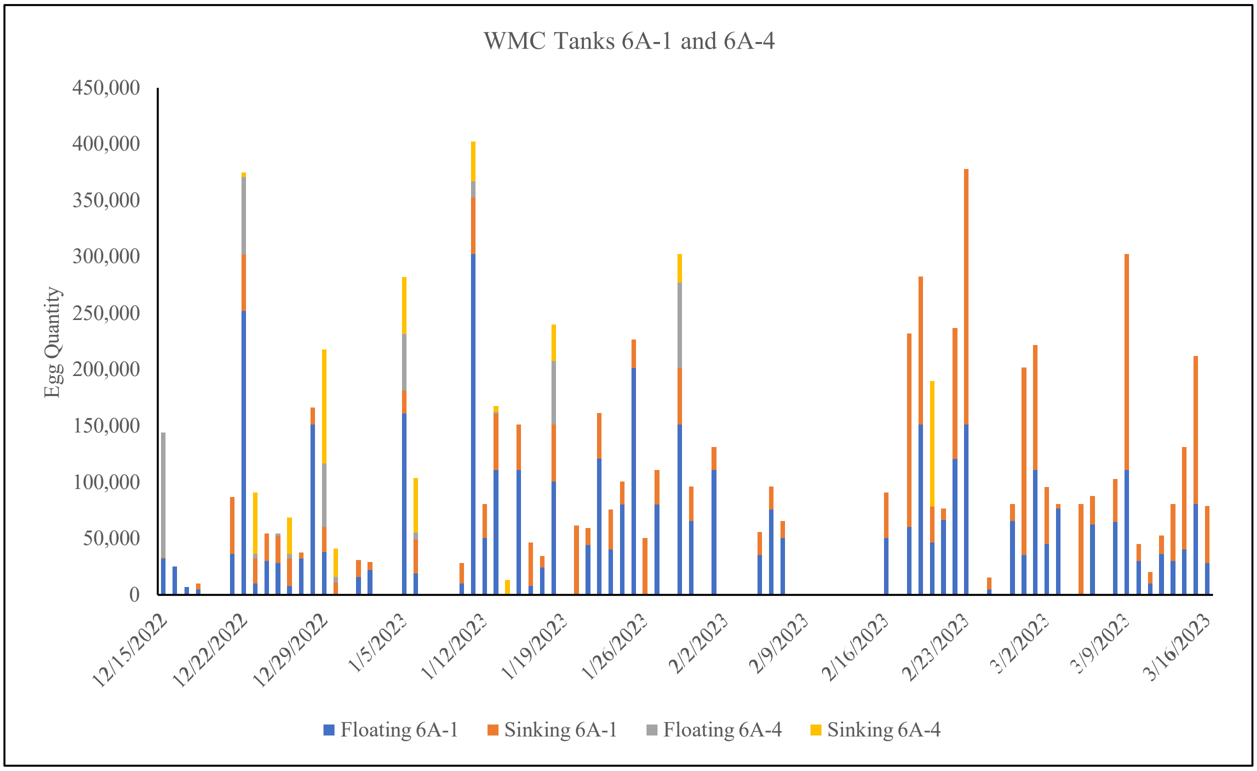

Figure 6. Frequency and quantity of volitional spawns occurring in 6-ft diameter tanks at WMC.

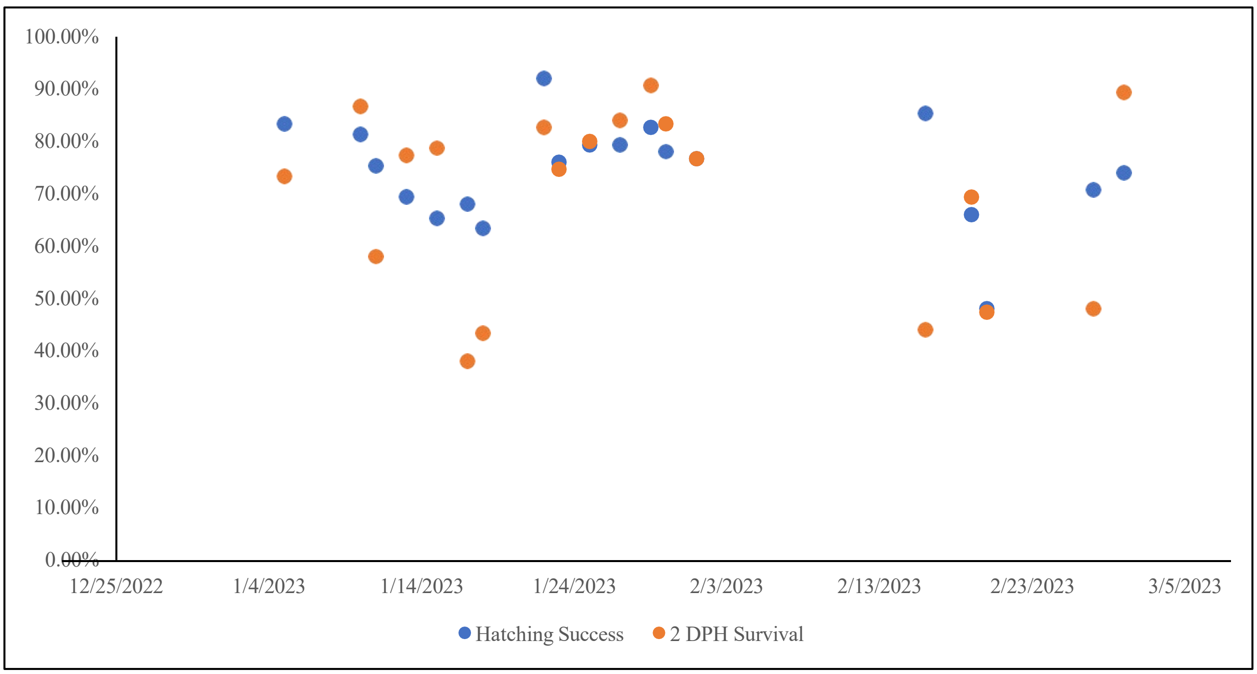

Figure 7. Mean viability estimates from floating eggs of spawns from the 6A-1 tank at WMC.

Optimization of husbandry protocols: Larval culture

A consistent supply of viable eggs and larvae at WMC provided opportunities to attempt both intensive and extensive larval culture. Eight attempts at intensive culture were conducted at WMC. Five of the first six attempts failed but the one that went on to be successful highlighted a need to reduce the light intensity over larval tanks from 1,000+ lux to approximately 650 lux. At the reduced light intensities, we were successful in three of the eight attempts while using approximately 115,900 eggs to produce more than 2,600 fully metamorphosed juveniles well beyond 40 DPH. A feeding combination utilizing high densities (up to 20 individuals per mL) of enriched rotifers at 2 DPH and Artemia (up to 3 individuals per mL) starting around 15 DPH and the exclusion of any algal paste for standard "greening" of the water was effective. Juveniles were also partially transitioned onto artificial diet combinations of Otohime and Artemac and Economac products (Table 3).

Extensive larval culture attempts took place in two of the small, 0.25 acre ponds at WMC. Ponds were filled and fertilized similarly to our standard protocols for other stock enhancement species. One pond was stocked with only eggs while the other pond was stocked with 0 DPH larvae. Due to small spawn sizes, ponds had to be sequentially stocked as eggs and larvae were available. Stocking began on January 18, 2023 and concluded on March 6, 2023 once 500,000 and 267,159 eggs and 0 DPH larvae, respectively, had been stocked into their allocated pond. Both ponds were harvested on May 16, 2023. For the egg-stocked pond, 102 fish were harvested at an average size of 98.88 mm and 8.85 g, while 1,104 fish averaging 73.14 mm and 3.72 g were harvested from the pond stocked with o DPH larvae.

While overall production numbers were low both intensively and extensively, results again provide us background data to improve upon as we refine and test new methods. A promising outcome from both culture methods was the extremely low rate of mal-pigmentation and body deformities (< 10 individuals of the 3,800+ produced). Juveniles produced using both methods have also been provided to collaborators for determination of sex ratio of the individuals.

Table 3. Feeding regime used for one of the successful, intensive larval culture production runs at WMC.

Days Post Hatch (DPH)	Green Water (Million cells/mL)	Rotifers (#/mL)	Artemia nauplii (#/mL)	Dry Diet (~0.5 g)
1				
2	0	10		
3	0	15		
4	0	7.86		
5	0	0		5X- Mix
6	0	10	0.25	3X- MIX
7	0	12.5	0	
8	0	14.5	0	
9	0	18.6	0	
10	0	9.6	0	
11	0	6	0	
12	0	4.7	0	
13	0	0	0.5	5X- MIX
14	0	12.5	0.25	1X- MIX
15	0	12.5	0	1X- MIX
16	0	10	0.25	1X- MIX
17	0	10	0.25	1X- MIX
18	0	10	0.5	1X- MIX
19	0	10	0.5	0
20	0	10	0.5	1X- MIX
21	0	10	0.5	1X- MIX
22	0	10	0.5	1X- MIX
23	0	10	0.5	1X- MIX
24	0	10	0.5	1X- MIX
25	0	7.5	0.5	1X- MIX
26	0	7.5	0.75	2X- MIX
27	0	5	0.75	2X- MIX
28	0	5	1	2X- MIX
29	0	2.5	1	2X- MIX
30	0	0	1.25	2X- MIX
31	0	0	1.25	2X- MIX
32	0	0	1.25	2X- MIX
33	0	0	1.25	2X- MIX
34	0	0	1.25	2X- MIX
35	0	0	1.5	2X- MIX
36	0	0	1.8	2X- MIX
37	0	0	2	2X- MIX
38	0	0	2	2X- MIX
39	0	0	2	2X- MIX
40	0	0	2	2X- MIX
41	0	0	2	2X- MIX
42	0	0	2	2X- MIX

Implement needed infrastructure renovations specific for southern flounder husbandry

To accommodate replicated spawning trials at WMC, 12 of the 5-ft diameter tanks there have been outfitted with external egg collectors for trials with pairs of spawning broodstock. Four, 8-tank systems with 10-gallon aquaria were also constructed at WMC to allow for future trials with juveniles to better understand requirements during that stage which lead to optimum sex ratios, growth, and survival. A small heat pump was also obtained to provide consistent temperatures during routine quality assessments of hatching success and survival to first feeding for all spawns obtained. Fiberglass troughs are also being obtained to determine their efficiency for extended growout of juveniles from intensive larval culture. Facilities upgrades at MRRI include the installation of new YSI water quality monitors on broodstock and larviculture systems, installation of rotifer culture systems, multiple different styles of larviculture and juvenile rearing systems, and the retrofitting of a system to be a recirculating system with additional small raceways for broodstock conditioning and housing during spawning season. Water polishing systems have been purchased and are in the process of installation at MRRI during FY24.

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. Table 4 shows the numbers and life history stage of animals that were sampled, and fin clips sent to SCDNR for further analysis. These samples will be processed to continue to evaluate patterns of gene flow and genetic health of the wild southern flounder population(s) to guide future broodstock management and stocking protocols.

Table 4. Genetic samples for adults (>300mm) and juveniles (<300mm) collected in NC and SC and archived in FY23.

State	Adults	Juveniles	Total
North Carolina	575	232	807
South Carolina	370	291	661

5: Construction and Maintenance of Marine Artificial Reefs

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

Program Period: July 2, 2022 to July 1, 2023

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:

Nine reef construction projects were carried out during this fiscal year on 9 separate artificial reef sites, adding approximately 107,518 cubic feet of hard bottom habitat to our offshore reefs. Projects that were completed are summarized below:

Date	Material	Reef Site
30 July 2022	Smart Reef Blocks and buoy	Ron McManus Memorial Reef
30 July 2022	Smart Reef Blocks and buoy	Lowcountry Anglers Reef
30 July 2022	Smart Reef Blocks and buoy	Beaufort 45' Reef
11 August 2022	Concrete Culvert/Junction Boxes	Georgetown Nearshore Reef
30 August 2022	100' Deck Barge with house	Eagles Nest Reef
19 September 2022	Eternal Reef Balls	Jim Caudle Reef
20 October 2022	Reef Balls	Will Goldfinch Reef
26 October 2022	75' Shrimp Trawler	Betsy Ross Reef
12 January 2023	64' Aluminum Yacht	North Inlet Reef

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

- Twenty-five 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.

- Six 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.

Smart Reef Buoy at Lowcountry Anglers Reef

Barge with deck house Eagles Nest Reef

Helicopter used to deploy divers for initial Smart Reef deployment.

6a: Assessing the Spatial Extent and Condition of State-Managed Shellfish

Project PI:	Dr. Peter Kingsley-Smith, Senior Marine Scientist Shellfish Research Section (SRS) SCDNR Marine Resources Research Institute (MRRI)
Project Participants:	Gary Sundin, Wildlife Biologist III, MRRI-SRS Lauren Faulk, Wildlife Biologist II, MRRI-SRS
Reporting Period:	July 1, 2022 to June 30, 2023

During FY2023, Shellfish Research Section (SRS) staff used a small, unmanned aerial system (sUAS) to map and monitor natural and restoration intertidal oyster reefs and other intertidal fish habitat in South Carolina. Staff collected habitat data that are being explored for their utility to address the following objectives: 1) to assess the extent and condition of the oyster resources; 2) to determine the effectiveness of current oyster resource management approaches; and 3) to explore changes in habitats and resources attributable to both natural and anthropogenic factors.

An additional goal of this effort was to work towards a practical oyster classification workflow for sUAS-derived data that can be integrated into a monitoring framework that will improve oyster resource management. Due in part to development of these initial workflows, the section was successful in securing federal funding through NOAA's NERRS Science Collaborative (NSC) program to collaborate with resource managers in South Carolina, North Carolina, Georgia, and Florida to further refine and develop sUAS-specific approaches to benefit South Carolina oyster management. The basic protocols developed from the flights described here are currently being used by section staff on data from the NSC project.

On July 14, 2022, staff conducted a mapping flight within State Shellfish Ground (SSG) S272 in the Sewee area of the South Carolina coast (see Figure 1). This flight was part of an overall effort that mapped oyster reef areas in two SSGs (S206W in the Folly River area and S272) with the assistance of graduate student Benjamin Aland from the University of South Carolina. Much of the initial effort was completed in June 2022 (covered in the FY2022 SRFAC report) with an additional flight completed during the current reporting period. In FY2023, Benjamin Aland completed an estimation of the classification accuracy of the flights using sets of randomly generated points and ground truth data points collected with global navigation satellite system (GNSS) equipment in the field at the time of the flights. The accuracy estimates were completed by using individual flight images for the randomized point data and by using overall area for the ground truth data. Ground truth data estimates were combined because there were necessarily fewer points for analysis. Accuracy was estimated by computing standard confusion matrices in which the proportion of both oyster and non-oyster substrates classified by the supervised computer algorithm were compared to observed data, with observed data being the orthoimagery for the random points, and the actual observed substrate for the ground truth data.

Results of the accuracy analyses are shown in Table 1. Overall accuracy was estimated for all products and is a combined estimate of errors of omission (reference sites left out of correct class) and errors of commission (reference sites included in an incorrect class). Acceptable overall accuracy may vary by project, but a classification accuracy of ≥80% is often considered a "good" target for map classification products. Cohen's Kappa coefficient values were also calculated. The Kappa coefficient ranges from 0 to 1 and compares classified results to expected results accounting for random chance, with 0 being a completely random relationship between classified and reference data and 1 being complete agreement between classified and reference data. Kappa coefficients are a more conservative estimate of classification accuracy because they account for the fact that some data are expected to be correctly classified by random chance. As with classification accuracy, acceptable Kappa values may vary depending on project and use case, although values ≥ 0.80 are almost universally considered good for raster classification products and with values ≥ 0.50 considered fair. The Folly area maps, covering smaller areas and having greater resolution, were more accurately classified than the Sewee area maps which covered larger areas and had lower resolution. The classification of the lower resolution Sewee area data was less accurate but showed fair agreement between observed and reference data. The work completed thus far suggests that sUAS approaches are useful for monitoring the extent of intertidal oysters and potentially changes in the extent of oyster reefs over time, which has valuable application for oyster resource management approaches.

During this reporting period, staff also mapped a 12.3 ha area within State Shellfish Ground S255 in Hamlin Creek near the Isle of Palms, South Carolina. This area is easily accessible from the Charleston metropolitan area and is a popular ground for both commercial and recreational shellfish harvesters. The ground was planted with loose shell in 2019 and was mapped using sUAS by staff less than a week post-planting. The ground was mapped again in November 2019, during the shellfish harvest season, and mapped again three years later during the FY2023 shellfish harvesting season. Figure 2 shows examples from a single mapped area for each of these time points. Detailed analyses of the data have not been completed, but observations are consistent with observations from other sites where loose shell was planted on relatively moderately sloped banks with soft substrate. Areas of deepest shell placement are most likely to result in the development of new oyster reefs. Areas of thinner or more sparse shell placement are less likely to develop into reefs, possibly due to the loss of surface shell through energetic relocation or burial by sediment. Furthermore, the successful and unsuccessful areas may be evident quite soon after initial placement. In terms of extent of exposed shell (live or dead), more change was observed in the first five months post-placement than in the subsequent three years (see Figure 2). These data contribute to a growing multi-year dataset which will continue to be useful for managers as they seek to maximize the effectiveness of loose shell planting effort and shellfish ground management.

During this reporting period, staff also completed an oyster mapping flight 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. As in previous years, an incremental volumetric increase was observed within the planted site. Figure 3 graphically illustrates changes over this period within a portion of the planted area. The planting has been successful, establishing a new oyster reef with harvestable-sized 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. Table 2 lists the volume changes observed within the monitored area. Immediately after planting in 2018, the site increased by 48.7 m^3 relative to the pre-planting volume. In 2023, the cumulative increase was 88.7 m^3, relative to pre-planting, indicating a net increase in volume of 40 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 shell planting success.

Table 1. Summary of flight dates, areas in hectares (ha) mapped, and accuracy data for four UAV oyster mapping flights completed in FY22 and FY23.

Site	Flight Date	Area(ha)	Random Point-generated		Ground Truth-generated	
			Accuracy (%)	Kappa values	Accuracy (%)	Kappa values
Folly 1	6/14/2022	1.3	88	0.76	95	0.90
Folly 2	6/14/2022	0.8	92	0.83		
Sewee 1	6/13/2022	10.2	76	0.52	80	0.61
Sewee 2	7/14/2022	24.1	76	0.51		

Table 2. Volume changes over time, estimated from UAV-derived elevation data, for a site in Murrells Inlet planted with loose shell in 2018 and monitored annually through 2023.

Flight information	Volume (m^3)	Change (m^3)	Cumulative Change (m^3)
Pre-planting (July 2018)	194.8	n/a	n/a
Post-planting (August 2018)	243.5	48.7	48.7
2.5 Years post-planting (January 2021)	250.5	7.0	55.7
3.5 Years post-planting (March 2022)	272.9	22.4	78.1
4.5 Years post-planting (January 2023)	283.5	10.6	88.7

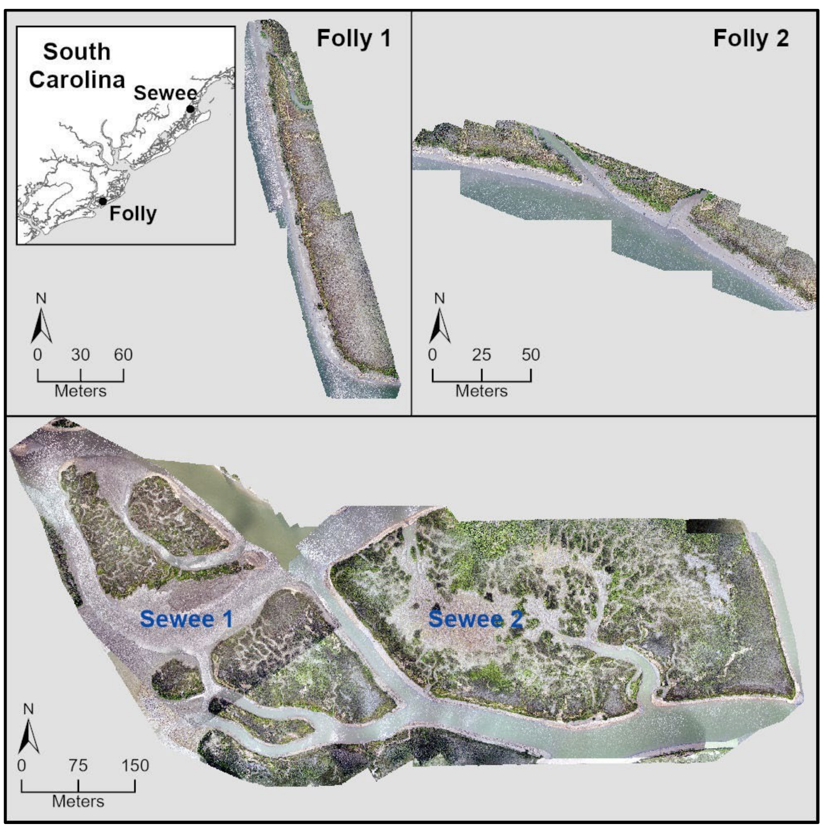

Figure 1. State Shellfish Ground areas mapped for oyster classification. Inset map (upper left) shows location of the sites on the South Carolina coast.

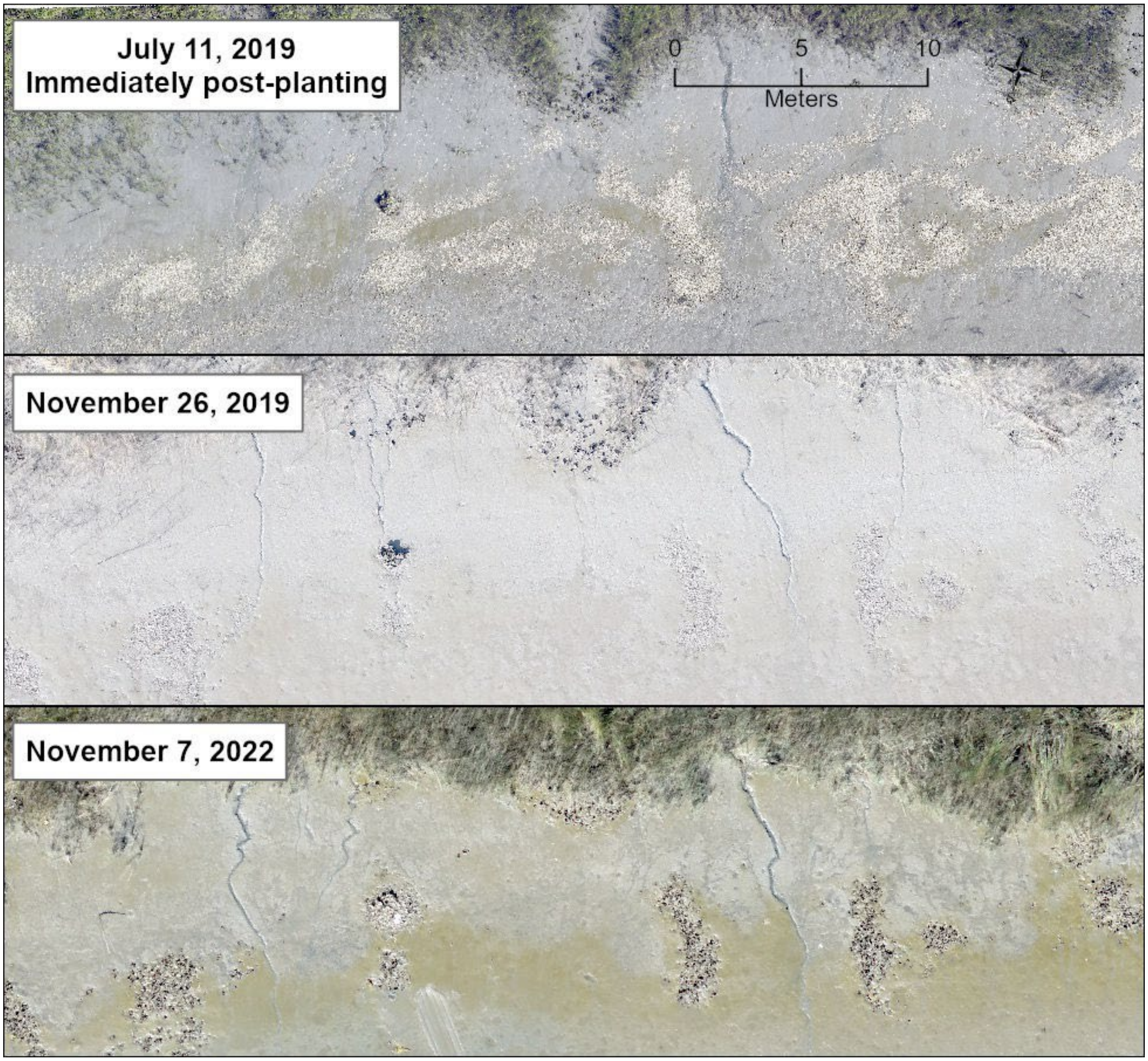

Figure 2. Time series of views from sUAS-derived imagery collected in S255 in Hamlin Creek showing a small area immediately after loose shell planting in July 2019 (*top panel*), approximately six months post-placement of oyster shell (*middle panel*), and 3+ years post planting (*bottom panel*). Areas that received relatively heavy placement of loose shell were most likely to persist and develop oyster reefs over time.

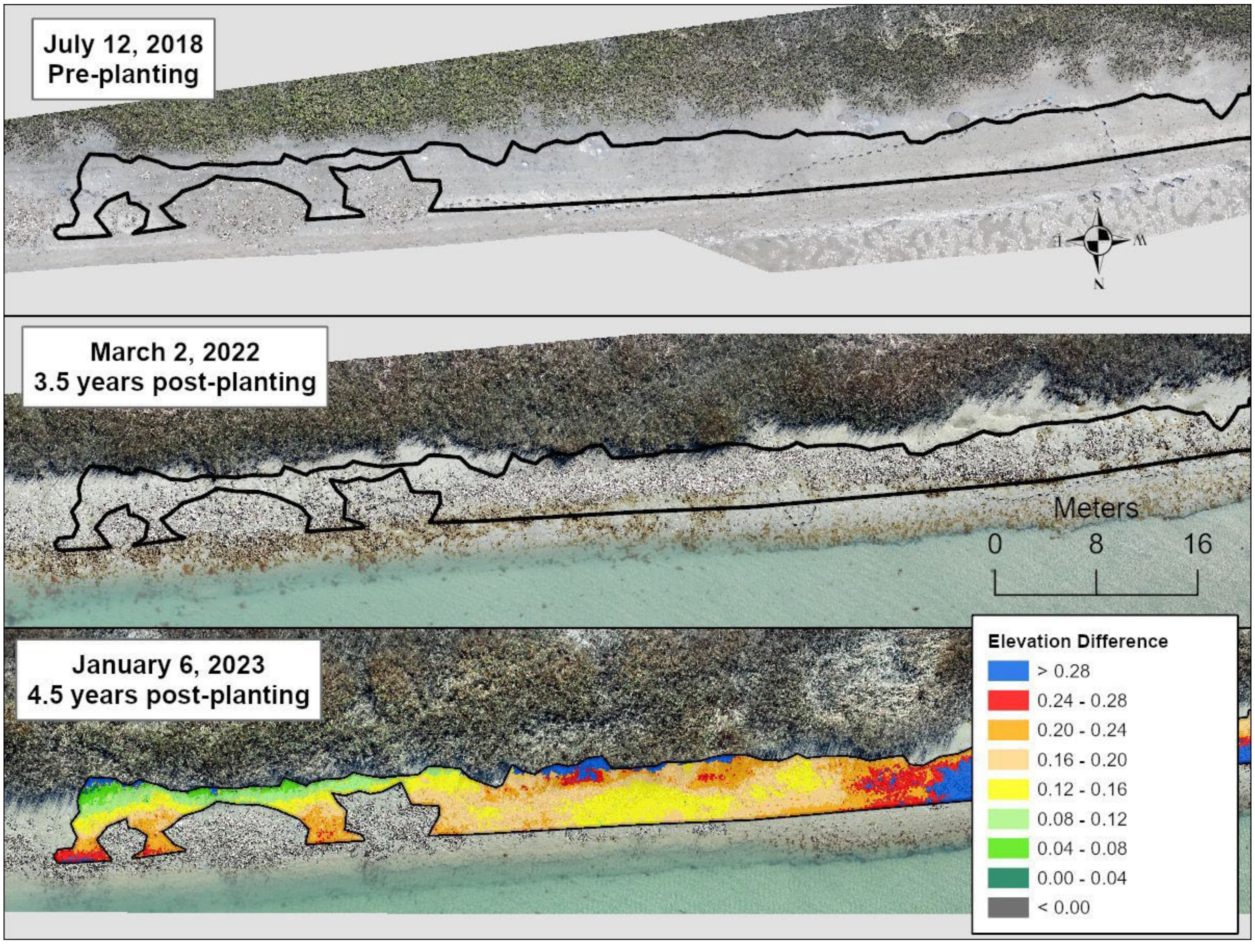

Figure 3. Time series of views from sUAS-derived imagery associated with the placement of loose oyster shell within State Shellfish Ground S357 in Murrells Inlet. The black border in all panels indicates the border of the analysis area, which excludes areas where established reefs existed prior to the 2018 planting. The *top panel* shows the shoreline pre-planting in July 2018, the *middle panel* shows that same shoreline approximately 3.5 years after planting in March 2022, and the *bottom panel* shows the shoreline more 4.5 years after planting in January 2023 with oyster growth, sediment accretion, and marsh accretion all occurring following shell planting. Warmer colors in the lower panel indicate higher levels of positive elevational changes and cooler colors indicate areas of elevation loss.

6b: Assessing natural mortality patterns of South Carolina intertidal oyster reefs to inform restoration and resource management.

During FY2023, staff in the Shellfish Research Section continued annual monitoring of wild intertidal oysters to explore patterns of mortality, recruitment, and other demographic parameters. During the winter (October 2022 – February 2023), 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 this year's sampling efforts, a total of 25,787 individual oysters were collected and measured. Since 2015 when this survey started, 196,377 oysters have been collected and measured. After oysters were processed in the lab their 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 3). In FY2023, the statewide natural mortality rate was 5.8%, which is a decrease from 6.5% observed in FY2022. In the first year of this project (2015), an anomalous rainfall event 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. In the two years following that event, natural mortality rates decreased, indicating a gradual recovery of the population. The past five years have been characterized by fluctuating mortality rates between 5% and 8%, which appears to be a baseline for wild intertidal oysters in South Carolina (Table 1, Figure 5).

The shell height-frequency data generated by measuring oysters collected through the winter is also used to assess relative recruitment success. The proportion of small oysters (< 1" shell height, assumed to be recruits) was calculated in each sample from each year of the oyster demographic survey. The distribution of the 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 relatively weak and management and/or restoration actions may be warranted. It should be noted that this is a relative index, in which the index for each season is estimated from all available data and therefore the estimates for past seasons may differ from year to year. 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 Joaquin. In FY2023 most sites experience average levels of recruitment using this index (Figure 6). There were no sites with below average recruitment and seven sites with above average recruitment. The higher recruitment sites were dispersed throughout the central and southern areas of the state (Figure 7). No particular hot spots of mortality were observed, although relatively high mortality was observed in Grice Cove (Charleston Harbor), Dewees Inlet, and in the South Edisto River. The combination of natural mortality rates and shell height-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.

In FY2023, staff began collecting simple chain rugosity data for all replicate quadrat samples collected as part of the demographic project. Rugosity is a measure of surface roughness and is a common index of habitat quality. A unitless rugosity index was calculated, with larger values indicating more rugose (rougher) surfaces and smaller values indicating less rugose (smoother) surfaces. A simple linear regression was performed, at the quadrat level, of the count of oysters with shell heights > 76.2 mm (legal commercial size) against the rugosity index (Figure 8). Although a positive relationship was observed, as indicated by a positive slope and a significant *p*-value ($p = 0.004$, $\alpha = 0.05$), the model was poor at explaining the variation in the data (adjusted $R^2 = 0.07$). Adding this additional parameter to data collection did not significantly decrease the efficiency of field teams collecting samples. Although initial results have not shown strong useful relationships thus far, the general approach is of interest to section researchers and collection of rugosity data will continue in the future, with the goal of continuing to explore and refine this method to eventually improve monitoring and management of intertidal oysters.

Figure 4. Location of sites sampled for natural oyster mortality during FY2023. Site codes for locations sampled are provided in Table 1.

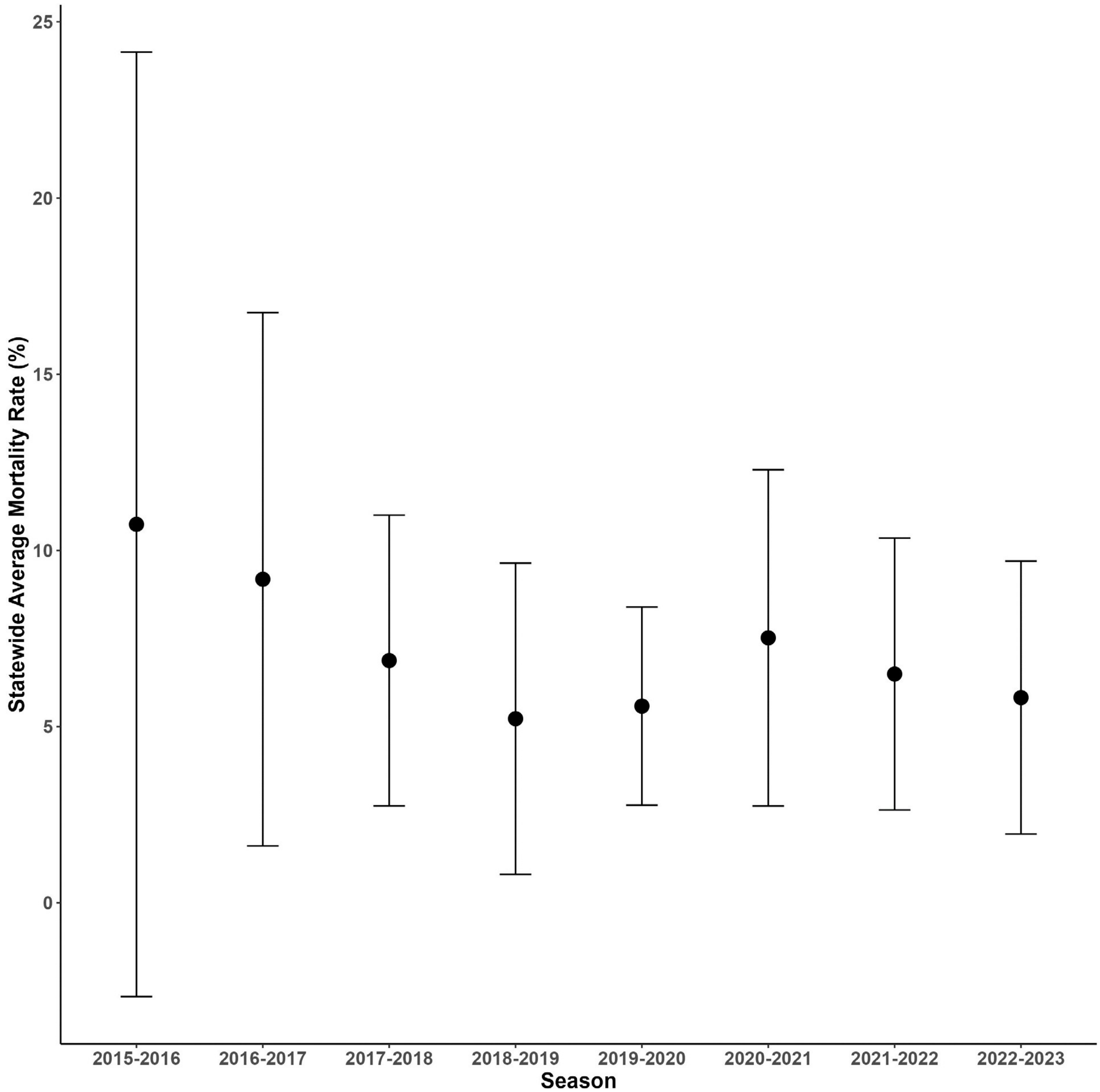

Figure 5. Statewide average natural mortality rates for wild intertidal oysters. Error bars denote standard deviations. The highest natural mortality was recorded during the first year of the survey (2015-2016), which coincided with an anomalous storm event. The last five years have shown more stable natural mortality rates fluctuation around 6-9% (see Table 1 for more details).

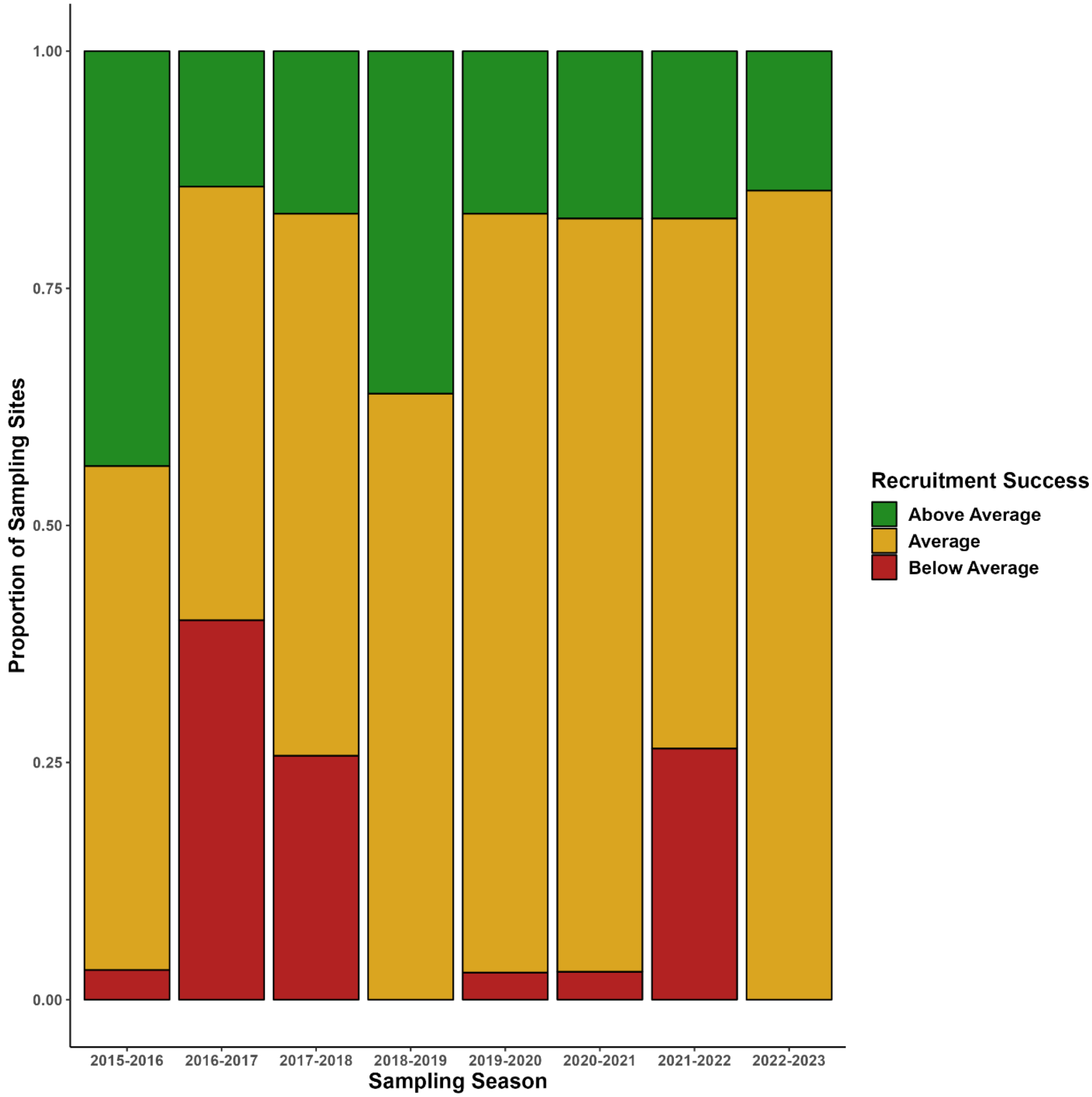

Figure 6. Proportions of sampling sites characterized by various levels of recruitment success (above average, average, and below average) for each winter season of demographic sampling. Relative recruitment success was determined based on the proportion of small (<1”) oysters in each sample that were assumed to be recruits.

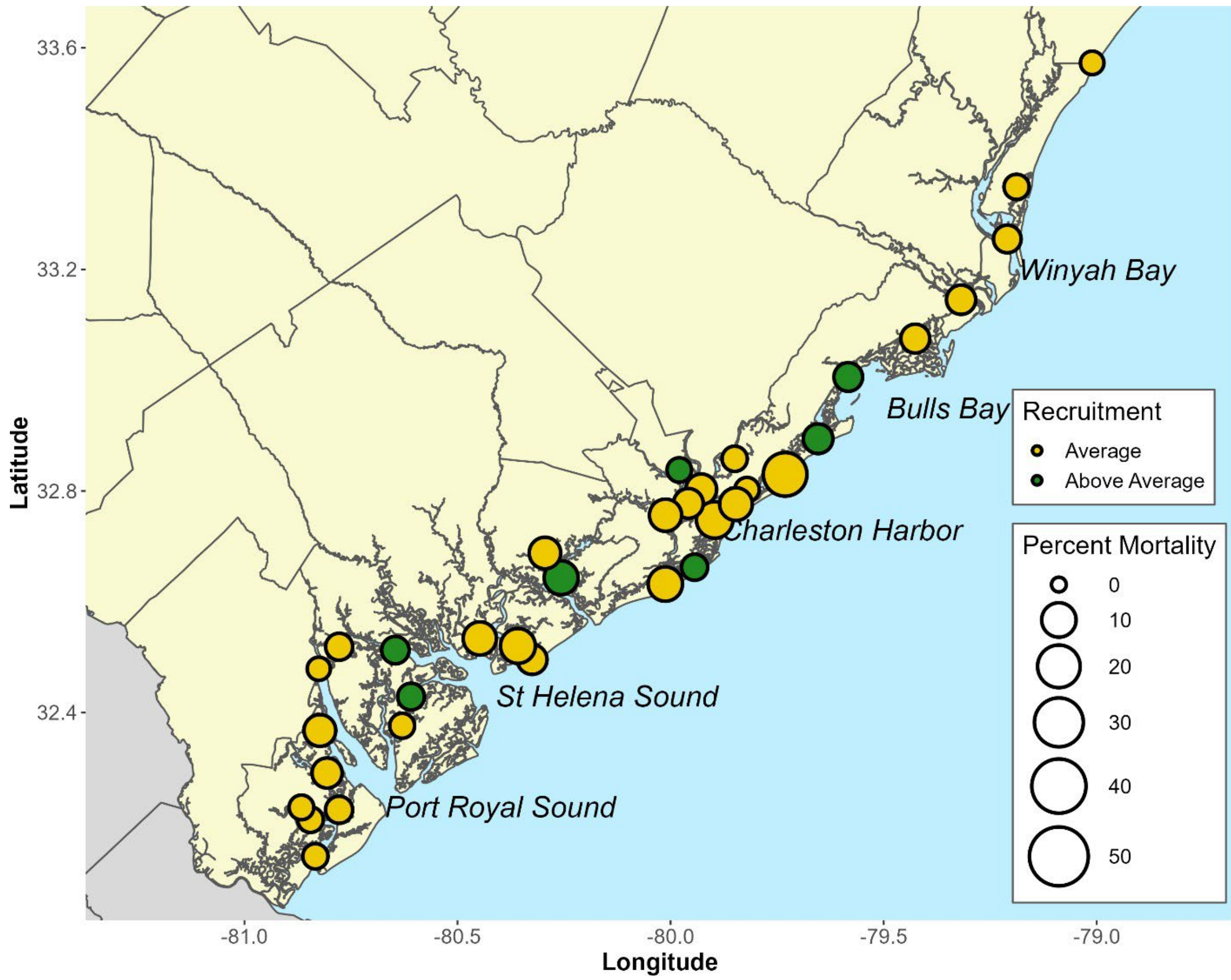

Figure 7. Map of sites sampled in 2022-2023. Recruitment index categories (average, above average) are indicated by circle fill color and percent mortality is illustrated by relative circle size.

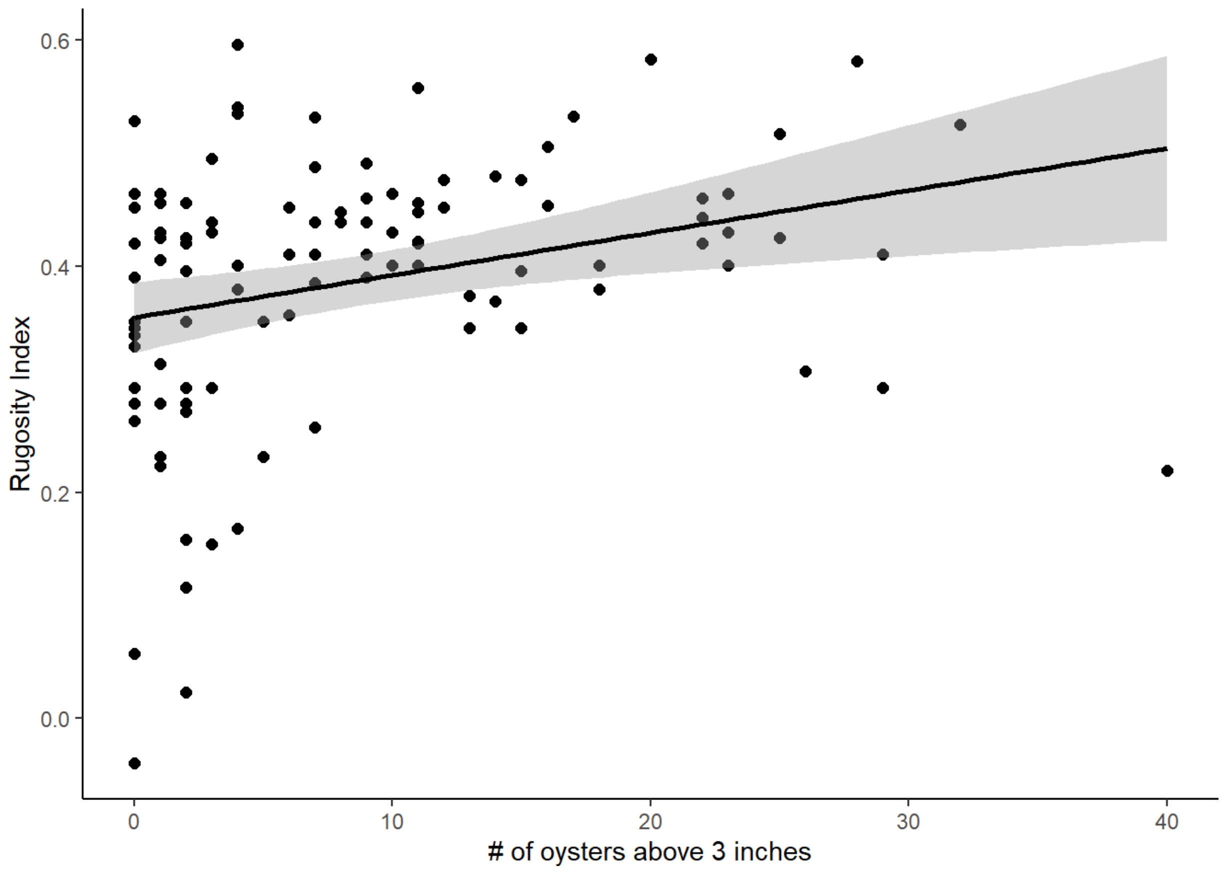

Figure 8. Linear regression analysis of the relationship between rugosity values and the number of individual oysters with shell heights > 3" for individual quadrat samples. The slope of the line was significantly different from zero (p = 0.004, α = 0.05), with a positive relationship between the two variables, however the amount of variance explained by the model was low ($R^2 = 0.07$).

Table 1. Summary of natural morality rates of oysters tabulated by sampling site and shown across sampling years from 2015-2016 to 2022-2023.

Site	Site Name	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	Mean
ASP	Ashepoo River	9.7	20	9.7	12	12.3	6.7	4.4	8.8	**10.4**
BBC	Big Bay Creek	11	9.9	4.9	3.1	6.1	19	9.4	5.9	**8.7**
BBF	Bears Bluff	3.7	8.6	4.6	3.5	4.8	10	4.3	9.5	**6.1**
BFT	Beaufort River	6.7	12	10	4.7	2.5	8	5.7	2.7	**6.5**
BLB	Bulls Bay	2.9	4.2	5.5	2.9	2.9	3.5	4.4	5.0	**3.9**
BRD	Broad River	9.8	1.6	3.1	5.4	2.2	6	3.6	1.9	**4.2**
BUL	Bull Creek	2.5	2.8	4.8	2.6	3.4	6.8	2.5	3.0	**3.6**
CBG	Calibogue Sound	7.7	17	10	9.8	7.6	29	21.9	2.8	**13.3**
CCH	Chechessee River	4.3	4.8	6.4	1.8	3.2	7.2	7.5	7.4	**5.3**
CLT	Colleton River	2.5	4.3	6.2	1.9	7	3.9	12.5	6.1	**5.5**
CPR	Cooper River	10	7.9	29.5	4.3	3.7	4.5	5.5	6.6	**9.1**
CRM	Cape Romain	4.7	5.8	3.4	4.3	5.2	7.6	6.2	5.2	**5.3**
CSG	Cosgrove Bridge	20	12	7.3	2.8	7.9	6.4	5.4	2.5	**8.0**
CSW	Coosaw River	6.2	3.3	3.6	3.1	2.2	6.6	4.4	4.2	**4.2**
DWE	Dewees Inlet	7.1	2.8	13	17	10	8	16.6	21.5	**12.0**
EDR	Edisto River	7.9	4.9	2.1	6	3.7	14	5.1	10.5	**6.7**
FLR	Folly River	4.8	4.1	8.2	3.4	9.8	6.4	4.8	3.3	**5.6**
FOS	Foster Creek	-	-	-	2.4	3.3	5.8	3.8	2.9	**3.6**
FSC	Fish Creek	-	6.8	3.7	-	-	-	-	-	**5.3**
GRC	Grice Cove	-	-	-	6.4	5.4	6.6	4.2	12.2	**7.0**
HAR	Charleston Harbor	16	27	6.9	6.8	-	-	-	-	**14.1**
HOG	Hog Island	3.5	7.5	6.3	2.2	6.9	6.9	4.6	4.0	**5.2**
INL	Inlet Creek	6.4	9.3	6.8	2.7	3.5	4.7	5.2	2.4	**5.1**
JIC	James Island Connector	19	8.9	9.2	5.5	9.6	7.3	5.1	5.8	**8.9**
MAY	May River	2.1	3.1	6.6	4.8	6.3	4.3	5	2.6	**4.3**
MRI	Murrells Inlet	-	3.6	5	3.8	9.7	4.4	2.5	2.0	**4.4**
NHI	North Inlet	4.4	5.1	6.6	0.4	7.4	6.9	7	2.8	**5.1**
SST	South Santee	77	3.9	9.8	12	7.1	5.1	5.1	5.5	**15.7**
STI	Stono Inlet	6	8.8	5	6.7	6.5	7.2	8.9	9.9	**7.4**
STR	Stono River	13	7.8	6.2	3.4	3.3	5.1	6.8	7.9	**6.7**
SWE	Sewee Bay	19	16	11	3	10.8	13	10.3	5.7	**11.0**
TGD	Toogoodoo Creek	5.3	6	4	3.4	3.3	5.7	6.3	7.3	**5.2**
TOL	Tolers Cove	7.1	5.6	9.9	2.1	2.8	5.4	9.8	8.3	**6.4**
WBR	Whale Branch	-	0.9	4	4.5	1.8	5.4	4	3.9	**3.5**
WND	Wando River	9.7	27	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	3.7	**4.0**
WYB	Winyah Bay	33	24	5.8	22	9.4	7.5	5.2	4.3	**14.0**
Mean		**10.9**	**8.6**	**7.1**	**5.2**	**5.7**	**7.7**	**6.5**	**5.8**	**7.2**

7: Shell Recycling/Planting, Research and Oyster Reef Management

Project PI/Participants: Ben Dyar, Andy Hollis, Stephen Czwartacki, Michael Hodges, Holly Sommers, Cody Potvin, Austin Thompson

Reporting Period: July 1, 2022 to June 30, 2023

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 FY2023 is 30,000 bushels of shell.
2. Site, build and maintain at least 1 new oyster shell recycling bins for public use.
3. Increase number of restaurants participating in oyster recycling program in the Charleston, Murrells Inlet, Beaufort/Hilton Head, Greenville, Florence, and Columbia 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. These SRFAC funds will cover personnel costs for these plantings
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 2023, **38,248** bushels (bu.) of shell were recycled. This is the largest 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 eleven counties. Recycled shell collected from these public drop-off facilities, individual oyster roasts, oyster roast caterers and local restaurants resulted in a savings of over **$183,133** by not having to purchase an equivalent quantity of out of state shell. We saw a 12.5% increase in the total amount of bushels

recycled from FY22 to FY23. The 4% decrease in shell recycled from restaurants was likely from Greenville's volunteer shell recycling program being put on hold (details to follow).

The program saw the purchase of four new hydraulic dump trailers and the donation of two hydraulic dump trailers from the Coastal Conservation Association (CCA).

Table 1: Sources of recycled shell in bushels and percent change from FY22 to FY23.

Shell Source	2022-2023	2022-2022	Difference
Restaurants	12688	13228	-4.1%
Public Drop-off Bins	17963	11195	60.5%
Events	4971	4011	23.9%
Public Trailers	975	2881	-66.2%
Caterers	1652	2676	-38.3%
Total	**38248**	**33991**	**12.5%**

2. Greenville County's Renewable Water Resources (ReWa) constructed a 20X20 public drop-off bin that is more accessible to the public (Fig. 1). Materials and labor to construct this bin were provided by ReWa. Upgrade of the 6-Mile Road public-drop off in the Town of Mt Pleasant was completed. The reconstruction of the Marine Resources Division campus bin at Ft. Johnson is to be completed before October 1, 2023. West Ashley's new public-drop off will be in the Rogue Motion parking lot off of Hwy 61, Charleston. Horry County Solid Waste Authority (SWA) will construct a bin and host a quarantine site at the Conway SWA facility. New public drop-off bins that are pending approval are as follows: (1) Cross Island Boat Landing bin in Beaufort, (2) Pigeon Point Boat Landing bin in the City of Beaufort, and (3) Veterans Terminal Bin in North Charleston. The CCA has agreed to supply the materials for all new public drop-off bins.

Figure 1: Upgraded public drop-off bin located in Greenville, SC Renewable Water Resources Facility

3. Ten new restaurants joined the Charleston shell recycling route including: Bar George, Belle Station, Coast Bar and Grill, Husk, Hymans, Island 71, Kingstide, Mainland Container Bar, Pelicans Nest, and The Quinte. Johnson Creek Tavern joined Beaufort's recycling efforts. The Shell Recycling and Planting program now collects shell from 72 restaurants, 60 of which are active weekly contributors in the Charleston area. A hydraulic can lift attached to a recycling trailer (Fig. 2) is used to service Charleston area restaurants. Educational presentations and partner recognition are continually being offered to partner restaurants to raise awareness within the restaurant community and increase recycling totals.

Figure 2: The restaurant can lift trailer, donated by CCA, gives DNR the ability to recycle shell from restaurants and smaller venues.

4. The volunteer recycling programs in Charleston, Beaufort and Greenville have donated over 600 hours of time to recycle a total of 1795 bushels of oyster shells valued at over $8,400.60. The volunteer recycling program in Greenville County was placed on hold after September 2022 due to some logistical issues. A total of 40.5 hours were donated to collect 149 bushels before the hold was placed. The newly constructed, more accessible public drop-off bin will support a sustainable volunteer program for the area. A total of 600 bushels were collected for FY21. Plans to reestablish the program are in progress. In Charleston, volunteers donated roughly 90 hours of time to collect 101.25 bushels from eight different restaurants and multiple seasonal roasts. In Beaufort, volunteers donated roughly 400 hours of time to collect nearly 1050 bushels of oysters from nine different restaurants. Moving forward, any Bluffton area restaurants will be picked up by I2Recycling through the Outside Foundation's shell recycling efforts (more information below).

   The Outside Foundation received multiple funding sources to continue shell recycling efforts in the Hilton Head area and to expand shell recyling efforts to the Bluffton area restaurants. I2Recycle, a private waste-management company, currently recycles from 20 restaurants on a weekly basis and has diverted more than 150+ tons of shell from the local landfill. The shell is taken to the Honey Horn public drop-off bin, bagged by volunteers, and deployed on the shoreline in local waters in partnership with SCDNR's SCORE program. A total of 1850 bags were made by 263 volunteers in FY23. The Outside Foundation is looking to become a statewide model program for cost effective management of shoreline erosion and maintenance of fisheries habitat through the cooperative efforts of the private section with regional, state, and local governments.

An Oyster Shell Recycling Co-op headed by Dead Dog Saloon in Murrels Inlet continues to maintain their partnerships with seven other local restaurants including Bovine's, Bubbas Dockside, Claw House, Creek Rats, 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. Plans to develop a volunteer-led shell recycling program for the area are in discussion. More easily accessible public drop-off bins are a necessary for a sustainable volunteer program in the area, and communications are in progress to address this issue.

Shell recycling efforts were highlighted in 12 press releases including: interviews with The State (Columbia, SC), The Charleston Post and Courier (Charleston, SC), WRNN News (Horry, SC), and several other online and television media outlets. Staff participated in a podcast with journalists from "Good Beer Hunting (dot) com" about conservation, sustainability, and the role of oysters on the coastal ecosystem and beyond. Additionally, Mayor Tecklenburg of Charleston, SC officially proclaimed November 22nd as Oyster Recycling Day in Charleston (Figure 3).

Figure 3: Mayor Tecklenburg of Charleston, SCDNR Staff, Charleston Waterkeeper staff, Coastal Conservation League staff, and the owner of Toadfish Outfitters during the proclamation announcement.

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. Educational and outreach materials are disseminated to seafood retail locations, oyster roast events, tackle shops, DNR licensing offices, and made available to partnering organizations to raise awareness about the full roast to shoreline process. A Roast Responsibly rack card was created to provide suggestions on hosting a more environmentally conscious event (Fig. 4). Social media platforms managed by SCDNR and program partners were also used to notify the public about how and where to recycle shell and were posted during known times of high oyster consumption such as holidays.

Figure 4: Roast Responsibly rack cards used to raise awareness about the responsibility of hosting oysters roasts and the process of replanting the oyster shell.

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. 9), 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 dining at restaurants that recycle their shells as well as caterers.

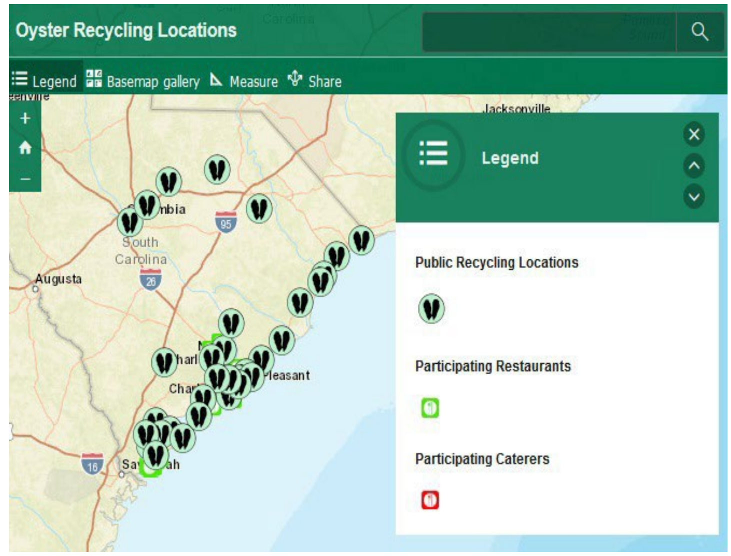

Figure 9: Interactive map showing locations of all public-drop off bins and participating restaurants

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 34,124 bushels of oyster shells were planted on State and Public Shellfish Grounds during the FY23 planting season, creating 10,593 m2 (2.75 acres) of shellfish habitat along approximately 1 mile of shoreline (Table 2 & Fig. 4).

Charleston County was planted using SRFAC funds, recycled shell, and purchased limestone. The Charleston County Clark Sound area was planted by DNR's oyster barge, The Indigo Princess. The Charleston County Seewee Bay area was planted using a contracted barge and monitored by SCDNR. Beaufort County was 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 2: 2023 State and Public Shellfish Ground planting tallies and acreages by county.

Location	Waterbody	Bushels	Acres	Miles
Charleston				
S205_1_23	Clark Sound	1348	0.08	0.04
S205_2_23	Clark Sound	1590	0.12	0.06
S205_3_23	Clark Sound	2112	0.08	0.08
S205_4_23	Clark Sound	2112	0.15	0.07
	S205 Total	**7162**	**0.43**	**0.25**
S272_1_23	Sewee Bay	4890	0.32	0.04
S272_2_23	Sewee Bay	990	0.05	0.02
S272_3_23	Sewee Bay	990	0.04	0.03

S272_4_23	Sewee Bay	2992	0.12	0.03
	S272 Total	**9862**	**0.53**	**0.12**
	Charleston Total	**17024**	**0.96**	**0.37**
Beaufort				
S068_1_23	Broad River	4000	0.43	0.07
S100_1_23	Trenchards Inlet	4100	0.31	0.07
S105_1_23	Harbor River	3000	0.21	0.05
S117_1_23	Distant Island Creek	2000	0.3	0.07
S117_2_23	Distant Island Creek	1000	0.18	0.04
	S117 Total	**3000**	**0.484**	**0.11**
S118_1_23	Wallace Creek	1000	0.13	0.06
S090_1_23	Beaufort River	2000	0.23	0.08
	Beaufort Total	**17100**	**1.794**	**0.44**
Grand Total		**34124**	**3**	**1**

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

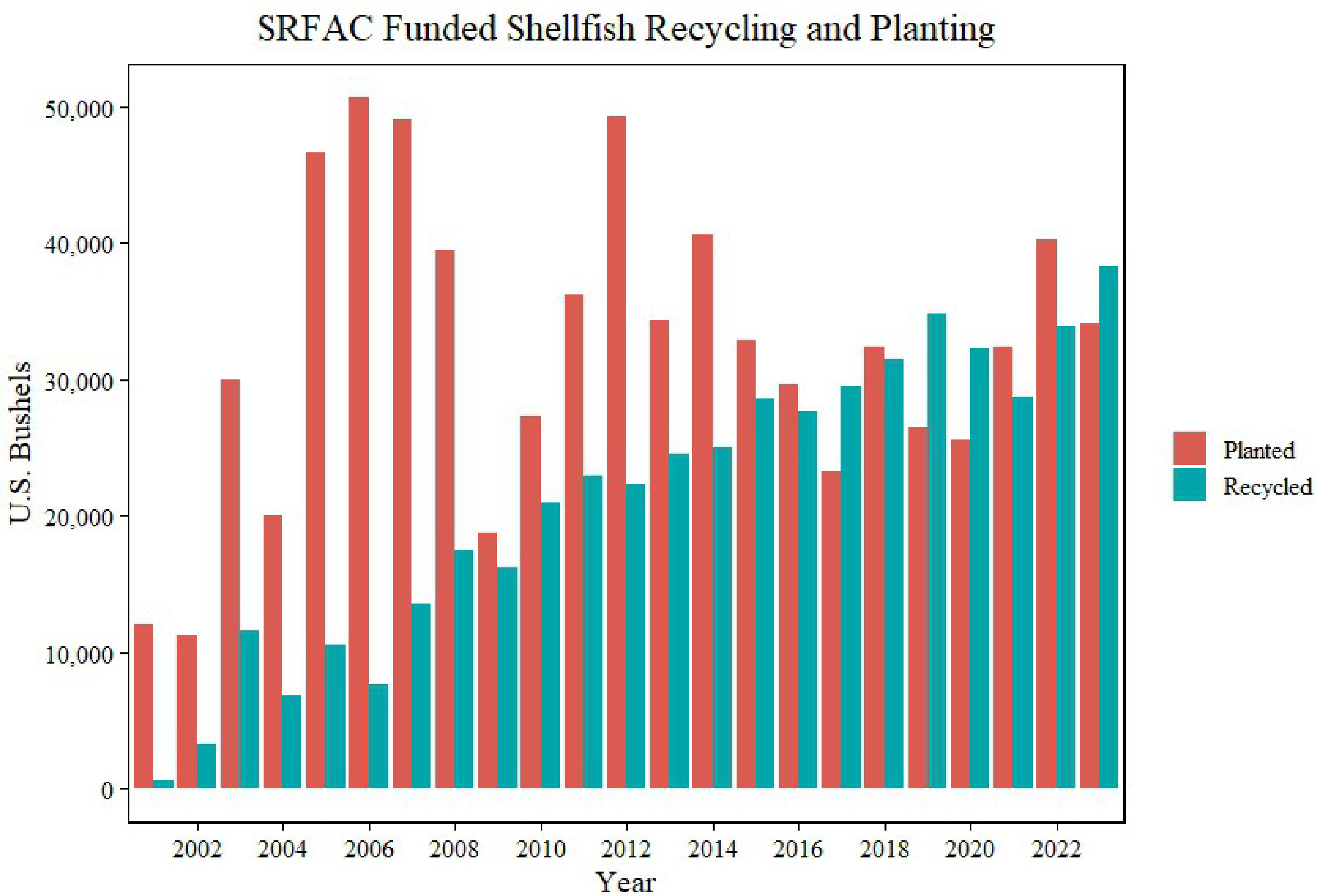

Figure 4: Histogram showing amounts of shell in bushels recycled and planted during FY23.

8. **3-Year Assessment (2022 assessments of sites planted in 2019)**: Twenty beds originally planted in 2019 were assessed to determine reef development success. Data from the remaining seven beds originally planted in 2019 was either corrupted or not taken. The beds monitored were assessed for footprint retention, quality of oysters, quantity and size of oysters, and coverage of the oyster bed within the footprint. Pre-planting, post-planting, 1-yr and 3-yr photographs were taken to document growth over time. Expected footprint retention on three-year-old large-scale planting sites on shellfish grounds is 70% based on historical data. Most sites increased in footprint. One site (Harbor River S105_1_19) had a 386% increase of footprint from the initial planting. This is a drastic increase in footprint retention and is suspected to be inaccurate most likely due to planting boundary poles being removed prior to monitoring and/or previously established wild oyster growth was included in the footprint walked. The Shellfish Management Section is implementing the use of ArcGIS mapping to increase data accuracy and efficiency. Using a composite scale including all qualitative metrics listed previously, eleven of the twenty sites assessed had

an overall “Average” success rating, four were categorized as “Good”, and six were “Marginal”, (Fig. 6).

Table 3: Site information, planting details and qualitative assessment data taken in 2023 of 3-yr sites planted in 2019.

Site slope/creek width	Completion Date	Est. US Bu. by OFM	Shell Type	Initial Footprint (m	Current Footprint (m^2)	Increase or Decrease	Recruit-ment	Date Assessed	Quantity of oysters	Quality of oysters	Size of oysters	Coverage of bed	Strata	Overall	%Vert
Charleston															
S205_1_19	6/3/2019	542.5	SC/G	220.5			1307								
S206E_1_19	6/21/2019	542.5	SC/G	215			1107								
S206E_2_19	6/19/2019	2135	SC/G	690											
S206W_1_19	6/19/2019	2100	SC/G	575			2408								
Lower Hamlin, Swinton Creek															
S251_1_19	6/3/2019	1275	SC/G	51.4	18.7	-32.7		11/7/2022	1	4	3	1	M	2.25	10
S251_2_19	6/11/2019	225	SC/G		12.5			11/7/2022	1	3	3	1	M	2	10
S251_3_19 (Management)	6/11/2019	400	SC/G	356.1	232.2	-123.9		11/7/2022	3	3	3	3	C	3	60
S251_4_19 (Management)	6/11/2019	225	SC/G	275.2	590.3	315.1		11/7/2022	3	4	2	2	C	2.75	40
S255_1_19	6/10/2019	1500	SC/G	849.8	1572.4	722.6		11/7/2022	4	5	4	3	C	4	50
Leadenwah Creek/Adams Creek															
S182_1_19	7/24/2019	1645	SC/G	420	402.7	-17.3	2111	11/1/2022	3.5	4	4	3	M/C	3.625	0
S182_2_19	7/23/2019	788	SC/G	600	102	-498	1060	11/1/2022							
S182_3_19	7/23/2019	263	SC/G		501.1			11/1/2022	2.5	4	3	2.5	C/G	3	40
S187_1_19	7/27/2019	1575	SC/G	420	940.3	520.3		11/1/2022	1.5	2.5	3	2	M/C	2.25	25
S187_2_19	7/27/2019	1565	SC/G	600				11/1/2022							
Beaufort															
Trenchards Inlet															
S100_1_19	8/5/2019	2014	G	943.7	2060	1116.3	3308	9/26/2022	5	3	3	4	F1/C	3.75	50
S100_2_19	8/6/2019	2014	G	1422.1	1650	227.9	3900	9/26/2022	4	4	5	4	F1	4.25	80
Station Creek															
R089_1_19	8/7/2019	260	G	187.8	420	232.2	1788	9/26/2022	3	3	3	1	C	2.5	40
R089_2_19	8/7/2019	1007	G	540.7	1280	739.3	900	9/26/2022	4	4	3	3	F1	3.5	50
Harbor River															
S105_1_19	8/14/2019	4482	G	1895.6	9218.5	7322.9	2508	10/20/2022	3	4	3.5	3	C	3.375	80
Georgetown															
Brookgreen (Oaks Creek)															
S354_1_19	7/10/2019	1080	G	451.6	690.4	238.8	2489	10/25/2022	4	4.5	3	4	C	3.875	80
Oaks Creek															
S357_1_19	7/3/2019	1700	G	896.8	1251.3	354.5	1135	10/25/2022	5	5	3.5	4	C	4.375	85
S357_2_19	6/28/2019	930	G	427.8	2142.6	1714.8	2887	10/25/2022	4	5	3.5	3	C	3.875	55
Woodland Cut															
S358_1_19	7/9/2019	300	G	155.4	110.2	-45.2		10/24/2022	3	5	4	2	C	3.5	50
S358_2_19	7/11/2019	1320	G	383.2	588.8	205.6	1349	10/24/2022	1.5	3	2	1.5	M	2	25
S358_3_19	7/11/2019	450	G	229.5	189.3	-40.2	829	10/24/2022	3	4	3	2.5	C	3.125	40
S358_4_19	7/6/2019	1100	G	416	1262.9	846.9	1964	10/24/2022	4	4	3	5	C	4	40
S358_5_19	7/8/2019	1080	G	330.2	1080.1	749.9	1068	10/24/2022	4	3	4	3	C	3.5	60

*Qualitative Rating from 1-5: 1 Poorest, 5 Best

Footprint Increase	1-poor	2-marginal	3-Average	4-Good	5- Excellent
Footprint Decrease	Less than 450	450-900	900-1400	1400-1700	> 1700

1-Year Assessment (2022 assessments of sites planted in 2021): Twelve beds planted in 2021 were sampled and spat measured with digital calipers to determine juvenile (Fig. 7) recruitment rates. Two beds were not sampled (S274_1_21 & S274_3_21) and four beds had incomplete data and could not be included in the Mean Oyster Recruitment Densities assessment. Of the twelve, six beds had "Poor" recruitment, three had "Marginal" recruitment, and three had "Average" recruitment (Fig. 6).

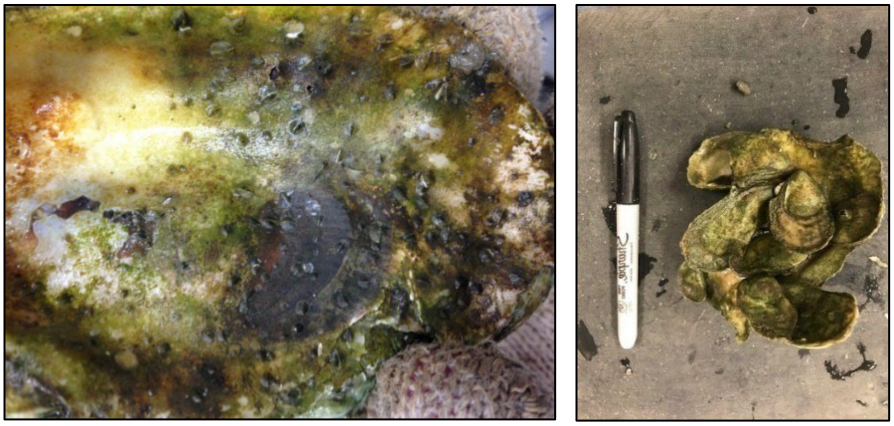

Figure 5: Juvenile oysters, or "spat" after settlement on recycled shell within hours (A) and 1 year post planting.

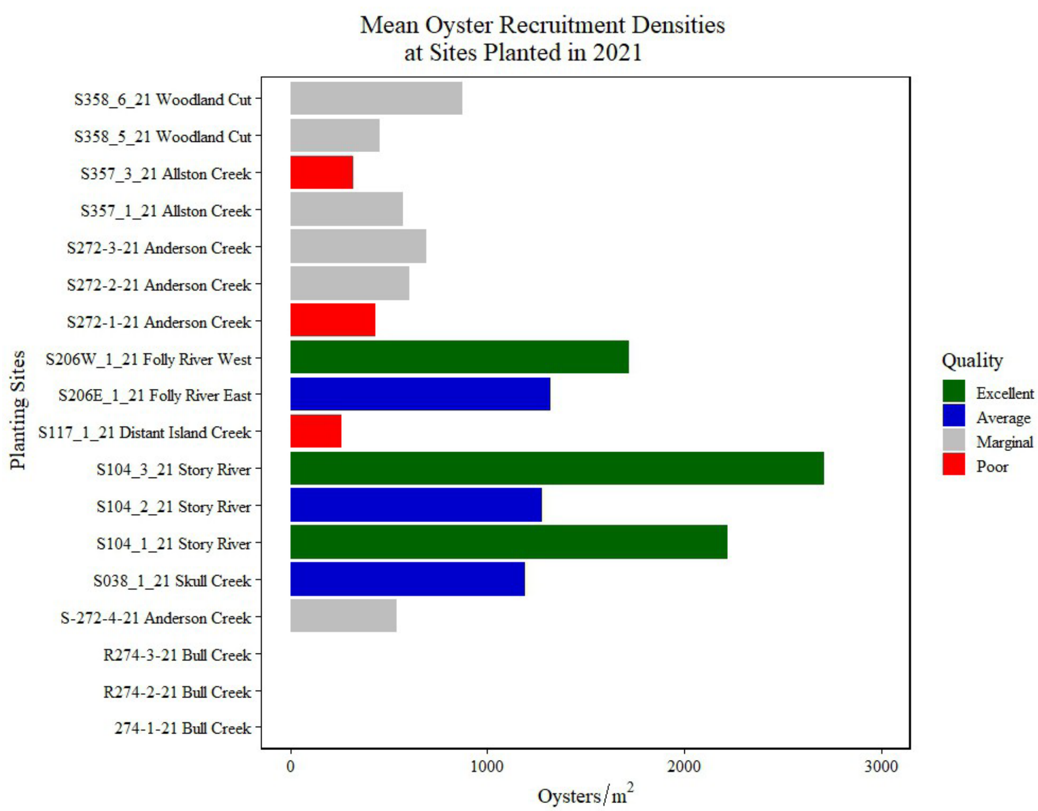

Figure 6: Recruitment densities for seven 1-yr sites planted in 2021 and measured in 2022 Bull Creek sites were not sampled/measured.

9&10. In FY23, maps of recreational shellfish harvesting grounds were made available on the Internet. These maps are updated annually. Recreational shellfish maps (Fig. 7) 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 FY23, 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. 8). 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.

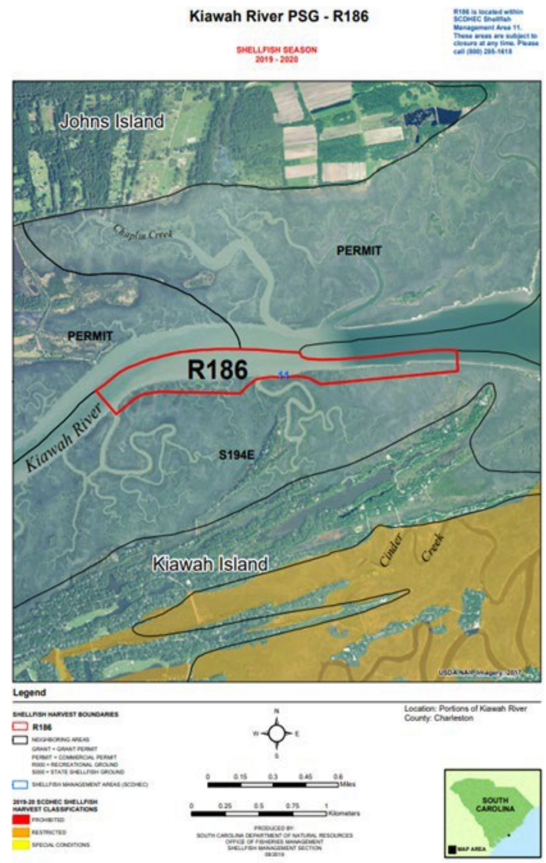

Figure 7: Example of PDF and paper maps of recreational shellfish grounds available upon online or by mail upon request

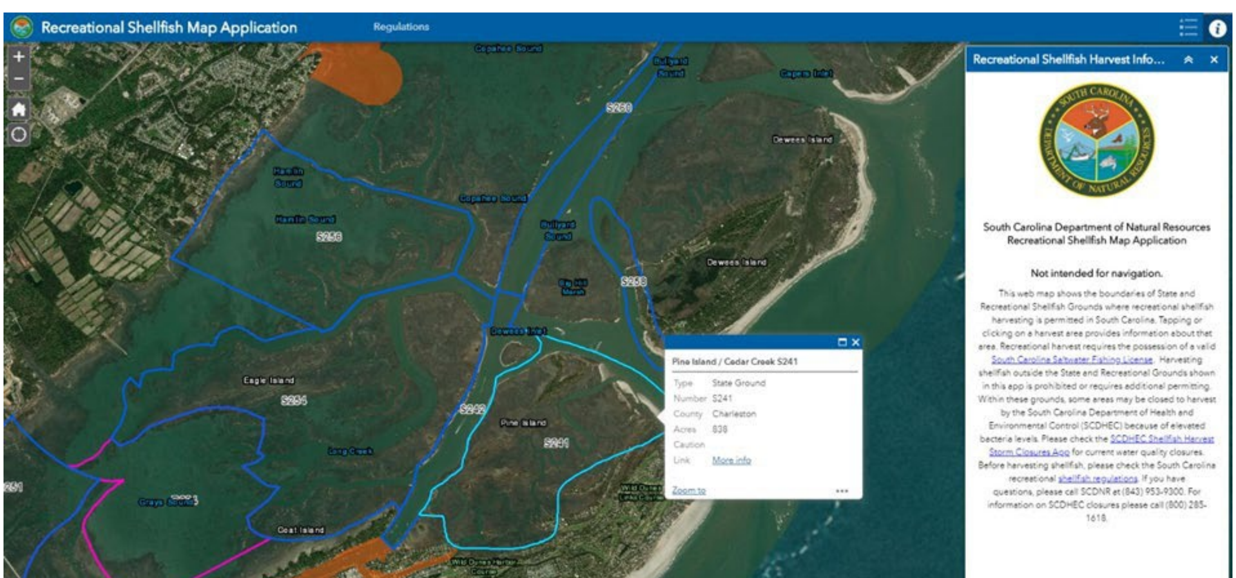

Figure 8: Interactive map available for viewing from any internet-enabled device

11. The assessment of shellfish ground boundary signs that need to be replaced is ongoing. We are reassessing areas that need sign replacement and/or repair due to lost or damaged signs. We are continually collecting GPS points for all new signs as well as existing signs to create a GIS map layer of all the collective shellfish boundary signs in the state.

8: Crustacean Research and Fishery-Independent Monitoring

Reporting Period: July 1, 2022 to June 30, 2023

Program PI: Dr. Peter Kingsley-Smith, Senior Marine Scientist
Shellfish Research Section (SRS),
Marine Resources Research Institute (MRRI)

Program Co-PIs: Dr. Michael Kendrick, SCDNR MRRI Associate Marine Scientist,
Dr. Daniel Sasson, SCDNR MRRI Assistant Marine Scientist &
Graham Wagner, SCDNR MRRI Wildlife Biologist III,
Crustacean Research and Monitoring Section (CRMS)

Executive summary:

Sampling for this program focuses on the collection of recreationally-important crustacean species at critical life stages within estuarine waters. Focal species are white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), and blue crabs (*Callinectes sapidus*). Sampling efforts and subsequent analyses facilitate the timely analysis of the development of crustacean species and are regularly used by the SCDNR Office of Fisheries Management to inform management decisions. Staff have documented trends in these focal species, with abundances of both white and brown shrimp appearing near long-term averages, and blue crab abundance values continuing to be lower than average. Due to the lack of availability of the R/V Silver Crescent from Oct 2022 – March 2023 (see below for details), assessment of current trends is more limited than in previous years.

Sampling for this program 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 six stations in and around the Charleston Harbor estuary and at 20 additional stations from the Wadmalaw River 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.

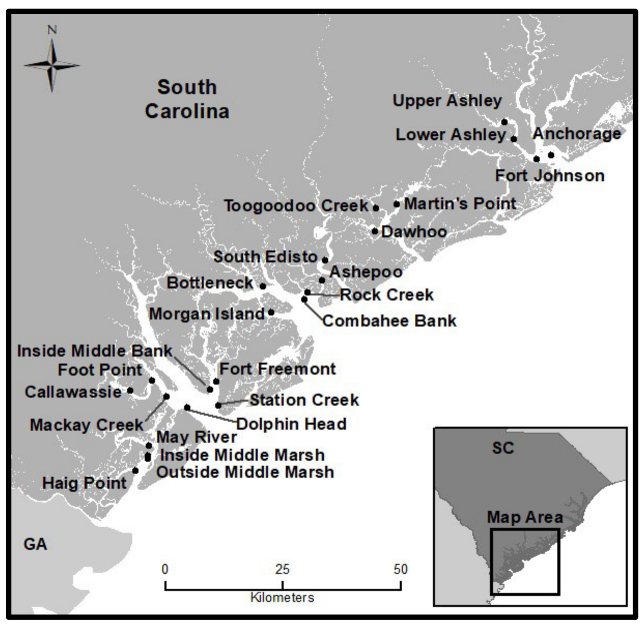

Figure 1. Estuarine trawl survey sampling stations.

Not all planned estuarine trawl survey dates were successfully completed during the past year due to the lack of availability of the R/V *Silver Crescent* from October 2022 – March 2023 due to damage sustained by the vessel from Hurricane Ian while moored at Fort Johnson. All other sampling events during the Program Period were completed.

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 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 remain in tidal creeks before migrating into larger water bodies with juvenile brown shrimp 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 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.

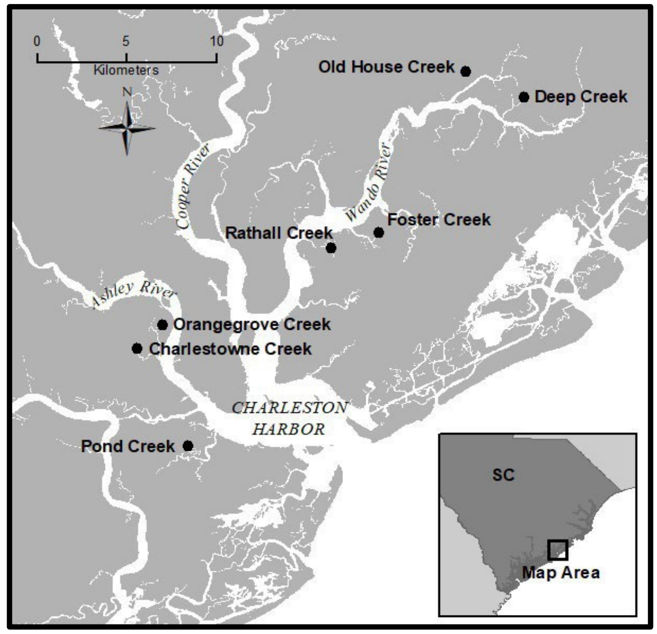

Figure 2. Creek Trawl survey sampling stations.

During the current reporting period, sampling was successfully completed in all months.

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

Due to the R/V *Silver Crescent* not being available from October 2022 – March 2023, additional crab pot sampling was added to the 2023 field schedule for this program. This included additional sampling in December and counts of commercial crab pots in these areas.

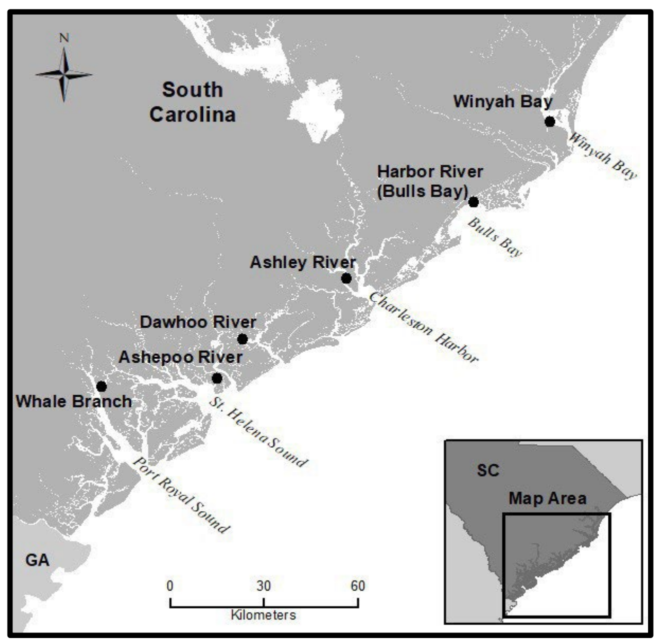

Figure 3. Statewide fall crab pot survey sampling stations.

PROGRAM FINDINGS FOR FY2023

White shrimp (*Penaeus setiferus*) abundance patterns.

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. Additionally, white shrimp abundance was much higher than the long-term mean in August and September 2022 (*Figure 4*). Overall, abundances were generally above or close to the long-term mean for months sampled, such that white shrimp were readily available for recreational harvest. Due to storm-induced damage to the R/V *Silver Crescent*, and delays to subsequent repairs, the monthly Estuarine Trawl Survey was not conducted from October 2022 through March 2023 such that data are not available for those months.

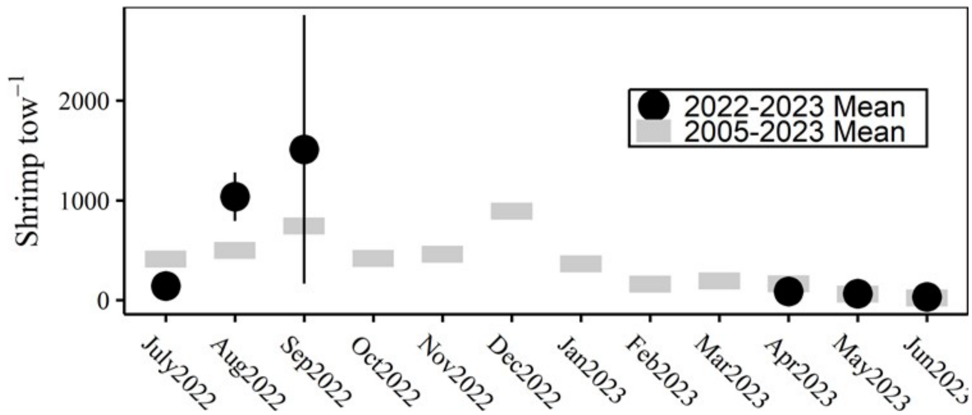

Figure 4: Monthly white shrimp abundance (mean ± S.E.) from the Estuarine Trawl Survey

White shrimp abundance for the creek trawl survey was generally below the time-series mean **(Figure 5A & C)** except for September **(Figure 5B)** when values were above the time-series mean.

Although the catch of white shrimp in the summer (May – August, **Figure 5A**) of 2022 in the creek trawl survey was below the long-term mean, the presence of 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 2022 (**Figure 5A-C**).

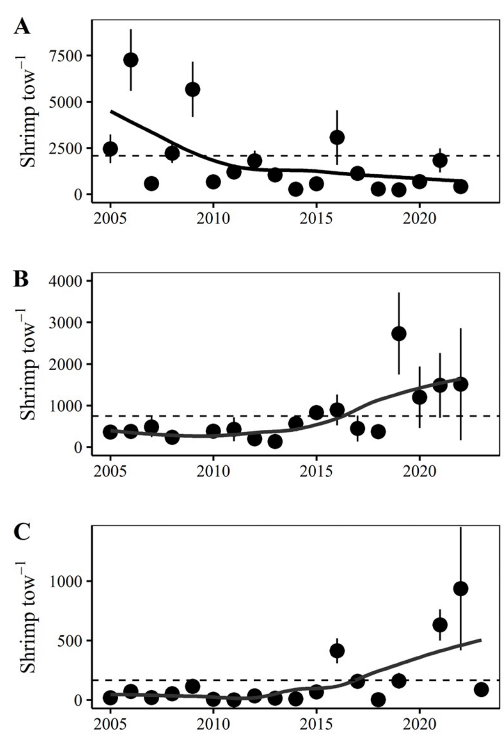

Figure 5: White shrimp abundance (mean ± S.E.) from May – August (A), September (B), and April (C) surveys. Samples collected from May – August are from the creek trawl survey, while samples collected in September and April are from the estuarine trawl survey. Dashed lines represent long-term means and solid lines represent smoothed trends.

Brown shrimp (*Penaeus aztecus*) abundance patterns.

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 2022, brown shrimp catches in the creek trawl survey **(Figure 6A)** and the estuarine trawl survey **(Figure 6B)** were near or slightly below the long-term mean.

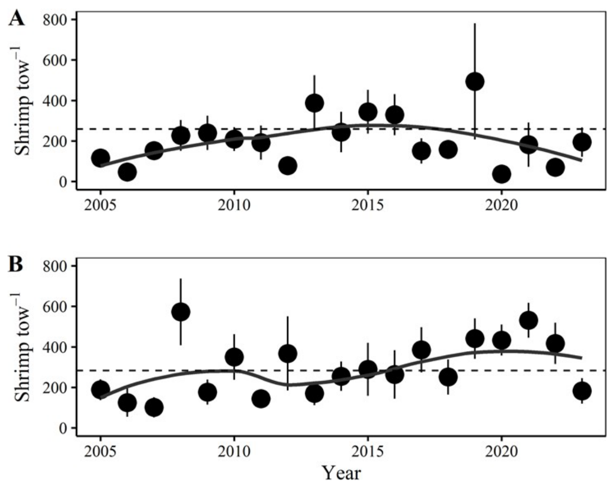

Figure 6: Trends in summer (May-July) brown shrimp abundance (mean ± S.E.) from creek trawl (A) and estuarine trawl (B) surveys. Dashed lines represent long-term means and solid lines represent smoothed trends.

Black gill prevalence trends

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 the fall (August-September) was similar to the long-term mean for both brown shrimp (*left*) and white shrimp **(***right,* **Figure 7).**

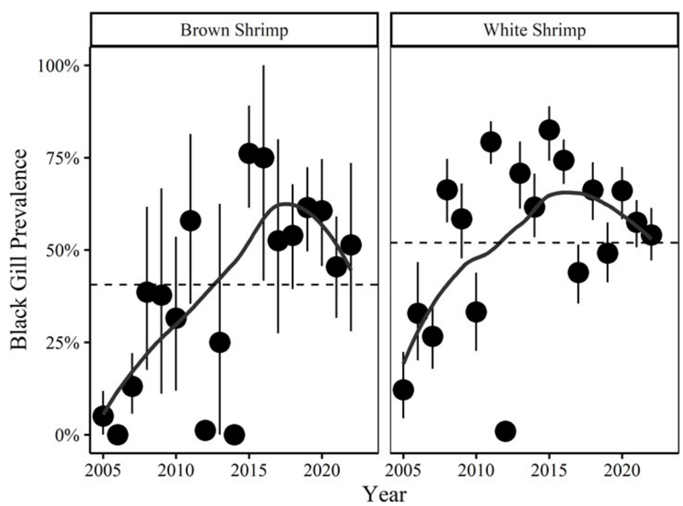

Figure 7: Trends in fall (August-September) 2022 black gill prevalence (mean ± S.E.) in brown shrimp and white shrimp collected from the estuarine trawl survey. Dashed lines represent long-term means and solid lines represent smoothed trends.

Blue crab (*Callinectes sapidus*) abundance patterns.

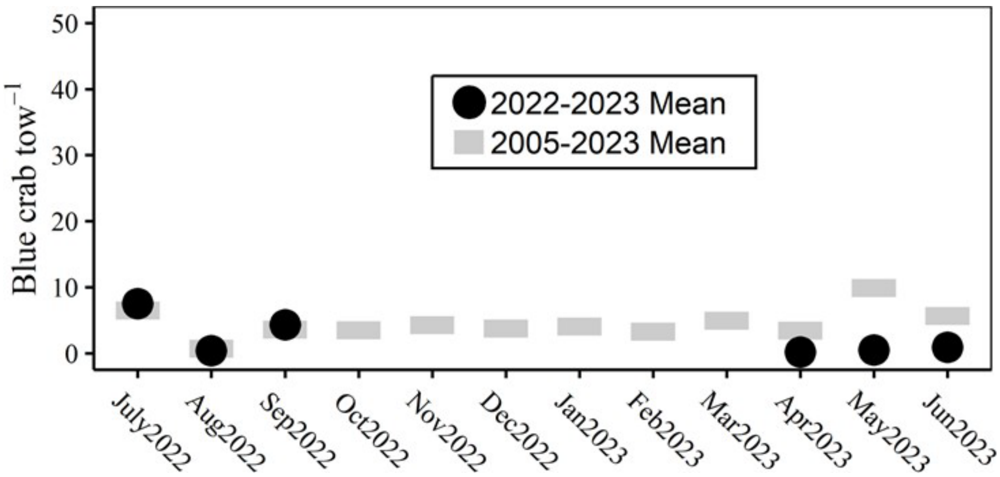

Figure 8. Monthly blue crab abundance (mean ± S.E.) from the estuarine trawl survey

Blue crab abundances in catches from the estuarine trawl survey were near the long-term mean from July 2022 through September 2022 (**Figure 8**). Due to storm-induced damage to the R/V *Silver Crescent*, and delays to subsequent repairs, the monthly Estuarine Trawl Survey was not conducted from October 2022 through March 2023 such that data are not available for those months. From April 2023 to June 2023 abundance was below the long-term mean **(Figure 8)**.

When separated by size, abundances of both legal-sized (≥5" carapace width, CW) and sublegal-sized (<5" carapace width, CW) blue crab were well below the long-term mean **(Figure 9)**.

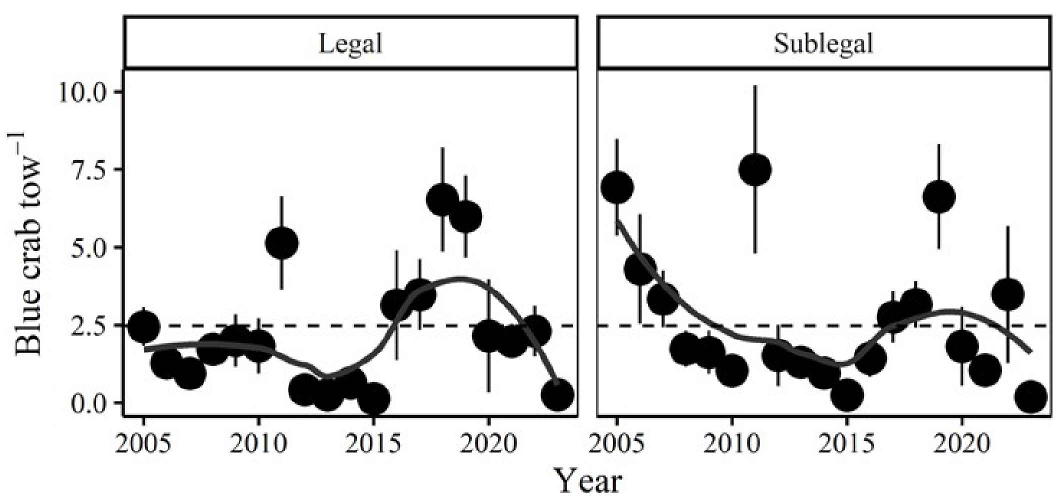

Figure 9. Blue crab abundance (mean ± S.E.) for legal- (≥5" CW) and sublegal- (<5" CW) sized blue crabs collected from April – September as part of the estuarine trawl survey. Dashed lines represent long-term means and solid lines represent smoothed trends.

Blue crab abundance in the creek trawl survey in the summer (May-June) of 2023 was also below the long-term mean (1995-2022; **Figure 10)**.

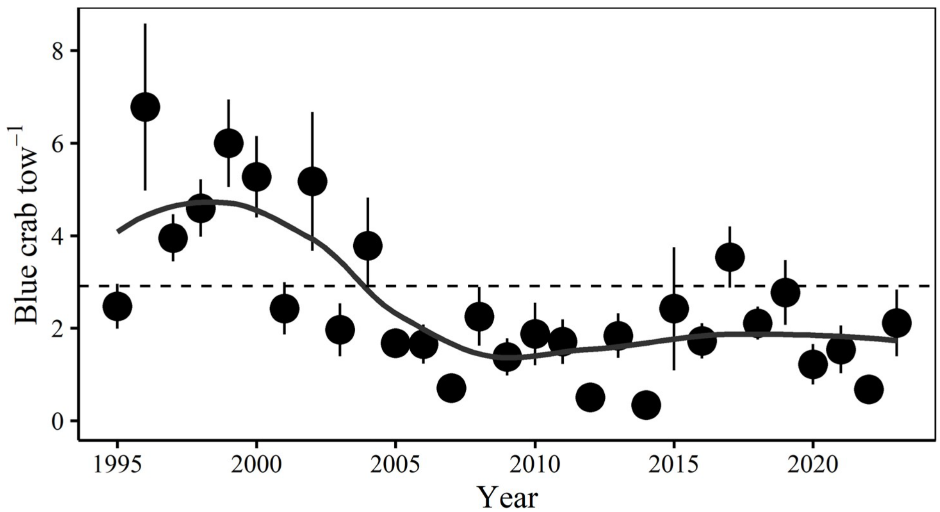

Figure 10. Summer (May-June) blue crab abundance (mean ± S.E.) from the creek trawl survey. Dashed line represents the long-term mean and the solid line represents the smoothed trend.

Blue crab abundance in the 2022 fall crab pot survey was well below the long-term mean (1995-2021; **Figure 11**). No clear pattern was detected in the number of commercial crab pots counted in different habitat types (lower estuary vs. upper estuary waters) or during different months of sampling (i.e., October, November, and December).

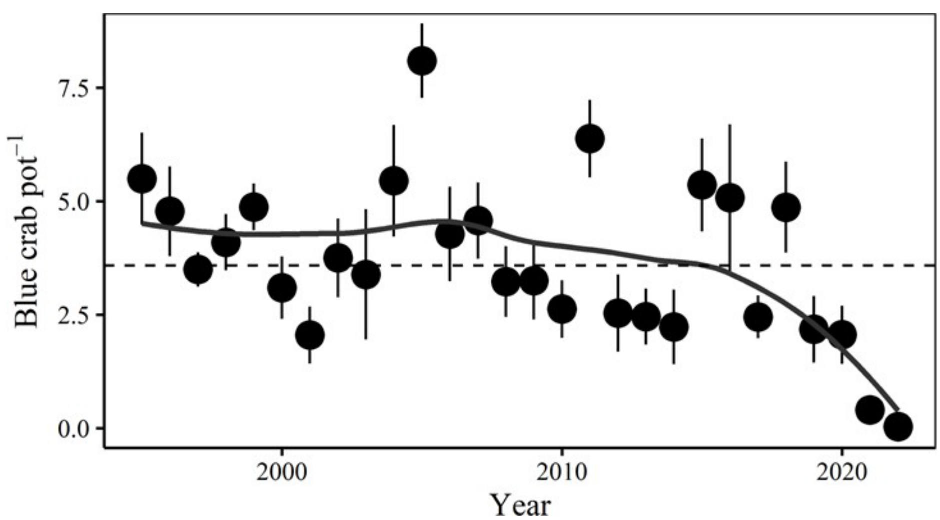

Figure 11. Fall (October-November) blue crab abundance (mean ± S.E.) from the statewide crab pot survey. Dashed line represents the long-term mean and the solid line represents the smoothed trend.

Blue crab symbiont study

As part of an effort to understand the role of diseases and parasites in determining interannual variability in blue crab (*Callinectes sapidus*) abundance, blue crab specimens were haphazardly collected monthly from the greater Charleston harbor estuary during the estuarine trawl survey, creek trawl survey, or fall crab pot survey and assessed for the presence of symbionts (including parasites as well as non-parasitic symbionts such as commensal organisms). A few blue crab specimens were also collected from SCDNR's Inshore Fisheries Section's trammel net survey.

A total of 346 individual blue crabs were collected spanning different seasons, sizes, life stages (juvenile and adult) and sexes (males and females). Individual crabs had samples of their hemolymph ('blood') retained for analysis to detect the presence of the parasitic dinoflagellate *Hematodinium*. Of the crabs collected, 139 were dissected to look for additional symbionts. Blue crabs used for dissections were kept alive and processed within 5 days of sampling. Specimens were visually assessed for external symbionts followed by dissections to allow for organ specific analysis of symbiont presence. If symbionts were observed, photos were taken, and the symbiont was preserved in 95% ethanol for archiving. All organisms were identified to the lowest practical taxonomic level.

Eight different symbiont groups were identified, including plagiorchiid trematodes, haplosporidians, tetraphyllid cestodes, rhabditid nematodes, ciliates, and nemertean worms (Table 1). The most prevalent parasite found during the study was the trematode *Microphallus basodactylus,* a flatworm parasite that encysts within blue crabs. This parasite occurred in 93% of all crabs and had the highest prevalence in the hepatopancreas. The haplosporidian *Urosporidian crescens* was also highly abundant, occurring as a hyperparasite of *M. basodactylus* in 41% of all crab specimens. When this haplosporidian occurs in high abundance it is the cause of pepper-spot disease.

Table 1. Overall and organ-specific symbiont prevalences across all blue crab specimens.

Order	Parasite	Overall	Gill	Hepatopancreas	Heart	Ganglion	Musculature
Plagiorchiida	*Microphallus basodactylus*	**93%**	10%	**85%**	33%	85%	N/A
Haplosporidia	*Urosporidian crescens**	41%	>1%	**34%**	4%	29%	12%
Sessilida	*Lagenophrys callinectes*	26%	**26%**	0%	0%	0%	N/A
Sessilida	Other**	42%	**42%**	0%	0%	0%	N/A
Tetraphyllidea	*Tetraphyllidean* spp.	3%	0%	0%	0%	**3%**	N/A
Rhabditida	*Hysterothylacium reliquens*	3%	1%	**2%**	0%	0%	N/A
Scalpellomorpha	*Octolasmis lowei*	1%	**1%**	0%	0%	0%	N/A
Monostilifera	*Carcinonemertes* spp.	1%	**1%**	0%	0%	0%	N/A

* *Urosporidian crescens* is a hyperparasite of the *Microphallus basodactylus.*
** Genera *Epistylis*, *Zoothamnium*, and *Vorticella*.

9: Marine Recreational Angler Conservation and Education Program

Program PIs: Matt Perkinson and Olivia Bueno

Reporting Period: July 1, 2022 to June 30, 2023

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 82 vessel-based education programs and 142 land-based programs to 8,766 students from grades K-12. Staff spent 18,832 contact hours with students and teachers. Four teacher workshops were held with a total of 52 teachers attending.
- Staff, along with Southwick Associates, conducted a web-based survey of recreational crabbers, collecting information on fishing habits, harvest, and preference for specific management options with over 9,000 respondents. Results from the survey were included in an omnibus report on blue crabs in South Carolina as requested by the South Carolina General Assembly. A targeted follow-up survey of those who indicated they had crabbed in 2022 collected additional information on the recreational sector.
- Staff continued a public outreach campaign aimed at addressing long term declines in the red drum population in South Carolina by focusing on best fishing practices and proper handling techniques as well as stressing the importance of adult spawning fish to the health of the population. Efforts in this campaign included social media posts, presentations to angling groups, a fish handling primer distributed to tackle shops (figure x), cover story in South Carolina wildlife, and a series of charter guide meetings (described below).
- Staff organized a series of "Charter Guide Summits" designed to provide information and gather feedback from the for-hire recreational fishing industry. Three meetings were held (Georgetown, Charleston, Beaufort Counties) with approximately 100 attendees. Additional meetings are planned for 2024.
- The scope of programs and number of anglers reached continued to increase during 2022-2023. 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 and Outdoor Events/Expos: 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	30	398	709.50
Pier/Dock Outreach Program	54	1800	184
Fishing Tournaments/Rodeos	4	313	130.50
Fishing Events	6	244	169
Outdoor Events/Expos	6	4,000 (est.)	139
Total	1	6, 755	1,332

- Virtual and in-person training events for Certified Fishing Instructors were held in coastal South Carolina, resulting in an additional 27 instructors. 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, Botany Bay WMA, Folly Beach Pier, Edisto Learning Center, City of Charleston, and various private organizations. Saltwater fishing outreach remains inclusive by hosting clinics specifically for minorities, women, military/veterans, mobility-impaired, and the bilingual community. A volunteer appreciation luncheon for fishing instructors and fish taggers was held in March.
- A total of 609 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 3,163 fish from a variety of species. Information was received from 630 recaptured fish and of those, 86 percent were released. Topics of interest to the recreational angling community were provided via the MGFTP newsletter, with a distribution to over 1,700 individuals.
- Fishing outreach staff aided tournament organizers from the Murrells Inlet Rotary Club, the Grand Strand Saltwater Anglers Association, and the Murrells Inlet Shillelagh Club in

holding live-release flounder fishing tournaments. Over 150 flounder were measured, weighed, tagged, and released during the three events.

- Staff participated in regional and national workgroups to promote angler engagement in scientific data collection and the increased use of descending devices in the offshore snapper-grouper fishery.
- Public information material was distributed through the Coastal Information Distribution System (CIDS). Seven days were spent delivering approximately 115,000 copies of printed material to 132 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. Vendors were asked to display a flyer describing best fishing practices for catch and release.

Item	Number Distributed
SW Fish Rulers Stickers	50,000
Rules and Regulations	30,000
Fish ID Charts	20,000
Guide to SW Fishes	4,000
Beginner Guides to SW Fishing	3,000
Crab Ruler Stickers	8,000
Total	**115,000**

Publications

Susanna Musick, Lewis Gillingham, Matt Perkinson, and Thom Teears. Virginia Game Fish Tagging Program: A Nontraditional Data Source for Fisheries Management. Transactions of the American Fisheries Society. 152 (4): 381-512.

Figure 1. Rich Barretto, a Certified Fishing Instructor, helps a mobility-impaired angler at Edisto Beach State Park.

Figure 2. Instructor Brad Schenk teaches a young angler how to properly hold a fish before release.

Figure 3. A youth angler with his first fish, a red drum at a Colonial Lake clinic in Charleston.

Figure 4. Partnering with the South Carolina Department of Veteran's Affairs and the US Marine Corps Recruits Depot, Parris Island to offer saltwater fishing clinics to veterans, military families, and active-duty military. Lima Company at the Marine Depot attended a fishing clinic as a means of decompression.

Figure 5. Certified instructor Charlie West helps a mobility-impaired and cancer treatment patient with fishing.

Figure 6. Matt Perkinson and Joey Coz present red drum data during a regional Charter Guide Summit in Beaufort County.

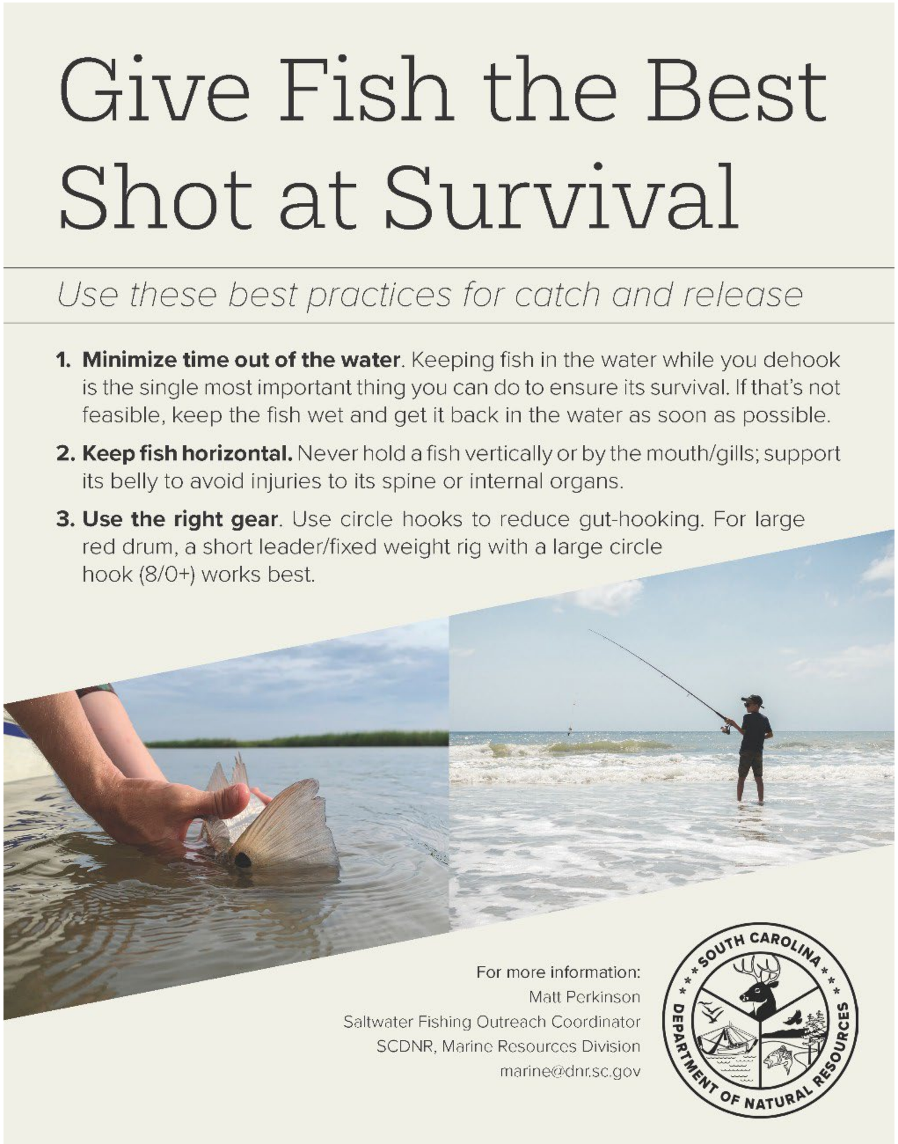

Figure 7. A flyer promoting proper fish handling techniques distributed as part of the Coastal Information Distribution System (CIDS).