THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2019-2020

AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE

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The Condition of South Carolina's Estuarine and Coastal Habitats During 2019-2020

Technical Report

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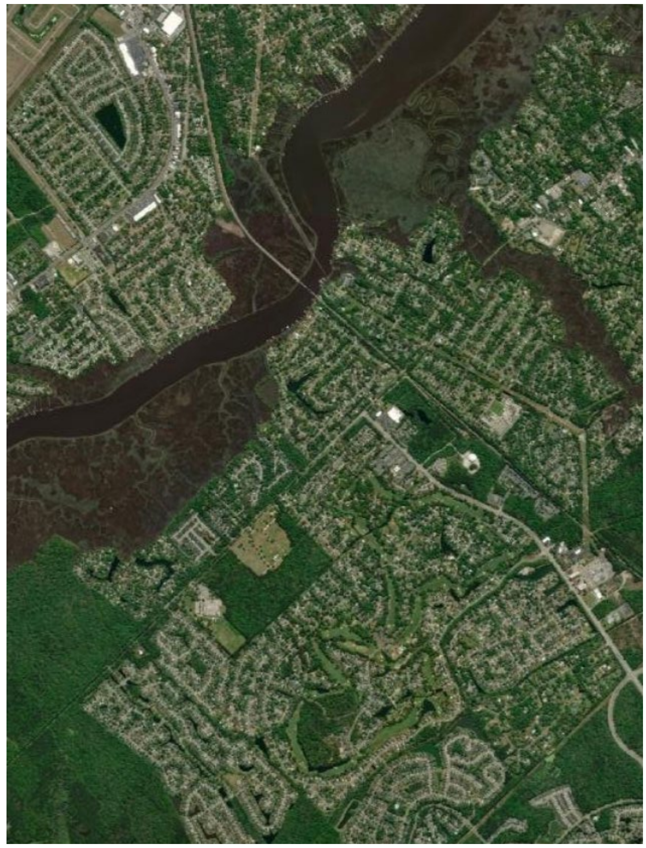
Table of Contents

INTRODUCTION

South Carolina's extensive coastal zone supports an abundance of oysters, shrimp, crabs, and finfish and provides a beautiful setting for residents and tourists to enjoy. In 2019, tourism expenditures in South Carolina's eight coastal counties exceeded $9.8 billion (U.S. Travel Association, 2020). In 2017, the state's coastal recreational and commercial fisheries contributed more than $557 million and $47 million in economic impact, respectively (National Marine Fisheries Service, 2021). A variety of sensitive estuarine areas provide attractive viewscapes while also serving as nursery or primary habitat for important fishery resources. Thus, it is critical to protect South Carolina's coastal habitats from degradation.

As in most coastal states, the population in the coastal counties of South Carolina has been rapidly increasing in recent years. According to the U.S. Census, 1.47 million people were living in South Carolina's eight coastal counties in 2020 (U.S. Census Bureau, 2022), an increase of 20% since 2010. By 2030, this number is expected to increase 27% to 1.86 million people (South Carolina Revenue and Fiscal Affairs Office, 2022). The associated expansion of housing, roads, and commercial and industrial infrastructure, combined with increased recreational utilization of our coastal waters, could result in increased risk for impacts to South Carolina's coastal habitats.

The South Carolina Estuarine and Coastal Assessment Program (SCECAP) was established in 1999 to begin evaluating the overall health of the state's estuarine habitats on a periodic basis using a combination of water quality, sediment quality, and biotic condition measures. This collaborative program involves the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) as the two lead state agencies, as well as the National Oceanic and Atmospheric Administration's National Ocean Service (NOAA/NOS) laboratories located in Charleston



Urban sprawl is one of the primary threats to the quality of South Carolina's estuarine habitats. (Ashley River, South Carolina)

(National Centers for Coastal Ocean Science Hollings Marine Laboratory). SCECAP and the U.S. Environmental Protection Agency's (USEPA) National Coastal Condition Assessment (NCCA) Program partnered on sample and data collection in 2000-2006, 2010, and again in 2020.

SCECAP represents an expansion of ongoing monitoring programs being conducted by both state and federal agencies and ranks among the first in the country to apply a comprehensive, ecosystem-based assessment approach for evaluating coastal habitat condition. While the NCCA Program provides useful information at the national and regional scale through their National Coastal Condition Reports (https://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-reports), many of the thresholds used for the national report are not as appropriate as thresholds developed specifically for South Carolina. Additionally, the SCECAP initiative collects data for parameters that are not collected by NCCA, collects data on a yearly basis, and collects juvenile capture density data for multiple species of finfish which are used in stock assessments.

There are several critical attributes of the SCECAP initiative which set it apart from other ongoing monitoring programs being conducted in South Carolina by SCDHEC (primarily focused on water quality) and SCDNR (primarily focused on fishery stock assessments). These include: (1) sampling stations throughout the state's estuarine habitats using a statistical survey approach that complements both agencies' ongoing programs involving fixed station monitoring networks, (2) using integrated measures of environmental and biological condition that provide a more complete evaluation of overall habitat quality, and (3) monitoring tidal creek habitats in addition to the larger open water bodies that have been traditionally sampled by both agencies. This last component is of particular importance because tidal creek habitats serve as important nursery areas for most of the state's economically valuable species and often represent the first point of entry for runoff from upland areas. Thus, tidal creek systems can provide an early indication of anthropogenic stress (Sanger et al., 1999a, b; Lerberg et al., 2000; Van Dolah et al., 2000; 2002; 2004; 2006; Holland et al., 2004; Sanger et al., 2015).

This technical report is part of a series of bi-annual reports describing the status of South Carolina's estuarine habitats. The 2019-2020 SCECAP report, as well as all reports for previous survey periods, can be obtained from the SCECAP website at http://www.dnr.sc.gov/marine/scecap/. Raw and summarized data from these surveys can be requested by contacting the Principal Investigator (Andrew Tweel; TweelA@dnr.sc.gov).

Long-term monitoring programs such as SCECAP must find a balance between using the same methods and measures for consistency across time, and incorporating new methods and measures as they are developed and proven.

METHODS

SCECAP uses sample collection and processing methods consistent with SCDHEC's water quality monitoring program methods in effect at the time of sample collection (SCDHEC, a-d) and the USEPA's National Coastal Condition Assessment (NCCA) Program (https://www.epa.gov/national-aquatic-resource-surveys/ncca). The sampling and analytical methods used for SCECAP are fully described in the first SCECAP report (Van Dolah et al., 2002). Long-term monitoring programs such as SCECAP must find a balance between using the same methods and measures for consistency across time, while incorporating new methods and measures as they are developed and proven. Some analytical methods used by SCECAP have been modified from the original methods and are fully described by Bergquist et al. (2009) and in this report. The data analysis methodology described in the following sections was consistently applied to data from all SCECAP survey periods.

2.1. Sampling Design

SCECAP sampling stations extend from Little River Inlet at the South Carolina-North Carolina border to the Savannah River at the South Carolina-Georgia border, and from the saltwater-freshwater interface to the mouth of each estuarine drainage basin. New station locations are assigned each year. Half of each year's station locations are randomly placed in tidal creeks (defined as water bodies approximately 10-100 m wide from marsh bank to marsh bank), and the other half are randomly placed in the larger open water bodies that form South Carolina's tidal rivers, bays, and sounds. Station locations within each habitat type are assigned using a Generalized Random Tessellation Stratified spatially balanced survey design (Stevens, 1997; Stevens and Olsen, 1999). From 1999-2006, 50-60 estuarine stations were sampled in South Carolina each year, but a change in funding led to smaller annual sampling efforts beginning in 2007 with a total of 30 stations (15 open water and 15 tidal creek) sampled each year. From 1999 through 2020, a total of 871 stations were sampled. The 60 stations sampled in 2019-2020 are shown in Figure 2.1.1.

Sampling occurs during the summer (late June through early September). This sampling window was chosen because summer temperatures and elevated biological activity can contribute to low dissolved oxygen levels that can be limiting to biota, and many fish and crustacean species of concern utilize the estuary for nursery habitat during the summer months. Most measures of water quality, sediment quality, and biological condition are collected within three hours on either side of low tide.

All data are stored in a relational database and validated using a rigorous quality assurance process. A copy of the Quality Assurance Project Plan is maintained at the SCDNR Marine Resources Research Institute.

2.2. Water Quality Measurements

Time-series measurements of temperature, salinity, dissolved oxygen (DO) and pH are obtained from the near-bottom waters of each station using YSI Model 6920 multiprobes logging at 15 minute intervals for 25 hours to assess conditions over two full tidal cycles, as well as representing both day and night conditions. Both SCDHEC and SCDNR field staff also collected an instantaneous measure of these parameters at several depths (0.3 m

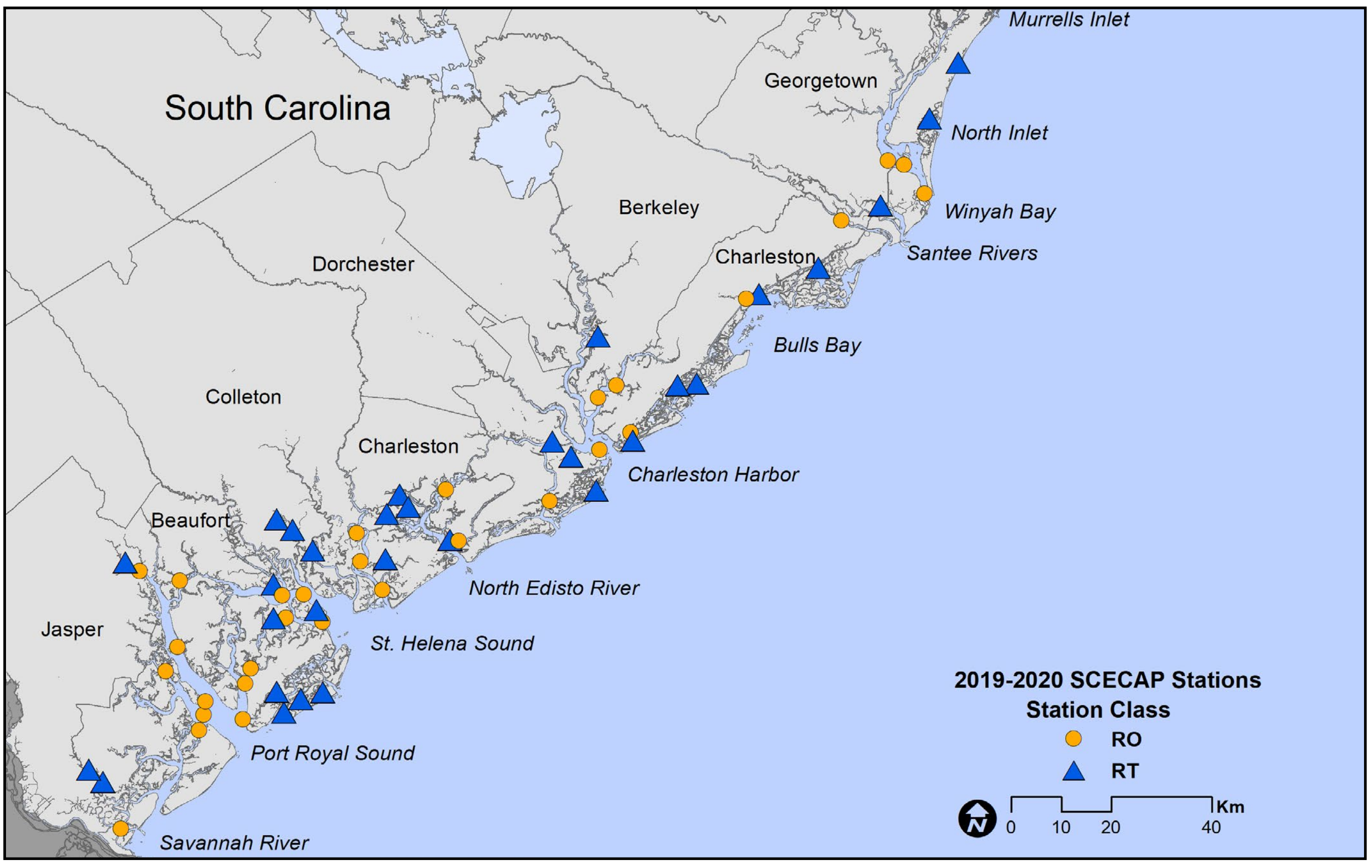
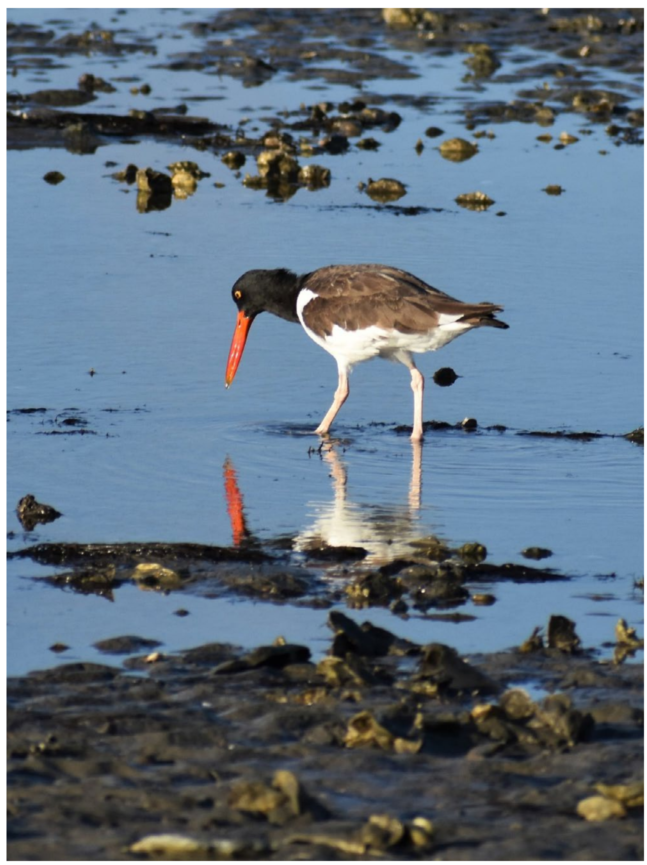


Figure 2.1.1. Locations of stations sampled during 2019 and 2020. RO = open water and RT = tidal creek.

Near-surface water samples are collected to measure concentrations of nutrients, chlorophyll a, and fecal coliform bacteria.

beneath the surface, in the middle of the water column, and 0.3 m above the bottom) during the primary station visit. Other primary water quality measures that are collected from near-surface waters include total nitrogen (TN; sum of nitrate/nitrite and total Kjeldahl nitrogen (TKN)), total phosphorus (TP), chlorophyll *a* (Chl-*a*), and fecal coliform bacteria. Secondary water quality measures are also collected from near-surface waters, including water clarity based on a Secchi disk measurement. Data for the secondary water quality measures are available upon request but are not described in this report because these measures are not included in the SCECAP Water Quality Index (WQI) or have no state water quality standards.

All nutrient and Chl-*a* samples for laboratory analyses are collected by rinsing an intermediate collection vessel three times with station water, inverting and inserting the collection vessel to a depth of 0.3 m, and then filling the collection vessel at that depth. Water for nutrient samples is then poured directly into sample bottles containing an acid preservative. Water for Chl-*a* samples is stored in the original collection vessel. Sample bottles for fecal bacteria are inverted, inserted to a depth of 0.3 m, and filled directly with station water. The bottles are stored on ice until they are returned to the laboratory for further processing. Bacteria samples and total nutrients are processed by SCDHEC using the standardized procedures in effect at the time of sample collection or analysis (SCDHEC, b-d). From 2011-2020, SCDHEC TN and TP values sampled concurrently with SCECAP were not available for many stations; therefore, 2011-2020 TN and TP values were calculated as the average of the nutrient data that were collected at those stations during the months of June, July, and August during the same year as SCECAP sampling, which includes – when available – both SCECAP same-date as well as routine monthly SCDHEC sampling. The number of values included in TN and TP averages ranged from one to four. Because the Eutrophic Index is calculated from TN, TP, and Chl-*a*, in order to process all Eutrophic Index parameter values in a consistent manner it was decided to average



South Carolina's wildlife need good water and sediment quality.

Chl-*a* values from June-August for the 2011-2020 period as well.

2.3. Sediment Quality Measurements

At least four bottom sediment samples are collected at each station using a stainless steel 0.04 m^2 Young grab deployed from an anchored boat that is repositioned between sample collections. The surficial sediments (upper 2 cm) of four or more grab samples are homogenized on-station in a stainless-steel bowl and placed in pre-cleaned containers for analysis of silt and clay content, total organic carbon (TOC), porewater total ammonia nitrogen (TAN), contaminants, and sediment toxicity. All sediment samples are kept on ice while in the field and then stored either at 4°C (toxicity, TAN) or frozen (contaminants, silt and clay content, TOC) until analyzed. Particle size analyses are performed using a modification of the pipette method described by Plumb (1981). Porewater TAN is measured using a Hach Model 700 colorimeter, and TOC is measured by GEL Laboratories in Charleston, SC. Contaminants measured in sediment include 22 metals, 89 polycyclic aromatic hydrocarbons (PAHs), 91 polychlorinated biphenyls (PCBs), 14 polybrominated diphenyl ethers (PBDEs) and 25 pesticides. All contaminants are analyzed by the NOAA/NOS National Centers for Coastal Ocean Science Hollings Marine Laboratory using procedures similar to those described by Kucklick et al. (1997), Long et al. (1997), Balthis et al. (2012), and Chen et al. (2012). Concentrations of a subset of the sediment contaminant parameters are used to calculate a mean Effects Range Median quotient (mERMq) which provides a convenient measure of sediment contamination on a biological impact basis for 24 compounds for which there are biological effects guidelines (Long and Morgan, 1990; Long et al., 1995; 1997; Hyland et al., 1999; 2003).

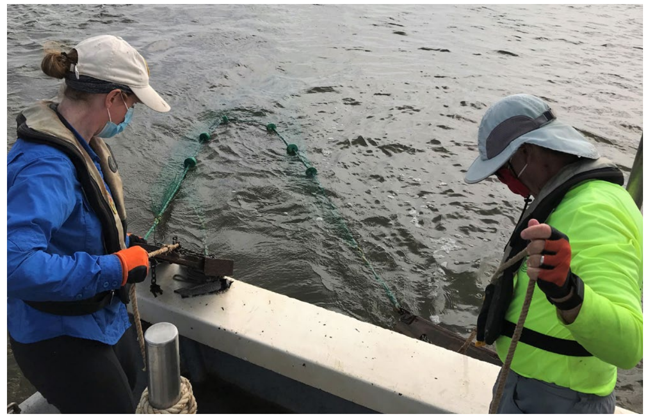
Sediment toxicity is assessed by the Microtox® solid-phase bioassay, which uses a photoluminescent bacterium *(Vibrio fischeri)* and protocols described by the Microbics Corporation (1992). In past reports, a 7-day juvenile clam growth assay using *Mercenaria mercenaria* and protocols described by Ringwood and Keppler (1998) was also incorporated in the toxicity component of the Sediment Quality Index (SQI), but results from the clam growth assay were not robust for 2011- 2016 due to supply limitations, overall low growth rate, and/or high clam mortality in the control samples, and this assay was discontinued after 2016. In some earlier survey periods, a 10-day whole sediment amphipod assay was performed as a third toxicity measure. The amphipod assay has generally proven to be very insensitive for South Carolina sediments and has not been retained as part of the suite of toxicity measures for the SCECAP program. The Microtox® assay may yield false positive results (Ringwood et al. 1997); to limit the impact of false positives, the assays were scored as "fair" for a positive toxicity result and "good" for a negative result in the sediment toxicity component of the SQI.

2.4. Biological Condition Measurements

Two whole samples collected by Young grab are each washed through a 0.5 mm sieve to collect the macrobenthic invertebrate fauna, which are then preserved in a 10% formalin/seawater solution containing Rose Bengal stain. All organisms from the two grabs are identified either to the species level or to the lowest practical taxonomic level if the specimen is too damaged or immature for accurate species level identification. A reference collection of benthic species collected for this program is maintained at the SCDNR Marine Resources Research Institute. The benthic data are incorporated into a Benthic Index of Biotic Integrity (B-IBI), based on number of taxa, abundance, dominance, and percent sensitive taxa (Van Dolah et al., 1999) which is used as the Biological Condition Index (BCI).

Fish and large invertebrates are collected by trawl at each station following benthic sampling to evaluate near-bottom nekton community composition. Two replicate trawl tows, pulled

To assess the community of macrobenthic invertebrate organisms living in the sediment, Young grab samples are washed through a 0.5 mm sieve, preserved, and then sorted and identified in the laboratory.



Fish and large invertebrates are collected by trawl, identified, counted, and measured.

in the same direction as tidal flow, are made sequentially at each station using a 4-seam trawl (5.5 m foot rope, 4.6 m head rope and 1.9 cm bar mesh throughout). Trawl tow lengths are standardized to 0.5 km for open water stations and 0.25 km for tidal creek stations. Occasionally, due to logistical limitations at stations, actual tows are slightly shorter than target tow lengths; when that occurs, actual tow length is recorded, and data from that trawl are only included in analyses if the tow was at least 50% of the target tow length. Mean abundances are corrected for the total area swept by the two trawl tows using the formula described by Krebs (1972). Fish, squid, large crustaceans, and horseshoe crabs captured are identified, counted, and checked for gross pathologies, deformities, or external parasites. Up to 30 individuals of each taxon are measured to the nearest centimeter. Most trawl organisms are released on station after identification and enumeration, with the exception of a small number of organisms that are brought back to the lab to confirm identification or for research use. Concentrations of contaminants in fish tissue were assessed from 2000-2006, 2010 (NCCA), and 2020 (NCCA), but tissue contaminant samples are no longer routinely collected by SCECAP due to funding constraints.

2.5. Integrated Indices of Estuarine Habitat Condition

One of the primary objectives of SCECAP is to develop integrated measures of estuarine condition that synthesize the program's large and complex environmental datasets. Such measures provide natural resource managers and the general public with simplified statements about the status and trends of the condition of South Carolina's coastal zone. Similar approaches have been developed by federal agencies for their National Coastal Condition Reports (https://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-reports) as well as by a few states and other entities using a variety of approaches (Carlton et al., 1998; Chesapeake Bay Foundation, 2021; Partridge, 2007).

Shrimp, crabs, and many fish species are dependent upon estuarine habitat for survival. In turn, commercial fishermen are dependent upon good estuarine habitat quality for their livelihoods.

SCECAP computes four integrated indices describing different components of the estuarine ecosystem: water quality (WQI), sediment quality (SQI), biological condition (BCI), and overall habitat quality. The WQI combines four measures, the SQI combines three measures, and the BCI includes only the B-IBI (Table 2.5.1). These three indices are then combined into a single integrated Habitat Quality Index (HQI). The integrated indices facilitate communication of multi-variable environmental data to the public and provide a more reliable tool than individual measures (such as DO, pH, etc.) for assessing estuarine condition. For example, one location may have degraded DO but normal values for all other measures of water quality, while a second location has degraded levels for the majority of water quality measures. If DO were the only measure of water quality used, both locations would be classified as having degraded condition with no basis for distinguishing between the two locations. However, an index that integrates multiple measures would likely not classify the first location as degraded yet detect the relatively greater degradation at the second location.

Table 2.5.1. Individual measures comprising the integrated Water Quality, Sediment Quality, and Biological Condition indices

Water Quality Index	Sediment Quality Index	Biological Condition Index
Dissolved Oxygen	Contaminants (mERMq)	B-IBI
Fecal Coliform Bacteria	Toxicity (Microtox ®)	
pH (salinity-corrected)	Total Organic Carbon	
Eutrophic Index		
Total Nitrogen		
Total Phosphorus		
Chlorophyll *a*		

Current methods for calculating the four integrated indices are described in detail in the 2005-2006 SCECAP report (Bergquist et al., 2009). Broadly, each individual measure from a sampled station that is included in the calculation of an integrated index is given a score of "good," "fair," or "poor." The thresholds used for scoring each measure are listed in Appendix 2. In the various graphics and tables of this report, these scores are depicted as green, yellow, and red, respectively. Thresholds for defining conditions as good, fair, or poor are based on 2008 state water quality standards (SCDHEC, a), published findings (Hyland et al., 1999 for mERMq; Van Dolah et al., 1999 for benthic condition), or percentiles of a historical database for the state based on SCECAP measurements collected from 1999-2006 (Bergquist et al., 2009). Each measure is given a numerical score (5, 3, and 0 for scores of good, fair, and poor, respectively) and the numerical scores of the individual measures are averaged into an integrated index value. The Water Quality, Sediment Quality, and Biological Condition indices are likewise given a score of good, fair, or poor using methods described in Van Dolah et al. (2004). The resulting numerical scores for the WQI, SQI, and BCI are then averaged into an overall Habitat Quality Index as shown in Table 2.5.2.

It is important to note that as new information has become available, the calculation

Table 2.5.2. Summary of possible index values and scores for the intergrated Habitat Quality Index, based on combinations of scores from the Water Quality Index, the Sediment Quality Index, and the Biological Condition Index

Component Index Scores			Habitat Quality Index	HQI
A	B	C	(Average)	Score
0	0	0	0.00	Poor (0)
3	0	0	1.00	Poor (0)
5	0	0	1.67	Poor (0)
3	3	0	2.00	Poor (0)
5	3	0	2.67	Fair (3)
5	5	0	3.33	Fair (3)
3	3	3	3.00	Fair (3)
5	3	3	3.67	Fair (3)
5	5	3	4.33	Good (5)
5	5	5	5.00	Good (5)

methodology used by SCECAP has been modified. Modifications include changes in the individual measures used in the integrated indices, threshold values, scoring processes, and methods used to address missing data. While these changes often do not result in very large changes in data interpretation, the results presented in this report for earlier years may not exactly match those in the previously published reports. However, the current report does reflect the updated data analysis approach applied to all previous survey periods.

2.6. The Presence of Litter

Litter is one of the more visible signs of habitat degradation. While the incidence of litter is not used in the overall Habitat Quality Index, the presence of litter in the trawl or on the banks for 250 meters on each side of the station is recorded.

2.7. Data Analysis

Use of the probabilistic statistical survey sampling design provides an opportunity to estimate, with confidence limits, the proportion of South Carolina's estuarine water classified as being in good, fair, or poor condition. These estimates are obtained through analysis of the cumulative distribution function (CDF) using procedures described by Diaz-Ramos et al. (1996) and using a program developed within the R statistical software environment (http://www.r-project.org/). The percent of the state's overall estuarine habitat scoring as good, fair, or poor for individual measures and for each of the indices is calculated after weighting the analysis by the proportion of the state's estuarine habitat represented by tidal creek (17%) and open water (83%) habitat. In the past, SCECAP used continuous values in these analyses, when possible, but this methodology was modified to use only categorical scores in order to improve 1) consistency with reporting by the SCDHEC Ambient Surface Water Quality Monitoring Network, and 2) calculation of the 95% confidence limit for each estimate. For brevity, graphical summaries in this report are primarily limited to overall estuarine habitat condition (tidal creek and open water combined).

RESULTS AND DISCUSSION

3.1. Water Quality

SCECAP collects a wide variety of water quality parameters each year as part of the overall investigation of estuarine habitat quality. Poor water quality measures, if observed repeatedly in a watershed, can provide an early warning of impaired habitat, especially related to nutrient enrichment and bacterial problems. Six parameters are considered to be the most relevant with respect to biotic health and human uses and have been incorporated into a Water Quality Index (WQI) developed by SCECAP. These include: 1) dissolved oxygen (DO), which is critical to healthy biological communities and depressed levels can reflect organic pollution; 2) pH, because research indicates that acidification of seawater driven by elevated atmospheric CO_2 concentrations will have adverse impacts on many organisms, including shellfish (Robbins and Lisle 2018; Baag and Mandal 2022) 3) fecal coliform bacteria, which are an indicator of potential human pathogens; and 4) a combined measure of total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* (Chl-*a*), which provides a composite measure of the potential for a water body to be experiencing nutrient enrichment and/or associated algal blooms. These latter three measures (TN, TP, and Chl-*a*) are combined into a Eutrophic Index, which is incorporated as one quarter of the weight of the overall WQI (Table 2.5.1).

Applying the WQI to 2019-2020 survey data, 92% of the state's estuarine habitat scored as being in good condition, 6% scored as fair, and 2% scored as poor (Figure 3.1.1). Among the WQI component parameters, the component with the highest percentages of habitat scoring as fair (18%) and poor (2%) was Mean Dissolved Oxygen (Figure 3.1.1, Appendix 3). Only 1% of SC estuarine habitat scored as poor for both pH and fecal coliform, and only 4% scored as poor for the Eutrophic Index. The proportion of the state's overall estuarine habitat with good water quality in 2019-2020 was higher than average relative to the full survey period (Figure 3.1.2).

As has been observed throughout the entire 1999-2020 SCECAP program, tidal creek habitat in 2019-2020 showed more variable and overall lower water quality compared to open water habitats (Table 3.1.1; Figure 3.1.3; Appendix 2). During the 2019-2020 survey, 97% and 70% of open water and tidal creek habitat, respectively, scored as good on the WQI (Appendix 2).

The geographic distribution of stations for the 2019-2020 survey period with good, fair, or poor WQI scores are shown in Figures 3.1.4, 3.1.5, 3.1.6, with scores and sub-scores shown in Appendix 3. Three of the 60 stations sampled in 2019-2020 had poor WQI, and all 3 were tidal creek stations (Appendix 3). The northernmost station with poor water quality (RT20225), due to poor to fair scores for DO, fecal coliform, pH, TN, and Chl-*a*, is located in Cape Romaine between Muddy Bay and the *ICW* in Charleston County (Figure 3.1.5). The remaining two stations with poor water quality are both located in inland sections of the Southern Region (Figure 3.1.6). RT20231 is located on the Chehaw River in Colleton County, and scored poor or fair for DO, fecal coliform, pH, and TP. RT19207 is located on the Coosawhatchie River in Jasper County, and also scored poor or fair for DO, fecal coliform, pH, and TP. In 2019-2020, 1 of the 30 open water stations and 6 of the 30 tidal creek stations had fair WQI scores.

When considering all years (1999-2020), portions of the state with a relatively high incidence of fair to poor water quality are concentrated in Winyah Bay; Santee Delta region; tidal creeks around Bulls Bay; Ashley River; drainage basins associated with the Dawho, Ashepoo, Combahee, and Broad Rivers; Jenkins Creek; and upstream portions of the New River and Wright River (Figures 3.1.4, 3.1.5, 3.1.6).

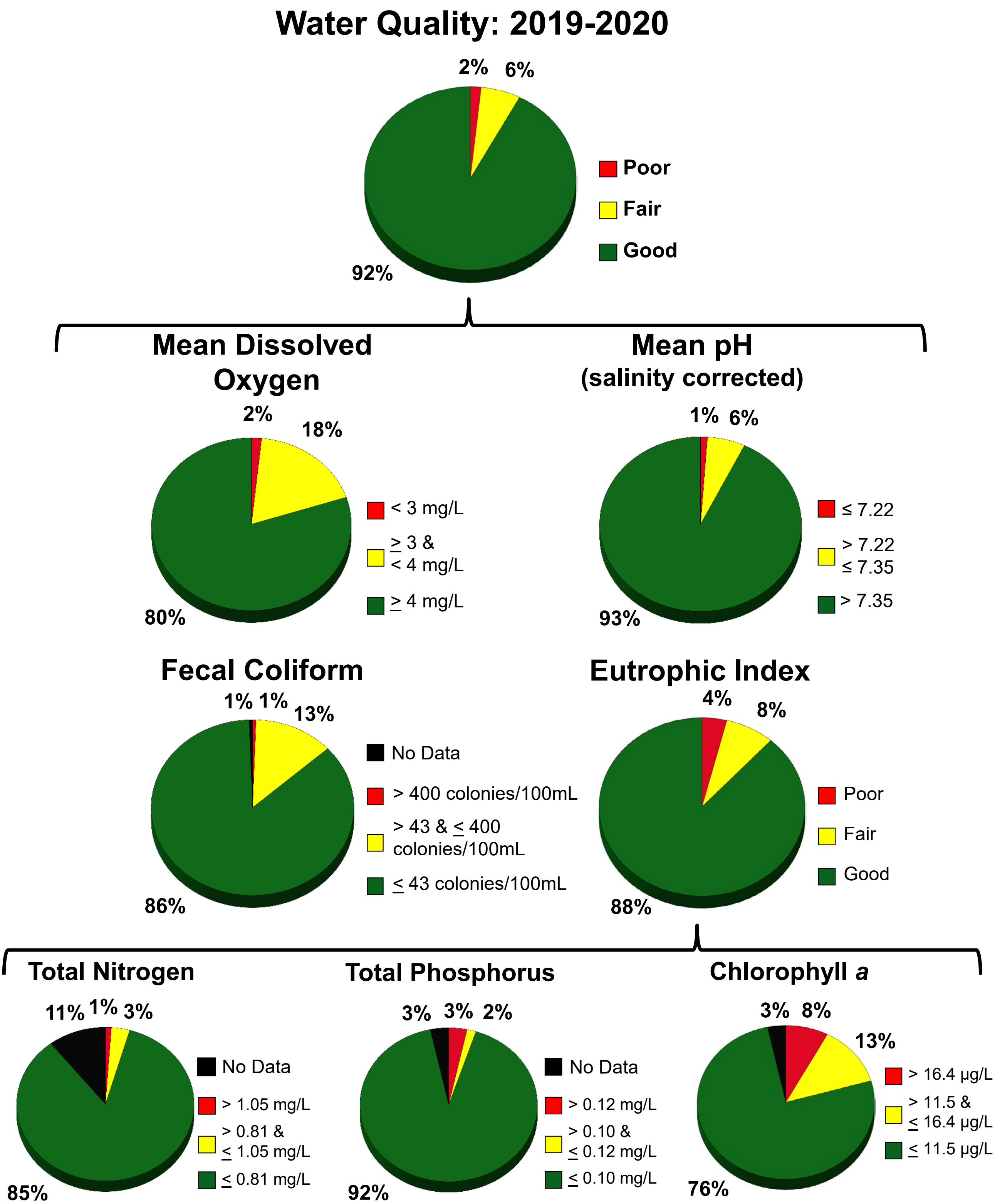


Figure 3.1.1. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2019 and 2020.

Table 3.1.1. Summary of mean water quality measures observed in tidal creek and open water habitats during each year for the SCECAP survey. Blue highlight indicates those measures included in the Water Quality Index.

Measure	Habitat	Year																					
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Water Quality Index	Open	4.56	4.83	4.64	4.73	4.57	4.66	4.77	4.80	4.78	4.85	4.90	4.65	4.58	4.93	4.72	4.72	4.90	4.75	4.90	4.82	4.72	4.83
	Creek	4.02	3.86	4.28	4.40	4.25	4.20	4.38	4.35	4.45	4.10	4.65	3.90	4.52	3.63	4.42	4.60	4.23	4.46	4.62	4.40	4.08	4.38
Dissolved Oxygen (mg/L)	Open	4.86	5.01	4.96	5.10	4.97	5.41	5.13	5.11	5.49	5.62	5.54	5.05	4.99	5.07	5.32	5.09	5.21	5.32	5.12	5.06	5.20	4.86
	Creek	4.00	4.12	4.45	4.51	4.58	5.10	4.12	4.33	4.53	4.50	4.41	4.12	4.59	3.40	4.40	4.65	4.51	4.83	4.51	4.38	3.94	4.58
pH	Open	7.58	7.53	7.67	7.71	7.39	7.75	7.59	7.68	7.68	7.68	7.63	7.58	7.59	7.62	7.43	7.53	7.60	7.56	7.64	7.55	7.58	7.48
	Creek	7.52	7.43	7.56	7.53	7.31	7.36	7.30	7.48	7.43	7.49	7.49	7.37	7.52	7.33	7.27	7.47	7.39	7.40	7.43	7.35	7.21	7.40
Fecal Coliform (col/100mL)	Open	47	11	14	9	25	17	12	24	17	13	19	10	23	6	21	38	3	15	4	13	10	14
	Creek	30	55	35	25	74	87	29	65	14	32	5	27	25	158	58	21	76	64	20	86	153	61
Total Nitrogen (mg/L)	Open	0.51	0.58	0.66	0.52	0.84	0.52	0.57	0.20	0.26	0.52	0.57	0.25	0.39	0.32	0.63	0.35	0.52	0.69	0.42	0.35	0.34	0.59
	Creek	0.69	0.75	0.72	0.58	0.72	0.64	0.67	0.20	0.32	0.65	0.62	0.32	0.21	0.48	0.56	0.38	0.61	0.46	0.38	0.39	0.39	0.72
Total Phosphorus (mg/L)	Open	0.08	0.06	0.06	0.05	0.06	0.08	0.08	0.07	0.06	0.05	0.07	0.09	0.09	0.05	0.06	0.07	0.06	0.08	0.06	0.07	0.07	0.05
	Creek	0.09	0.10	0.09	0.06	0.09	0.12	0.08	0.07	0.06	0.09	0.09	0.09	0.09	0.06	0.08	0.08	0.06	0.09	0.07	0.08	0.08	0.06
Chlorophyll *a* (µg/L)	Open	10.3	9.1	10.1	10.1	6.9	8.4	7.7	7.4	11.0	9.2	7.2	9.2	8.7	7.6	2.9	6.6	9.2	8.8	9.5	10.4	13.8	11.6
	Creek	12.6	12.5	10.8	9.7	11.6	12.0	8.0	10.1	10.9	8.9	7.8	12.1	9.7	8.6	4.9	5.9	9.8	12.3	12.2	10.9	16.3	14.6
Temperature (°C)	Open	30.2	29.4	29.5	29.1	28.5	29.1	30.0	29.7	29.8	29.0	28.5	30.8	30.1	29.9	28.9	29.1	29.7	30.8	29.4	28.9	30.4	30.1
	Creek	30.1	29.8	29.5	29.0	29.0	29.6	29.9	30.2	30.3	29.9	29.9	31.2	30.7	29.8	29.3	29.6	30.3	30.7	29.8	29.7	30.6	30.4
Salinity (ppt)	Open	26.2	28.1	28.2	31.0	19.9	28.4	25.9	31.1	30.3	31.3	26.4	30.8	30.5	29.1	21.1	24.6	30.4	25.9	27.7	24.6	26.1	25.8
	Creek	31.1	31.5	29.4	32.1	20.8	26.2	23.2	32.3	29.3	32.0	30.9	29.7	34.2	30.7	19.7	28.9	30.0	26.6	27.8	23.0	23.2	25.7

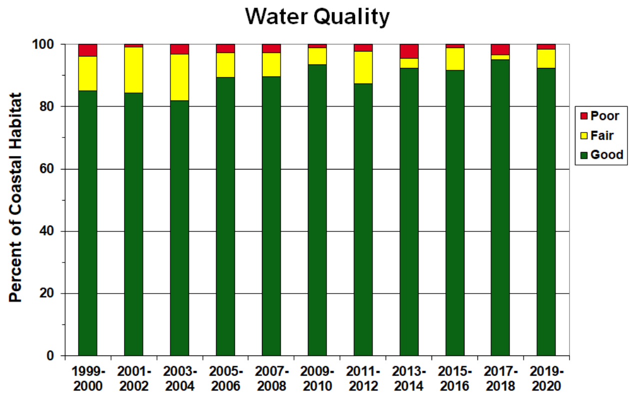


Figure 3.1.2. Percent of coastal waters corresponding to each Water Quality Index category by survey period.

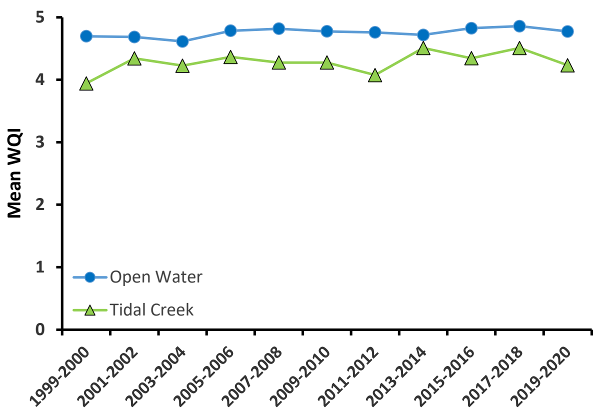


Figure 3.1.3. Water Quality Index scores observed by survey period and habitat type.

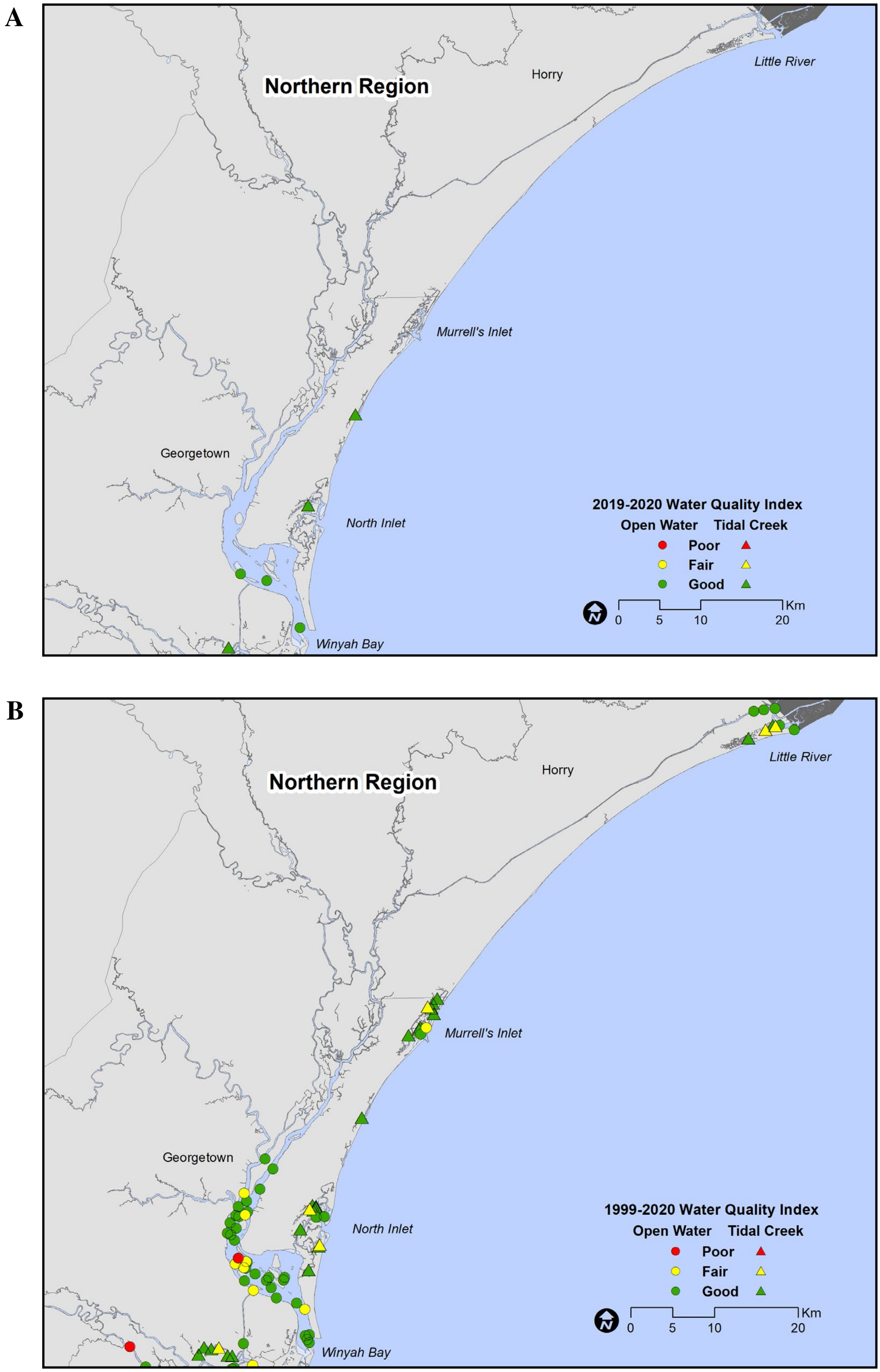
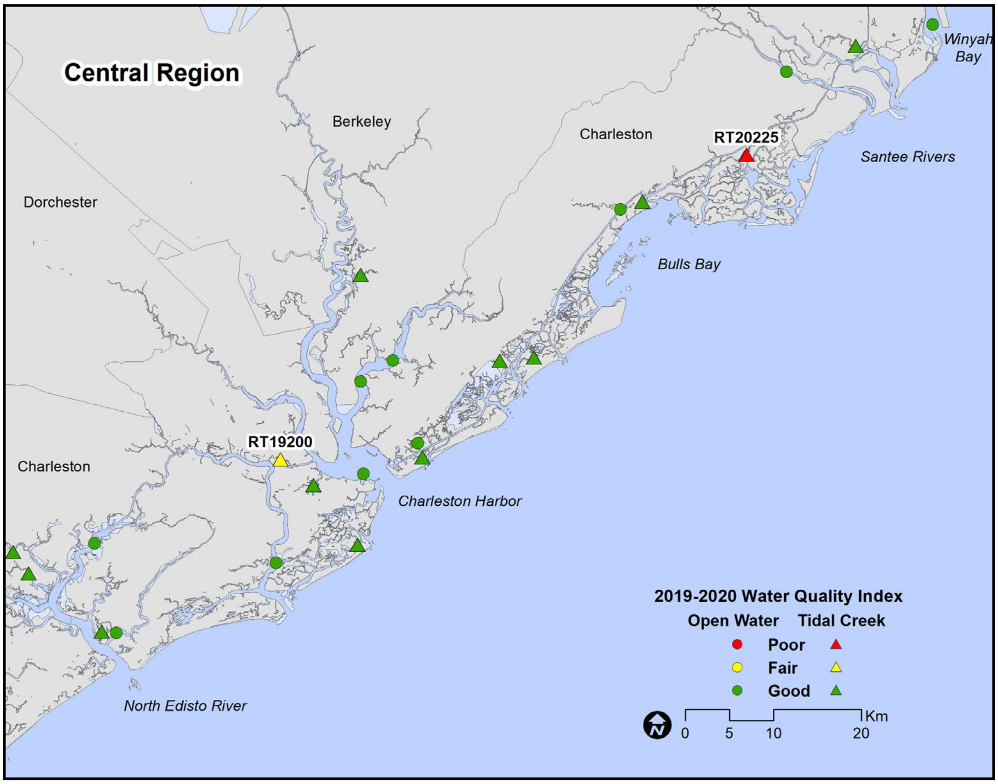


Figure 3.1.4. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the northern region of South Carolina

A



B

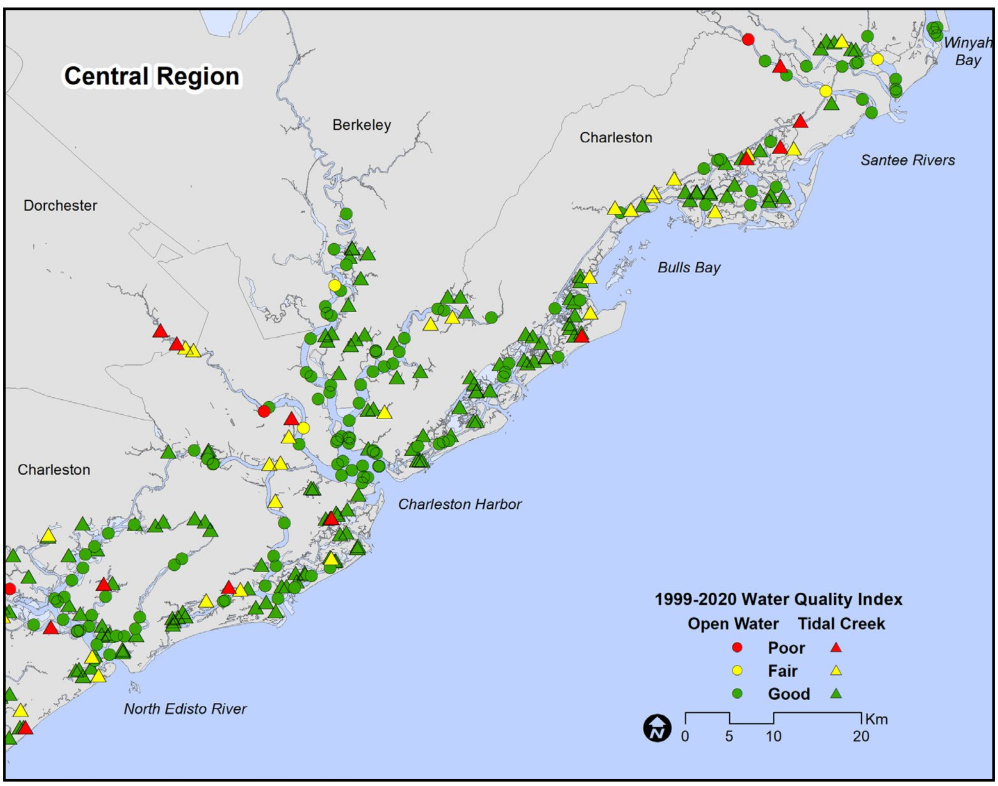


Figure 3.1.5. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the central region of South Carolina.

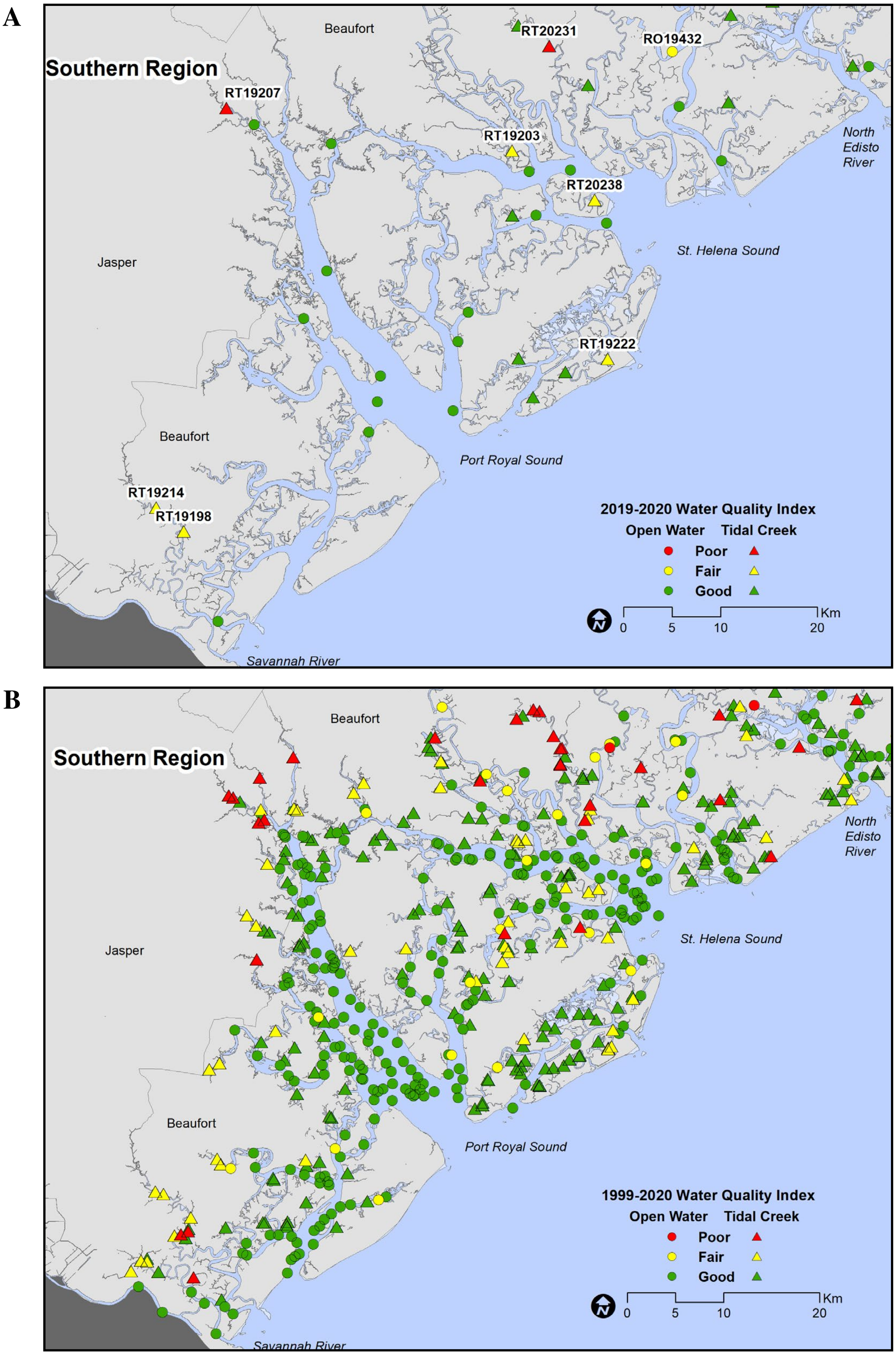


Figure 3.1.6. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the southern region of South Carolina.

3.2. Sediment Quality

Sediment quality measurements remain an essential component of our overall estuarine habitat quality assessment because sediments: 1) support invertebrate communities that form the base of the food web for many other species of concern, 2) exchange nutrients and gases with overlying water in support of overall estuarine function, and 3) serve as a sink for many contaminants which can accumulate over time, providing an informative measure of long-term exposure to contaminants in an area.

Although multiple sediment quality measures are collected by SCECAP, the three metrics considered to be the most indicative of sediment condition are 1) a combined measure of 24 organic and inorganic contaminants that have published biological effects thresholds (mERMq; Long and Morgan, 1990; Long et al., 1995; 1997; Hyland et al., 1999; 2003), 2) a measure of sediment toxicity based on the Microtox® bioassay that indicates whether contaminants are present at concentrations that have adverse biological effects, and 3) Total Organic Carbon (TOC), which can have adverse effects on bottom-dwelling biota when elevated and serves as a good predictor of benthic community condition (Hyland et al., 2005).

During the 2019-2020 survey using the SQI, 83% of South Carolina's estuarine habitat had sediment in good condition, with 11% in fair condition and 6% in poor condition (Figure 3.2.1). Throughout the 1999-2020 timeframe, the percentage of estuarine habitat with good sediment quality started high (88%) in 1999-2000, fell to its lowest levels in 2001-2004 (75-79%), and steadily improved from 2009-2010 (83%) through 2015-2016 (92%). The percentage of estuarine habitat with good SQI declined slightly in the 2017-2018 survey to 86%, and then to 83% in 2019-2020 (Figure 3.2.2) which is below the average level for the survey. Mean SQI was slightly lower at tidal creek stations than at open water stations for the 2019-2020 survey period (Figure 3.2.3), although tidal creek SQI was higher than open water SQI in 2020, as has sometimes occurred in the past (Table 3.2.1).

Three stations scored as having poor sediment quality in the 2019-2020 survey, all of which were sampled in 2020: 2 open water stations and 1 tidal creek station (Figures 3.2.4, 3.2.5, 3.2.6; Appendix 3). The open water stations with poor sediment quality are both located in or near the mouth of Charleston Harbor in Charleston County. RO20444 is located in Charleston Harbor, 1.8 km west-northwest of Fort Sumter National Monument, and scored fair on contaminants and toxicity, and poor on TOC. RO20456 is located in Inlet Creek between Mount Pleasant and the ICW and scored fair on contaminants and poor on TOC. The tidal creek station that scored poor on sediment quality is located in the Dawho River about 300 meters west of SC highway 174 and scored fair on contaminants and poor on TOC (RT20236). In 2019-2020, 8 of the 60 SCECAP stations scored as having fair SQI scores, and 5 of the 8 were tidal creek stations.

When all survey periods (1999-2020) are considered collectively, areas with clusters of poor to fair SQI scores were observed in Winyah Bay; Santee Delta region; Cape Romain and Bulls Bay area; Cooper River and Charleston Harbor; North Edisto, Dawho, and South Edisto Rivers; portions of the Combahee River and its drainages; creeks north of Whale Branch; and the New, Wright, and Savannah Rivers (Figures 3.2.4, 3.2.5, 3.2.6).

3.3. Biological Condition

3.3.1 Benthic Communities

Benthic macrofauna serve as ecologically important components of the food web by consuming detritus, plankton, and smaller organisms living in the sediments and in turn serve as prey for fish, shrimp, and crabs. Benthic macrofauna are also relatively sedentary, and many species are sensitive to changing environmental conditions. As a result, these organisms are important biological indicators of water and sediment quality and are useful in

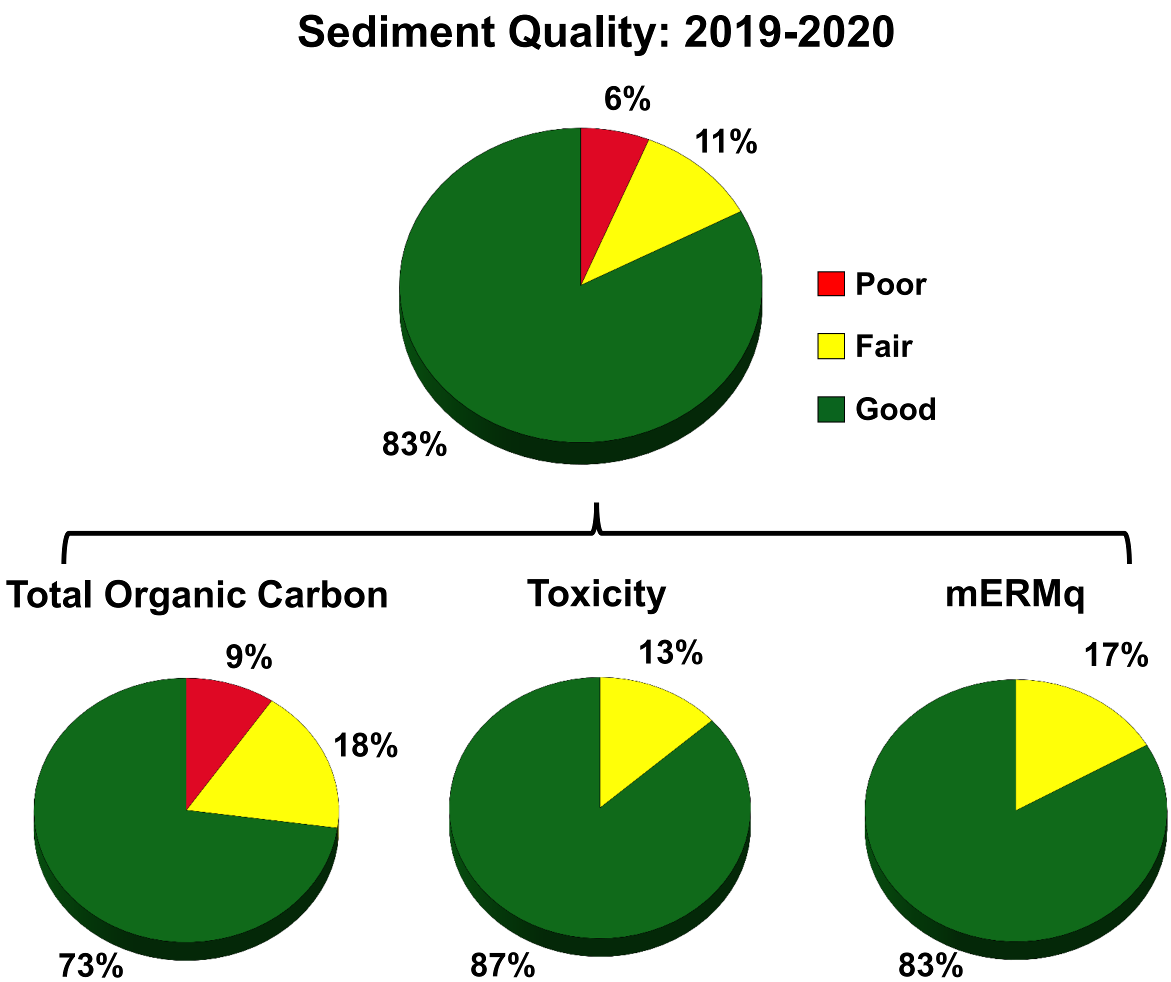


Figure 3.2.1. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Sediment Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2019 and 2020.

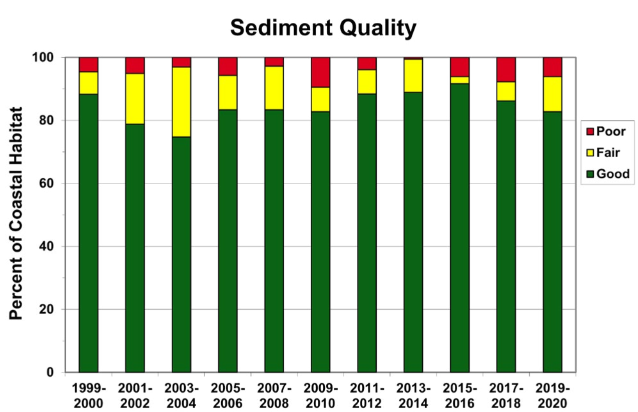


Figure 3.2.2. Percent of coastal waters corresponding to each Sediment Quality Index category by survey period.

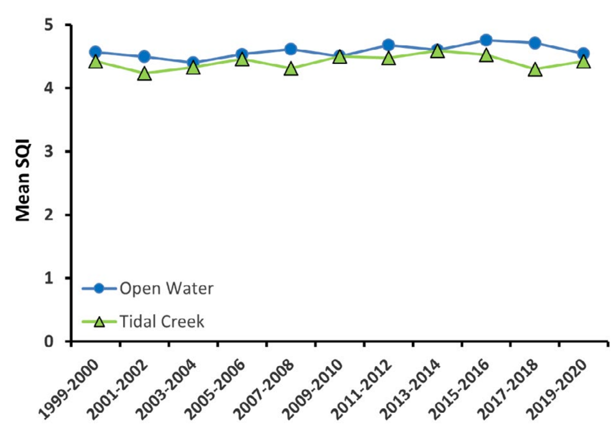
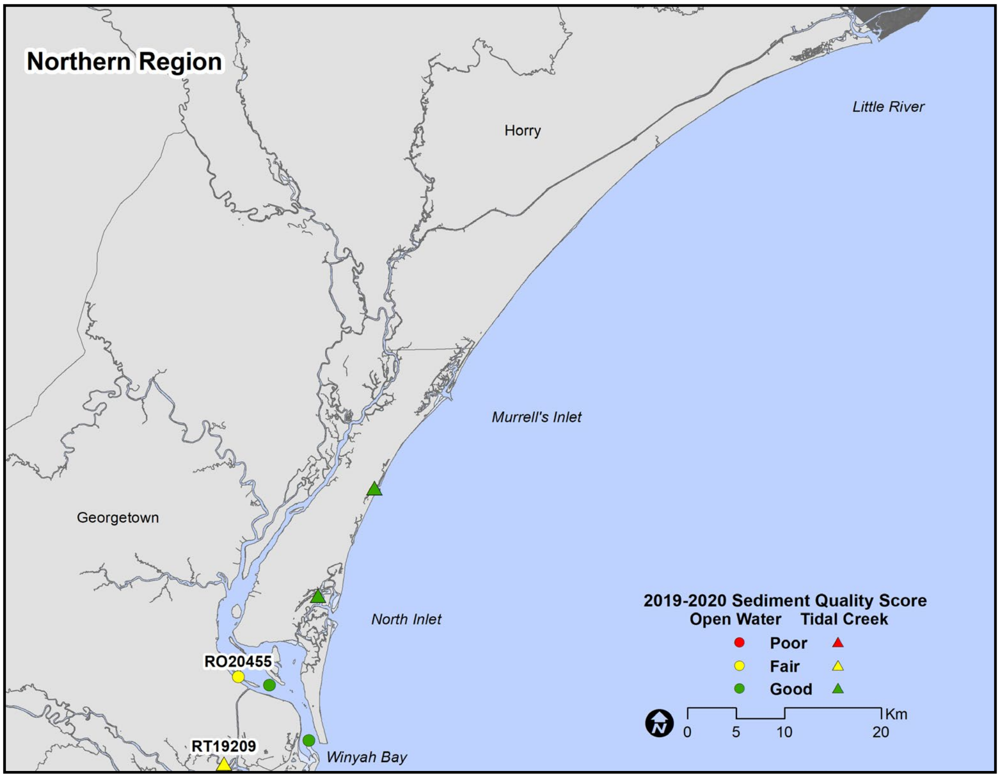


Figure 3.2.3. Sediment Quality Index scores observed by survey period and habitat type.

A



B

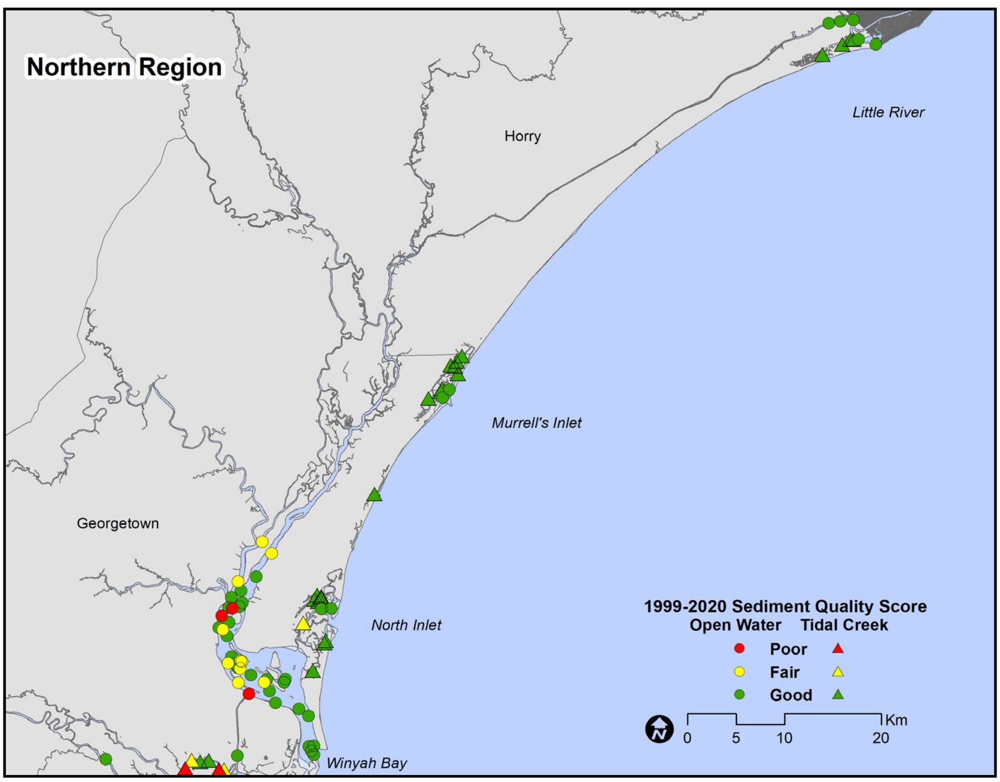
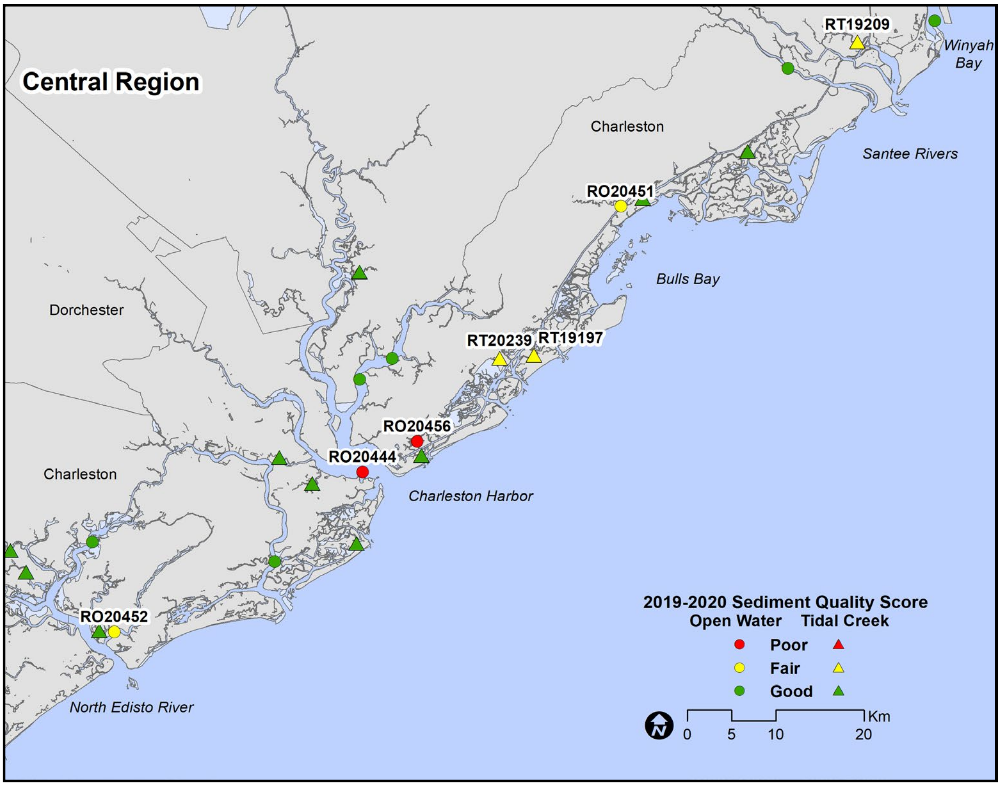


Figure 3.2.4. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the northern region of South Carolina.

A



B

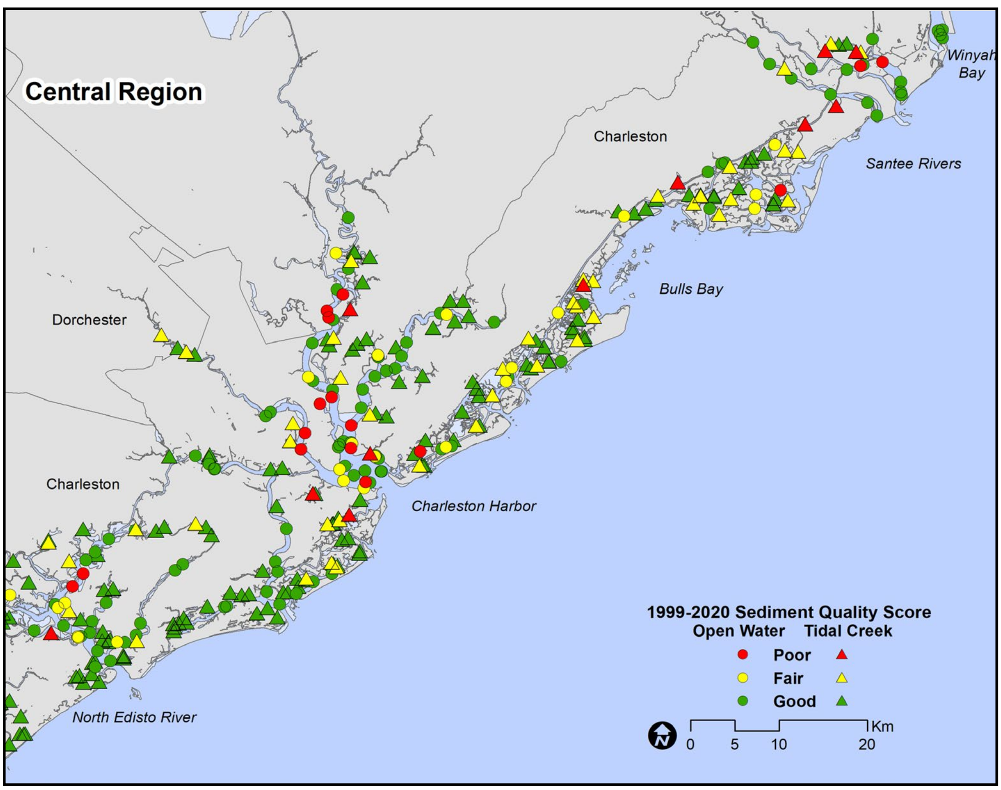
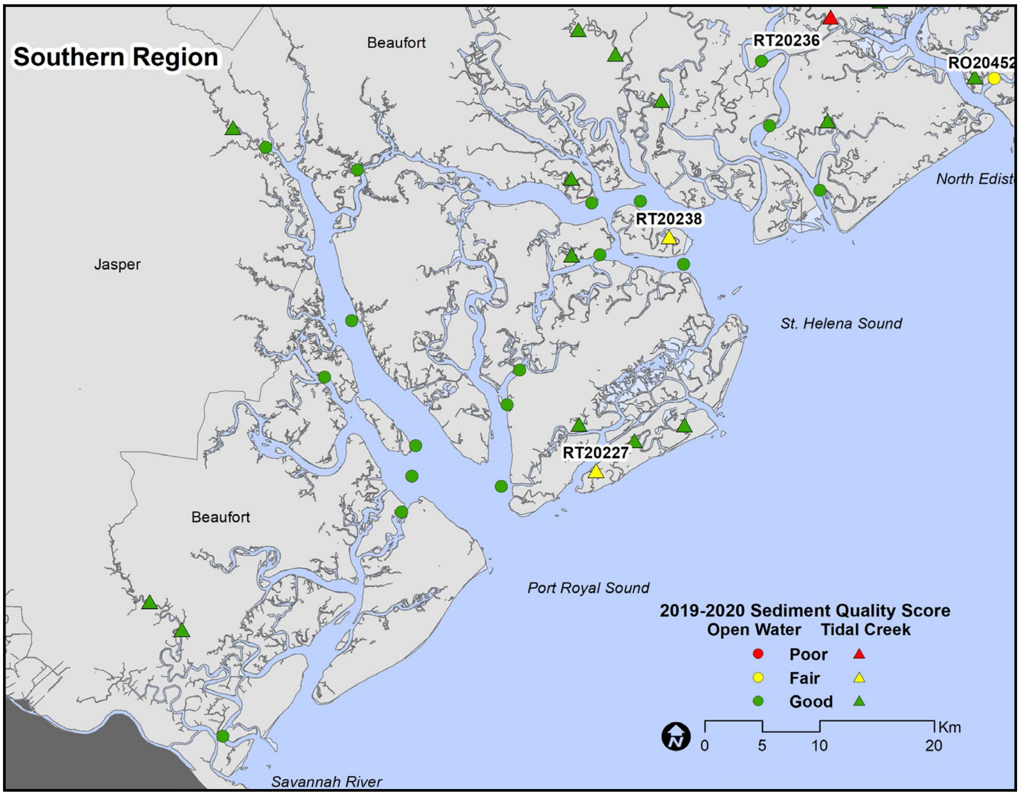


Figure 3.2.5. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the central region of South Carolina.

A



B

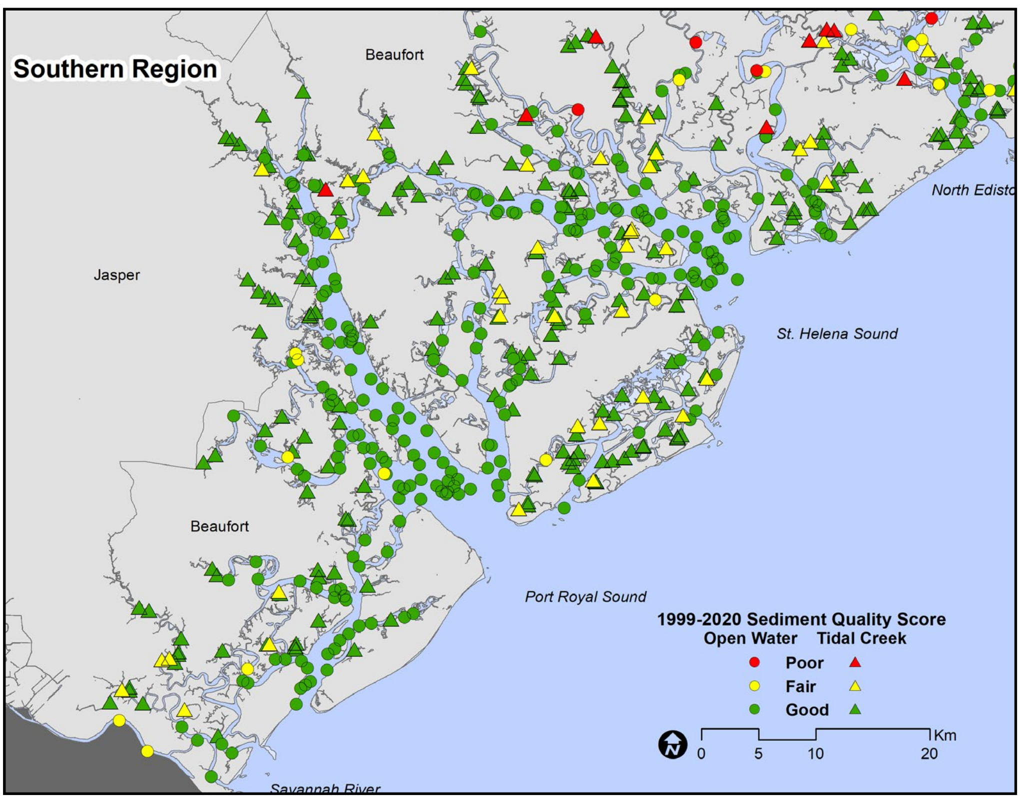


Figure 3.2.6. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the southern region of South Carolina.

Table 3.2.1. Summary of mean sediment quality measures observed in tidal creek and open water habitats during each year for the SCECAP survey. Blue highlight indicates those measures included in the Sediment Quality Index.

Measure	Habitat	Year																					
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sediment Quality Index	Open	4.52	4.61	4.59	4.40	4.43	4.37	4.53	4.53	4.53	4.69	4.40	4.60	4.71	4.64	4.73	4.47	4.56	4.96	4.60	4.82	4.87	4.22
	Creek	4.43	4.41	4.17	4.30	4.26	4.40	4.33	4.59	4.16	4.47	4.78	4.22	4.84	4.11	4.36	4.82	4.38	4.67	4.02	4.58	4.49	4.36
Total Organic Carbon (%)	Open	0.86	0.63	0.94	0.84	0.74	0.88	0.70	0.77	0.79	0.70	1.15	0.62	0.89	0.75	0.45	1.20	1.35	0.81	1.93	0.99	1.29	2.36
	Creek	1.08	1.33	1.30	1.39	1.30	1.12	1.48	1.03	1.71	1.06	1.08	1.35	0.43	1.67	1.85	0.86	2.24	2.05	3.72	2.60	2.78	3.08
mERMq	Open	0.013	0.013	0.013	0.017	0.014	0.015	0.013	0.017	0.013	0.014	0.213	0.018	0.020	0.014	0.019	0.017	0.011	0.008	0.011	0.006	0.007	0.016
	Creek	0.015	0.014	0.017	0.015	0.018	0.016	0.018	0.013	0.022	0.015	0.011	0.025	0.016	0.020	0.023	0.013	0.016	0.013	0.016	0.010	0.008	0.017
Microtox Bioassay (% toxic)	Open	37.9	40.0	26.7	43.3	46.7	53.3	40.0	24.0	33.3	20.0	20.0	33.3	6.7	33.3	6.7	33.3	20.0	6.7	0.0	20.0	6.7	20.0
	Creek	51.9	50.0	60.0	46.7	56.7	50.0	36.0	28.0	42.9	40.0	20.0	33.3	0.0	40.0	20.0	6.7	6.7	6.7	26.7	13.3	6.7	20.0
Silt & Clay (%)	Open	22.3	15.1	23.0	20.5	15.4	24.2	17.7	17.9	22.7	18.7	26.8	15.8	16.4	21.5	12.3	29.1	18.9	10.6	18.1	7.9	10.6	24.2
	Creek	32.0	31.8	30.3	30.9	34.3	26.0	37.4	21.0	40.7	23.4	27.6	26.9	15.2	42.0	36.8	21.3	39.4	31.8	37.7	21.7	22.3	35.7
Total Ammonia Nitrogen (mg/L)	Open	2.62	2.91	2.51	3.64	3.22	4.13	1.95	2.09	1.69	3.44	3.24	1.96	1.99	2.46	2.03	5.89	1.81	1.03	2.92	1.39	1.09	2.49
	Creek	2.79	3.06	3.46	2.75	4.74	2.17	2.48	2.16	2.04	2.23	2.97	3.62	1.04	4.49	2.21	1.45	2.27	2.87	2.70	1.59	1.45	2.03

monitoring programs to assess overall coastal and estuarine health (Hyland et al., 1999; Van Dolah et al., 1999). The BCI, which is used to score estuarine habitat in terms of benthic community quality, is based upon the Benthic Index of Biotic Integrity (B-IBI; Van Dolah et al., 1999).

The Benthic Index of Biotic Integrity (B-IBI; Van Dolah et al., 1999) provides a convenient, broad index of benthic community condition, but because this index combines four measures into a single value, it does not provide detailed information on community composition. Traditional community descriptors such as total faunal density, number of species (species richness), species evenness (J'), and species diversity (H') can be lower in more stressful environments. This is because fewer and fewer species within a community can tolerate increasingly stressful conditions, such as those caused by decreasing dissolved oxygen or increasing sediment contamination. Using published literature, species that are sensitive to pollution can be identified in order to examine potential patterns in estuarine contamination.

As in most previous surveys, mean B-IBI values were higher in open water habitats than in tidal creeks in 2019-2020 (Figure 3.3.1; Table 3.3.1). The relatively lower B-IBI values often seen in tidal creek habitats likely reflects the more stressful conditions of shallow tidal creek systems compared to tidal rivers and bays.

The BCI, which is used to score estuarine habitat in terms of benthic community quality, simplifies the B-IBI to a score of good, fair, or poor. During the 2019-2020 survey, using the BCI, 87% of the 12% as fair, and 1% as poor (Figure 3.3.2). The percentage of the state's estuarine habitat scoring as good in 2019-2020

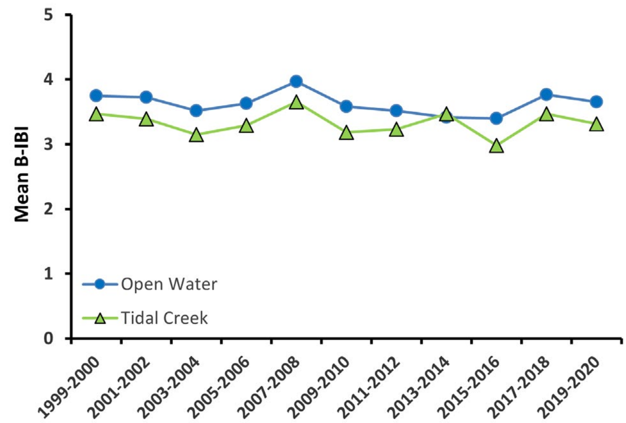


Figure 3.3.1. Benthic Index of Biological Integrity scores observed by survey period and habitat type.

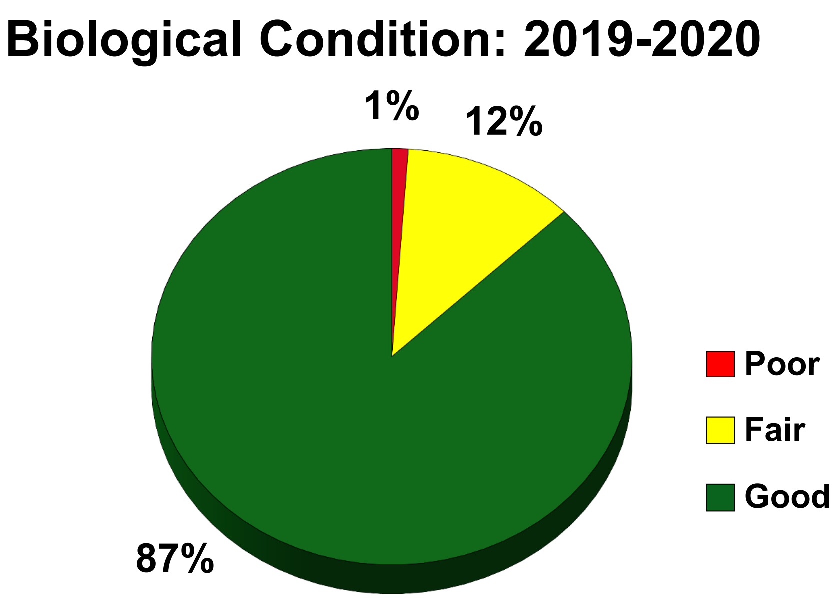


Figure 3.3.2. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Biological Condition Index. Percentage is based on data obtained from 30 stations for each habitat during 2019 and 2020.

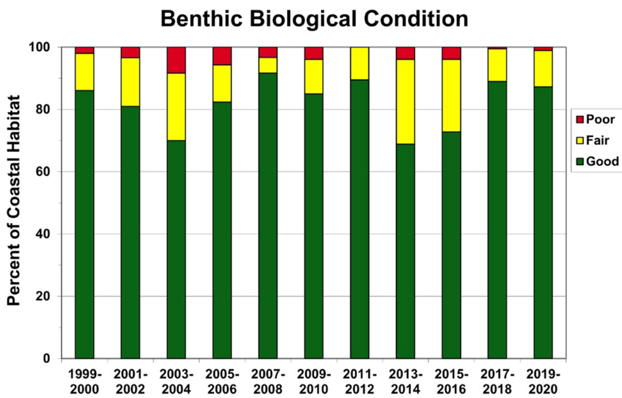


Figure 3.3.3. Percent of coastal waters corresponding to each Biological Condition Index category by survey period.

was similar to the 2017-2018 level and higher than the survey-wide average (Figure 3.3.3).

As with the more traditional indices above, open water habitats typically — although not always — supported higher densities and percentages of sensitive fauna than tidal creek habitats (Table 3.3.1). Taxonomic groups such as amphipods, mollusks, and polychaetes occupy a diverse range of habitats, but their abundances — relative to each other — vary fairly predictably with environmental conditions. For example, polychaetes tend to dominate the communities of shallow, muddy tidal creek habitats whereas amphipods and mollusks become increasingly more abundant in sandier oceanic environments (Little, 2000). An overall comparison between SCECAP benthic communities in tidal creek and open water habitats support these expected patterns, with the densities and proportions of amphipods and mollusks generally being higher in open water habitats and the proportion of polychaetes higher in tidal creek habitats (Table 3.3.1).

The geographic distribution of stations with good, fair, or poor BCI scores during the 2019-2020 survey period is shown in Figures 3.3.4, 3.3.5, 3.3.6 and Appendix 3. Only 2 of the 60 stations sampled in 2019-2020 scored as poor for the BCI: a tidal creek station on Minim Creek in Georgetown County (RT19209), and a tidal creek station on the New River in Beaufort County (RT19214). Both stations had elevated sediment TOC, and one of the two stations, RT19209, scored as toxic based on the Microtox® test and had elevated Chl-*a*. The other station, RT19214, had elevated fecal coliform bacteria levels as well as depressed (relatively acidic) pH. These factors (with the exception of elevated fecal coliform which is more of a risk to human health) likely contributed to a stressful environment for benthic fauna. In 2019-2020, 6 of the 30 tidal creek stations scored fair on the BCI, compared to 3 of 30 open water stations.

Historically, poor to fair BCI scores have been observed in Winyah Bay; Santee Delta region; creeks near the ICW by Cape Romain; the upper Wando River; the Cooper and Ashley Rivers; the Edisto and Dawho Rivers; Combahee River drainages; creeks near Whale Branch; and the Wright and Savannah Rivers (Figures 3.3.4, 3.3.5, 3.3.6).

3.3.2 Fish and Large Invertebrate Communities

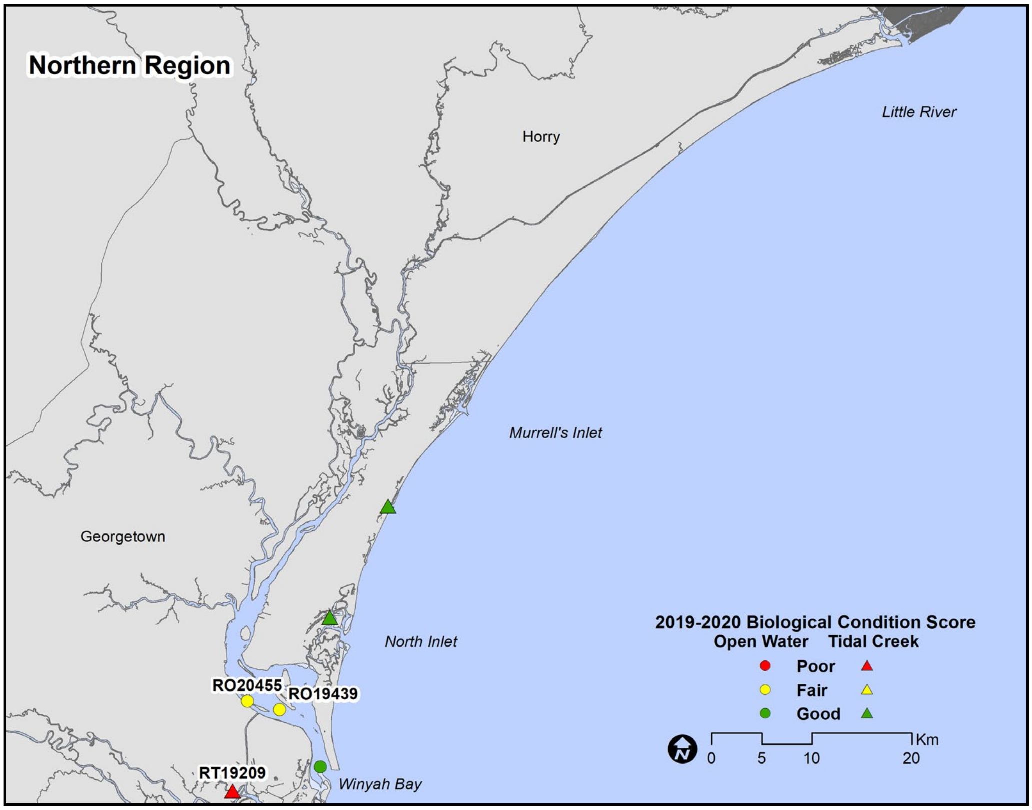
South Carolina's estuaries provide food, habitat, and nursery grounds for diverse communities including fish and large invertebrates such as shrimp and blue crab (Joseph, 1973; Mann, 1982; Nelson et al., 1991). These communities include many important species that contribute significantly to the state's economy and the well-being of its citizens. Estuaries present naturally stressful conditions that limit species' abilities to use this habitat. Add to that human impacts, such as commercial and recreational fishing, coastal urbanization, and habitat destruction, and the estuarine environment can change substantially, leading to decreases in abundances of important fish and invertebrate species.

Densities of fish (finfish, sharks, rays), decapods (crabs, shrimp), and all fauna combined (fish, squid, decapods, and horseshoe crabs) were generally higher in tidal creek habitats compared to open water habitats (Table 3.3.2). This likely reflects the importance of shallower creek habitats as refuge and nursery habitat for many of these species. Due to the often very uneven

Table 3.3.1. Summary of mean benthic biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates the measure used to represent Biological Condition. The measures highlighted in yellow collectively sum to 100%.

Measure	Habitat	Year																					
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biological Condition Index	Open	4.62	4.73	4.50	4.63	4.00	4.30	4.68	4.32	4.53	5.00	4.40	4.87	5.00	4.73	4.60	3.87	4.47	4.27	4.73	5.00	4.73	4.87
	Creek	4.37	4.77	4.32	4.23	3.97	4.33	4.20	4.52	4.40	4.73	4.87	3.80	4.47	4.33	4.07	4.73	4.07	4.33	4.33	4.13	3.80	4.73
B-IBI (Carolinian Province)	Open	3.76	3.73	3.55	3.90	3.48	3.55	3.74	3.52	3.93	4.00	3.50	3.67	3.57	3.47	3.77	3.07	3.57	3.23	3.87	3.67	3.57	3.73
	Creek	3.24	3.70	3.38	3.40	3.08	3.22	3.04	3.54	3.37	3.93	3.57	2.80	3.37	3.10	2.97	3.97	2.90	3.07	3.53	3.40	3.13	3.50
Overall Density (individuals/m^2)	Open	5354	6292	4095	7198	4236	4127	5282	4513	6873	8626	2698	3288	4616	2377	5893	2938	4319	2386	5482	6801	2542	6961
	Creek	2363	4659	4710	5001	3198	2863	2282	5060	3008	6395	2843	2133	2222	6328	2267	4563	1997	2388	6473	4656	2913	3683
Number of Species	Open	25.9	22.1	17.5	26.7	18.9	18.7	21.1	19.0	22.5	23.8	15.3	19.1	15.9	14.4	20.0	14.0	21.0	13.9	20.0	16.3	16.6	21.1
	Creek	14.8	19.7	17.5	20.7	14.4	15.8	12.0	22.2	14.1	23.3	15.6	10.7	15.2	14.7	10.9	22.6	10.8	12.0	16.9	19.4	15.2	15.7
Species Evenness (J')	Open	0.76	0.70	0.72	0.73	0.73	0.74	0.74	0.77	0.69	0.68	0.78	0.79	0.74	0.74	0.66	0.80	0.73	0.74	0.71	0.67	0.79	0.70
	Creek	0.72	0.69	0.71	0.70	0.72	0.72	0.75	0.67	0.74	0.72	0.72	0.67	0.76	0.62	0.66	0.75	0.72	0.74	0.68	0.66	0.71	0.70
Species Diversity (H')	Open	3.29	2.81	2.74	3.14	2.67	2.84	2.94	2.99	2.94	2.99	2.72	3.17	2.72	2.68	2.70	2.67	2.99	2.54	2.84	2.48	2.88	2.86
	Creek	2.59	2.85	2.78	2.78	2.33	2.65	2.41	2.75	2.64	3.03	2.72	2.07	2.81	2.22	2.07	3.19	2.30	2.53	2.61	2.62	2.52	2.62
Percent Sensitive Taxa	Open	13.4	26.8	19.6	16.5	16.4	24.1	19.5	17.9	19.8	19.6	14.1	14.8	14.8	23.3	13.7	11.7	17.7	18.4	30.4	31.4	20.6	11.5
	Creek	10.0	16.5	12.0	8.2	11.5	8.9	13.5	14.6	14.4	14.3	15.4	9.8	18.3	8.5	5.9	22.8	9.1	4.6	15.9	8.4	12.7	14.3
Percent Amphipods	Open	10.9	18.6	12.7	13.2	17.5	17.5	16.3	12.7	13.7	9.5	12.3	15.6	8.7	16.4	12.6	10.4	12.3	15.5	24.3	16.9	18.8	6.5
	Creek	6.1	11.8	4.5	5.3	7.8	4.5	12.9	10.4	13.7	14.2	8.6	1.6	5.9	6.7	7.0	7.0	8.5	9.1	10.4	3.6	9.1	13.4
Percent Molluscs	Open	5.9	7.9	10.0	9.6	7.8	8.5	2.8	10.6	6.4	6.3	7.9	5.2	12.1	9.2	3.9	7.8	8.3	6.7	8.1	5.1	6.0	11.1
	Creek	3.5	6.0	5.7	6.2	5.6	4.9	1.8	5.0	4.5	3.5	5.0	2.0	8.1	2.4	3.3	9.6	3.2	5.4	6.1	3.4	5.7	6.2
Percent Polychaetes	Open	56.3	54.3	60.3	57.2	52.3	50.3	56.7	50.3	54.2	59.8	50.2	61.5	60.9	50.0	62.0	46.6	64.0	44.0	48.6	45.4	52.7	54.7
	Creek	68.8	57.8	69.7	70.9	53.4	70.9	59.4	68.5	59.4	65.0	59.4	73.0	76.3	73.6	62.6	63.6	71.3	63.7	58.8	66.9	56.0	54.0
Percent Other Taxa	Open	26.8	19.2	16.9	20.0	22.4	23.8	24.2	26.4	25.7	24.4	29.7	17.7	18.3	24.4	21.5	35.2	15.4	33.7	19.0	32.6	22.5	27.7
	Creek	21.6	24.4	20.0	17.6	31.5	19.7	25.8	16.0	22.4	17.3	27.0	23.4	9.6	17.3	27.1	19.8	17.1	21.8	24.8	26.1	29.2	26.5

A



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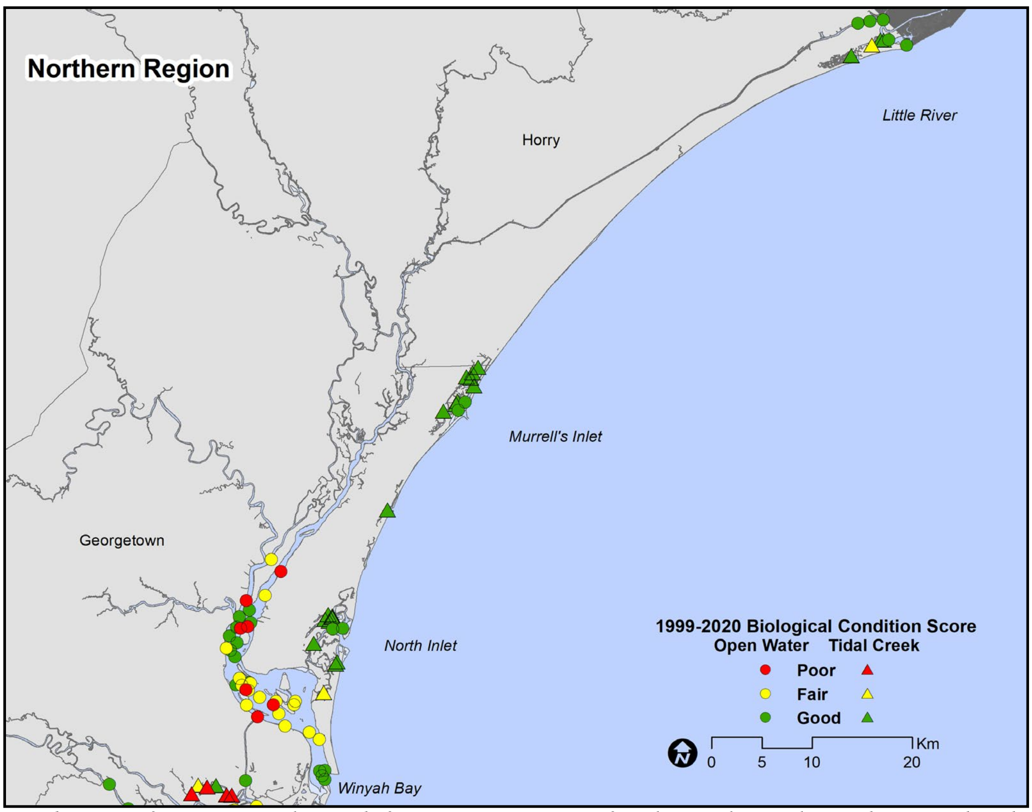
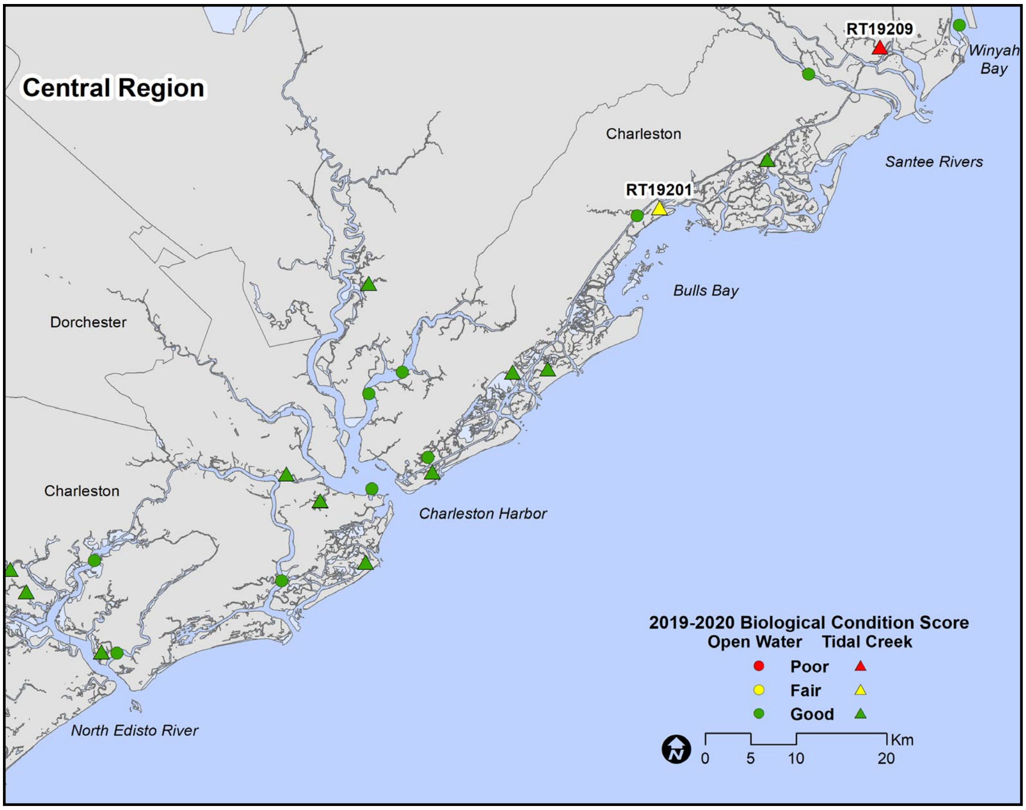


Figure 3.3.4. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2019-2020 (A) and 1999-2020 (B) periods for the northern region of South Carolina.

A



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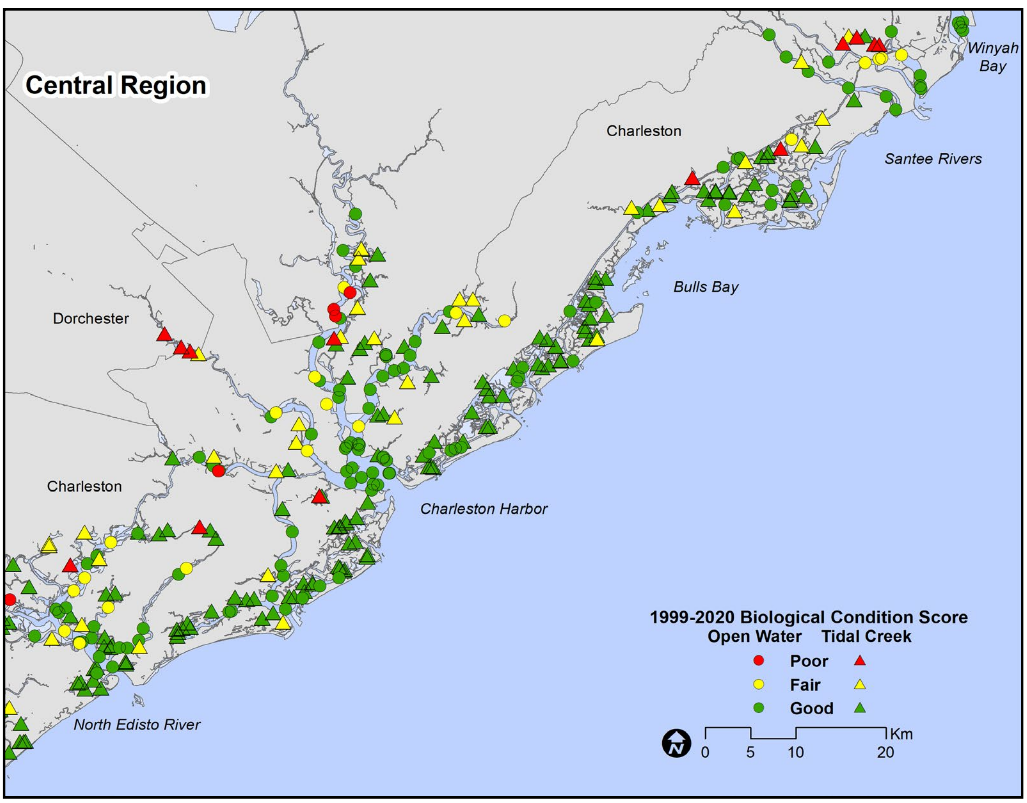


Figure 3.3.5. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2019-2020 (A) and 1999-2020 (B) periods for the central region of South Carolina.

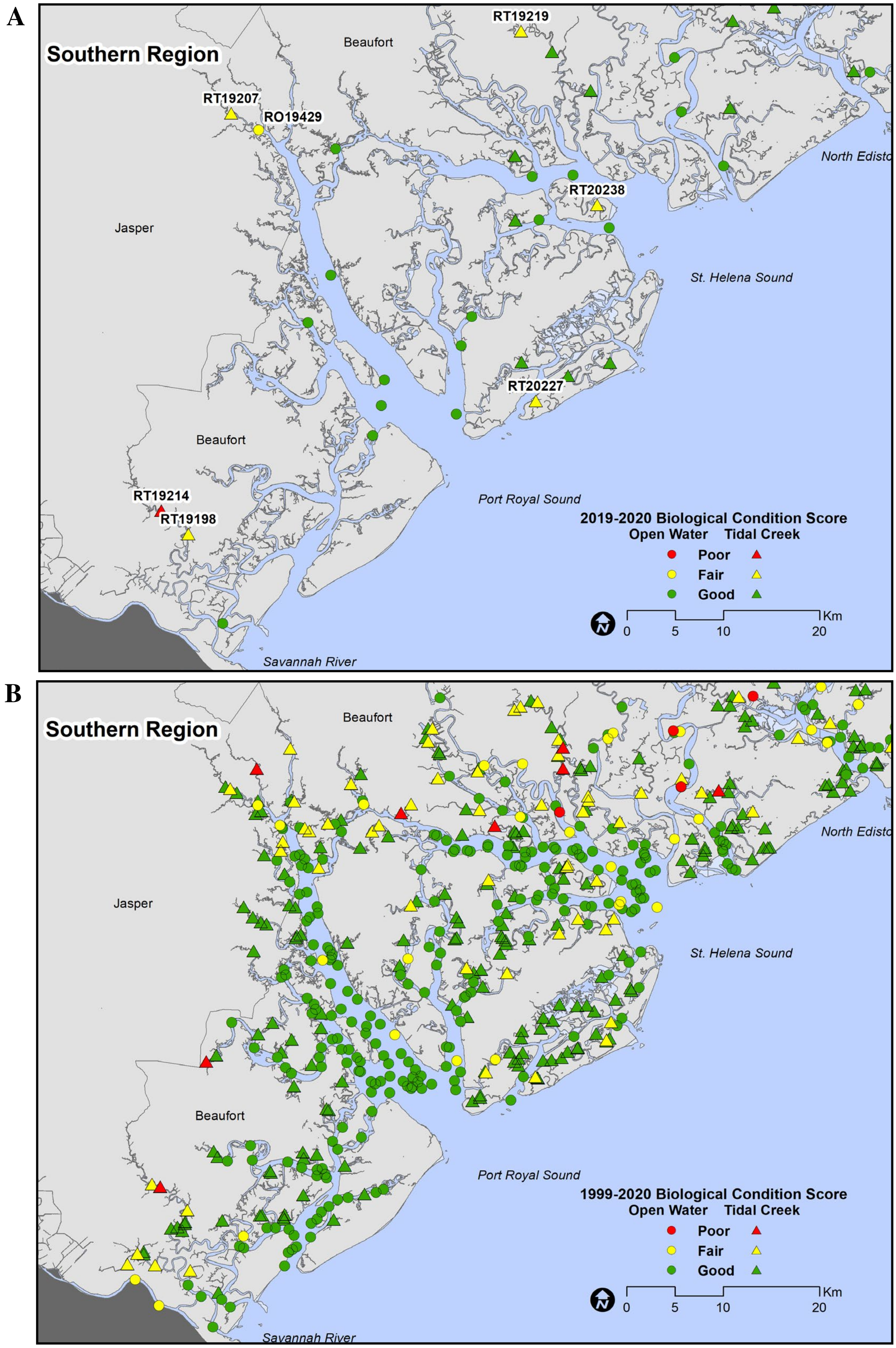


Figure 3.3.6. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2019-2020 (A) and 1999-2020 (B) periods for the southern region of South Carolina.

distribution of organisms in estuaries which can result in one or two very large catches strongly influencing a survey period mean, overall trawl capture densities were summarized by habitat and survey period in two ways: (1) calculating the mean of trawl densities across all stations in each survey period, and (2) identifying the median of trawl densities across all stations in each survey period. For the most part, the trends in overall trawl capture density over time and by habitat were similar across both summarization methods (Figures 3.3.7). Trawl capture densities of all fauna combined in both tidal creek and open water habitats started off at relatively high levels from 1999-2006, underwent a sharp decline in 2007-2008, and then ranged between low and medium densities from 2009-2018 with a temporary increase in density in the 2011-2012 survey period. The lowest overall densities in both open water and tidal creek habitats were observed in 2015 (Table 3.3.2), driven by low densities of fishes and white shrimp (*Penaeus setiferus*). The trawl capture densities observed in 2019-2020 were well above the survey average and similar to the densities observed early in the program.

SCECAP provides a fishery-independent assessment of several of South Carolina's commercially and recreationally important fish and crustacean species. Of these, the most common species collected by SCECAP include the fishes spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), and weakfish (*Cynoscion regalis*); and the crustaceans white shrimp, brown shrimp (*Penaeus aztecus*), and Atlantic blue crab (*Callinectes sapidus*). Spot, white shrimp, brown shrimp, and Atlantic blue crabs were generally more abundant in tidal creek habitats, whereas Atlantic croaker and weakfish had higher mean densities in open water habitats (Table 3.3.2). In a recent detailed analysis of weakfish, spot, and Atlantic croaker catches, Sanger et al. (2022) found evidence that SCECAP captures of weakfish from 1999-2020 have remained fairly constant through time, while spot shows decreasing trends in two different metrics: the percent of stations where this species was caught over time as well as their abundance at the stations where they were caught. In contrast, Atlantic croaker showed an increase in percent of stations where caught from 1999-2020 as well as generally stable abundances at stations where caught (Sanger et al. 2022).

3.4. Incidence of Litter

As the coastline of South Carolina changes and more people access our shorelines and waterways, the incidence of litter (plastic bags and bottles, abandoned crab traps, etc.) is likely to increase. The primary sources of litter include storm drains, roadways and recreational and

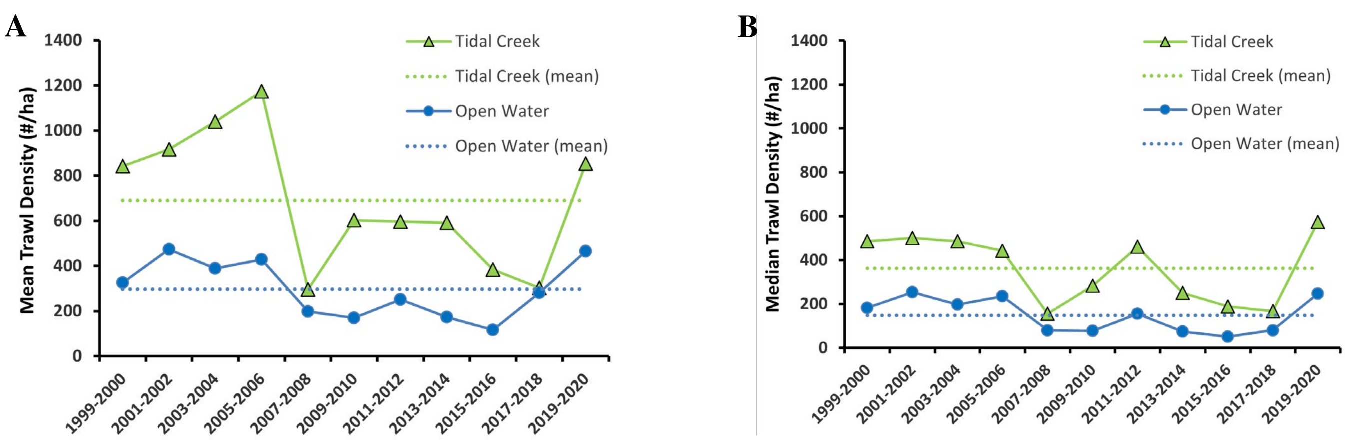


Figure 3.3.7. Mean (A) and median (B) overall trawl capture density (# individuals captured per hectare) observed by survey period and habitat type. The dashed lines represent the means of the annual mean densities (A) and the means of the annual median densities (B) observed for the full 1999-2020 survey period by habitat type.

Table 3.3.2. Summary of fish and large invertebrate biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Fish (blue) include finfish, sharks, and rays. Large invertebrates (yellow) include decapods, horseshoe crabs, and squid. All Density (and No. Species) measures represent mean density (and mean number of species per station), with the exception of "Overall Density: Median". Densities are in units of individuals/hectare.

Measure	Habitat	Year																					
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Overall Density: Mean	Open	329	324	389	557	325	453	381	476	281	116	91	247	325	177	155	191	67	166	111	449	770	159
	Creek	831	853	698	1137	760	1321	738	1611	296	295	329	876	387	804	656	528	244	524	318	285	911	795
Overall Density: Median	Open	149	216	181	326	196	197	232	239	123	36	43	112	199	112	58	91	51	51	69	91	377	116
	Creek	565	406	399	601	467	503	500	384	196	116	123	442	384	536	333	167	217	159	167	167	754	395
No. Species	Open	7.8	7.5	8.0	9.2	7.2	8.3	8.2	7.9	8.4	5.6	4.7	7.6	8.5	5.8	5.9	4.9	4.4	5.3	5.2	6.5	8.0	7.7
	Creek	8.6	9.6	8.2	9.4	8.5	9.5	9.3	8.1	7.1	6.1	6.3	9.3	8.4	9.5	7.7	7.2	5.5	6.5	6.1	7.1	8.5	8.7
No. Fish Species	Open	5.3	5.0	5.7	6.5	5.4	5.9	5.7	5.9	6.1	4.1	3.5	4.8	6.3	3.8	4.3	3.4	2.9	3.5	3.6	3.9	5.5	5.4
	Creek	5.8	6.6	5.7	6.7	6.0	6.4	6.4	5.8	4.9	4.0	4.5	6.1	5.7	6.7	5.3	5.5	3.1	4.2	3.6	4.9	5.9	5.9
Fish Density	Open	202	198	203	297	178	218	196	237	154	92	37	99	178	73	86	100	43	74	44	348	547	96
	Creek	314	373	319	273	299	331	308	171	99	196	98	180	183	282	111	157	94	119	112	145	493	339
Croaker Density	Open	3	48	37	112	71	25	27	27	51	5	5	11	31	14	12	24	10	15	2	73	185	39
	Creek	9	8	16	18	12	6	6	1	14	1	11	27	3	10	20	9	8	4	8	10	9	22
Spot Density	Open	7	18	67	27	23	50	57	29	12	21	1	11	52	2	7	4	1	7	3	72	4	4
	Creek	72	131	112	39	71	95	147	24	13	44	29	41	32	58	16	51	13	7	13	16	89	58
Weakfish Density	Open	12	24	23	42	3	52	11	14	11	11	2	8	9	4	3	20	1	7	4	23	39	7
	Creek	14	6	4	12	3	3	8	2	8	4	4	2	2	6	5	2	0	3	1	7	14	17
No. Decapod Species	Open	1.7	1.8	1.7	2.0	1.5	1.6	1.8	1.4	1.5	0.9	1.1	2.0	1.7	1.7	1.3	1.2	0.9	1.3	1.1	2.0	1.5	1.7
	Creek	2.0	2.2	1.8	2.0	2.0	2.4	2.4	1.7	1.8	1.5	1.1	2.4	2.0	2.3	2.0	1.1	1.8	1.8	2.1	1.7	2.1	2.1
Decapod Density	Open	89	96	171	248	137	211	166	226	111	16	53	138	138	99	64	89	21	85	59	94	204	40
	Creek	476	425	346	788	429	945	385	1417	182	74	207	678	188	510	538	354	140	396	187	123	360	361
Blue Crab Density	Open	2	8	1	1	3	3	3	6	0	0	0	1	3	1	1	2	0	1	0	4	0	2
	Creek	4	22	5	5	11	18	21	9	10	3	0	14	5	123	10	1	2	7	6	4	4	3
Brown Shrimp Density	Open	8	42	108	69	51	34	46	34	63	9	10	47	23	25	16	74	10	29	9	20	58	4
	Creek	127	69	97	135	67	128	150	41	27	37	13	105	35	40	23	10	42	3	15	30	95	28
White Shrimp Density	Open	77	42	56	166	78	173	111	184	43	6	42	88	110	69	46	12	11	54	48	56	125	31
	Creek	339	323	238	631	348	792	208	1364	143	25	193	544	141	342	502	342	95	382	159	85	250	328

commercial activities on or near our waterways. Beyond the visual impact, litter contributes to the mortality of wildlife through entanglement, primarily with fishing line and fishing nets, and through ingestion of plastic bags and other small debris particles. Some litter will also break down to microplastics which are of increasing concern and impact. Additionally, invasive species may be spread through the movement of litter from one area to another (Kiesling et al. 2015).

During the 2019-2020 survey period, litter was visible in 27% of our state's estuarine habitat and was present at the same proportion of stations in both tidal creek and open water habitats. Visible litter hit its highest level at SCECAP stations (34%) in 2007-2008, its second highest level (27%) in the present survey period of 2019-2020, which was closely followed by 26% in the 2017-2018 survey period. For all other survey periods the percentage of estuarine habitat with visible litter was less than 20%.

3.5. Overall Habitat Quality

Using the HQI for the 2019-2020 assessment period, 87% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition (Figure 3.5.1), 13% of the state's estuarine habitat was in fair condition, with none scoring in poor condition. The percent of coastal habitat in good condition has fluctuated over time; the survey period with the lowest percent of habitat with good HQI was in 2003-2004 (77%), and the highest periods were in 2007-2008 and 2011-2012 (92-93%; Figure 3.5.2). When the two habitats were considered separately, a greater percentage of tidal creek habitat during the 2019-2020 survey was in fair to poor condition (30% fair, 0% poor) as compared to open water habitats (10% fair, 0% poor; Appendix 2). This difference between habitat quality in tidal creek and open water habitats observed in 2019-2020 is consistent with previous SCECAP surveys (Figure 3.5.3).

During the 2019-2020 survey period, 12 of the 60 stations were observed to have fair habitat quality, and 9 of those 12 stations were tidal creek stations. Geographically, SCECAP stations with fair habitat quality ranged from Winyah Bay down to the New River (Figures 3.5.4, 3.5.5, 3.5.6; Appendix 3).

Stations in Winyah Bay; Santee Delta region; Cooper and Ashley Rivers; Dawho River region; Combahee River drainages; inland drainages of the Broad River; and New, Wright, and Savannah Rivers historically show a persistent pattern of degraded habitat quality (Figures 3.5.4, 3.5.5, 3.5.6). Winyah Bay, Charleston Harbor, and the Savannah River area all have a history of industrial activity and/or high-density urban development that likely contributed to the degraded conditions in these areas. The causes of degraded habitat quality in the Santee Delta, areas draining into St. Helena Sound (home to the Ashepoo-Combahee- Edisto (ACE) Basin National Estuarine Research Reserve (NERR), and in the headwaters of the Port Royal Sound are not entirely clear.

3.6. Program Uses and Activities

SCECAP continues to be an effective collaboration between the SCDNR, SCDHEC, and NOAA to assess the condition of South Carolina's coastal environment. The results of these assessments have been used extensively in research, outreach, and planning by staff from these and other institutions and organizations. As mentioned earlier, SCECAP partnered with the USEPA's National Coastal Condition Assessment (NCCA) Program in data collection in 2020. This was an exciting opportunity to expand the list of parameters collected (e.g., fish tissue contaminants) and to continue to participate in the national assessment.

The long term SCECAP dataset was recently used in a data synthesis project that linked 20 years of SCECAP data to land cover, temperature, and precipitation data (Hill, 2020). Previous discrete studies have found an association between increased coastal development and elevated concentrations of sediment contami-

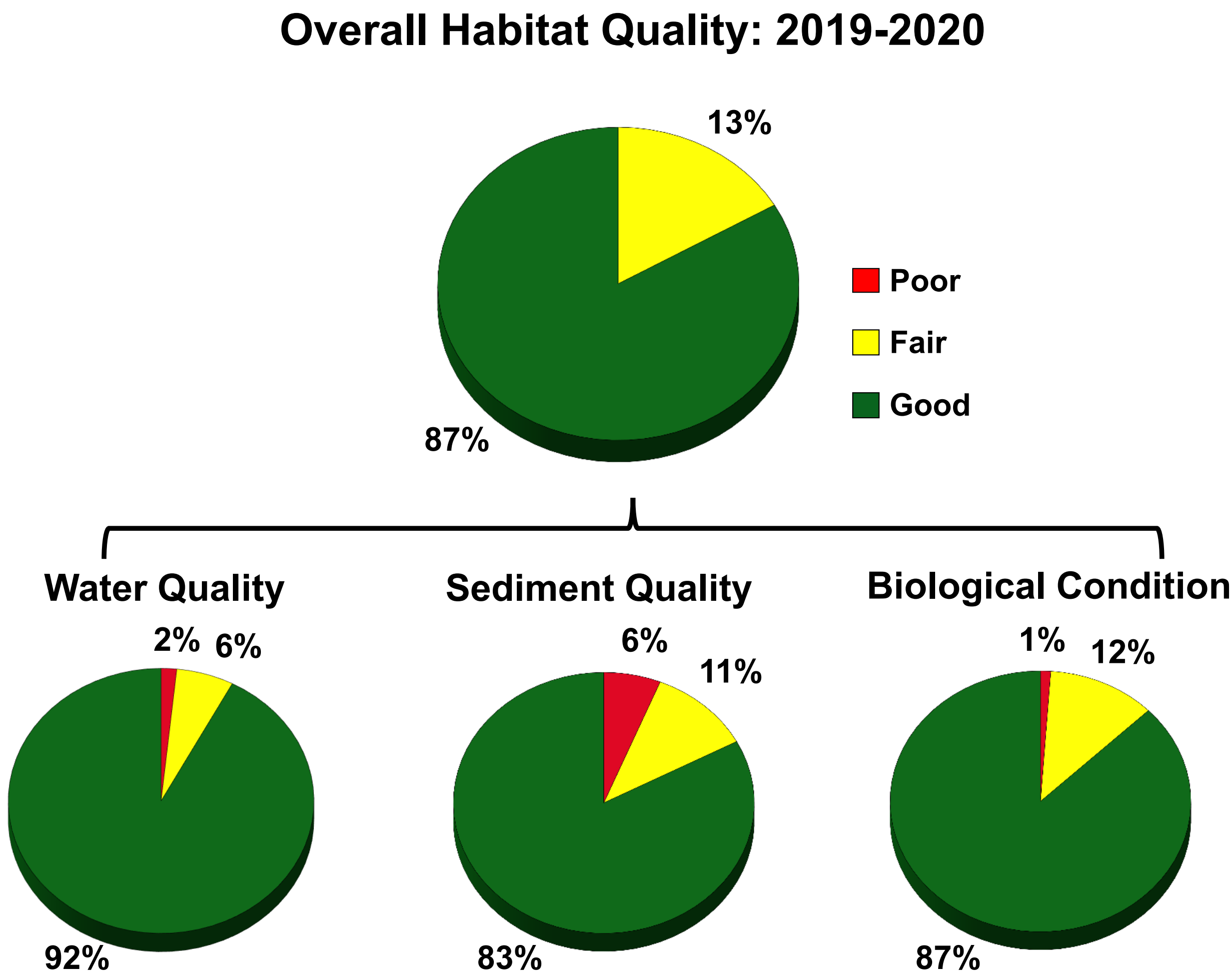


Figure 3.5.1. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Habitat Quality Index and the component indices that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2019 and 2020.

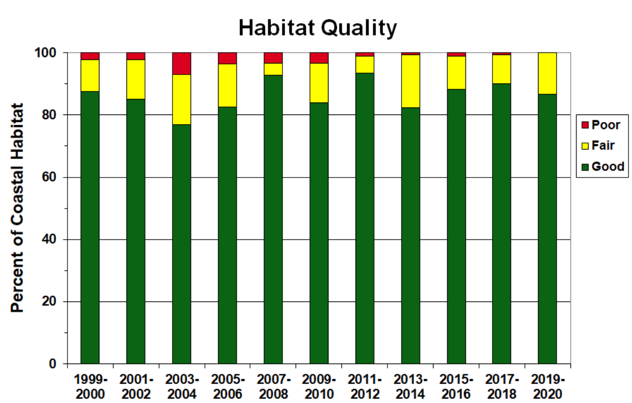


Figure 3.5.2. Percent of coastal waters corresponding to each Habitat Quality Index category by survey period. The Habitat Quality Index is calculated as the average of the Water Quality Index, Sediment Quality Index, and Biological Condition Index.

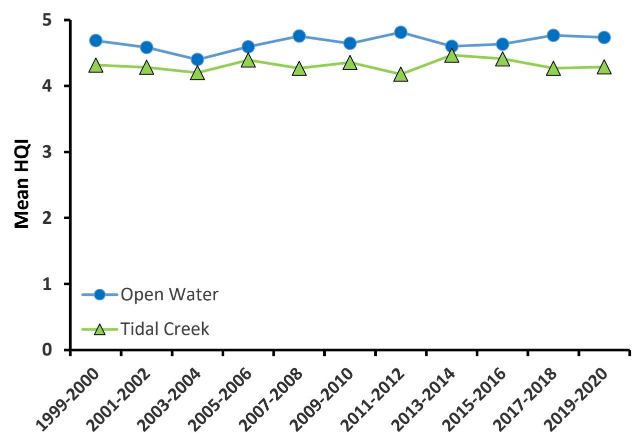
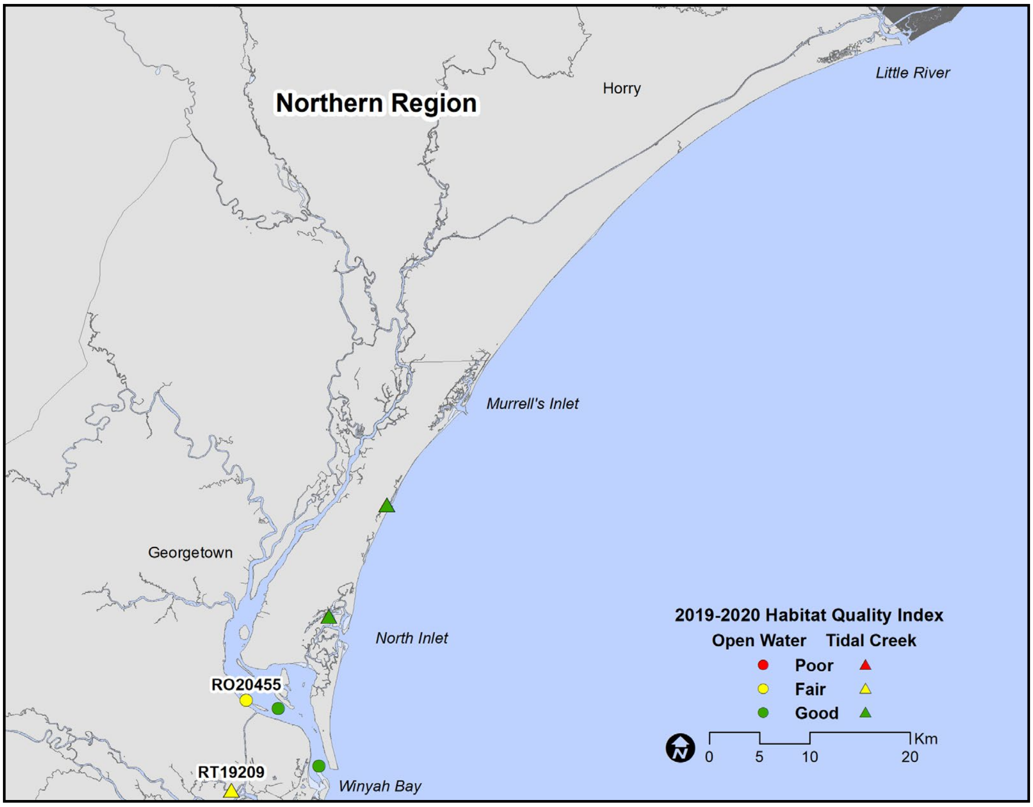


Figure 3.5.3. Habitat Quality Index scores observed by survey period and habitat type.

A



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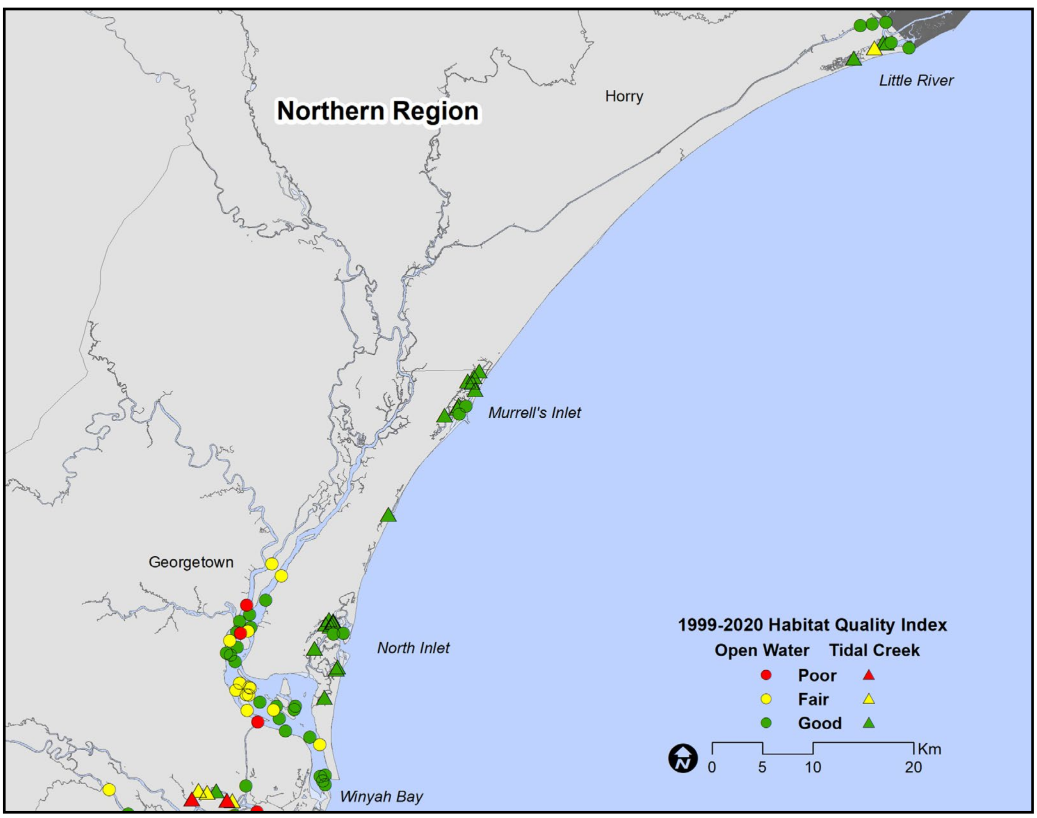

Figure 3.5.4. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the northern region of South Carolina.

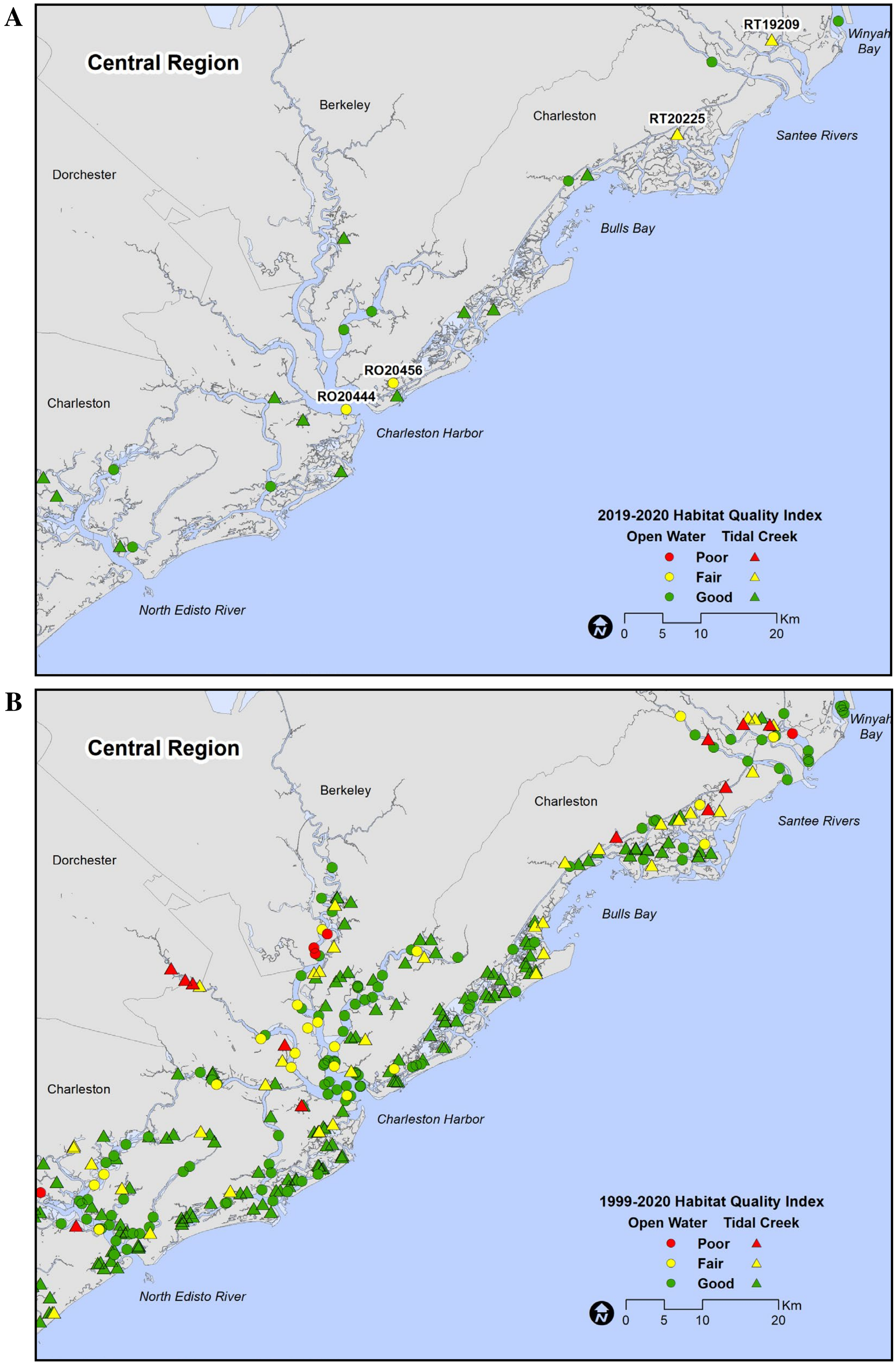

Figure 3.5.5. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the central region of South Carolina.

A

B

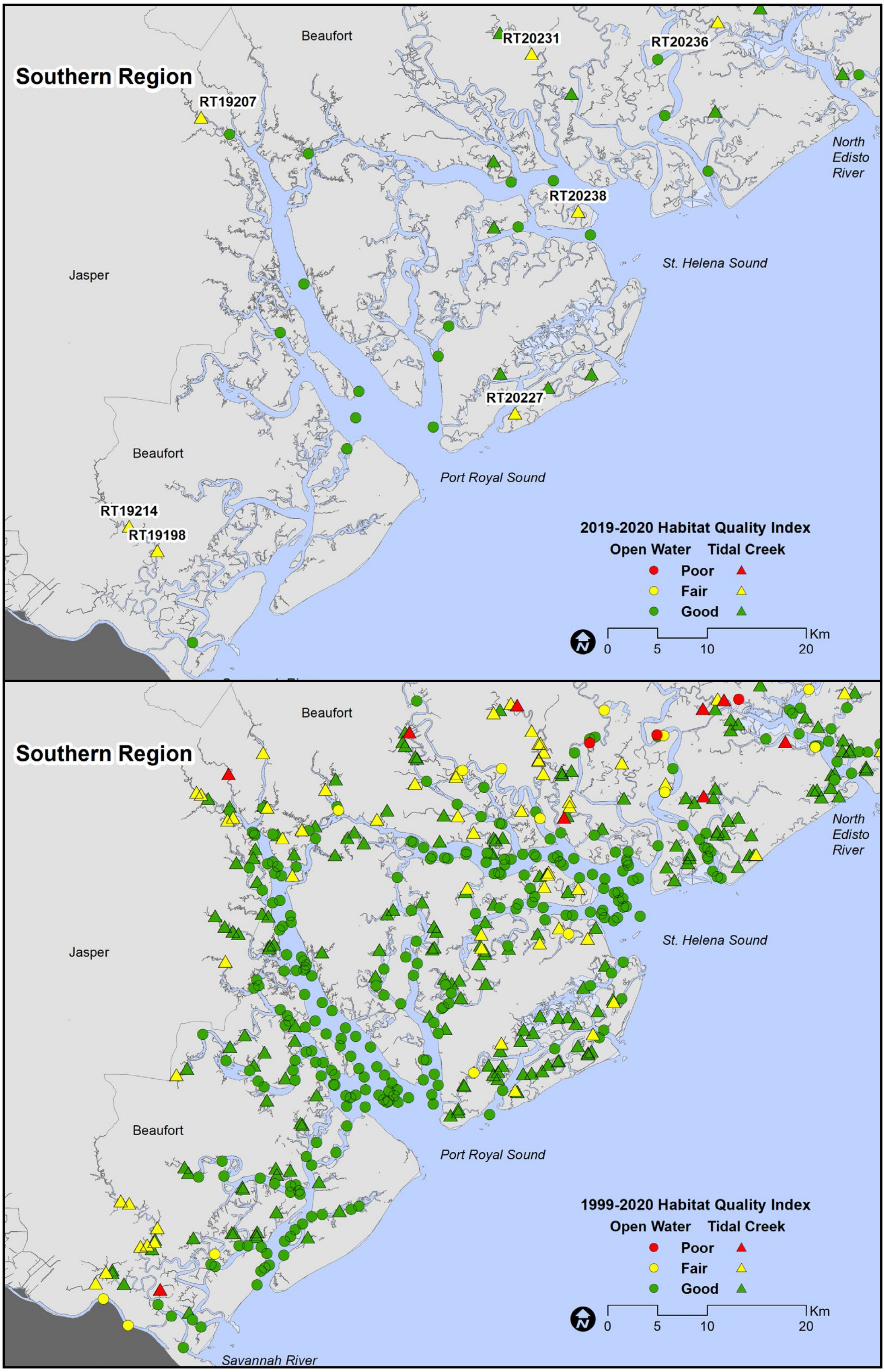

Figure 3.5.6. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2019-2020 (A) and 1999-2020 (B) periods for the southern region of South Carolina.

nants (Sanger et al. 2015); analysis of the 20-year SCECAP dataset found similar relationships, including at larger spatial scales than had been previously observed, and incorporated additional environmental factors. Increases in temperature and extreme precipitation events were noted during the study period, and these events were associated with changes in environmental quality. For instance, cool and wet winters preceding summers when SCECAP samples were collected were associated with increases in sediment contaminant concentrations. This study was made possible through a collaboration with the College of Charleston and South Carolina Sea Grant Consortium.

SCECAP is collaborating with the Port Royal Sound Foundation to conduct a synthesis of the 1999-2020 SCECAP data for the Port Royal Sound watershed. During this time, SCECAP sampled 123 tidal creek and 156 open water stations which provides enough samples to conduct a statistically defensible assessment of condition of the Port Royal Sound coastal waters within two 11-year time frames. This is the first time we have used the SCECAP data at a watershed scale and we look forward to conducting similar analyses for other watersheds.

In addition, SCECAP data have been requested by a number of entities. The U.S. Army Corps of Engineers has requested data several times over the years including for the ongoing Charleston Peninsula Coastal Storm Risk Management Study. Clemson Extension is conducting a watershed based planning effort for Edisto Island for which SCECAP water quality provided needed baseline information. On an ongoing basis, SCDNR staff mine the SCECAP database for updated fishery-independent information regarding the status of various crustacean species as part of the Marine Resources Division's annual assessment of stocks. In 2021, SCDNR's Heritage Trust Program requested data on a brackish water crustacean to improve understanding of its range and preferred habitat.

SCECAP data have also been used in combination with data from similar sampling efforts by NOAA to compare habitat quality in National Estuarine Research Reserves (NERRs) throughout the southeastern U.S. (Balthis et al. the 2015).

Finally, the SCECAP database provides complementary data on the distribution and relative abundance of key recreational species (e.g., spot, Atlantic croaker, weakfish) using unbiased sampling at a broad array of stations representing tidal creek and open water estuarine habitats. These data complement information obtained from other SCDNR programs (e.g., inshore recreational finfish program, SEAMAP), by sampling in areas those programs do not target, by monitoring young of the year abundances for multiple recreationally important finfish species (a life stage not targeted by other fisheries monitoring programs), and by collecting a wealth of environmental data that can be used to relate stock condition to the health of estuarine systems. Weakfish, Atlantic croaker, and spot abundance data from SCECAP are reported in the annual SCDNR Compliance Reports to the Atlantic States Marine Fisheries Commission (ASMFC).

The program maintains sampling at a minimum of 30 stations each year to provide for a total of 60 stations (30 tidal creek, 30 open water) for each two-year assessment period. This is considered to be the minimum effort required to make statistically defensible assessments of condition for the coastal waters of our state. Continuing this program on a long-term basis will provide valuable information on trends in estuarine condition that are likely to be affected by continued coastal development.

ACKNOWLEDGMENTS

The credit for the immense amount of work involved in planning and implementing project of this size, (e.g., collection and processing of samples and environmental data, data analysis, and finally writing this report) goes to many people. Some have been involved since its inception in 1999 while others may have only been involved for a summer. Either way, the project cannot be completed without the dedicated efforts of these individuals. We would like to thank Andrew Tweel for leading the SCECAP field efforts during the 2019-2020 seasons. Tony Olsen and staff at the USEPA NHEERL, Corvallis, OR assisted in developing the sampling design and CDF routines used in the analysis.

The bulk of the field work falls on two groups, the staff of the SCDNR's Environmental Research Section (ERS) and SCDHEC's Aquatic Science Programs. In addition to the authors, SCDNR field teams included Catharine Parker, Aaron Burnette, Leona Forbes, Norm Shea, Joseph Cowan, Kimberly Sitta, Lloyd Hill, Nicole King, Meghan Reilly, Hannah Kuhl, and Chelsea Woodruff, and SCDHEC field teams included Nick Pangborn, Ronnie Marin, and Emily Bores.

Once the diverse array of samples arrived back at the lab at the end of a field day, they were distributed to laboratories at SCDNR (where benthic community and sediment samples were processed by ERS staff) and to the laboratories of collaborating agencies. Staff at the NOAA / NOS National Centers for Coastal Ocean Science Hollingsd Marine Laboratory processed sediment chemistry and toxicology assays (LouAnn Reed, Joe Wade, Katy Chung, and Brian Shaddrix, a contractor to NCCOS via CSS inc.). Staff at the SCDHEC Bureau of Environmental Health Services, Analytical and Radiological Environmental Services Division that processed the nutrient, fecal bacteria, and Chl-*a* samples included Susan Jackson and Carey Merriweather (Central Lab) and Jacqueline Adams and Sharon Gilbert (Region 7 ECQ Trident Lab).

Katie Slack with SCDNR Graphics generated the layout of this report.

Finally, we wish to thank the individuals who provided technical peer-review of this document. Jeffrey Hyland, Olivia Hernandez, and A.K. Leight provided valuable comments that improved the quality of this report.

The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the authors and do not necessarily reflect the views of NOAA or the Department of Commerce.

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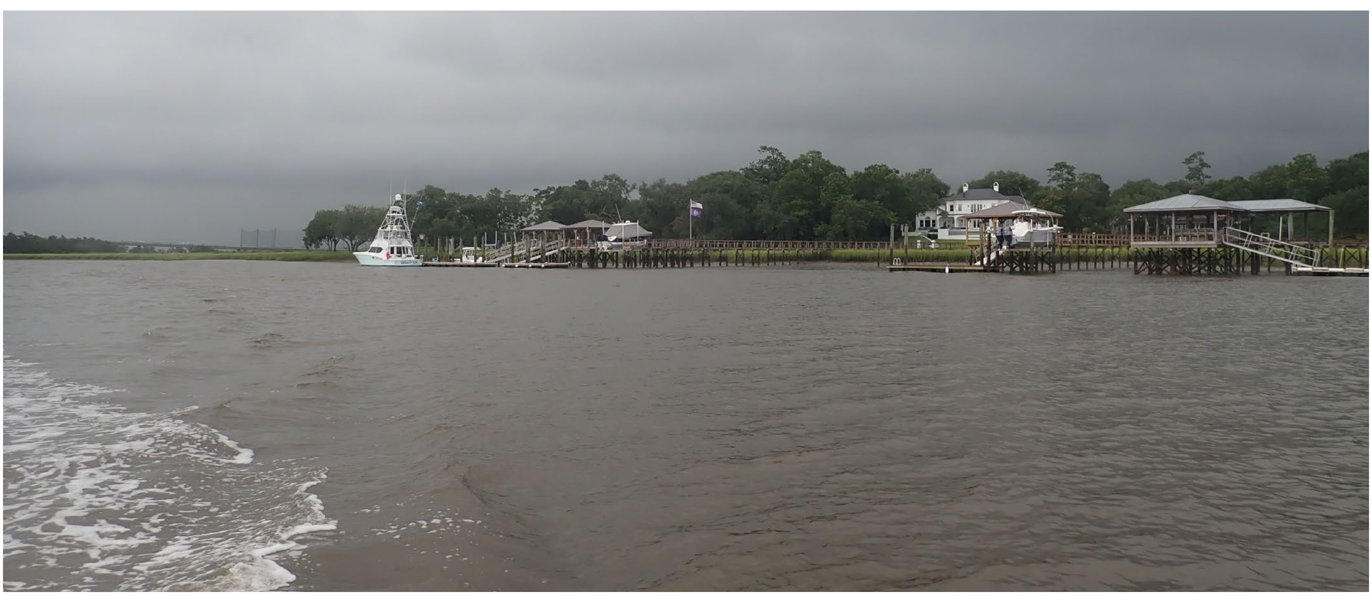

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Appendix 1. Summary of station locations and dates sampled in 2019 through 2020. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2019
Station Information -- Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO19427	Open	33.20995	-79.19256	3.7	7/31/2019	Georgetown	NDV	Winyah Bay; 1.0 miles SSW of shellfish site 05-24
RO19428	Open	32.66729	-80.00024	5.5	7/08/2019	Charleston	R<1	Stono River channel off Battery Island boat landing near sh. site 11-33
RO19429	Open	32.54513	-80.87125	3.4	8/27/2019	Jasper	R>1	Coosawhatchie River downstream of Dawson Island
RO19430	Open	32.25859	-80.74593	4.0	7/30/2019	Beaufort	R<1	Skull Creek near Chechessee River
RO19431	Open	32.46019	-80.56137	6.4	7/17/2019	Beaufort	R<1	Morgan River between Boatswain Pond Creek and Parrot Creek
RO19432	Open	32.61187	-80.41078	2.1	7/16/2019	Charleston	NDV	S. Edisto River; 1.5 miles WSW of ICW mouth
RO19433	Open	32.28686	-80.73637	3.0	8/14/2019	Beaufort	R>1	Chechessee River near confluence with Broad River
RO19434	Open	32.34266	-80.64803	2.7	8/14/2019	Beaufort	R>1	Cowen Creek at confluence with Beaufort River
RO19435	Open	32.50990	-80.35719	4.3	7/16/2019	Charleston	R>1	S. Edisto River downstream of mouth of St. Pierre Creek
RO19436	Open	32.85198	-79.89527	1.5	7/10/2019	Charleston	I<1	Wando River; 1 mile S of I-526 bridge
RO19437	Open	32.40891	-80.79175	8.5	7/30/2019	Beaufort	R>1	Broad River; 1.7 miles N of SC-170 bridge
RO19438	Open	32.56090	-80.40353	4.6	7/16/2019	Colleton	NDV	S. Edisto River; 1.7 miles NE of Fenwick Cut
RO19439	Open	33.26210	-79.23522	2.4	7/31/2019	Georgetown	I>1	Winyah Bay; 0.9 miles SSE of site MD-278
RO19440	Open	32.68880	-80.22011	2.4	7/09/2019	Charleston	I<1	Wadmalaw River; 0.7 miles S of the mouth of Oyster House Creek
RO19441	Open	32.08265	-80.91154	0.3	8/13/2019	Beaufort	I>1	New River at the mouth of Walls Cut

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away.

Station Information -- Tidal Creeks

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT19193	Creek	33.34462	-79.17931	2.7	7/31/2019	Georgetown	NDV	Bly Creek
RT19197	Creek	32.87479	-79.68420	1.5	7/10/2019	Charleston	NDV	Santee Pass
RT19198	Creek	32.16660	-80.94907	5.5	8/13/2019	Jasper	I>1	New River; 1.2 miles N of Coleman Island
RT19200	Creek	32.77343	-79.99349	1.5	7/10/2019	Charleston	R<1	Wappoo Creek south of Farmfield Rd and Lining Ct
RT19201	Creek	33.03345	-79.54964	1.2	7/10/2019	Charleston	R>1	Unnamed tributary to Harbor River in Cape Romain NWR
RT19203	Creek	32.52043	-80.58780	1.8	7/17/2019	Beaufort	NDV	Unnamed creek in Chisolm Islands
RT19204	Creek	32.59842	-80.21236	4.0	7/09/2019	Charleston	R>1	Unnamed tributary to Adams Creek; 1 mile SW of Rockland
RT19206	Creek	32.31426	-80.53001	0.9	8/14/2019	Beaufort	NDV	Skull Creek on Pritchards Island
RT19207	Creek	32.56093	-80.90173	2.1	8/27/2019	Jasper	R>1	Coosawhatchie River; 0.4 mi E of Dawson Creek Landing
RT19208	Creek	32.56466	-80.34937	2.1	7/16/2019	Charleston	R<1	Shingle Creek on Scananwah Island upstream of Milton Creek
RT19209	Creek	33.18971	-79.28672	1.8	7/31/2019	Georgetown	NDV	Minim Creek on Minim Island
RT19214	Creek	32.18856	-80.97913	2.7	8/13/2019	Beaufort	R>1	New River; 1.4 miles SE of Cook Landing
RT19215	Creek	32.58138	-80.50376	1.2	7/17/2019	Colleton	NDV	Unnamed tributary to New Chehaw River; E of Big Island
RT19219	Creek	32.63731	-80.58053	3.4	7/17/2019	Colleton	R<1	Chehaw River; 0.5 miles NE of Old Chehaw Boat Landing
RT19222	Creek	32.32622	-80.48381	4.9	8/14/2019	Beaufort	R<1	Old House Creek near shellfish site 16B-06F on Fripp Island

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away.

SCECAP 2020
Station Information -- Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO20442	Open	32.50205	-80.52359	11.6	8/25/2020	Beaufort	NDV	Coosaw River; 1.9 miles WNW of shellfish site 14-10
RO20443	Open	33.16383	-79.37173	2.4	7/21/2020	Charleston	NDV	South Santee River; 0.5 miles SE of Collins Creek
RO20444	Open	32.75761	-79.89308	9.8	7/14/2020	Charleston	I<1	Charleston Harbor; 1.1 miles NW of Fort Sumter ferry terminal
RO20445	Open	32.52737	-80.78625	5.5	8/19/2020	Beaufort	R>1	Haulover Creek; 260 yd SW of confluence with Whale Branch
RO20446	Open	32.27847	-80.65356	8.2	8/04/2020	Beaufort	R<1	Beaufort River at confluence with Port Royal Sound
RO20447	Open	32.50108	-80.56894	3.7	8/26/2020	Beaufort	R>1	Coosaw River; 0.7 miles ENE of shellfish site 14-16A
RO20448	Open	32.87332	-79.85571	7.3	7/14/2020	Charleston	R>1	Wando River; 0.75 miles SW of shellfish site 09B-02
RO20449	Open	32.31079	-80.73293	3.4	8/05/2020	Beaufort	R>1	Broad River across from Parris Island
RO20450	Open	32.37002	-80.63629	5.5	8/04/2020	Beaufort	R<1	Cowen Creek; 0.6 miles SSW of shellfish site 15-18
RO20451	Open	33.02550	-79.57671	2.4	7/21/2020	Charleston	R<1	ICW; 0.35 miles SW of shellfish site 07-03
RO20452	Open	32.59693	-80.19447	4.0	7/29/2020	Charleston	R<1	Bohicket Creek near Sea Island Yacht Club Rd
RO20453	Open	32.36472	-80.81694	2.1	8/05/2020	Beaufort	R<1	Chechessee River; 1.3 miles SW of Edgar Glenn Landing
RO20454	Open	32.45253	-80.48410	10.4	8/18/2020	Beaufort	R>1	Morgan River near Coffin Creek
RO20455	Open	33.27018	-79.26943	4.3	7/22/2020	Georgetown	R<1	Winyah Bay; 1 mile NW of west channel light 2
RO20456	Open	32.78826	-79.82673	3.7	7/15/2020	Charleston	R>1	Inlet Creek; 150 yd SSE of shellfish site 09A-27

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away.

Station Information -- Tidal Creeks

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT20223	Creek	32.96183	-79.89392	5.2	8/11/2020	Berkeley	I>1	Flagg Creek; 0.6 miles south of BP AMOCO chemical plant
RT20224	Creek	32.68069	-80.31907	1.8	7/28/2020	Charleston	R<1	Toogoodoo Creek; 300 yd NE of shellfish site 12B-45
RT20225	Creek	33.07991	-79.42209	1.8	7/21/2020	Charleston	NDV	Dupre Creek; 450 yd SSW of shellfish site 06B-20
RT20227	Creek	32.29084	-80.56590	3.4	8/04/2020	Beaufort	R>1	Moon Creek; 0.4 miles E of confluence with Trenchards Inlet
RT20228	Creek	32.77400	-79.82159	3.7	7/15/2020	Charleston	R<1	Narrows Creek; 100 yd SE of shellfish site 09A-20
RT20231	Creek	32.61790	-80.54629	4.9	8/25/2020	Colleton	R<1	Chehaw River; 1.1 miles W of Social Hall Creek
RT20232	Creek	32.68492	-79.90115	3.0	7/08/2020	Charleston	R<1	Unnamed tributary to Rat Island Creek
RT20234	Creek	32.46019	-80.58752	3.7	8/19/2020	Beaufort	R>1	Boatswain Pond Creek; 1 mi from confluence with Morgan River
RT20236	Creek	32.64612	-80.34597	4.3	7/28/2020	Charleston	R>1	Dawho River; 0.5 miles NE of Fishing Creek
RT20238	Creek	32.47433	-80.49708	3.7	8/18/2020	Beaufort	NDV	Morgans Back Creeks (eastern creek)
RT20239	Creek	32.87230	-79.72565	1.0	7/15/2020	Charleston	R<1	Toomer Creek; 0.8 miles NNW of confluence with ICW
RT20240	Creek	32.65848	-80.30029	1.0	7/28/2020	Charleston	R<1	Tom Point Creek near Park Island
RT20241	Creek	33.44378	-79.11502	1.8	8/12/2020	Georgetown	R<1	Pawleys Island Creek; 200 yd NNE of Shell Rd Boat Ramp
RT20243	Creek	32.32729	-80.58141	2.4	8/04/2020	Beaufort	R>1	Western tributary to Scott Creek; 130 yd NW of confluence
RT20244	Creek	32.74655	-79.95392	3.0	7/14/2020	Charleston	R<1	Unnamed tributary to James Island Creek

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away.

Appendix 2. Summary of the criteria and amount of open water and tidal creek habitat scoring as good, fair or poor for each SCECAP parameter and index for 2019 through 2020.

Index / Parameter	Criteria			2019-2020 Survey					
				Percent of Open Water Habitat			Percent of Tidal Creek Habitat		
	Poor	Fair	Good	Poor	Fair	Good	Poor	Fair	Good
WATER QUALITY									
Water Quality Index				0.0	3.3	96.7	10.0	20.0	70.0
Dissolved Oxygen (mg/L)	< 3	3 ≤ x < 4	≥ 4	0	17	83	10	27	63
pH (salinity corrected)	≤ 7.22	7.22 < x ≤ 7.35	> 7.35	0	3	97	7	20	73
Fecal Coliform (cfu/100mL)	> 400	43 < x ≤ 400	≤ 43	0	10	90	3*	27*	67*
Eutrophic Index				3	7	90	7	13	80
Total Nitrogen (mg/L)	> 1.05	0.81 < x ≤ 1.05	≤ 0.81	0***	3***	87***	7****	3****	77****
Total Phosphorus (mg/L)	> 0.12	0.10 < x ≤ 0.12	≤ 0.10	3*	0*	93*	3*	10*	83*
Chlorophyll *a* (µg/L)	> 16.4	11.5 < x ≤ 16.4	≤ 11.5	7*	10*	80*	13*	27*	57*
SEDIMENT QUALITY									
Sediment Quality Index				6.7	10.0	83.3	3.3	16.7	80.0
Contaminants (ERM-Q)	> 0.058	0.020 < x ≤ 0.058	≤ 0.020	0	17	83	0	17	83
Toxicity	≥ 2	1 ≤ x < 2	< 1	0	13	87	0	13	87
Sediment TOC (%)	> 5	3 ≤ x ≤ 5	< 3	10	13	77	7	40	53
BIOLOGICAL CONDITION									
Benthic-IBI	< 2	2 ≤ x < 3	≥ 3	0.0	10.0	90.0	6.7	20.0	73.3
HABITAT QUALITY									
Habitat Quality Index				0.0	10.0	90.0	0.0	30.0	70.0

Percentages in fields marked with asterices do not add up to 100 because data were missing, resulting in no score for the represented areas.

* Data from one station was missing. *** Data from three stations were missing. **** Data from four stations were missing.

Appendix 3. Summary of the Water Quality, Sediment Quality, Biological Condition, and Habitat Quality Index scores and their component measure scores by station for 2019 through 2020. Green represents good condition, yellow represents fair condition, and red represents poor condition. The actual Habitat Quality Index score is shown to allow the reader to see where the values fall within the above general coding criteria. See text for further details on the ranges of values representing good, fair, and poor for each measure and index score.

Station	Water Quality								Sediment Quality				Biological Condition	Habitat Quality	County	Location
	Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Index (B-IBI)	Habitat Quality Index		
RO19427							5	5				5	5	5.0	Georgetown	Winyah Bay; 1.0 miles SSW of shellfish site 05-24
RO19428							5	5				5	5	5.0	Charleston	Stono River channel off Battery Island boat landing near sh. site 11-33
RO19429							5	5				5	3	4.3	Jasper	Coosawhatchie River downstream of Dawson Island
RO19430							5	5				5	5	5.0	Beaufort	Skull Creek near Chechessee River
RO19431							5	5				5	5	5.0	Beaufort	Morgan River between Boatswain Pond Creek and Parrot Creek
RO19432							0	3				5	5	4.3	Charleston	S. Edisto River; 1.5 miles WSW of ICW mouth
RO19433							5	5				5	5	5.0	Beaufort	Chechessee River near confluence with Broad River
RO19434							5	5				5	5	5.0	Beaufort	Cowen Creek at confluence with Beaufort River
RO19435							5	5				5	5	5.0	Charleston	S. Edisto River downstream of mouth of St. Pierre Creek
RO19436							5	5				5	5	5.0	Charleston	Wando River; 1 mile S of I-526 bridge
RO19437							5	5				5	5	5.0	Beaufort	Broad River; 1.7 miles N of SC-170 bridge
RO19438							5	5				5	5	5.0	Colleton	S. Edisto River; 1.7 miles NE of Fenwick Cut
RO19439							3	5				5	3	4.3	Georgetown	Winyah Bay; 0.9 miles SSE of site MD-278
RO19440							5	5				5	5	5.0	Charleston	Wadmalaw River; 0.7 miles S of the mouth of Oyster House Creek
RO19441							3	5				5	5	5.0	Beaufort	New River at the mouth of Walls Cut
RT19193							5	5				5	5	5.0	Georgetown	Bly Creek
RT19197							5	5				3	5	4.3	Charleston	Santee Pass
RT19198							5	3				5	3	3.7	Jasper	New River; 1.2 miles N of Coleman Island
RT19200							3	3				5	5	4.3	Charleston	Wappoo Creek south of Farmfield Rd and Lining Ct
RT19201							5	5				5	3	4.3	Charleston	Unnamed tributary to Harbor River in Cape Romain NWR
RT19203							5	3				5	5	4.3	Beaufort	Unnamed creek in Chisolm Islands
RT19204							5	5				5	5	5.0	Charleston	Unnamed tributary to Adams Creek; 1 mile SW of Rockland
RT19206							5	5				5	5	5.0	Beaufort	Skull Creek on Pritchards Island
RT19207							5	0				5	3	2.7	Jasper	Coosawhatchie River; 0.4 mi E of Dawson Creek Landing
RT19208							5	5				5	5	5.0	Charleston	Shingle Creek on Scananwah Island upstream of Milton Creek
RT19209							5	5				3	0	2.7	Georgetown	Minim Creek on Minim Island
RT19214							5	3				5	0	2.7	Beaufort	New River; 1.4 miles SE of Cook Landing
RT19215							5	5				5	5	5.0	Colleton	Unnamed tributary to New Chehaw River; E of Big Island
RT19219							3	5				5	3	4.3	Colleton	Chehaw River; 0.5 miles NE of Old Chehaw Boat Landing
RT19222							5	3				5	5	4.3	Beaufort	Old House Creek near shellfish site 16B-06F on Fripp Island

Station	Water Quality								Sediment Quality				Biological Condition	Habitat Quality	County	Location
	Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Index (B-IBI)	Habitat Quality Index		
RO20442							5	5				5	5	5.0	Beaufort	Coosaw River; 1.9 miles WNW of shellfish site 14-10
RO20443							5	5				5	5	5.0	Charleston	South Santee River; 0.5 miles SE of Collins Creek
RO20444							5	5				0	5	3.3	Charleston	Charleston Harbor; 1.1 miles NW of Fort Sumter ferry terminal
RO20445							5	5				5	5	5.0	Beaufort	Haulover Creek; 260 yd SW of confluence with Whale Branch
RO20446							5	5				5	5	5.0	Beaufort	Beaufort River at confluence with Port Royal Sound
RO20447							5	5				5	5	5.0	Beaufort	Coosaw River; 0.7 miles ENE of shellfish site 14-16A
RO20448							5	5				5	5	5.0	Charleston	Wando River; 0.75 miles SW of shellfish site 09B-02
RO20449							5	5				5	5	5.0	Beaufort	Broad River across from Parris Island
RO20450							5	5				5	5	5.0	Beaufort	Cowen Creek; 0.6 miles SSW of shellfish site 15-18
RO20451							5	5				3	5	4.3	Charleston	ICW; 0.35 miles SW of shellfish site 07-03
RO20452							5	5				3	5	4.3	Charleston	Bohicket Creek near Sea Island Yacht Club Rd
RO20453							5	5				5	5	5.0	Beaufort	Chechessee River; 1.3 miles SW of Edgar Glenn Landing
RO20454							5	5				5	5	5.0	Beaufort	Morgan River near Coffin Creek
RO20455							5	5				3	3	3.7	Georgetown	Winyah Bay; 1 mile NW of west channel light 2
RO20456							5	5				0	5	3.3	Charleston	Inlet Creek; 150 yd SSE of shellfish site 09A-27
RT20223							3	5				5	5	5.0	Berkeley	Flagg Creek; 0.6 miles south of BP AMOCO chemical plant
RT20224							5	5				5	5	5.0	Charleston	Toogoodoo Creek; 300 yd NE of shellfish site 12B-45
RT20225							0	0				5	5	3.3	Charleston	Dupre Creek; 450 yd SSW of shellfish site 06B-20
RT20227							5	5				3	3	3.7	Beaufort	Moon Creek; 0.4 miles E of confluence with Trenchards Inlet
RT20228							5	5				5	5	5.0	Charleston	Narrows Creek; 100 yd SE of shellfish site 09A-20
RT20231							5	0				5	5	3.3	Colleton	Chehaw River; 1.1 miles W of Social Hall Creek
RT20232							5	5				5	5	5.0	Charleston	Unnamed tributary to Rat Island Creek
RT20234							5	5				5	5	5.0	Beaufort	Boatswain Pond Creek; 1 mi from confluence with Morgan River
RT20236							5	5				0	5	3.3	Charleston	Dawho River; 0.5 miles NE of Fishing Creek
RT20238							0	3				3	3	3.0	Beaufort	Morgans Back Creeks (eastern creek)
RT20239							5	5				3	5	4.3	Charleston	Toomer Creek; 0.8 miles NNW of confluence with ICW
RT20240							5	5				5	5	5.0	Charleston	Tom Point Creek near Park Island
RT20241							5	5				5	5	5.0	Georgetown	Pawleys Island Creek; 200 yd NNE of Shell Rd Boat Ramp
RT20243							5	5				5	5	5.0	Beaufort	Western tributary to Scott Creek; 130 yd NW of confluence
RT20244							3	5				5	5	5.0	Charleston	Unnamed tributary to James Island Creek