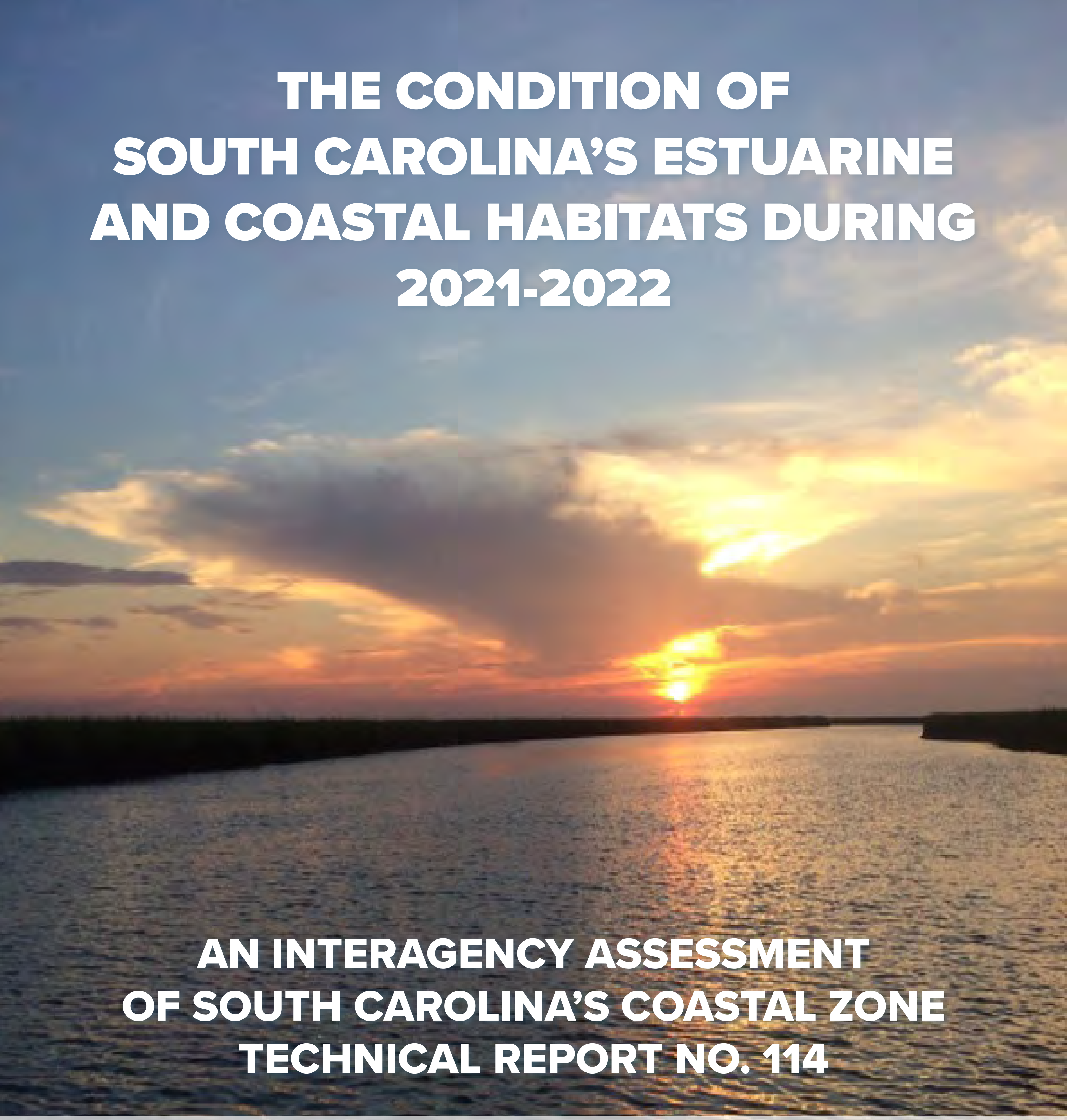

THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2021-2022

AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE

TECHNICAL REPORT NO. 114

South Carolina Department of Natural Resources
SC DEPARTMENT of ENVIRONMENTAL SERVICES
U.S. Fish & Wildlife Service, Department of the Interior
NOAA

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The Condition of South Carolina’s Estuarine and Coastal Habitats During 2021-2022

Technical Report

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2024

SCECAP
South Carolina Estuarine and Coastal Assessment Program

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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.

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

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 Environmental Services (SCDES; formerly SC 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) Hollings Marine Laboratory located in Charleston, SC. 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 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 SCDES (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 biannual reports describing the status of South Carolina's estuarine habitats. The 2021-2022 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 SCDES'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. South Carolina's estuarine habitats can be subdivided into two habitat types: approximately 83% are larger open water bodies - formed by tidal rivers (>100 m wide), bays, and sounds - and the other 17% consists of smaller tidal creeks (defined as water bodies approximately 10-100 m wide from marsh bank to marsh bank). New station locations are assigned each year, half of which are randomly placed in each habitat type 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. Because these data are averaged across two sampling seasons to achieve the necessary sample size for percent area estimates, interannual variability in conditions is better understood by exploring raw values within habitat types and years in the context of the overall dataset. From 1999 through 2022, a total of 931 stations were sampled. The 60 stations sampled in 2021-2022 are shown in Figure 2.1.1 and station information is detailed in Appendix 1.

Sampling occurs during the summer (originally late June through early September; now focused on July and August). This sampling

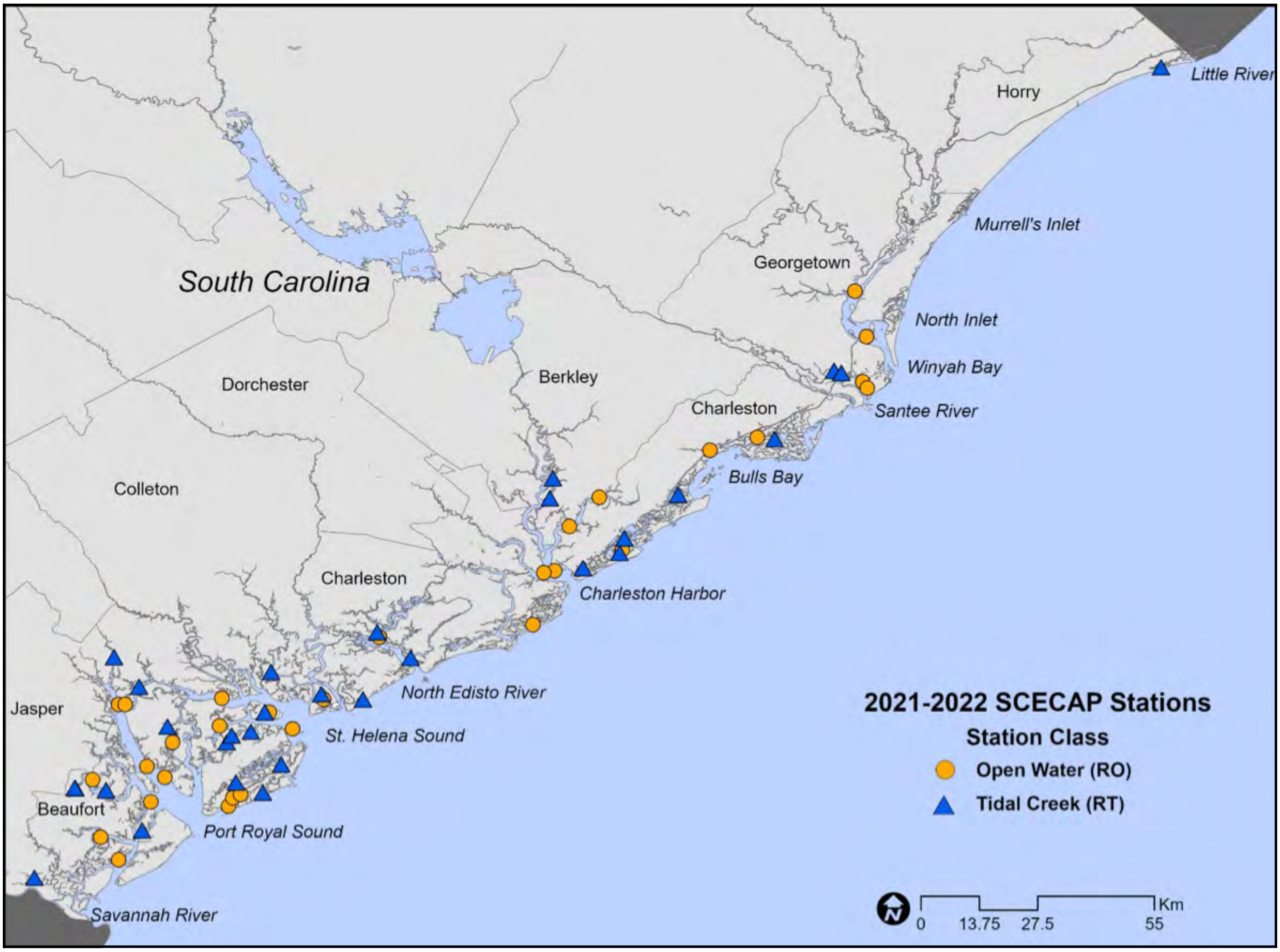


Figure 2.1.1. Locations of stations sampled during 2021 and 2022.

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. SCDES maintains a Quality Assurance Project Plan for water quality sampling components conducted by their department.

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, 6600, or EXO2 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 SCDES and SCDNR field staff also collected an instantaneous measure of these parameters at several depths (0.3 m beneath the surface, in the middle of the water column, and 0.3 m above the bottom) during the 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 enterococcus 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 do not have state water quality standards.

A handheld multi-meter (right) is used to collect water quality at different depths, and a data logging instrument (left) is deployed to collect bottom water quality throughout two high-low tidal cycles.

All nutrient samples for laboratory analyses were 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 depth. Water for nutrient samples was then poured directly into sample bottles containing a sulfuric acid preservative. Sample bottles for Chl-*a* and fecal bacteria were inverted, inserted to a depth of 0.3 m, and filled directly with station water. All water samples were stored on ice until they were returned to the laboratory for further processing. Bacteria samples and total nutrients were processed by SCDES using the standardized procedures in effect at the time of sample collection or analysis (SCDHEC, b-d). From 2011-2022, SCDES TN and TP values from SCECAP-specific samples were not available for many stations; therefore, 2011-2022 TN and TP values were calculated as the average of the nutrient data that were collected at those stations during routine monthly SCDES sampling for the months of June, July, and August. This includes, when available, both SCECAP-specific sampling and routine monthly SCDES sampling. The number of values included in TN and TP averages ranged from one to four. Because the Eutrophic Index was calculated from TN, TP, and Chl-*a*, in order to process all Eutrophic Index parameter values in a consistent manner, it was decided to apply the same method to Chl-*a* values from June-August for the 2011- 2022 period as well.

2.3. Sediment Quality Measurements

Bottom sediment samples were collected at each station using a stainless steel 0.04 m^2 Young grab deployed from an anchored boat that was repositioned between sample collections. The surficial sediments (upper 2 cm) of four or more grab samples were homogenized on-station in a stainless steel bowl (sterilized with 70% ethanol) 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 were 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 were performed using a modification of the pipette method described by Plumb (1981). Porewater TAN was measured using a Hach Model 700 colorimeter, and TOC was 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 legacy pesticides. All contaminants were 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 were 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 was 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

A Young grab is used to collect samples for sediment quality and benthic biological condition.

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 SCECAP. 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.

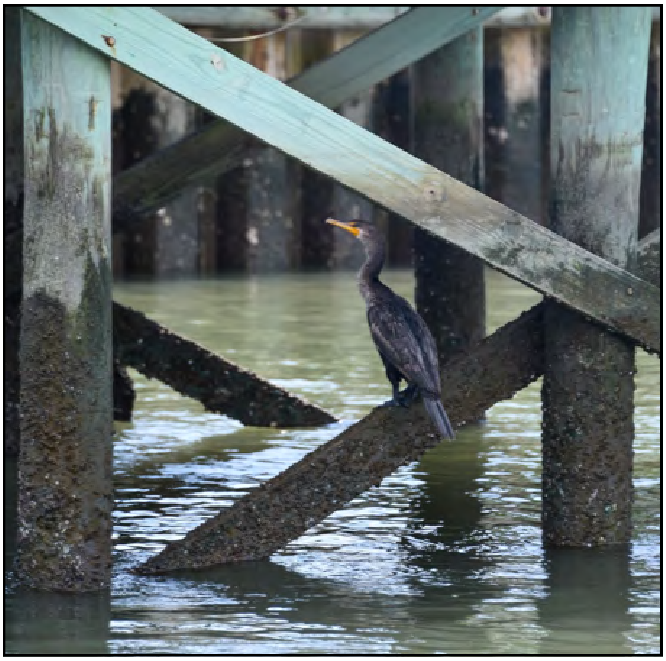
2.4. Biological Condition Measurements

Two whole benthic samples were collected by a Young grab; each sample was washed through a 0.5 mm sieve to collect the macrobenthic invertebrate fauna, which were then preserved in a 10% formalin/seawater solution containing Rose Bengal stain. All organisms from the two grabs were identified either to the species level or to the lowest practical taxonomic level if the specimen was 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 were incorporated into a Benthic Index of Biotic Integrity (B-IBI) for the Carolinian Province, based on number of taxa, abundance, dominance, and percent sensitive taxa (Van Dolah et al., 1999) which was used as the Biological Condition Index (BCI).

A macrobenthic invertebrate sample is collected and rinsed through a 0.5 mm sieve before being preserved for processing in lab.

Fish and large invertebrates were collected by trawl at each station following benthic sampling to evaluate near-bottom nekton community composition. Two replicate trawl tows, pulled in the same direction as tidal flow, were 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 were 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 were slightly shorter than target tow lengths; when that occurs, actual tow length was recorded, and data from that trawl were only included in analyses if the tow was at least 50% of the target tow length. Mean abundances were corrected for the total area swept by the two trawl tows using the formula described by Krebs (1972). Captured fish, squid, large crustaceans, and horseshoe crabs were identified, counted, and checked for gross pathologies, deformities, or external parasites. Up to 30 individuals of each taxon were measured to the nearest centimeter. Most trawl organisms were released on station after identification and enumeration, with the exception of a small number of organisms that were 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); tissue contaminant samples are no longer routinely collected by SCECAP due to funding constraints.

Trawl catches often exhibit uneven distribution of organisms in estuaries which can result in one or two very large catches strongly influencing survey results. To mitigate this effect, 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.



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

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

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 state agencies and other entities using a variety of approaches (Carlton et al., 1998; Chesapeake Bay Foundation, 2021; Partridge, 2007).

For SCECAP analysis, four integrated indices are computed describing components of the estuarine ecosystem: water quality (WQI), sediment quality (SQI), biological condition (BCI), and overall habitat quality. The WQI combines three measures and one metric, 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.

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

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.

Table 2.5.2. Summary of possible index values and scores for the integrated Habitat Quality Index, based on combinations of scores from the Water Quality Index (A), the Sediment Quality Index (B), and the Biological Condition Index (C).

Component Index Scores			Habitat Quality Index (Average)	HQI Score
A	B	C		
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)

It is important to note that as new information has become available, the calculation 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 language and 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 to improve 1) consistency with reporting by the SCDES Ambient Surface Water Quality Monitoring Program, 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 at depressed levels can reflect organic pollution; 2) pH, 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*), that can indicate potential nutrient enrichment and/or associated algal blooms in a water body. 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 2021-2022 survey data, 97% of the state's estuarine habitat scored as being in good condition, 1% 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 poor (5%) was Chl-*a* and fair (18%) was fecal coliform bacteria (Figure 3.1.1, Appendix 3). Only 1% of SC estuarine habitat scored as poor for pH, fecal coliform, TN, and Eutrophic Index. The proportion of the state's overall estuarine habitat with good water quality in 2021-2022 was higher than average relative to the full survey period (Figure 3.1.2).

As has been observed throughout the entire 1999-2022 SCECAP program, tidal creek habitat in 2021-2022 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 2021-2022 survey, 100% of open water and 83% of tidal creek habitats, scored as good on the WQI (Appendix 2).

The geographic distribution of stations for the 2021-2022 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. Of the 60 stations sampled in 2021-2022, 3 tidal creeks and no open water stations had poor WQI (Appendix 3). All three of these stations were sampled in 2022 and occurred in or near St. Helena Sound in the Southern Region (Figure 3.1.6). The first station with poor water quality (RT22001), located in a tidal creek behind Edisto Island, was due to poor to fair scores for DO, fecal coliform, pH, TP, and Chl-*a*. The second station (RT22009), located in a tidal creek on Morgan Island, was due to poor to fair scores for DO and pH. The third station (RT22020), located in a tidal creek in front of Fenwick Island, scored poor or fair for DO, fecal coliform, pH, and TN. In 2021-2022, none of the 30 open water stations and 2 of the 30 tidal creek stations had fair WQI scores.

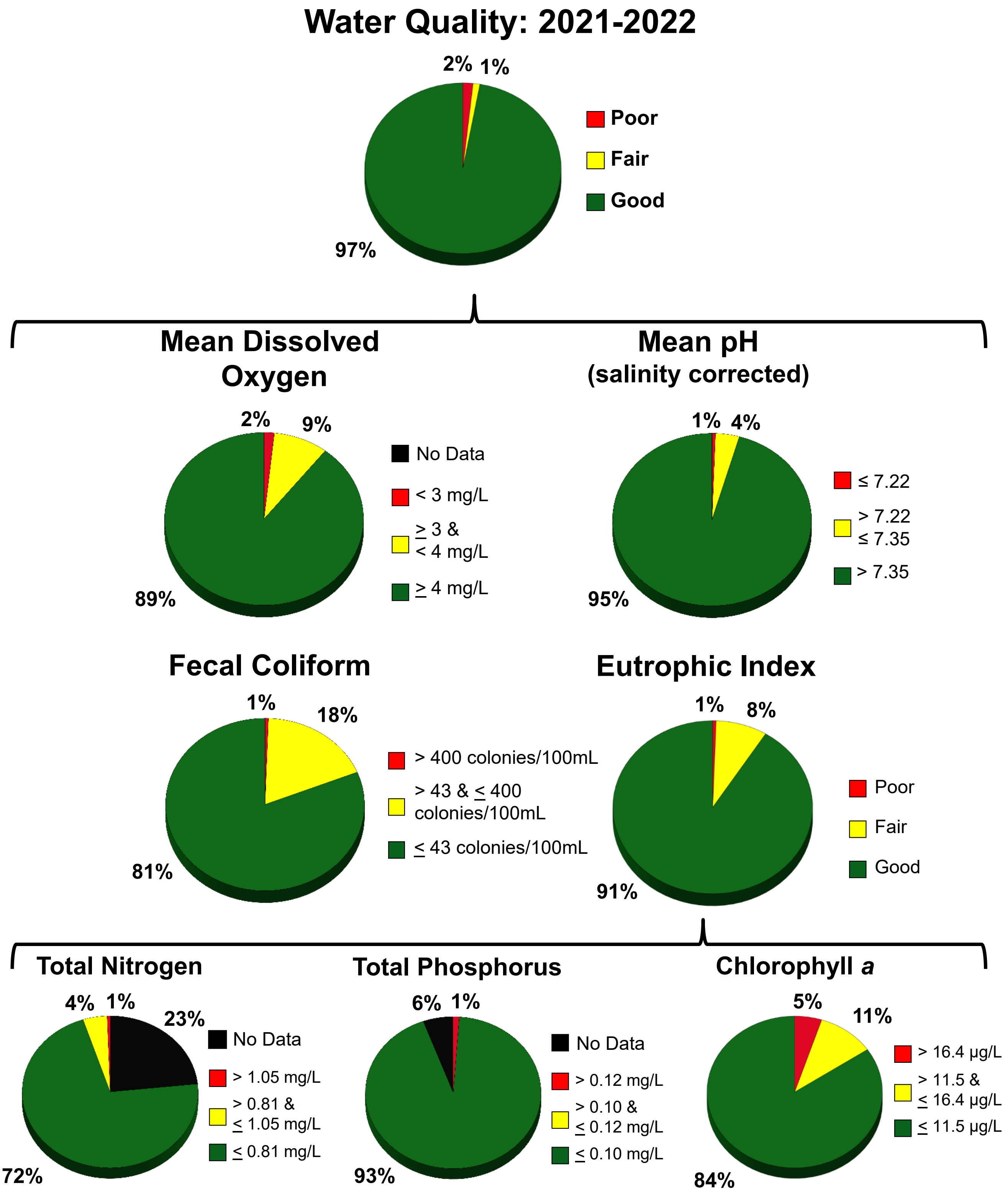


Figure 3.1.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2021 and 2022.

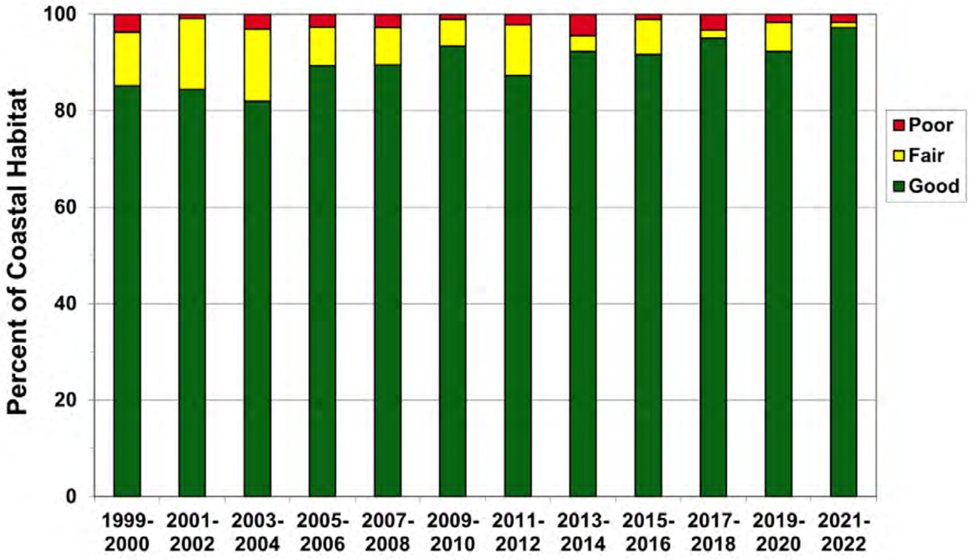


Figure 3.1.2. Percent of coastal habitats corresponding to each Water Quality Index category by survey period

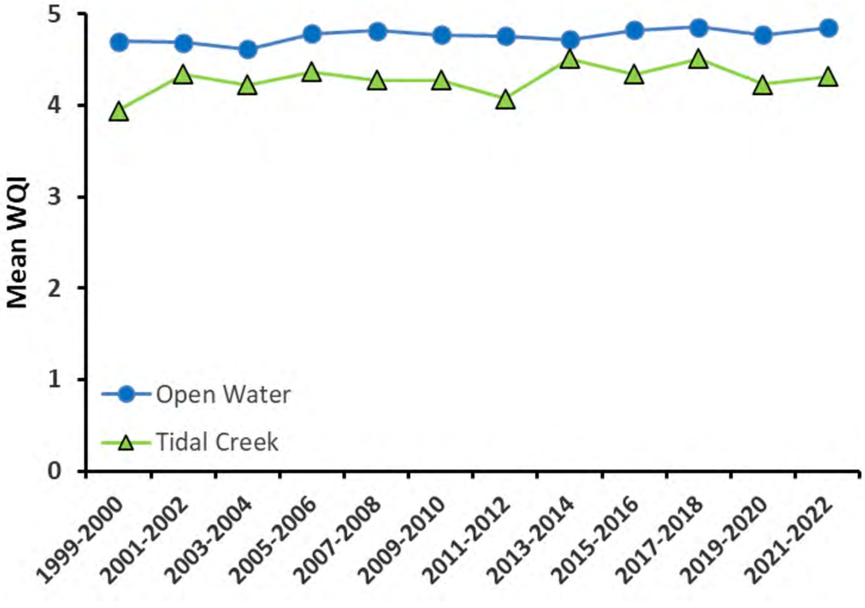
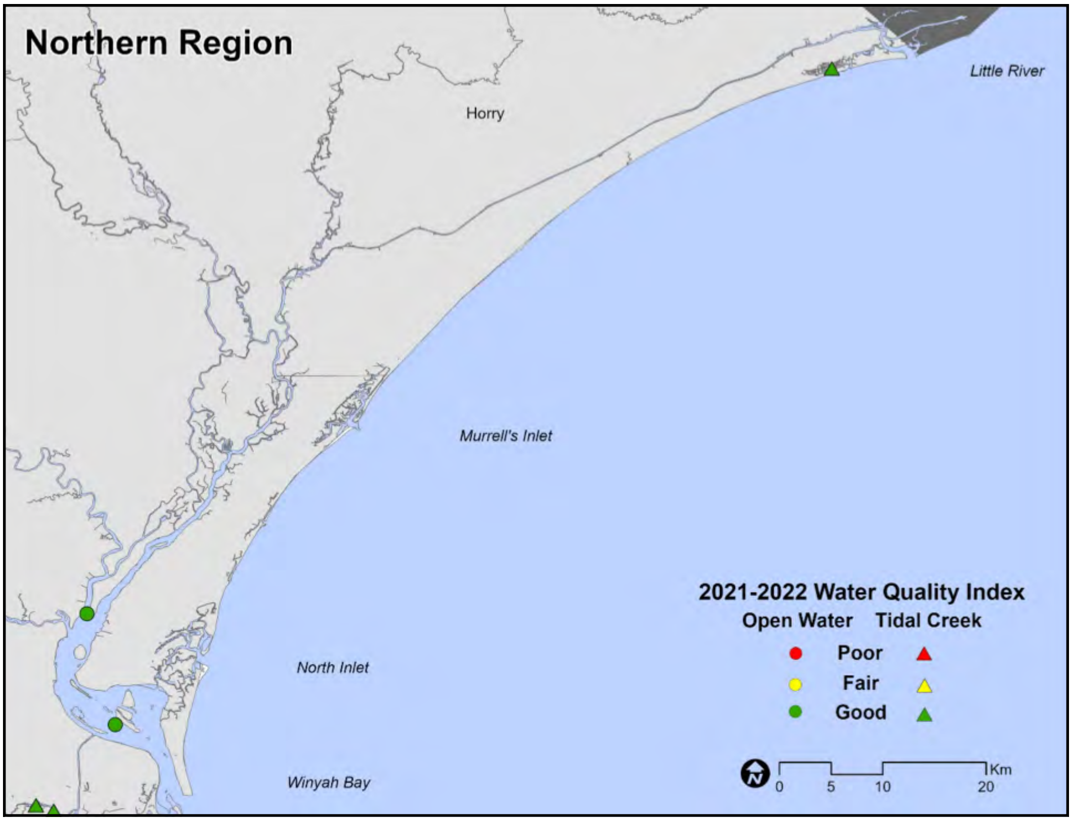


Figure 3.1.3. Water Quality Index scores observed by survey period and habitat type.

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	2021	2022
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	4.83	4.80	4.72	4.83	4.90	4.80
	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	4.48	4.23	4.08	4.38	4.70	3.93
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	5.23	5.08
	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	4.50	4.09
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	7.56	7.62
	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	7.37	7.36
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	9	20
	Creek	30	55	35	25	74	87	29	65	14	32	5	27	25	158	58	21	76	64	20	86	153	61	23	216
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	0.40	0.44
	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	0.40	0.60
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	0.04	0.06
	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	0.06	0.07
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	8.2	7.0
	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	9.9	8.8
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	29.2	29.4
	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	29.4	29.2
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	25.8	28.9
	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	23.6	26.3



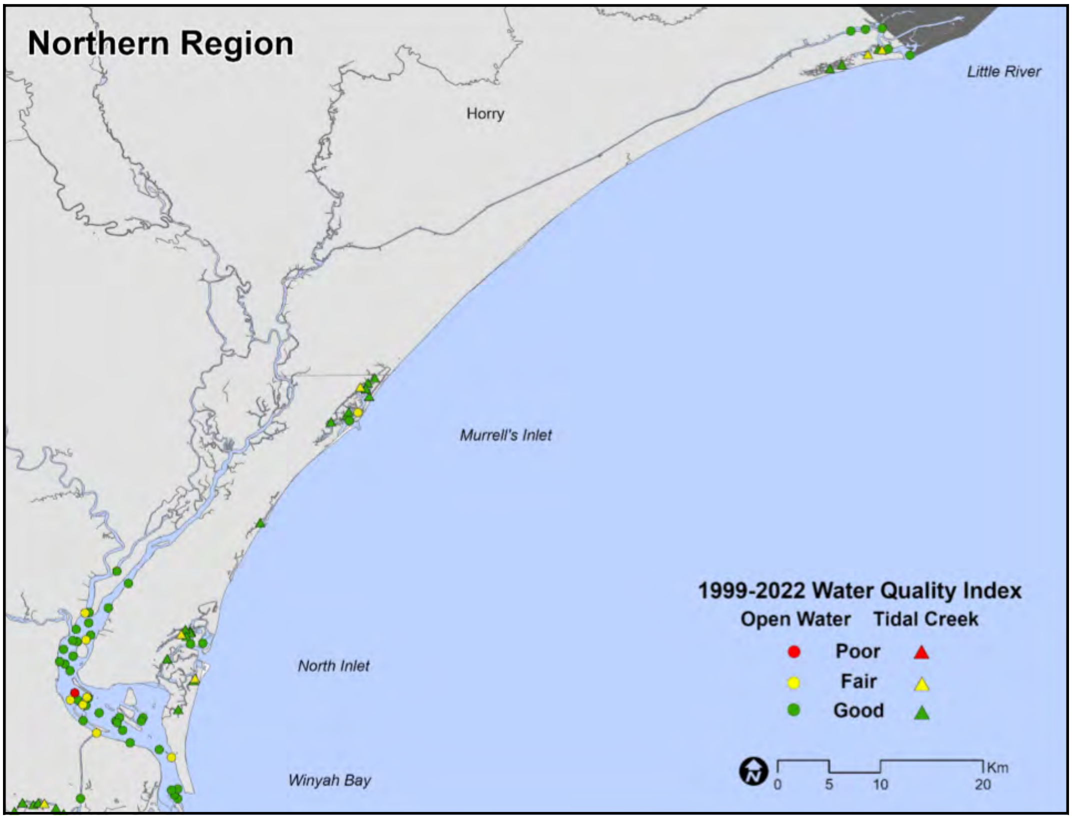
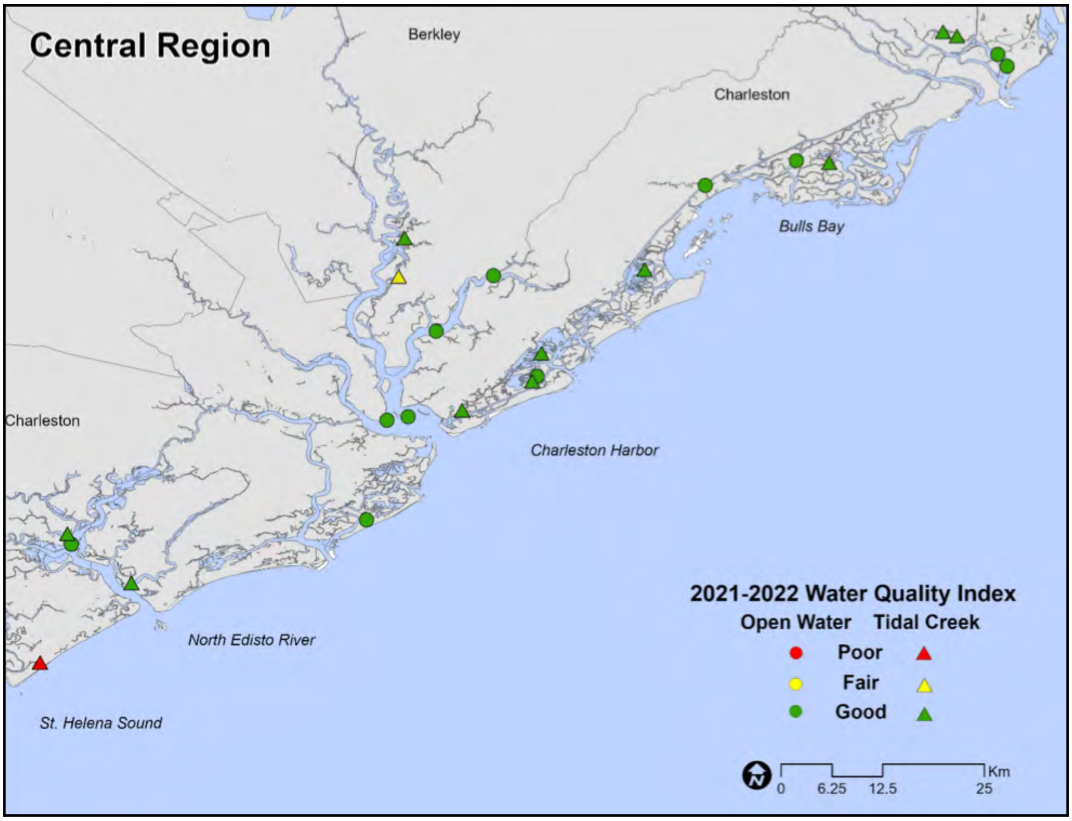


Figure 3.1.4. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the northern region of South Carolina.



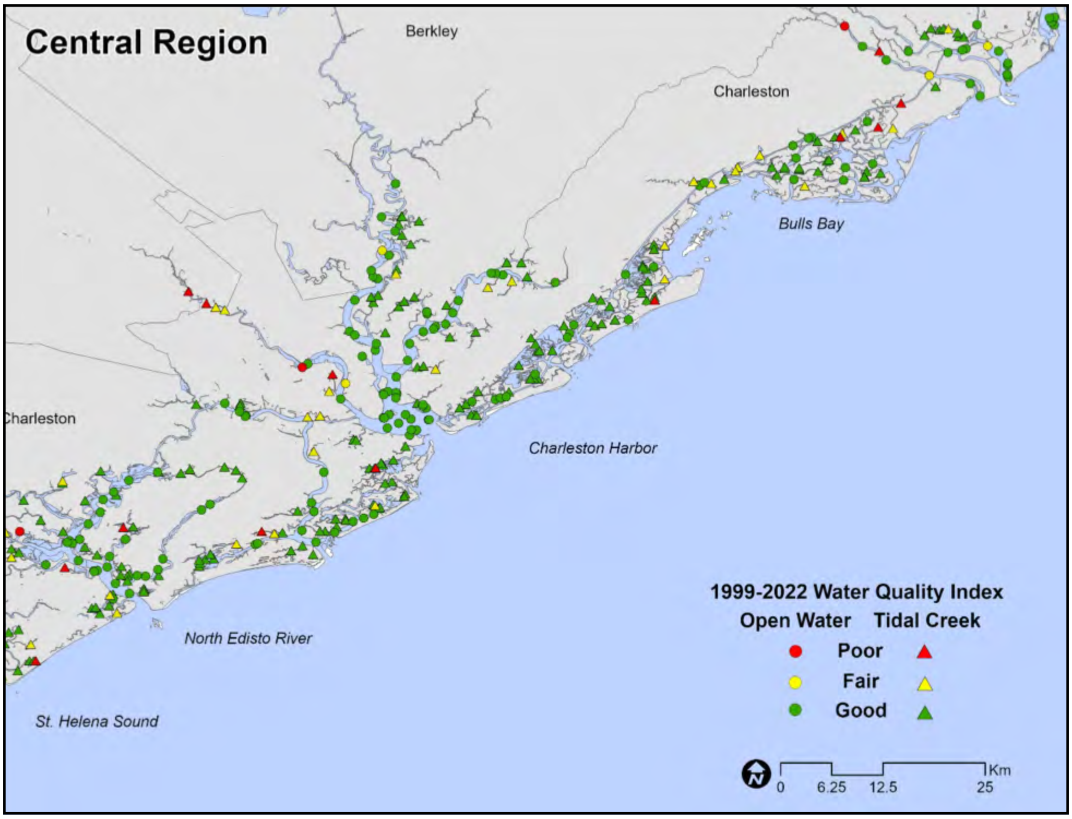


Figure 3.1.5. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the central region of South Carolina.

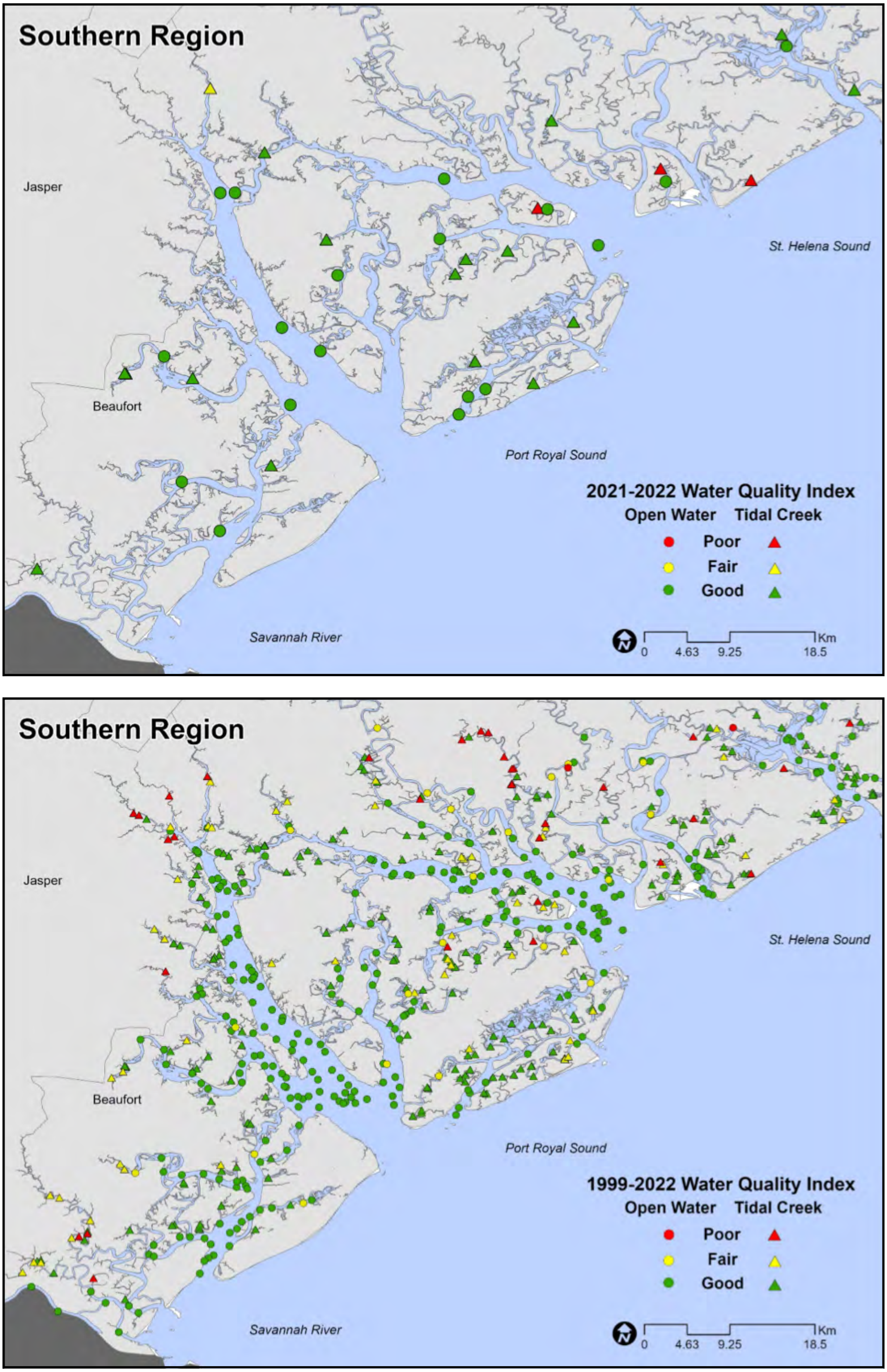


Figure 3.1.6. Distribution of stations with good, fair, or poor scores for the Water Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the southern region of South Carolina.

When considering all years (1999-2022), 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; upper reaches of 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).

3.2. Sediment Quality

Sediment quality measurements remain an essential component of our overall estuarine habitat quality assessment. Benthic sediments support invertebrate communities that form the base of the food web for many other species of concern; exchange nutrients and gases with overlying water in support of overall estuarine function; and 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 2021-2022 survey using the SQI, 92% of South Carolina's estuarine habitat had sediment in good condition, 7% in fair condition, and 1% in poor condition (Figure 3.2.1). The percentage of estuarine habitats with good sediment quality has varied throughout the course of the monitoring. After an initial decline in the early years (2001-2004), with the lowest levels reached in the 2003-2004 survey (75%), values have been generally trending upwards. The 2021-2022 survey period tied with 2015-2016 period for the highest proportion of sediment in good condition to date (Figure 3.2.2).

SQI was slightly lower at tidal creek stations than at open water stations for the 2021-2022 survey period (Figure 3.2.3). Mean SQI was almost identical between habitats in 2022 (0.02 difference), indicating that stations sampled in 2021 drove the pattern during this sampling period (Table 3.2.1).

In 2021-2022, 5 of the 60 SCECAP stations scored as having fair and 1 having poor SQI scores. In 2021, all open water sampling stations had good sediment quality and 2 tidal creek sites were rated as fair. In 2022, there were 2 open water sites rated as fair, 1 tidal creek rated as fair, and 1 tidal creek site in poor condition (Figures 3.2.4, 3.2.5, 3.2.6; Appendix 3). The station with poor sediment quality (RT22011) was located off of the Cooper River in Charleston County. This site scored poor for TOC and fair for toxicity and contaminants.

When all survey periods (1999-2022) 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).

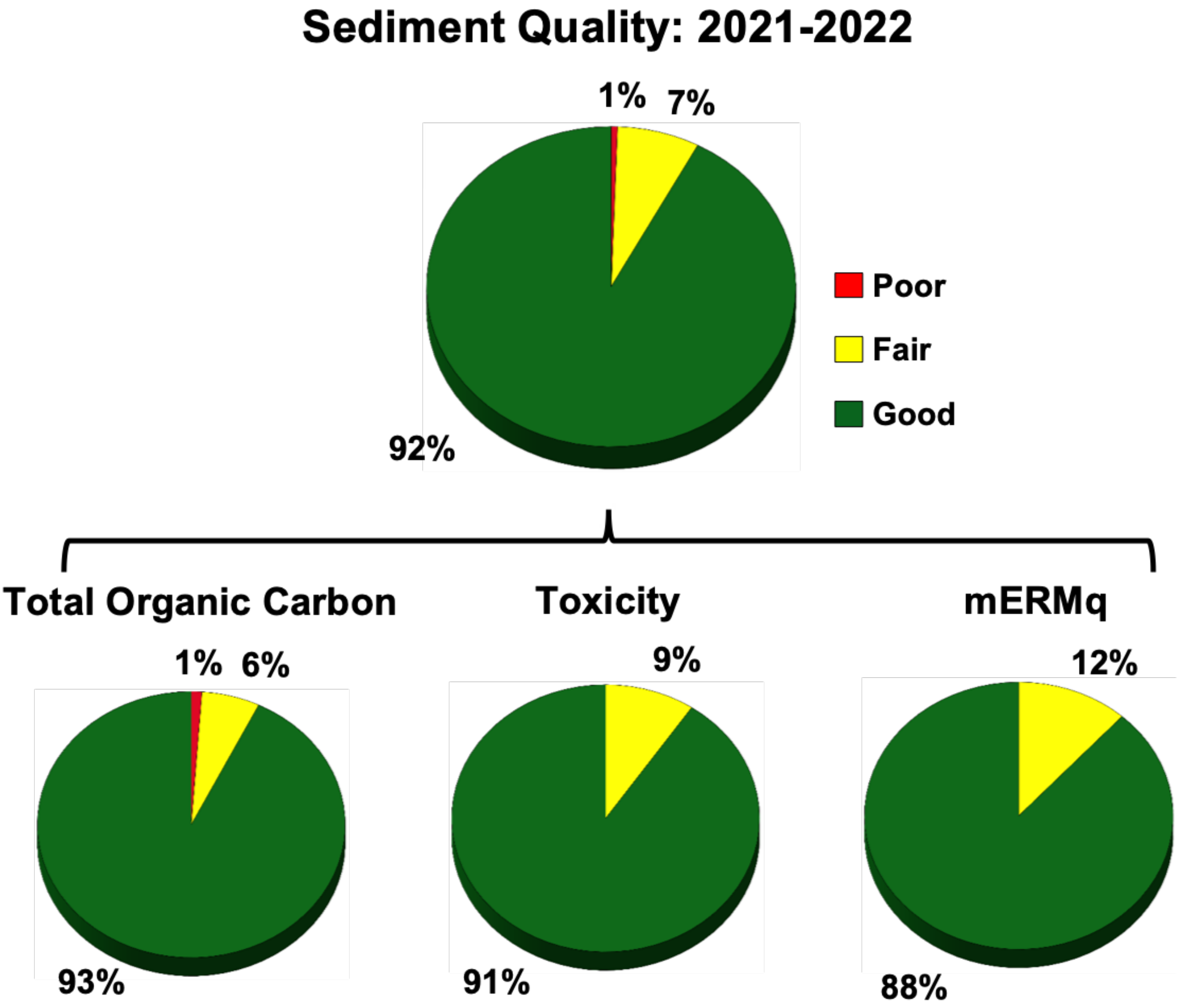


Figure 3.2.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Sediment Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2021 and 2022.

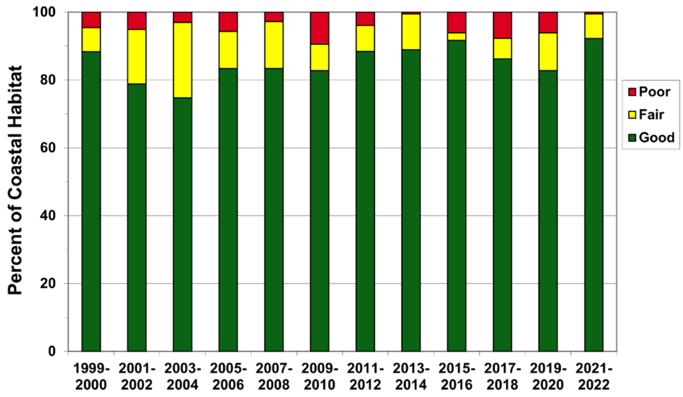


Figure 3.2.2. Percent of coastal habitats corresponding to each Sediment Quality Index category by survey period.

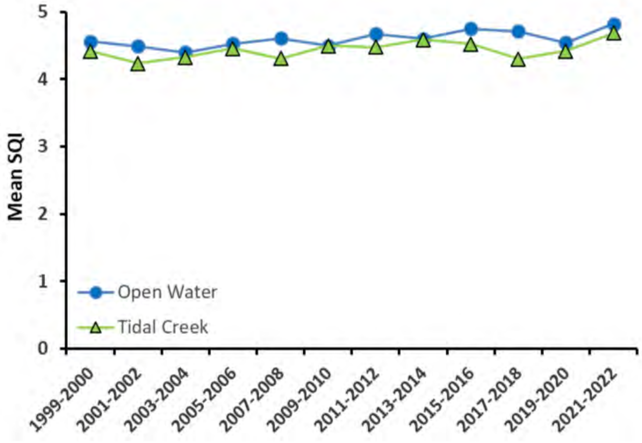
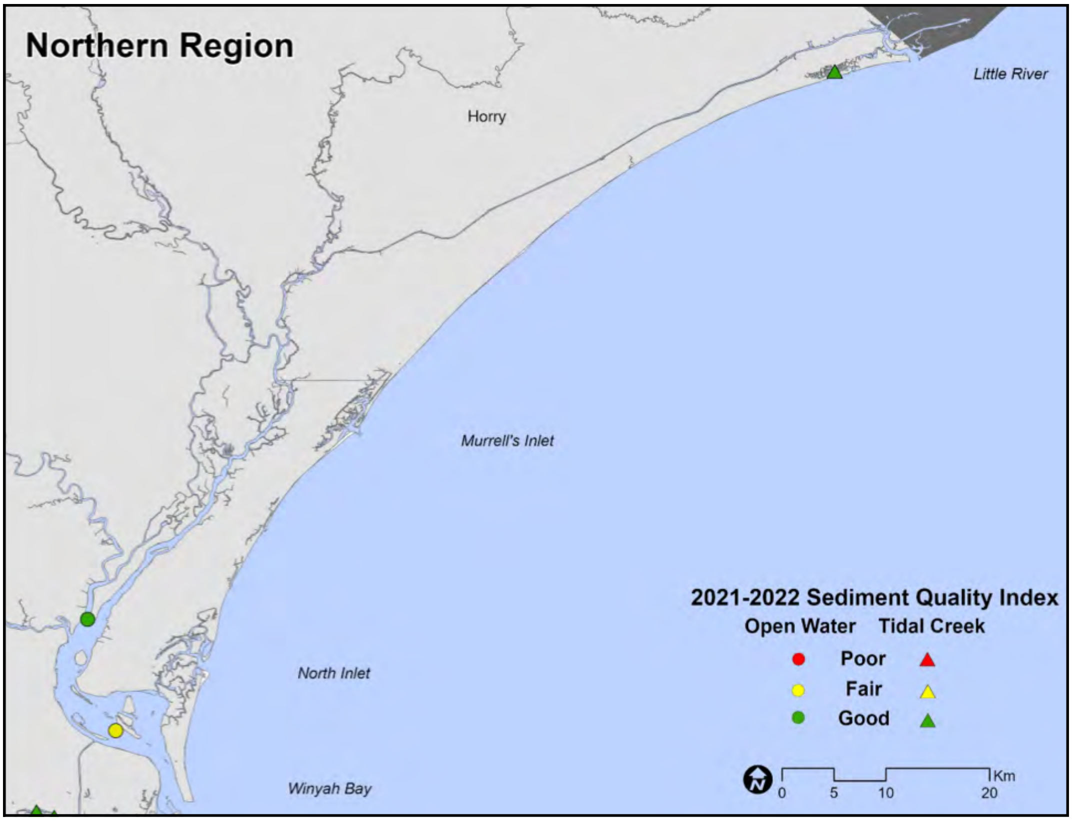


Figure 3.2.3. Sediment Quality Index scores observed by survey period and habitat type.

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	2021	2022
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	4.91	4.73
	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	4.67	4.71
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	1.16	0.92
	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	1.25	1.72
mERM-Q	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	0.008	0.010
	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	0.014	0.012
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	0.0	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	6.7	6.7
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	11.4	18.6
	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	30.0	34.2
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	1.93	0.94
	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	2.25	1.75



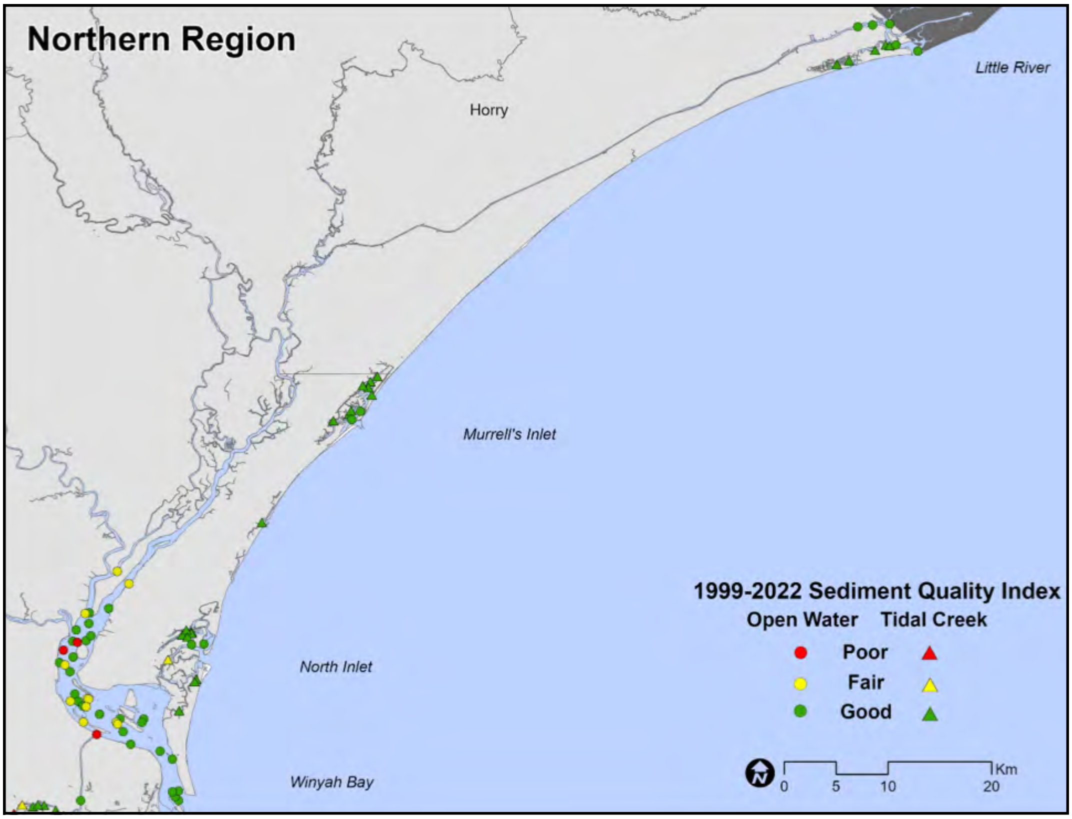
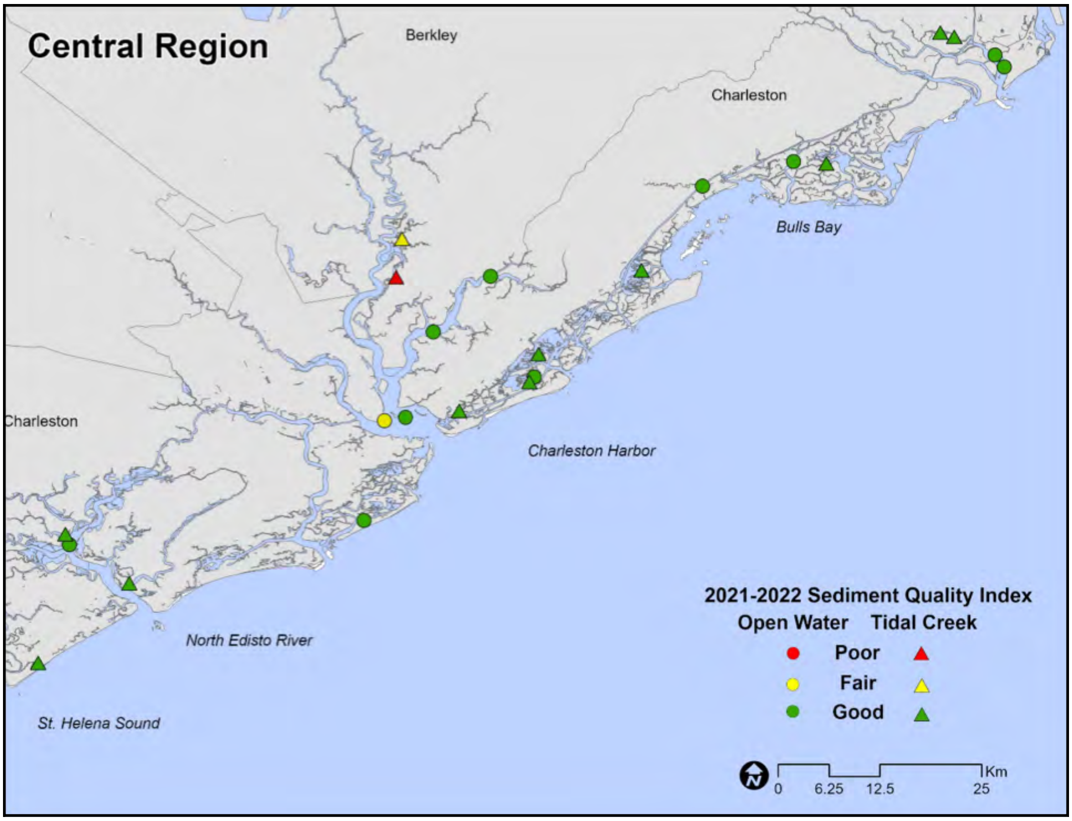


Figure 3.2.4. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the northern region of South Carolina.



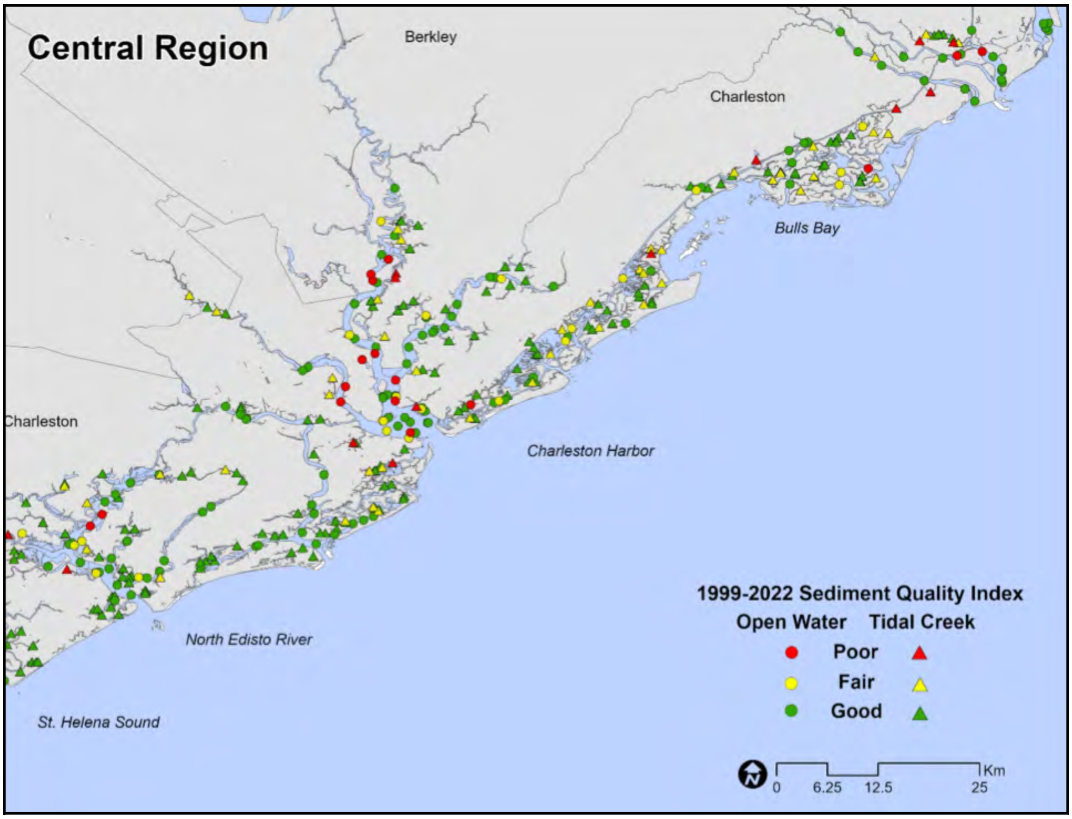
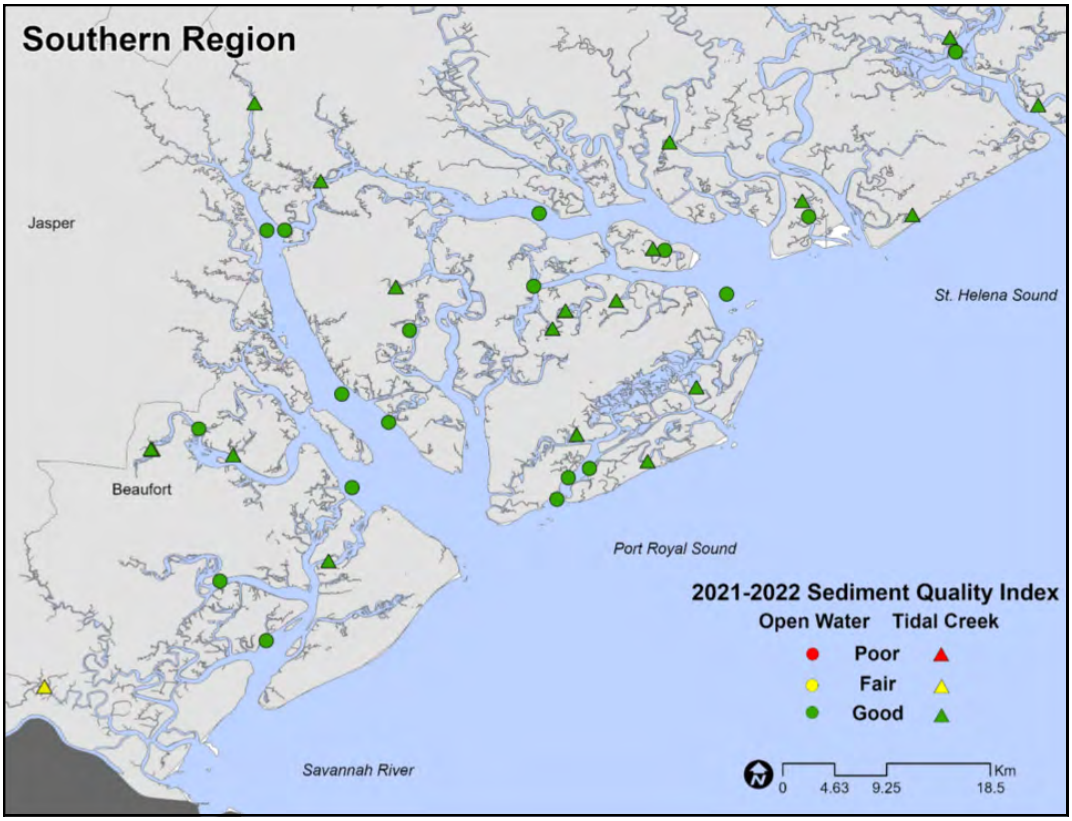


Figure 3.2.5. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the central region of South Carolina.



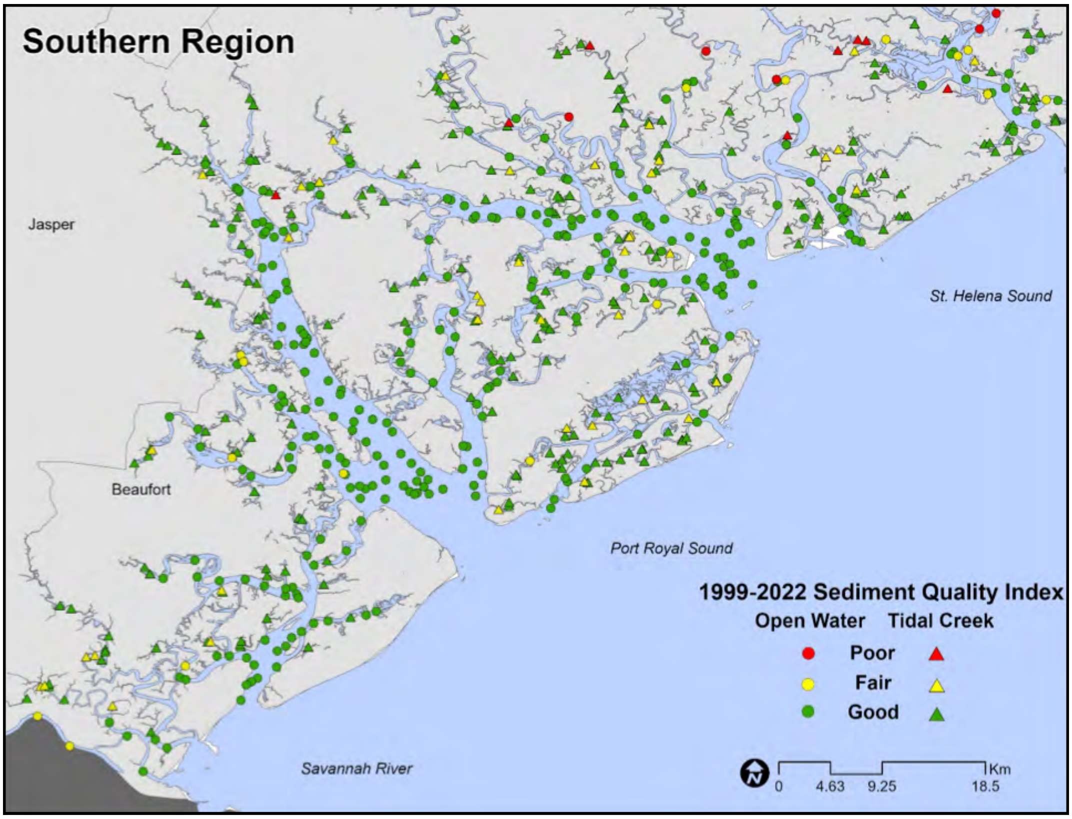


Figure 3.2.6. Distribution of stations with good, fair, or poor scores for the Sediment Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the southern region of South Carolina.

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 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 for the Carolinian Province (B-IBI; Van Dolah et al., 1999).

The Benthic Index of Biotic Integrity 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 [R]), 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 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 2021-2022 (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 Benthic Community Index (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 2021-2022 survey, using the BCI, 87% of the estuarine habitat scored as good, 12% as fair, and 2% as poor (Figure 3.3.2). The percentage of the state's estuarine habitat scoring as good in 2021-2022 was lower than in more recent survey periods but remained higher than the survey-wide average (85.5%) (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 somewhat 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 2021- 2022 survey period is shown in Figures 3.3.4, 3.3.5, 3.3.6 and Appendix 3. Only 3 of the 60 stations sampled in 2021-2022 scored as poor for the BCI and were all tidal creek stations: one in Whale Branch in Beaufort County (RT21251), one in the Wright River in Jasper County (RT22006), and one in Yellow House Creek in Berkeley County (RT22016). Stations RT21251 and RT22006 had elevated sediment contaminants; but the latter also had elevated TOC and scored fair for DO and pH. These factors likely contributed to a stressful environment for benthic fauna. Station RT22016 had elevated fecal coliform (which is more of a risk to human health than habitat suitability); however, the sediment was largely composed of sand (75%) which, in a tidal creek habitat, may contribute to lack of biological diversity (only 3 species found, 7 individuals total). In 2021-2022, 6 of the 30 tidal creek stations scored fair on the BCI, compared to 3 of the 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 upper Broad River; and the New, Wright, and Savannah Rivers (Figures 3.3.4, 3.3.5, 3.3.6).

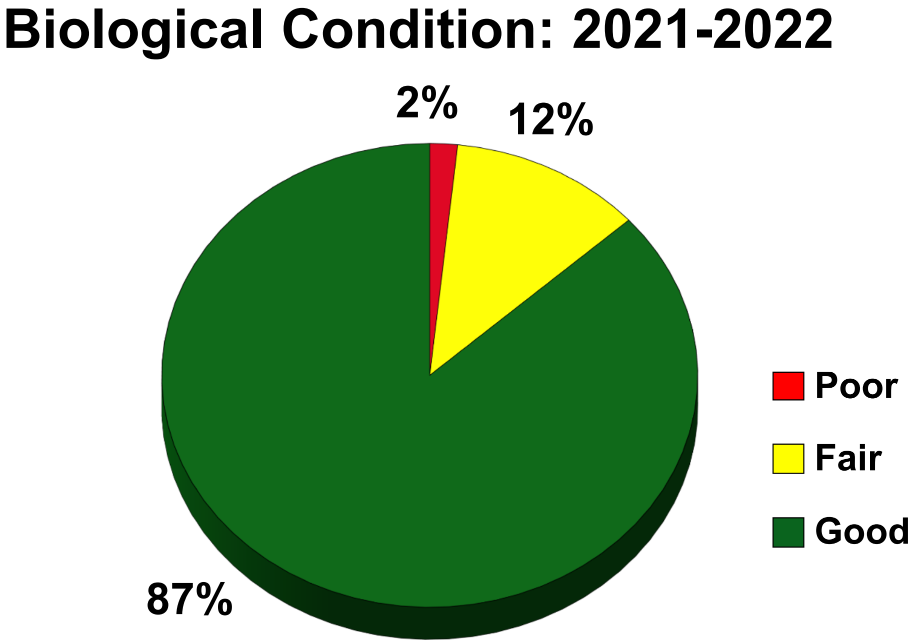


Figure 3.3.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Biological Condition Index. Percentage is based on data obtained from 30 stations for each habitat during 2021 and 2022.

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.

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	2021	2022
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	5.00	4.60
	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	4.13	4.07
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	1.16	0.92
	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	1.25	1.72
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	11.4	18.6
	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	30.0	34.2
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	1.93	0.94
	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	2.25	1.75
Overall Density (individuals/m2)	Open	5354	6292	4095	7198	4236	4127	5282	4513	6873	8626	2698	3288	4616	2377	5893	2938	4319	2386	5482	6801	2542	6961	5122	8620
	Creek	2363	4659	4710	5001	3198	2863	2282	5060	3008	6395	2843	2133	2222	6328	2267	4563	1997	2388	6473	4656	2913	3683	3596	8085
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	23.6	24.9
	Creek	14.8	19.8	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	12.5	24.9
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	0.73	0.71
	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	0.74	0.70
Species Diversity (H')	Open	3.30	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	3.28	3.08
	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	2.49	2.86
Percent Sensitive Taxa	Open	13.4	26.8	19.6	16.5	16.5	24.1	19.6	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	16.4	15.7
	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	5.3	7.9
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	17.4	4.8
	Creek	6.1	11.8	4.5	5.3	7.9	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	3.5	5.2
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	9.9	8.9
	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	2.5	5.4
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	52.6	66.2
	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	59.4	73.5
Percent Other Taxa	Open	26.8	19.3	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	20.1	20.1
	Creek	21.6	24.4	20.0	17.6	33.2	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	34.6	15.8

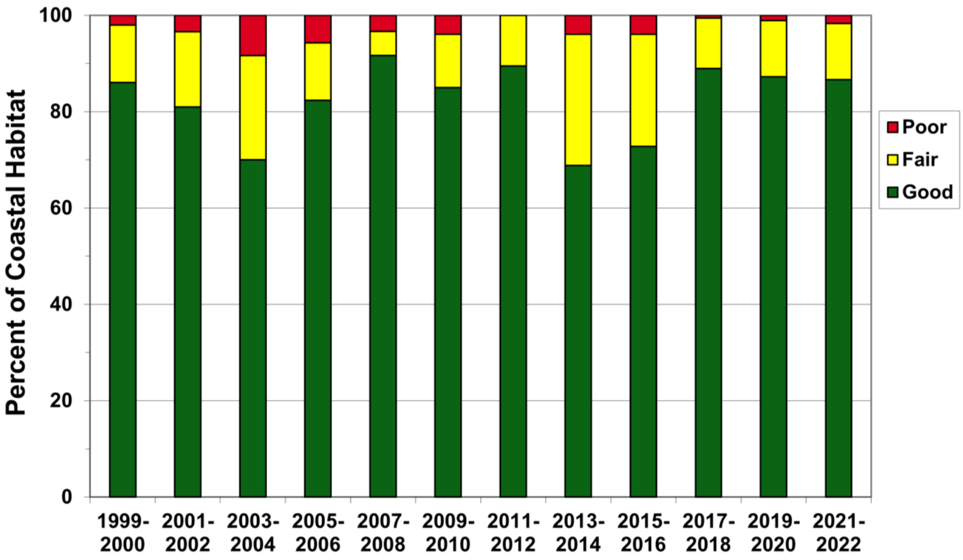


Figure 3.3.2. Percent of coastal haitats corresponding to each Biological Condition Index category by survey period.

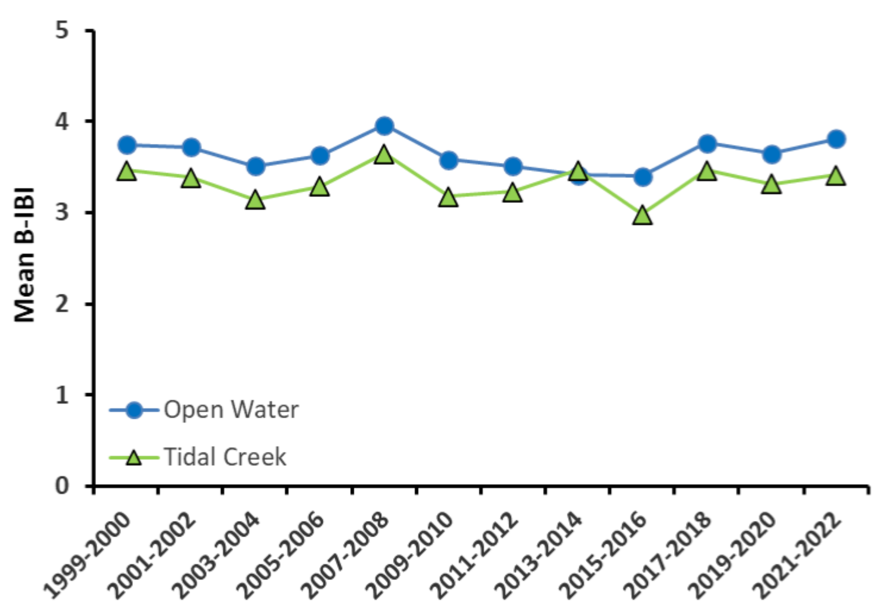
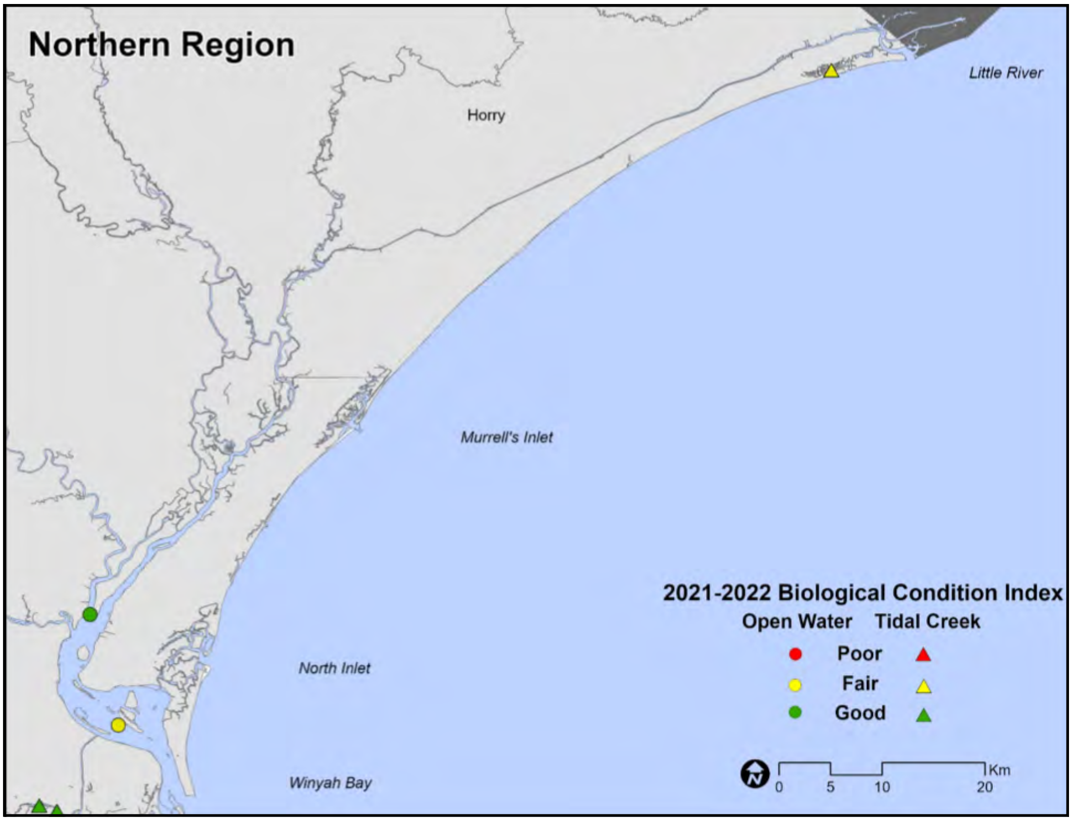


Figure 3.3.3. Benthic Index of Biological Integrity scores observed by survey period and habitat type.



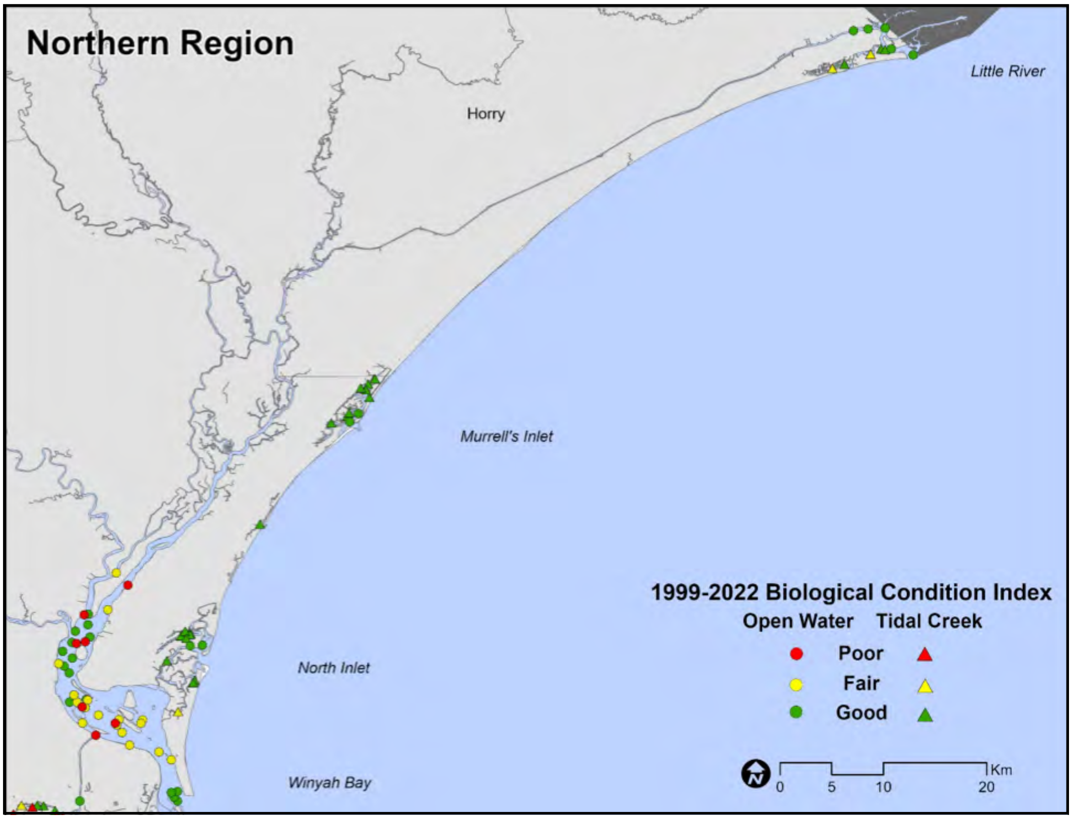
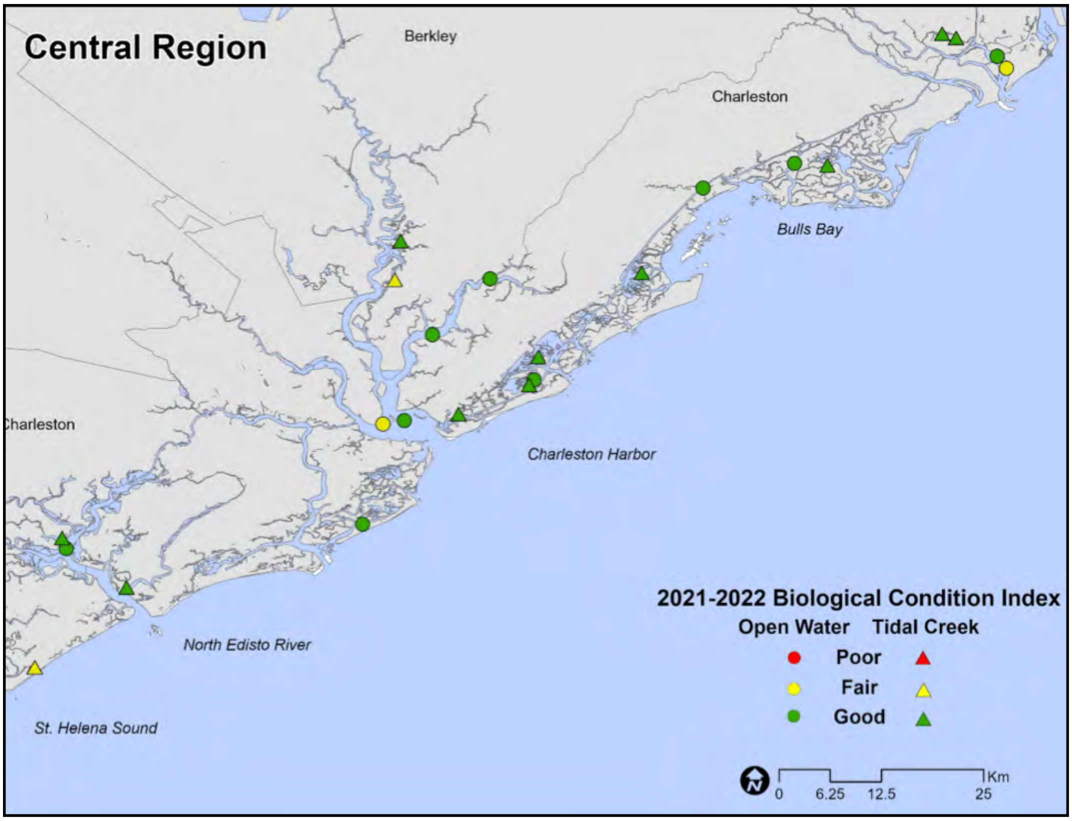


Figure 3.3.4. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the northern region of South Carolina.



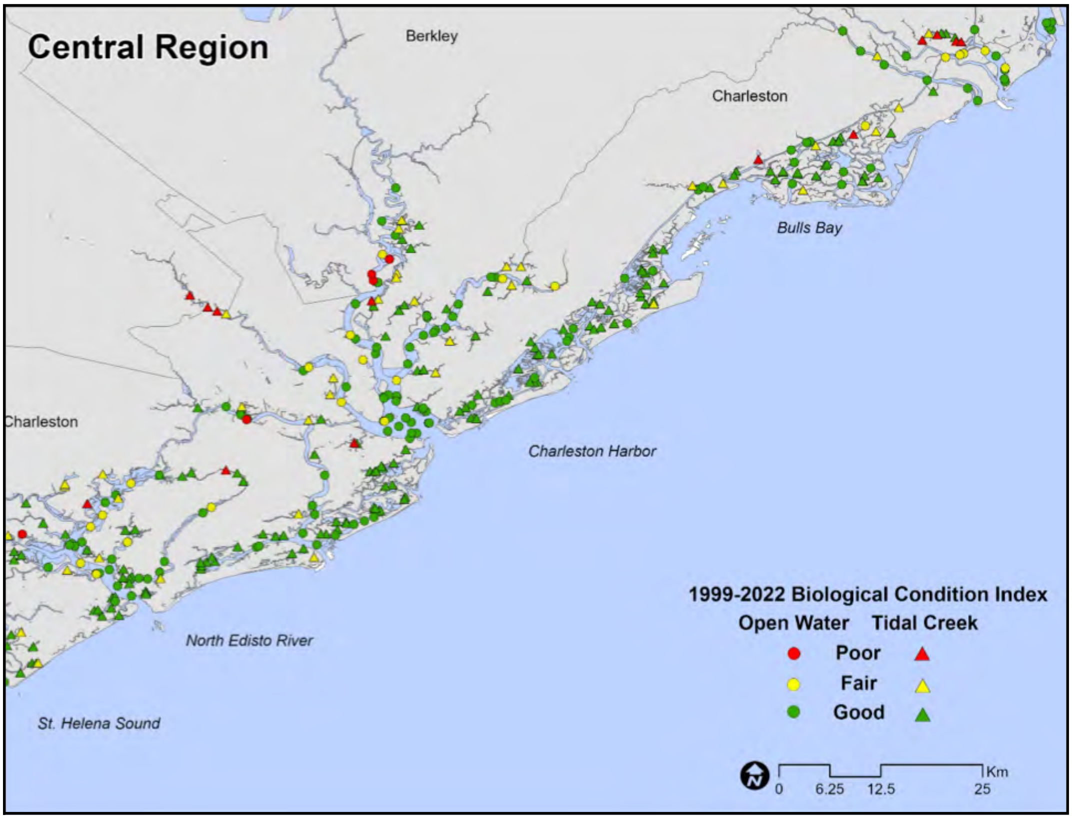


Figure 3.3.5. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the central region of South Carolina.

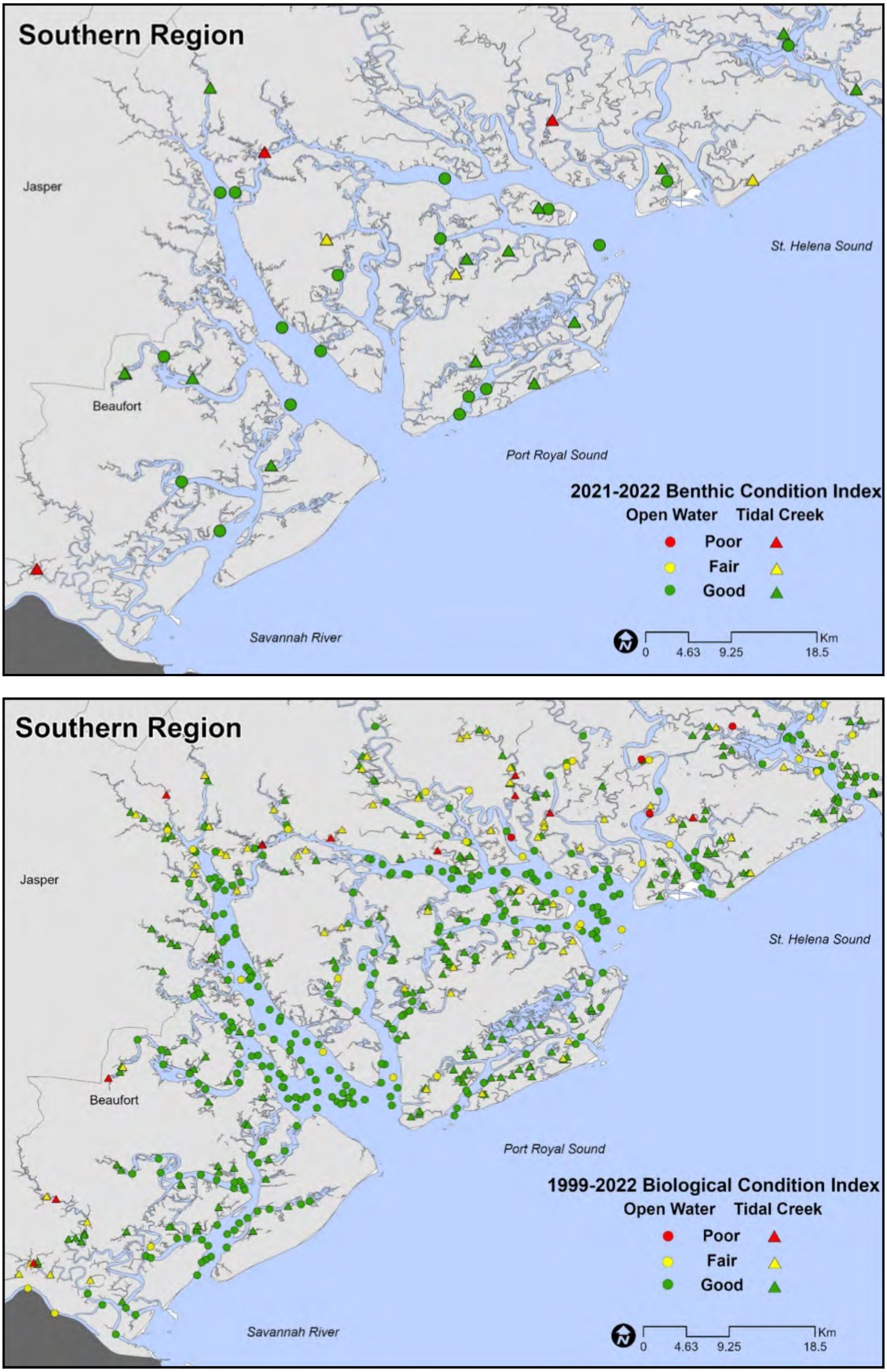


Figure 3.3.6. Distribution of stations with good, fair, or poor scores for the Biological Condition Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the southern region of South Carolina.

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. The estuarine environment is highly dynamic, and added human impacts - such as commercial and recreational fishing, coastal urbanization, and habitat destruction - can result in substantial changes, 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. Both mean and median summarization methods yielded similar trends in overall trawl capture density over time and by habitat (Figure 3.3.7, Figure 3.3.8). 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. Catch densities have been on the rise over the last two survey periods, driven by high brown shrimp (*Penaeus aztecus*) and white shrimp (*P. setiferus*) densities. The lowest overall densities in both open water and tidal creek habitats were observed in 2015, driven by low densities of fishes and white shrimp (Table 3.3.2). The trawl capture densities observed in 2021-2022 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 (*Penaeus setiferus*), brown

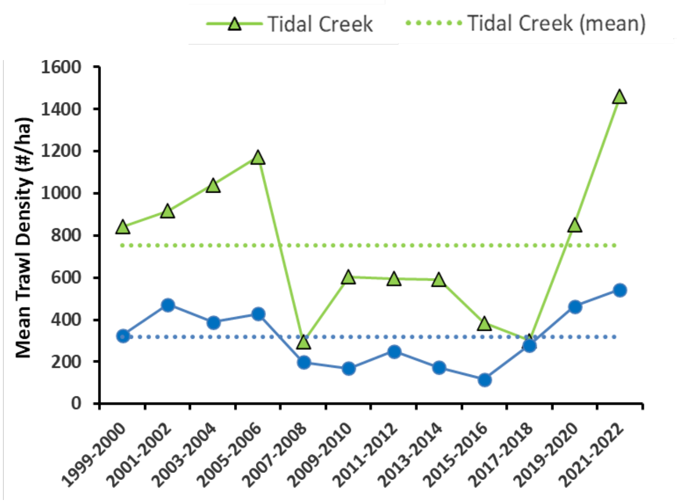


Figure 3.3.7. Mean overall trawl capture density (# individuals captured per hectare) observed by survey period (and averaged over the full 1999-2022 survey period) and habitat type.

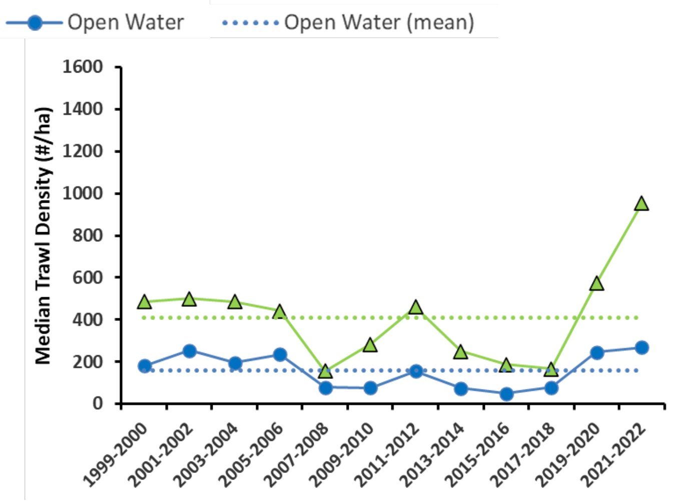


Figure 3.3.8. Median overall trawl density (# individuals captured per hectare) observed by survey period (and averaged over the full 1999-2022 survey period) and habitat type.

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 include finfish, sharks, and rays. Large invertebrates 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	2021	2022
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	340	747
	Creek	831	853	698	1137	760	1321	738	1611	296	295	329	876	387	804	656	528	244	524	318	285	911	795	1286	1637
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	150	388
	Creek	565	406	399	601	467	503	500	384	196	116	123	442	384	536	333	167	217	159	167	167	754	395	623	1283
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	8.1	9.7
	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	8.9	10.1
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	187	197
	Creek	314	373	319	273	299	331	308	171	99	196	98	180	183	282	111	157	94	119	112	145	493	339	784	633
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	5.9	6.9
	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	6.1	6.5
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	105	485
	Creek	476	425	346	788	429	945	385	1417	182	74	207	678	188	510	538	354	140	396	187	123	360	361	449	825
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	1.4	2.0
	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	2.2	2.7
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	8	18
	Creek	72	131	112	39	71	95	147	24	13	44	29	41	32	58	16	51	13	7	13	16	89	58	207	46
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	21	21
	Creek	9	8	16	18	12	6	6	1	14	1	11	27	3	10	20	9	8	4	8	10	9	22	95	27
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	25	19
	Creek	14	6	4	12	3	3	8	2	8	4	4	2	2	6	5	2	0	3	1	7	14	17	10	11
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	0	1
	Creek	4	22	5	5	11	18	21	9	10	3	0	14	5	123	10	1	2	7	6	4	4	3	8	6
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	19	315
	Creek	127	69	97	135	67	128	150	41	27	37	13	105	35	40	23	10	42	3	15	30	95	28	45	96
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	85	162
	Creek	339	323	238	631	348	792	208	1364	143	25	193	544	141	342	502	342	95	382	159	85	250	328	391	699

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 consistent 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 the percentage 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 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 (Kiessling et al. 2015).

During the 2021-2022 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%) was observed in the present survey period of 2021-2022, 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 2021-2022 assessment period, 90% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition, 9% of the state's estuarine habitat was in fair condition, and 1% in poor condition (Figure 3.5.1). The poor scoring site (RT22011) scored poor to fair across all indices due to elevated values of chlorophyll-*a*, fecal coliform bacteria, sediment TOC, toxicity, and contaminants; and low values of DO. This site is located upstream of the Charleston Port- a highly industrialized area- and adjacent to several dredge spoil islands.

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 2021-2022 survey was in fair to poor condition (23% fair, 3% poor) as compared to open water habitats (7% fair, 0% poor; Appendix 2). This difference between habitat quality in tidal creek and open water habitats observed in 2021-2022 is consistent with previous SCECAP surveys (Figure 3.5.3). During the 2021-2022 survey period, 9 of the 60 stations were observed to have fair habitat quality, and 7 of those 9 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).

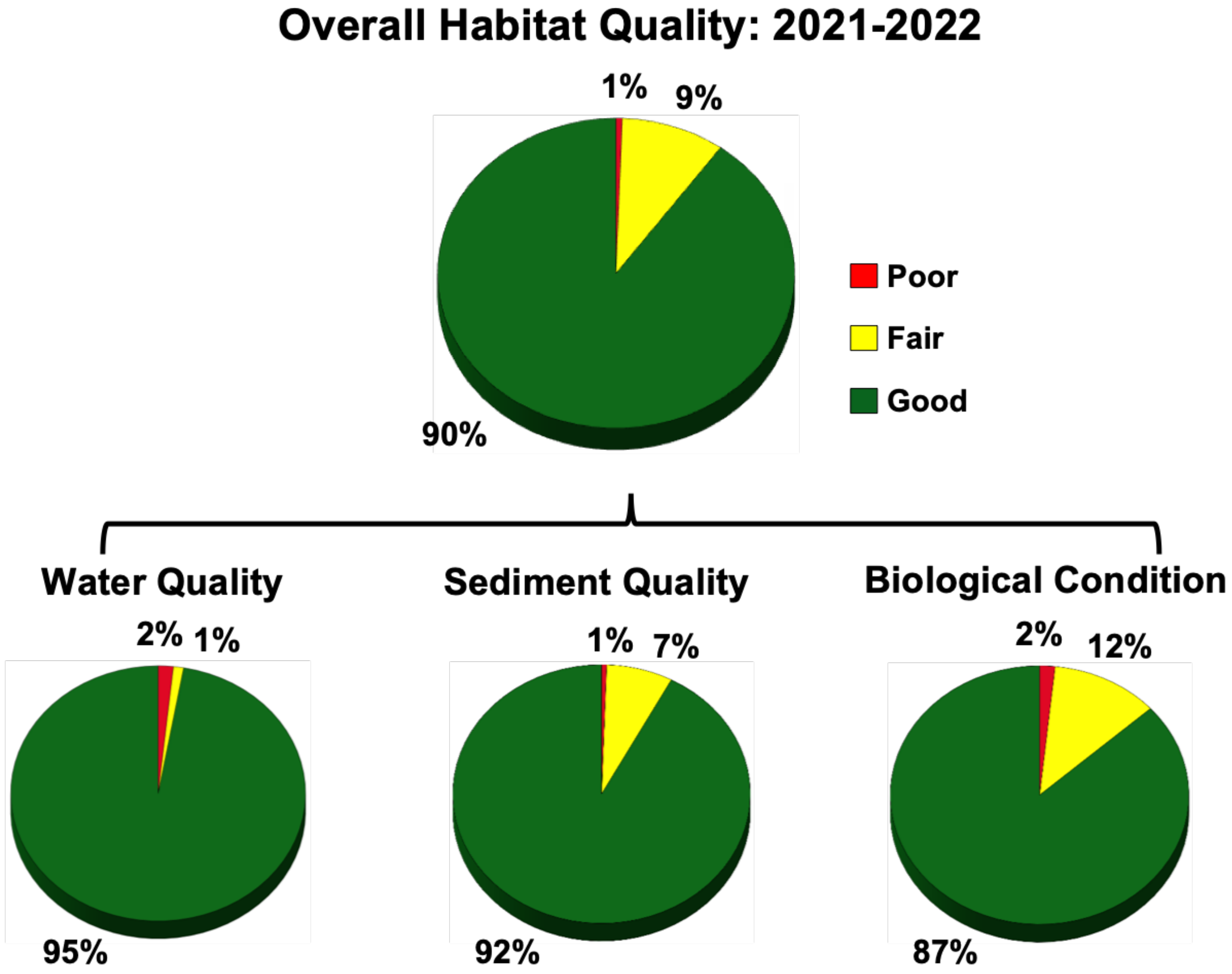
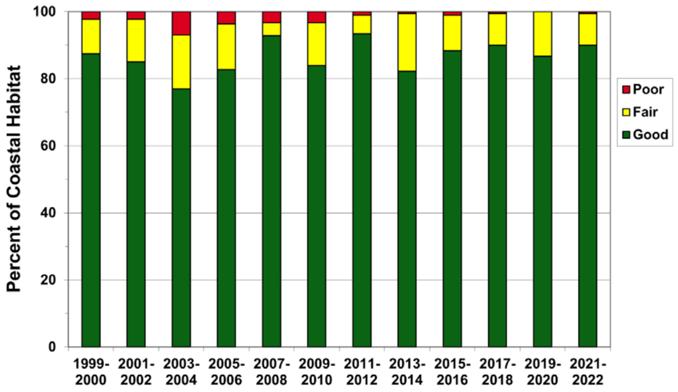


Figure 3.5.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Habitat Quality Index and the component indices that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2021 and 2022.



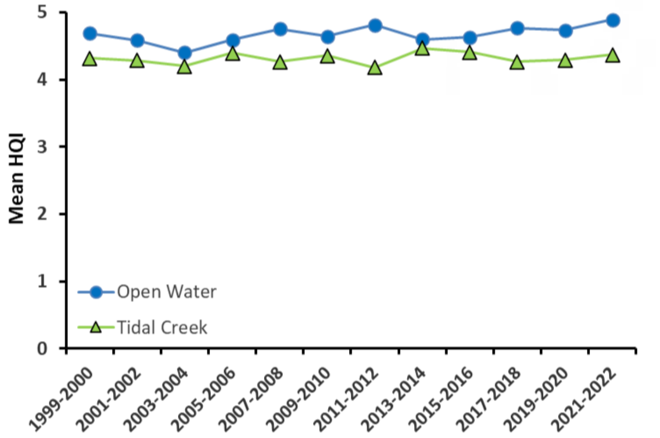
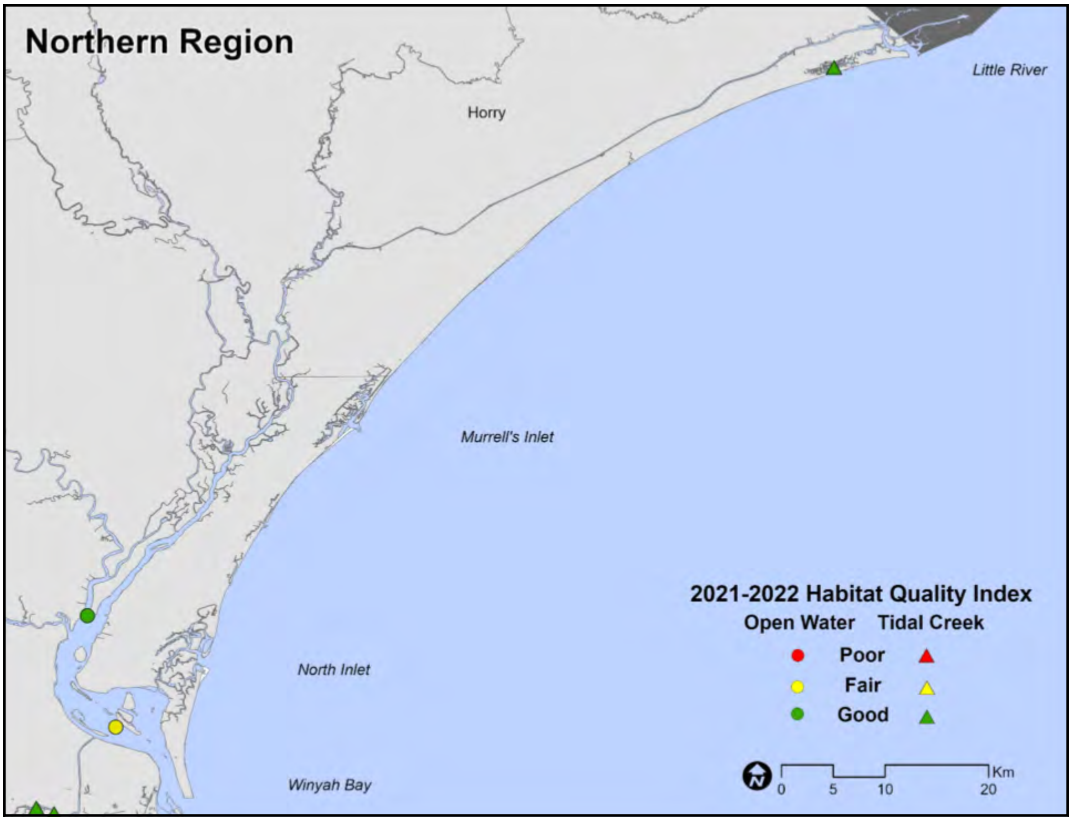


Figure 3.5.2. Percent of coastal habitats corresponding to each Habitat Quality Index category by survey period.

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



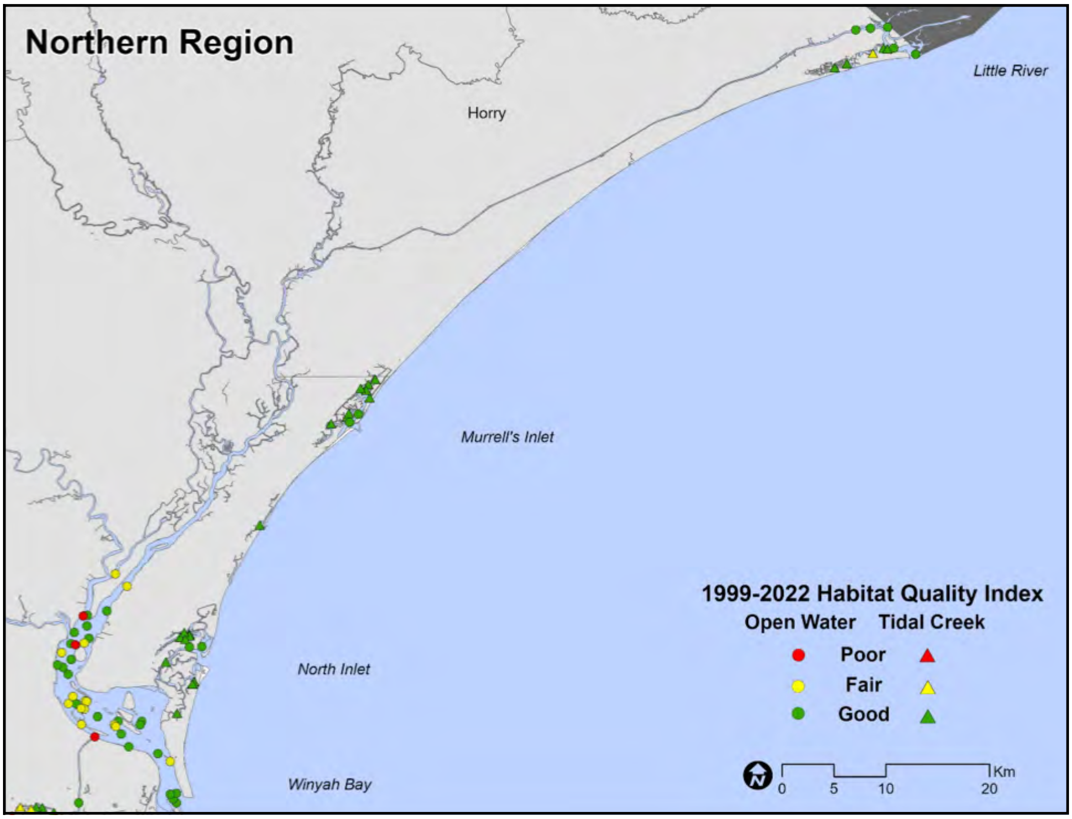
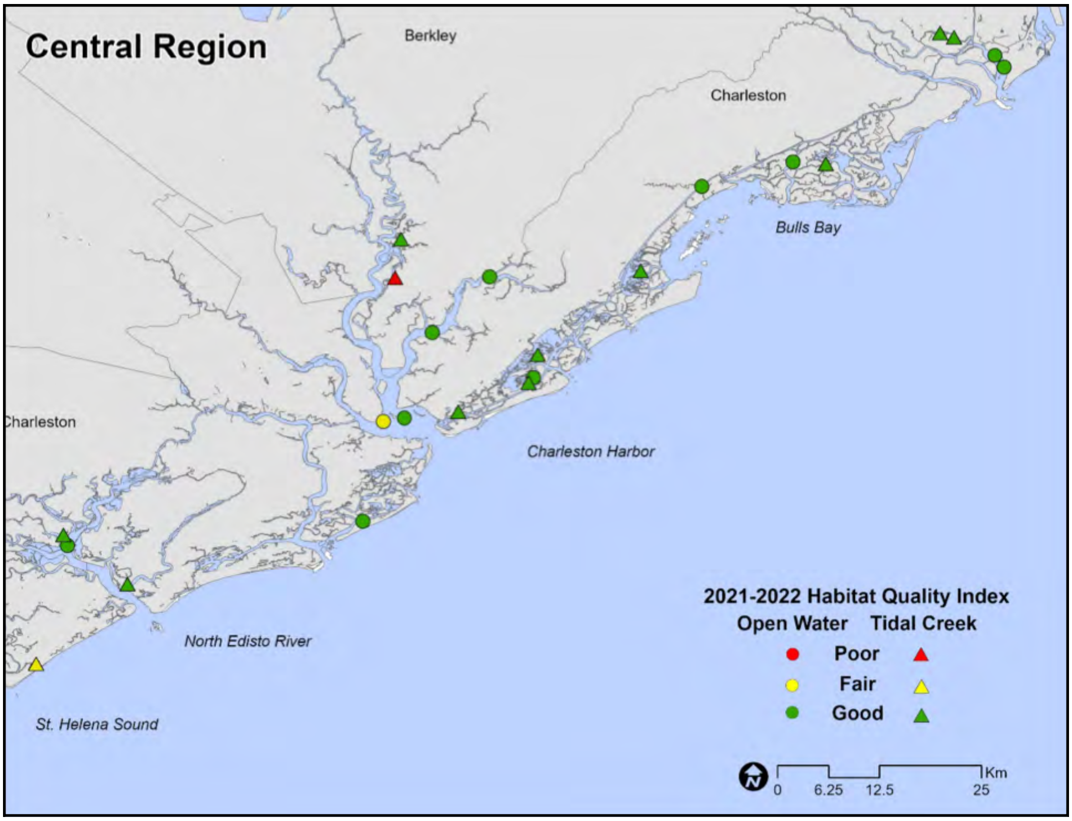


Figure 3.5.4. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the northern region of South Carolina.



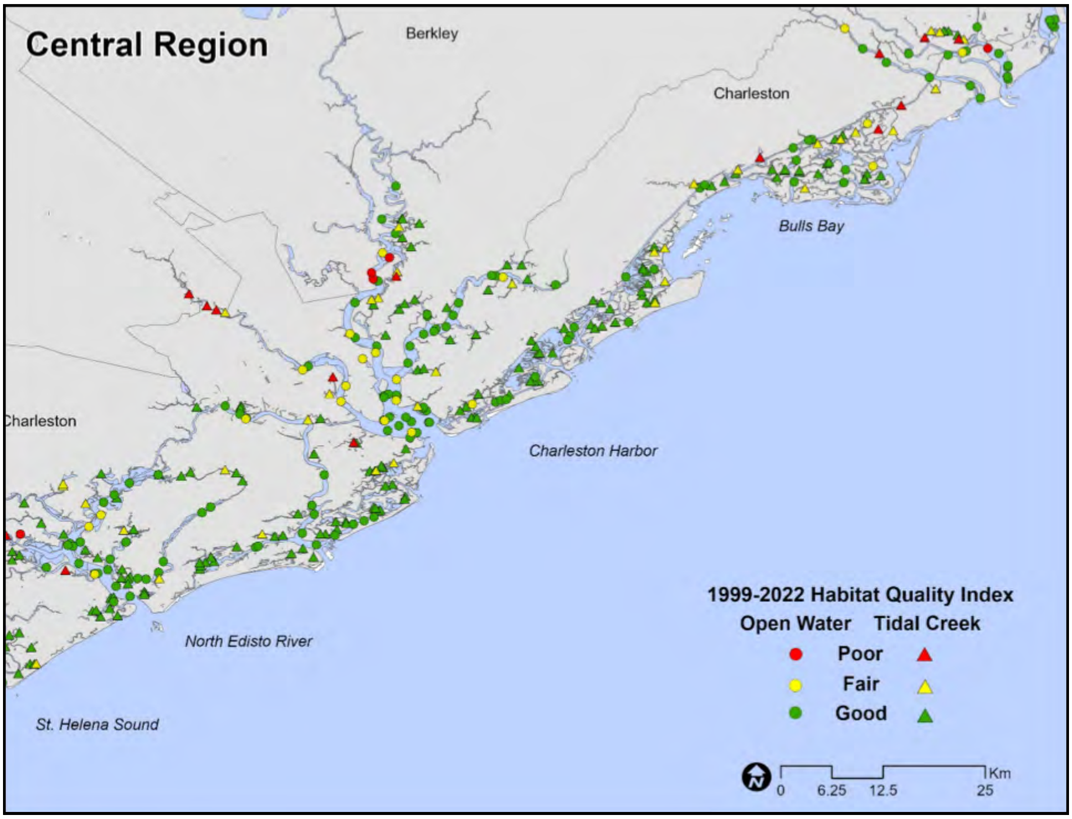
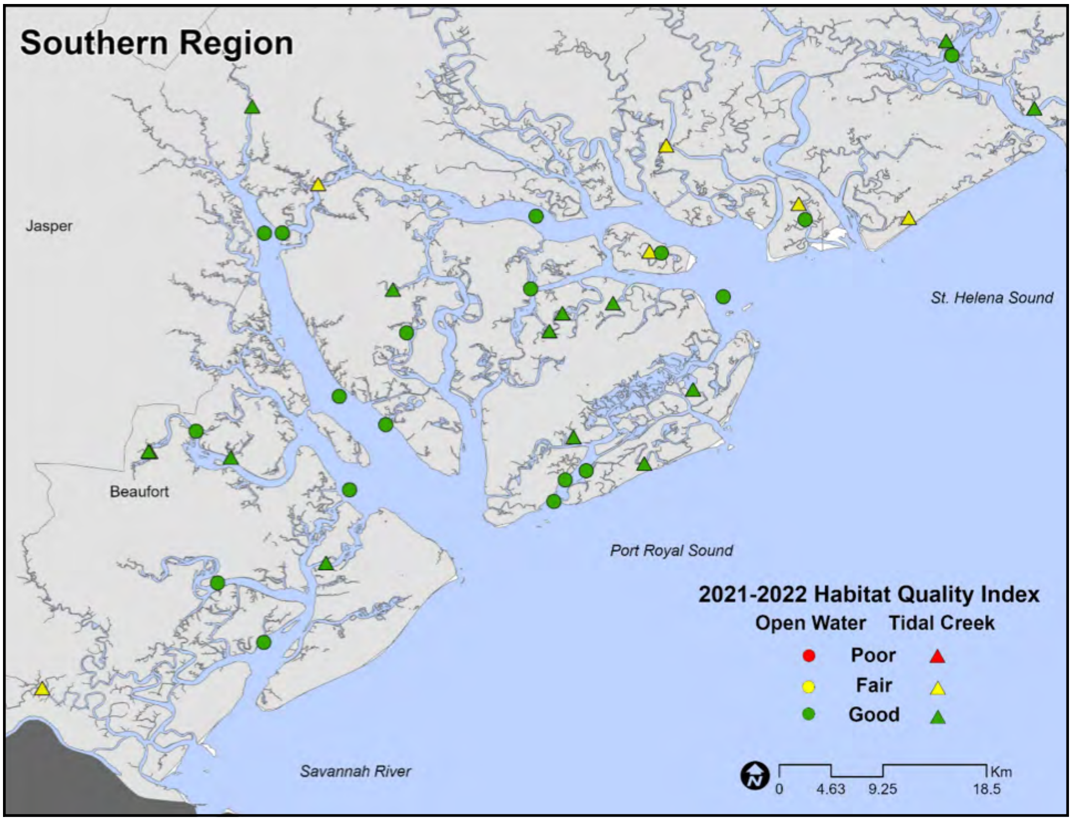


Figure 3.5.5. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the central region of South Carolina.



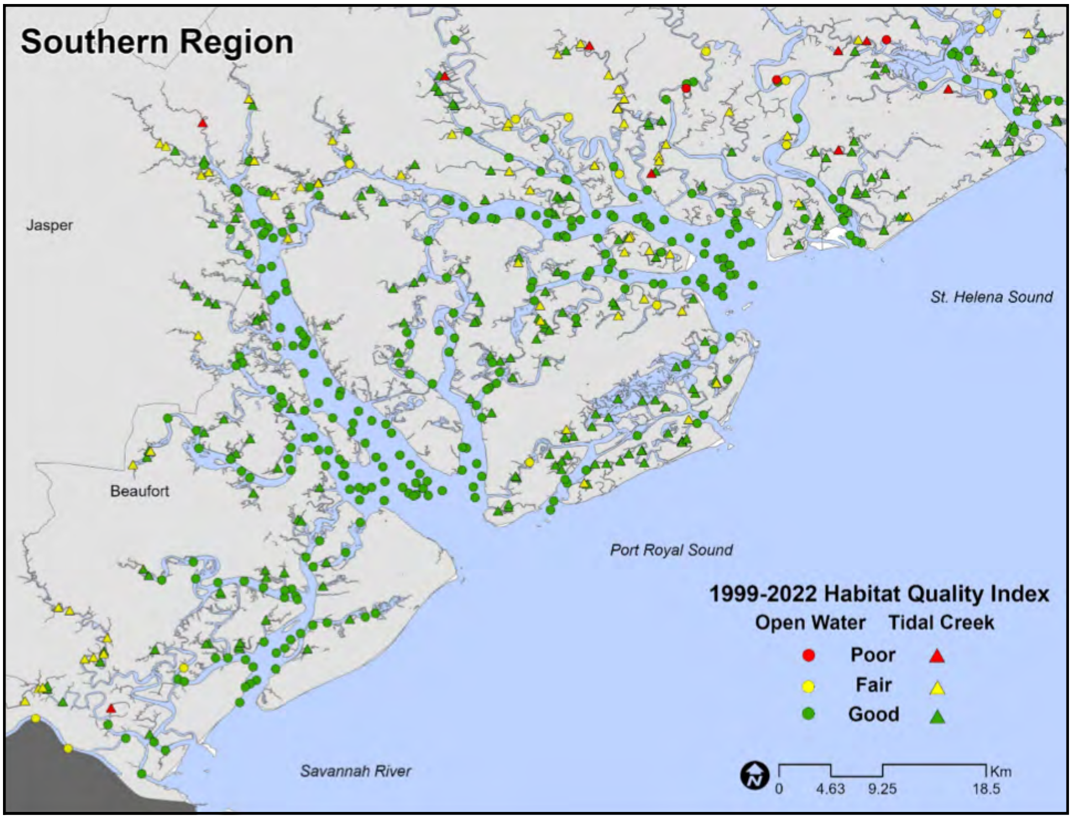


Figure 3.5.6. Distribution of stations with good, fair, or poor scores for the Habitat Quality Index during the 2021-2022 (top) and 1999-2022 (bottom) periods for the southern region of South Carolina.

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. It is unclear what factors are contributing to the degraded habitat quality in the Santee Delta, areas draining into St. Helena Sound (home to the Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve), and in the headwaters of the Port Royal Sound.

3.6. Program Uses and Activities

SCECAP continues to be an effective collaboration between the SCDNR, SCDES, 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. One recent example leveraged the SCECAP sampling framework to study microplastics in South Carolina estuaries (Tierney 2023).

Recent research and increasing public awareness have raised many questions related to the prevalence of microplastics in coastal habitats and biota. A total of 131 estuarine sediment samples were collected between 2019 and 2022 and analyzed for microplastic concentration and type using a density separation method and examined using microscopy (Kell 2020). Ten percent of plastic particles were also analyzed using micro-raman spectroscopy (Beckingham et al., 2023). All but one sediment sample were found to contain microplastics at an average concentration of 182 microplastics per kilogram dry sediment. Particles identified included fragments, fibers, films, foams, tire and road wear particles, and microbeads. Polymer analysis revealed that the dominant polymer types were polypropylene, polyester, and polyethylene terephthalate (collectively PET), comprising 63% of particles tested. Tidal creek habitats contained significantly greater concentrations than open water sites. One hypothesis for this difference is that tidal creek habitats generally contain finer substrates indicative of lower current velocities that are conducive to the settling of particles such as microplastics. No relationship was found between coastal development density in the watersheds surrounding sampling sites, suggesting that microplastics are widespread and easily transported.

SCDNR staff collaborated 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. The majority of Port Royal Sound's large tidal creeks and open waters, based on SCECAP data, was classified as good or healthy estuarine habitat. Environmental quality was higher in the Sound compared to summaries of the entire SC coastal area. Similar to findings from the coast-wide summaries, tidal creeks in the Sound were observed to be more stressful habitats compared to open water areas. There were a few open water and several tidal creek sites with impairments in the quality of the water, sediment, or biological condition resulting in some sites having impaired habitat quality. In addition, there were some indications of decreasing quality from the first eleven-year period (1999-2009) compared to the second eleven-year period (2010-2020) resulting in more sites having more impaired environmental quality. Although the existing SCECAP dataset in Port Royal Sound cannot be used to directly assess if coastal development in the Sound's watershed is related to estuarine quality due to the lack of sufficient data in the sub-watersheds experiencing growth; other studies have shown linkages between sub-watershed scale stressors (e.g., population, impervious cover) and the physical, chemical, and biological changes in small tidal creeks. The combined assessment of landscape alterations and monitoring for potential changes in environmental quality is a critical component in understanding potential impacts of growth on the Port Royal Sound region. This is the first time SCECAP data have been used at a watershed scale and this may be a useful approach for future analyses.

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. Florida A&M University has used SCECAP benthic data for a genetic diversity study. Clemson Extension has conducted 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 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-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 to the Atlantic States Marine Fisheries Commission (ASMFC).

The SCECAP program has developed and maintained high quality field and laboratory methods for the study of coastal ecosystems. These methods have been utilized in other SCDNR projects related to coastal development and climate change impacts.

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.

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The bulk of the field work falls on two groups, the staff of the SCDNR's Environmental Research Section (ERS) and SCDES's Aquatic Science Monitoring Section. In addition to the authors, SCDNR field teams included Sharleen Johnson, Catharine Parker, Gabi Tutelo, Sarah Liss, Eric Wehmeyer, Jacob Jones, Norm Shea, Joseph Cowan, and Annabelle Tierney; and SCDES field teams included Nick Pangborn, Ronnie Martin, 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 Hollings Marine Laboratory processed sediment chemistry and toxicology assays (LouAnn Reed, Emily Pisarski, Katy Chung, and Brian Shaddrix, a contractor to NCCOS via CSS inc.). Staff at the (formerly) SCDHEC Bureau of Environmental Health Services, Analytical and Radiological Environmental Services Division in the Columbia Central Laboratory processed the nutrient and chlorophyll-*a* samples. Fecal bacteria samples were analyzed by the Beaufort and Charleston Regional Laboratories.

Kieran Ash with SCDNR Graphics generated the layout of this report.

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APPENDIX 1

Summary of station locations and dates sampled in 2021 through 2022. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2021

Station Information — Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO21457	Open	32.21030	-80.86005	4.7	8/24/2021	Beaufort	R<1	May River by Myrtle Island
RO21459	Open	33.17350	-79.24849	1.5	7/21/2021	Georgetown	NDV	North Santee Bay
RO21460	Open	32.77401	-79.89976	6.7	7/14/2021	Charleston	R>1	Charleston Harbor 0.65 mi E of Shutes Folly
RO21461	Open	32.49117	-80.82244	5.1	8/04/2021	Jasper	R<1	Broad River 0.7 mi W of the mouth of Whale Branch
RO21462	Open	32.27591	-80.59022	7.3	8/10/2021	Beaufort	R>1	Trenchards Inlet 1.1 mi ENE of Morse Island Creek
RO21463	Open	32.50486	-80.60445	3.4	8/03/2021	Beaufort	R<1	Coosaw River 1.43 mi NNW of Sams Point Boat Ramp
RO21464	Open	32.92931	-79.80540	5.2	7/13/2021	Berkeley	R<1	Wando River 1.1 mi ENE of Hwy 41 bridge
RO21465	Open	32.33741	-80.72491	4.0	8/25/2021	Beaufort	I<1	Broad River by Parris Island
RO21466	Open	32.29313	-80.58121	1.7	8/10/2021	Beaufort	R>1	Trenchards Inlet 0.56 mi WNW of Moon Creek
RO21467	Open	33.05592	-79.47068	5.3	8/17/2021	Charleston	R>1	Five Fathom Creek 0.8 MILES SSW of Mathews Creek
RO21469	Open	32.33218	-80.87735	2.4	8/24/2021	Beaufort	R<1	Colleton River by Callawassie Island
RO21470	Open	32.47527	-80.50394	2.7	8/03/2021	Beaufort	NDV	Morgan Back Creek
RO21471	Open	33.36494	-79.26449	3.4	7/21/2021	Georgetown	I<1	Mouth of Great Pee Dee River at Georgetown
RO21472	Open	32.81829	-79.75728	3.7	8/17/2021	Charleston	R>1	Long Creek 0.48 ENE of Gray Bay
RO21473	Open	32.16265	-80.82301	1.4	8/24/2021	Beaufort	R>1	Calibogue Sound 0.4 mi SSW of Bryan 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.

Station Information — Tidal Creeks

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT21245	Creek	33.05486	-79.43468	3.7	8/17/2021	Charleston	NDV	Little Papas Creek W of Muddy Bay
RT21249	Creek	32.31637	-80.91428	3.0	8/24/2021	Beaufort	R<1	Okatie River SW of Garrett's Point
RT21250	Creek	32.30703	-80.51776	3.4	8/10/2021	Beaufort	R>1	Skull Creek N of E end of Pritchards Island
RT21251	Creek	32.53130	-80.77945	2.7	8/04/2021	Beaufort	R<1	Whale Branch 2 mi N of Greys Hill Landing
RT21252	Creek	32.64624	-80.27576	5.6	7/13/2021	Charleston	R>1	Tom Point Creek 0.3 mi from Wadmalaw River
RT21253	Creek	32.44667	-80.71931	1.0	8/11/2021	Beaufort	R<1	Salt Creek 0.3 mi S of La Frene Rd
RT21254	Creek	32.43574	-80.54279	3.7	8/03/2021	Beaufort	R<1	Unnamed tributary to Eddings Point Creek
RT21255	Creek	32.84489	-79.75256	8.2	8/17/2021	Charleston	R>1	Unnamed tributary to Dewees Creek
RT21256	Creek	33.84018	-78.61713	2.1	8/25/2021	Horry	R<1	House Creek by 53rd Ave N bridge
RT21258	Creek	32.36658	-80.47865	1.7	8/11/2021	Beaufort	R>1	Unnamed tributary to Fripps Inlet
RT21259	Creek	32.97188	-79.90359	6.1	8/18/2021	Berkeley	I<1	Cooper River Cut by BP chemical plant
RT21261	Creek	32.93707	-79.63873	3.2	8/18/2021	Charleston	R>1	Unnamed tributary to Anderson Creek
RT21262	Creek	32.41330	-80.59390	1.9	8/03/2021	Beaufort	R<1	Jenkins Creek near S end of Dataw Island
RT21263	Creek	32.59366	-80.83234	1.2	8/04/2021	Jasper	R<1	Pocotaligo River 0.38 mi N of Bray Island
RT21269	Creek	33.19925	-79.30885	5.5	7/21/2021	Georgetown	NDV	Minim Creek N of Minim 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 2022

Station Information — Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO22301	Open	33.02906	-79.57119	1.0	7/19/2022	Charleston	R>1	ICW across from mouth of Awendaw Creek
RO22302	Open	32.77038	-79.92287	2.7	7/13/2022	Charleston	R<1	Charleston Harbor NE of White Point Gardens
RO22303	Open	32.41119	-80.70827	3.9	8/09/2022	Beaufort	R<1	Battery Creek NE of Deer Island
RO22304	Open	32.49121	-80.80833	4.3	7/26/2022	Beaufort	R>1	Mouth of Whale Branch at Broad River
RO22305	Open	33.16037	-79.23833	1.8	7/19/2022	Georgetown	NDV	North Santee Bay
RO22306	Open	32.66026	-79.94564	4.3	7/12/2022	Charleston	R<1	Folly River 200 meters W of SC 171
RO22307	Open	32.44653	-80.60899	2.1	8/10/2022	Beaufort	R<1	Point Creek at Morgan River Dr S
RO22308	Open	32.28507	-80.75423	2.9	7/27/2022	Beaufort	R>1	Chechessee River NE of mouth of Mackay Creek
RO22309	Open	33.26840	-79.23983	1.9	7/19/2022	Georgetown	I>1	Winyah Bay NE of mouth of Minim Creek Canal
RO22310	Open	32.86816	-79.86889	5.2	7/13/2022	Charleston	R>1	Wando River at mouth of Foster Creek
RO22311	Open	32.50199	-80.38885	1.2	8/24/2022	Colleton	NDV	Fish Creek north of Jefford Creek
RO22312	Open	32.36028	-80.76251	10.4	7/26/2022	Beaufort	R>1	Broad River 1.5 mi NW of mouth of Archers Creek
RO22313	Open	32.63363	-80.27107	7.8	8/23/2022	Charleston	R>1	Wadmalaw River at junction with Dawho River
RO22314	Open	32.30059	-80.56437	4.9	8/09/2022	Beaufort	R>1	Trenchards Inlet opposite the mouth of Skull Creek
RO22315	Open	32.44003	-80.45436	5.1	8/10/2022	Beaufort	R>1	St. Helena Sound off mouth of Morgan River

* 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
RT22001	Creek	32.50433	-80.30578	1.2	8/23/2022	Colleton		Unnamed creek behind Edisto Island
RT22002	Creek	32.42774	-80.58348	1.5	8/10/2022	Beaufort	R<1	Jenkins Creek NE of Dataw Island Kayak Launch
RT22005	Creek	32.31680	-80.91560	3.3	7/26/2022	Beaufort	R<1	Okatee River
RT22006	Creek	32.12692	-81.00084	6.0	8/18/2022	Jasper	I>1	Wright River 0.75 mi SE of Turnbridge Landing
RT22007	Creek	32.78220	-79.84016	0.9	7/13/2022	Charleston	R<1	Western branch of Conch Creek
RT22008	Creek	32.59209	-80.20508	4.3	8/23/2022	Charleston	R<1	Mouth of Adams Creek
RT22009	Creek	32.47727	-80.51349	3.5	8/10/2022	Beaufort	NDV	Mouth of unnamed creek to W Morgan Back Creeks
RT22010	Creek	32.22734	-80.77319	1.5	7/27/2022	Beaufort	R<1	Mouth of unnamed creek off Skull Creek
RT22011	Creek	32.92953	-79.91013	2.7	7/12/2022	Berkeley	I>1	Yellow House Creek slack reach
RT22013	Creek	32.32821	-80.57449	1.2	8/09/2022	Beaufort	NDV	Unnamed creek off E branch of Scott Creek
RT22015	Creek	32.81414	-79.76274	2.4	7/13/2022	Charleston	R<1	Seven Reaches
RT22016	Creek	32.56237	-80.50017	2.0	8/24/2022	Colleton	NDV	Mouth of Rock Creek at the Ashepoo River
RT22017	Creek	32.31204	-80.84950	3.5	7/26/2022	Beaufort	R<1	Mouth of Callawassie Creek
RT22019	Creek	33.19455	-79.29346	2.7	7/19/2022	Georgetown	NDV	Minim Creek SE of Cork Creek
RT22020	Creek	32.51550	-80.39397	2.0	8/24/2022	Colleton	NDV	Unnamed creek off Fish 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 2021 through 2022.

Index / Parameter	Criteria			2021-2022 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	< 3	$3 \le x < 4$	≥ 4	0	0	100	10	7	83
Dissolved Oxygen (mg/L)	< 3	$3 \le x < 4$	≥ 4	0	7	93	10	20	70
pH (salinity corrected)	≤ 7.22	$7.22 < x \le 7.35$	> 7.35	0	0	100	3	23	73
Fecal Coliform (cfu/100mL)	> 400	$43 < x \le 400$	≤ 43	0	17	83	3	27	70
Eutrophic Index	< 3	$3 \le x < 4$	≥ 4	0	7	93	3	17	80
Total Nitrogen (mg/L)	> 1.05	$0.81 < x \le 1.05$	≤ 0.81	0**	3**	73**	3**	10**	63**
Total Phosphorus (mg/L)	> 0.12	$0.10 < x \le 0.12$	≤ 0.10	0*	0*	93*	7	0	93
Chlorophyll *a* (µg/L)	> 16.4	$11.5 < x \le 16.4$	≤ 11.5	3	10	87	13	13	73
SEDIMENT QUALITY									
Sediment Quality Index	< 3	$3 \le x \le 4$	> 4	0	7	93	3	10	87
Contaminants (ERM-Q)	> 0.058	$0.020 < x \le 0.058$	≤ 0.020	0	10	90	0	20	80
Toxicity	≥ 2	$1 \le x < 2$	< 1	0	10	90	0	7	93
Sediment TOC (%)	> 5	$3 \le x \le 5$	< 3	0	7	93	7	3	90
BIOLOGICAL CONDITION									
Benthic-IBI	< 2	$2 \le x < 3$	≥ 3	0	10	90	10	20	70
HABITAT QUALITY									
Habitat Quality Index	≤ 2	$1.5 < x \le 2.5$	> 2.5	0	7	93	3***	23***	73***

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 two stations were missing. ** Data from seven stations were missing. ***No stations missing, standard rounding resulted in <100% total

APPENDIX 3

Summary of the Water Quality, Sediment Quality, Biological Condition, and Habitat Quality Index scores and their component measure scores by station for 2021 through 2022. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT". Green represents good condition, yellow represents fair condition, red represents poor condition, and no color indicates missing or unavailable data. 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.

2021 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		
RO21457	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	May River by Myrtle Island
RO21459	🟩	🟨	🟩	🟩	🟩	🟨	5	5	🟩	🟩	🟩	5	5	5.0	Georgetown	North Santee Bay
RO21460	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Charleston Harbor 0.65 mi E of Shutes Folly
RO21461	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Jasper	Broad River 0.7 mi W of the mouth of Whale Branch
RO21462	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Trenchards Inlet 1.1 mi ENE of Morse Island Creek
RO21463	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟨	5	5	5.0	Beaufort	Coosaw River 1.43 mi NNW of Sams Point Boat Ramp
RO21464	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟨	🟩	5	5	5.0	Berkeley	Wando River 1.1 mi ENE of Hwy 41 bridge
RO21465	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Broad River by Parris Island
RO21466	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Trenchards Inlet 0.56 mi WNW of Moon Creek
RO21467	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Five Fathom Creek 0.8 MILES SSW of Mathews Creek
RO21469	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Colleton River by Callawassie Island
RO21470	🟩	🟩	🟩	🟩	🟩	🟨	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Morgan Back Creek
RO21471	🟩	🟨	🟩	🟨	🟩	🟨	3	5	🟩	🟩	🟩	5	5	5.0	Georgetown	Mouth of Great Pee Dee River at Georgetown
RO21472	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Long Creek 0.48 ENE of Gray Bay
RO21473	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Calibogue Sound 0.4 mi SSW of Bryan Creek
RT21245	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟨	5	5	5.0	Charleston	Little Papas Creek W of Muddy Bay
RT21249	🟩	🟩	🟩	🟩	🟩	🟨	5	5	🟨	🟩	🟨	3	3	3.0	Beaufort	Okatie River SW of Garrett's Point
RT21250	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Skull Creek N of E end of Pritchards Island
RT21251	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	0	3.0	Beaufort	Whale Branch 2 mi N of Greys Hill Landing
RT21252	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Tom Point Creek 0.3 mi from Wadmalaw River
RT21253	🟩	🟩	🟩		🟩	🟨	5	5	🟩	🟩	🟩	5	3	5.0	Beaufort	Salt Creek 0.3 mi S of La Frene Rd
RT21254	🟨	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Unnamed tributary to Eddings Point Creek
RT21255	🟩	🟩	🟩		🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Unnamed tributary to Dewees Creek
RT21256	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	3	5.0	Horry	House Creek by 53rd Ave N bridge
RT21258	🟩	🟩	🟩	🟨	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Unnamed tributary to Fripps Inlet
RT21259	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟥	🟩	3	5	5.0	Berkeley	Cooper River Cut by BP chemical plant
RT21261	🟩	🟩	🟩		🟩	🟨	5	5	🟩	🟩	🟨	5	5	5.0	Charleston	Unnamed tributary to Anderson Creek
RT21262	🟨	🟨	🟩		🟩	🟨	5	5	🟩	🟩	🟩	5	3	5.0	Beaufort	Jenkins Creek near S end of Dataw Island
RT21263	🟨	🟨	🟨	🟩	🟥	🟩	3	3	🟩	🟩	🟩	5	5	5.0	Jasper	Pocotaligo River 0.38 mi N of Bray Island
RT21269	🟩	🟨	🟩	🟩	🟩	🟥	3	5	🟩	🟩	🟩	5	5	5.0	Georgetown	Minim Creek N of Minim Island

2022 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		
RO22301	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	ICW across from mouth of Awendaw Creek
RO22302	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟨	🟨	🟨	3	3	3.0	Charleston	Charleston Harbor NE of White Point Gardens
RO22303	🟨	🟨	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Battery Creek NE of Deer Island
RO22304	🟩	🟩	🟩	⬜	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Mouth of Whale Branch at Broad River
RO22305	🟩	🟩	🟩	⬜	🟩	🟩	5	5	🟩	🟩	🟩	5	3	5.0	Georgetown	North Santee Bay
RO22306	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Folly River 200 meters W of SC 171
RO22307	🟨	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Point Creek at Morgan River Dr S
RO22308	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Chechessee River NE of mouth of Mackay Creek
RO22309	🟩	🟩	🟩	🟩	🟩	🟥	3	5	🟨	🟩	🟨	3	3	3.0	Georgetown	Winyah Bay NE of mouth of Minim Creek Canal
RO22310	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Wando River at mouth of Foster Creek
RO22311	🟩	🟨	🟩	⬜	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Colleton	Fish Creek north of Jefford Creek
RO22312	🟩	🟩	🟩	🟩	⬜	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Broad River 1.5 mi NW of mouth of Archers Creek
RO22313	🟩	🟨	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Wadmalaw River at junction with Dawho River
RO22314	🟩	🟩	🟩	🟩	⬜	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Trenchards Inlet opposite the mouth of Skull Creek
RO22315	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟨	🟩	🟩	5	5	5.0	Beaufort	St. Helena Sound off mouth of Morgan River
RT22001	🟥	🟥	🟨	🟩	🟥	🟥	0	0	🟩	🟩	🟩	5	3	3.0	Colleton	Unnamed creek behind Edisto Island
RT22002	🟩	🟩	🟨	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Jenkins Creek NE of Dataw Island Kayak Launch
RT22005	🟩	🟩	🟨	🟨	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Okatee River
RT22006	🟨	🟩	🟨	🟩	🟩	🟩	5	5	🟩	🟨	🟨	3	0	3.0	Jasper	Wright River 0.75 mi SE of Turnbridge Landing
RT22007	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Western branch of Conch Creek
RT22008	🟩	🟨	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Mouth of Adams Creek
RT22009	🟥	🟩	🟥	🟩	🟩	🟩	5	0	🟩	🟩	🟩	5	5	3.0	Beaufort	Mouth of unnamed creek to W Morgan Back Creeks
RT22010	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Mouth of unnamed creek off Skull Creek
RT22011	🟨	🟨	🟩	🟩	🟩	🟥	3	3	🟨	🟥	🟨	0	3	0.0	Berkeley	Yellow House Creek slack reach
RT22013	🟨	🟩	🟨	⬜	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Unnamed creek off E branch of Scott Creek
RT22015	🟩	🟩	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	5	5.0	Charleston	Seven Reaches
RT22016	🟩	🟨	🟩	🟩	🟩	🟩	5	5	🟩	🟩	🟩	5	0	3.0	Colleton	Mouth of Rock Creek at the Ashepoo River
RT22017	🟩	🟩	🟩	🟥	🟩	🟩	3	5	🟩	🟩	🟩	5	5	5.0	Beaufort	Mouth of Callawassie Creek
RT22019	🟩	🟨	🟩	🟩	🟩	🟥	3	5	🟩	🟩	🟩	5	5	5.0	Georgetown	Minim Creek SE of Cork Creek
RT22020	🟥	🟨	🟨	🟨	🟩	🟩	5	0	🟩	🟩	🟩	5	5	3.0	Colleton	Unnamed creek off Fish Creek