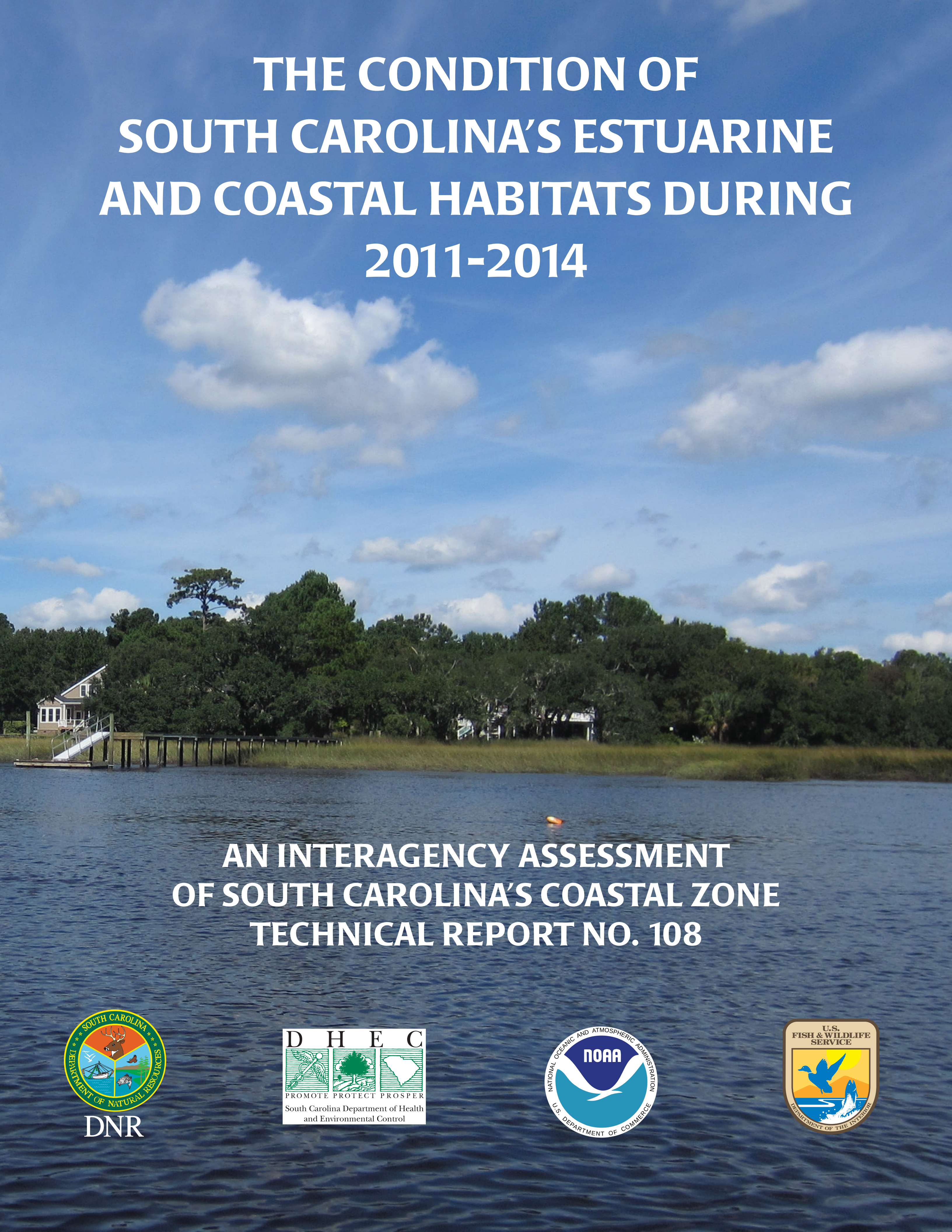


THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2011-2014

AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE
TECHNICAL REPORT NO. 108

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
DNR

DHEC
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

The Condition of South Carolina's Estuarine and Coastal Habitats During 2011-2014

Technical Report

Prepared by:

D.M. Sanger, S.P. Johnson, M.V. Levisen, S.E. Crowe

Marine Resources Division
South Carolina Department of Natural Resources
217 Fort Johnson Road
Charleston, SC 29412

D.E. Chestnut, B. Rabon

Bureau of Water
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

M.H. Fulton, E.F. Wirth

Center for Coastal Environmental Health and Biomolecular Research
National Oceanic and Atmospheric Administration
National Ocean Service Laboratory
219 Fort Johnson Road
Charleston, SC 29412

Technical Report No. 108

2016

This document should be cited as follows:

Sanger, D.M., S.P. Johnson, M.V. Levisen, S.E. Crowe, D.E. Chestnut, B. Rabon, M.H. Fulton, and E.F. Wirth. 2016. The Condition of South Carolina's Estuarine and Coastal Habitats During 2011-2014: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 108. 58p.

Cover photo courtesy of SCDNR Staff

Table of Contents

INTRODUCTION

South Carolina's extensive coastal zone provides a beautiful setting for residents and tourists to enjoy, and supports an abundance of natural resources that can be harvested. In 2013, domestic travel expenditures in South Carolina's eight coastal counties exceeded 7 billion dollars (U.S. Travel Association, 2014). In 2011, a total of 305,063 anglers spent over 2 million days saltwater fishing in our state (Southwick Associates, 2012). South Carolina's most economically important fishery species rely upon a variety of sensitive coastal habitat types that serve as nursery or primary habitat during one or more life stages. Thus, it is critical to protect our coastal habitats from degradation.

As in most coastal states, the population in the coastal counties has been rapidly increasing in recent years, with more than 1.3 million people estimated to be living in South Carolina's eight coastal counties in 2014 (U.S. Census Bureau, 2014). This number is expected to increase by another 15% by 2030 (South Carolina Budget and Control Board, 2013). The associated expansion of housing, roads, and commercial and industrial infrastructure, combined with increased recreational utilization of our coastal waters, will result in increased risk for serious 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 (Center for Coastal Environmental Health and Biomolecular Research and the Hollings Marine Laboratory). The U.S. Environmental Protection Agency (USEPA) Gulf Ecology Division in Gulf Breeze, FL became actively involved in SCECAP shortly after the inception of the program, and utilized SCECAP data from 2000-2006 and again in 2010 in their National Coastal Condition Assessment (NCCA) program.

Urban sprawl is one of the primary threats to the quality of South Carolina's estuarine habitats.

Historically, 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 *(http://water.epa.gov/type/oceb/assessmonitor/nccr/index.cfm)*, SCECAP provides us with the ability to expand the assessment for the state of South Carolina by collecting additional data for parameters of state relevance as well as using thresholds developed specifically for the state.

There are several critical attributes of the SCECAP initiative that set it apart from other ongoing monitoring programs being conducted in South Carolina by SCDHEC (primarily for water quality) and SCDNR (primarily for fishery stock assessments). These include: (1) sampling sites throughout the state's estuarine habitats using a random, probability-based 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 sampled historically 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; Holland et al., 2004; Sanger et al., 2015a).

This technical report is part of a series of reports describing the status of South Carolina's estuarine habitats. The 2011-2014 SCECAP report, as well as all reports for previous survey periods, can be obtained from the SCECAP web site at *http://www.dnr.sc.gov/marine/scecap/*. Raw and summarized data from these surveys can be can be requested by contacting the Principal Investigator.

METHODS

The sampling and analytical methods used for SCECAP are fully described in the first SCECAP report (Van Dolah et al., 2002). Some of the analytical methods have been modified and are fully described by Bergquist et al. (2009) and in this report. This program uses 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 NCCA program (*http://www.epa.gov/national-aquatic-resource-surveys/ncca)*. 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.

2.1. Sampling Design

Historically, 50-60 stations were sampled annually, but a discontinuation of some funding forced a downsizing of the effort beginning in 2007 to a total of 30 stations sampled each year. Sampling sites extend from the 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 near the mouth of each estuarine drainage basin. Half of the stations each year are randomly placed in tidal creeks (defined as water bodies < 100 m wide, and generally > 10 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. Stations sampled in 2011-2012 and 2013-2014 are shown in Figure 2.1.1 and listed in Appendix 1. By surface area, approximately 17% of the state's estuarine water represents creek habitat, and the remaining 83% represents the larger open water habitat (Van Dolah et al., 2002). Stations within each habitat type are selected using a probability-based, random tessellation, stratified sampling design (Stevens, 1997; Stevens and Olsen, 1999), with new station locations assigned each year.

The primary sampling period for all sampling components is during the summer (July through

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.

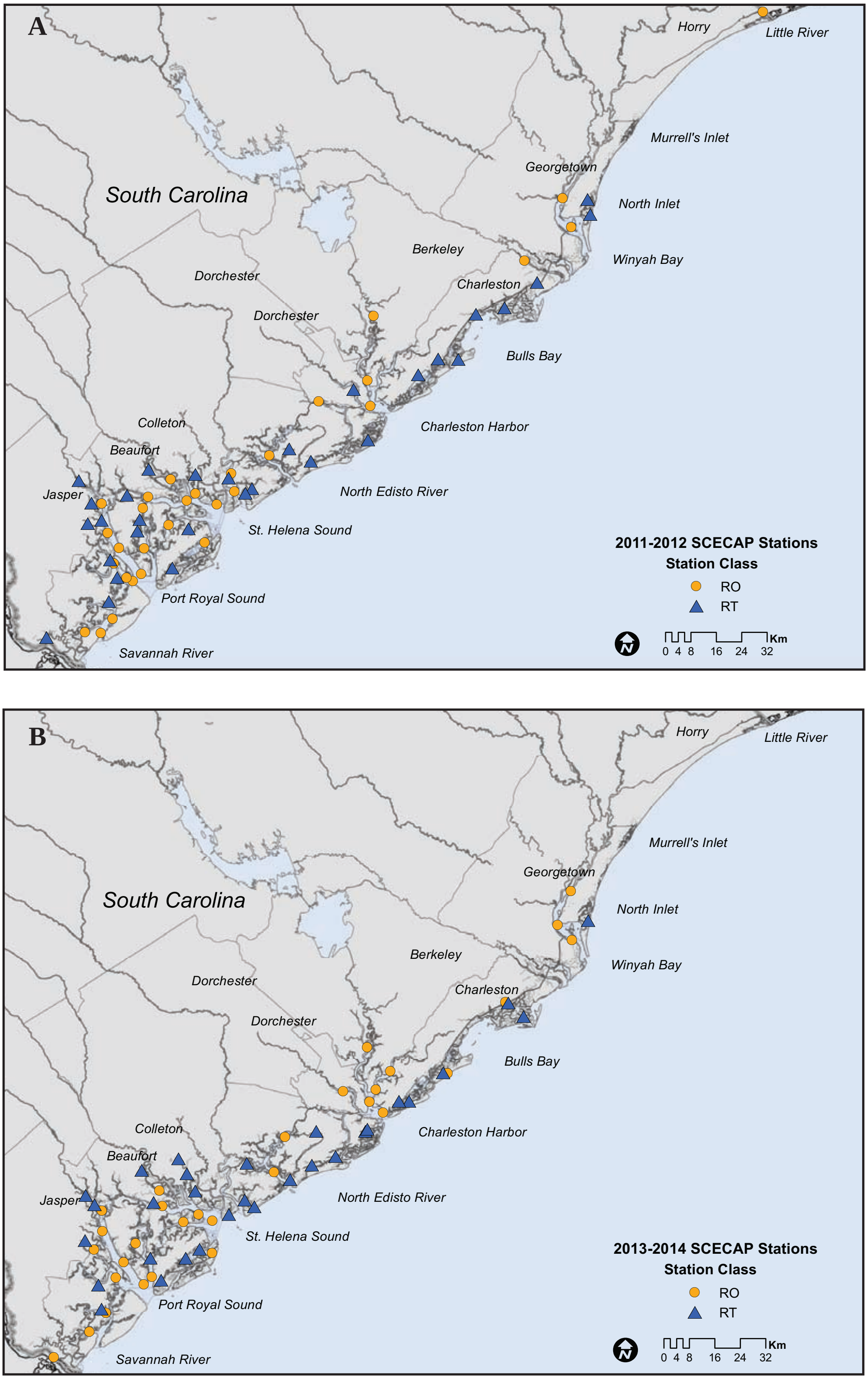


Figure 2.1.1. Locations of stations sampled in 2011-2012 (A) and in 2013-2014 (B). RO = open water and RT = tidal creek.

August). The summer period was selected because it represents a period when some water quality variables may be limiting to biota, and it is a period when many fish and crustacean species of concern utilize the estuary for nursery habitat. The same sites (15 tidal creek and 15 open water) are also sampled monthly for the calendar year by SCDHEC for selected water quality measures to meet that agency's mandates (data not reported here). Most measures of water and sediment quality and biological condition are collected within a 2-3 hr time period around low tide. Observations are made at each site to document the presence of litter and to note the proximity of the site to urban/suburban or industrial development. All data collected go through a rigorous quality assurance process to validate the data sets. A copy of the Quality Assurance Project Plan is maintained at the SCDNR Marine Resources Research Institute. Methods described in the following sections apply to all SCECAP survey periods.

2.2. Water Quality Measurements

Time-series measurements of temperature, salinity, dissolved oxygen (DO) and pH are obtained from the near-bottom (i.e. ~0.3 m above bottom) waters of each site using YSI Model 6920 multiprobes logging at 15 min intervals for 25 hrs to assess conditions over two full tidal cycles, representing both day and night conditions. Both SCDHEC and SCDNR field staff also collect an instantaneous measure of these parameters at several depths in the water column during the primary site 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 concentrations. Secondary water quality measures that are also collected from near-surface waters include total organic carbon (TOC), total suspended solids (TSS), turbidity, and water clarity based on a Secchi disk measurement. For some survey periods, dissolved nutrient concentrations and five-day biochemical oxygen demand (BOD5) were collected, but these measures have generally been discontinued due to budget limitations. 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 or have no state water quality standards.

All water quality samples are collected by inserting pre-cleaned water bottles to a depth of 0.3 m and then filling the bottle directly at that depth. The bottles are stored on ice until they are returned to the laboratory for further processing. Bacteria samples, total nutrients, and Chl-*a* are processed by SCDHEC using the standardized procedures in effect at the time of sample collection or analysis (SCDHEC b,c,d). In 2011-2014, SCDHEC TKN values concurrent with SCECAP sampling were not available for many sites, resulting in our not being able to calculate TN; therefore, 2011-2014 TN, TP, and Chl-*a* values were calculated by taking an average of the SCDHEC data that were collected at those sites during the months of June, July, and August during the same year as SCECAP sampling.

2.3. Sediment Quality Measurements

At least six 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 samples. The

SCDNR research vessel (RV Rosey), used for sampling SCECAP stations.

surficial sediments (upper 2 cm) of four or more grab samples are homogenized on-site and placed in pre-cleaned containers for analysis of silt and clay content, total organic carbon (TOC), total ammonia nitrogen (TAN), contaminants, and sediment toxicity. All sediment samples are kept on ice while in the field and then stored either at 4ºC (toxicity, porewater) 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 ammonia is measured using a Hach Model 700 colorimeter, and TOC is measured on a Perkin Elmer Model 2400 CHNS Analyzer. Contaminants measured in the sediments include 22 metals, 28 polycyclic aromatic hydrocarbons (PAHs), 80 polychlorinated biphenyls (PCBs), 14 polybrominated diphenyl ethers (PBDEs) and 22 pesticides. All contaminants are analyzed by the NOAA/NOS Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) using procedures similar to those described by Kucklick et al. (1997), Long et al. (1997), Balthis et al. (2012), and Chen et al. (2012). The sediment contaminant concentrations are simplified into a mean Effects Range Median Quotient (ERM-Q) which provides a convenient measure of overall contamination based on 24 compounds for which there are biological effects guidelines (Long and Morgan, 1990; Long et al., 1995, 1997; Hyland et al., 1999).

Sediment toxicity is measured using two bioassays: 1) the Microtox® solid-phase assay using a photoluminescent bacterium, *Vibrio fischeri*, and protocols described by the Microbics Corporation (1992), and 2) a 7-day juvenile clam growth assay using *Mercenaria mercenaria* and protocols described by Ringwood and Keppler (1998). Toxicity in the Microtox® assay is based on criteria described by Ringwood et al. (1997; criterion #6: toxic when scores of < 0.5 if silt/clay < 20% and scores of < 0.2 if silt/clay > 20%). For the clam assay, sediments are considered toxic if growth (change in dry weight) is < 80% of that observed in control sediments and there was a statistically significant difference ($p < 0.05$). Results from the 7-day clam growth assay were not available for 2014 due to overall high mortality, likely due to stress experienced by the seed clams while being shipped to the laboratory. 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.

2.4. Biological Condition Measurements

Two of the samples collected by Young grab are washed through a 0.5 mm sieve to collect the macrobenthic invertebrate fauna, which are then preserved in a 10% buffered formalin/seawater solution containing Rose Bengal stain. All organisms from the two grabs are identified to the species level or to the lowest practical taxonomic level if the specimen is immature or too damaged for accurate identification. A reference collection of all 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; Van Dolah et al., 1999).

A sample of fish and crabs captured in a SCECAP trawl tow.

Fish and large invertebrates are collected by trawl at each site following benthic sampling to evaluate near-bottom community composition. The trawls are generally targeting smaller fish (often young of the year) as well as shrimp and crabs that use the estuary as a nursery area and habitat. Two replicate tows are made sequentially at each site 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 sites and 0.25 km for creek sites. Fish, squid, large crustaceans, and horseshoe crabs captured are identified to the species level, counted, and checked for gross pathologies, deformities, or external parasites. Up to 25 individuals of each species are measured to the nearest centimeter. Mean abundances are corrected for the total area swept by the two trawls using the formula described by Krebs (1972). Tissue contaminant samples are no longer collected by SCECAP due to cost 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 (USEPA, 2001; 2004; 2006) as well as by a few states and other entities using a variety of approaches (Carlton et al., 1998; Chesapeake Bay Foundation, 2007; Partridge, 2007).

SCECAP computes four integrated indices describing different components of the estuarine ecosystem: water quality, sediment quality, biological condition and overall habitat quality. The Water Quality Index (WQI) combines four equally-weighted measures: dissolved oxygen, fecal coliform bacteria, salinity-corrected pH, and the Eutrophic Index (Table 2.5.1). The Eutrophic Index combines three equally-weighted measures: total nitrogen, total phosphorus, and chlorophyll *a*. The Sediment Quality Index (SQI) combines three equally-weighted measures: the Effects Range Median Quotient (ERM-Q; the estimated biological effect of 24 sediment contaminants), toxicity (as assessed by a bacterial assay and a seed clam assay), and total organic carbon. The Biological Condition Index (BCI) includes only the Benthic Index of Biotic Integrity (B-IBI); each station's B-IBI value is converted directly into a Biological Condition Index score. The Water Quality, Sediment Quality, and Biological Condition indices are then equally weighted and combined into a single integrated Habitat Quality Index (HQI). The integrated indices improve public communication of multi-variable environmental data and provide a more reliable tool than individual measures (such as DO, pH, etc.) for assessing estuarine condition. For example, one location may have apparently 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 and yet detect the relatively greater degradation at the second location.

Current methods for calculating the four integrated indices are described in detail in the 2005-2006 SCECAP report (Bergquist et al.,

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 (ERM-Q)	B-IBI
Fecal Coliform Bacteria	Toxicity	
pH (salinity-corrected)	Total Organic Carbon	
Eutrophic Index		
Total Nitrogen		
Total Phosphorus		
Chlorophyll *a*		

2009). Broadly, each individual measure taken at a sampled station and used to calculate the integrated indices is given a score of "good," "fair," or "poor." In the various graphics and tables of this report, good conditions are indicated by green, fair by yellow, and poor by red. Thresholds for defining conditions as good, fair, or poor are based on state water quality standards (SCDHEC, 2008), published findings (Hyland et al., 1999 for ERM-Q; Van Dolah et al., 1999 for benthic condition; Ringwood et al., 1997 and Ringwood and Keppler, 1998 for toxicity measures), or percentiles of a historical database for the state based on SCECAP measurements collected from 1999-2006 (Bergquist et al., 2009). The thresholds used in this report are listed in Appendix 2. These index values are given a numerical score or ranking (good as highest (5), fair as intermediate (3), poor as lowest (0)) and averaged into an integrated index value (described in general terms in Van Dolah et al. (2004)). 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 scores for the WQI, SQI, and BCI are averaged into an overall Habitat Quality Index and numerically scored as shown in Table 2.5.2. 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 may not exactly match those in previous reports. However, the current report does reflect the updated approach applied to all measures and previous survey periods.

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, the Sediment Quality Index, and the Biological Condition Index.

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)

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 was recorded.

2.7. Data Analysis

Use of the probability-based sampling design provides an opportunity to statistically 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 programs developed within the R statistical package. 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 data 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 Water Quality Monitoring Network, and 2) calculation of the 95% confidence limit for each estimate. Additionally, the difference in scores between tidal creek and open water habitats is now well-established in South Carolina (Van Dolah et al., 2002; 2004; 2006; 2013; Bergquist et al., 2009; 2011; Appendix 2). For brevity, graphical summaries in this report are primarily limited to overall estuarine habitat condition (tidal creek and open water combined). SCECAP data are stored in a relational database.

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 drainage system, can provide an early warning of impaired habitat, especially related to nutrient enrichment and bacterial problems. Six of those 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 for SCECAP. These include: 1) dissolved oxygen (DO), which is critical to healthy biological communities and can reflect organic pollution; 2) pH, which measures the acidity of a water body and can indicate the influence of various types of human input, such as atmospheric deposition from industry and vehicle emissions, runoff from land sources, etc.; 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 equals one quarter of the weight of the overall WQI.

Applying the WQI to 2011-2012 survey data, 87% of the state's estuarine habitat coded as being in good condition, 11% coded as fair, and 2% coded as poor (Figure 3.1.1a). Based on the 2013-2014 survey, 92% of the state's estuarine habitat coded as being in good condition, 4% coded as fair, and 4% coded as poor (Figure 3.1.1b). For both the 2011-2012 and 2013-2014 surveys, none of the four component measures of the WQI had more than 5% of the coastal habitat rating as poor.

The proportion of the state's overall estuarine habitat with good water quality has remained fairly constant from the 2005-2006 survey through to the 2013-2014 survey, ranging from 87% to 94% (Figure 3.1.2).

As has been observed throughout the entire 1999-2014 SCECAP program, tidal creek habitat in 2011-2014 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 2011-2012 survey, 93% of open water habitat scored as good on the WQI, compared to 57% of tidal creek habitat. During the 2013-2014 survey, 93% and 87% of open water and tidal creek habitat, respectively, scored as good on the WQI (Appendix 2).

The distribution of stations for the 2011-2014 survey period with good, fair, or poor WQI scores are shown in Figures 3.1.4a, 3.1.5a, and 3.1.6a and in Appendix 3. Eight of the 120 stations sampled from 2011-2014 had poor water quality: one in Georgetown County, three in Charleston County, one in Colleton County, and three in Jasper County (Appendix 3). The Georgetown station with poor water quality, the only open water station in this category, was in Winyah Bay, northwest of Malady

South Carolina's wildlife need good water quality.

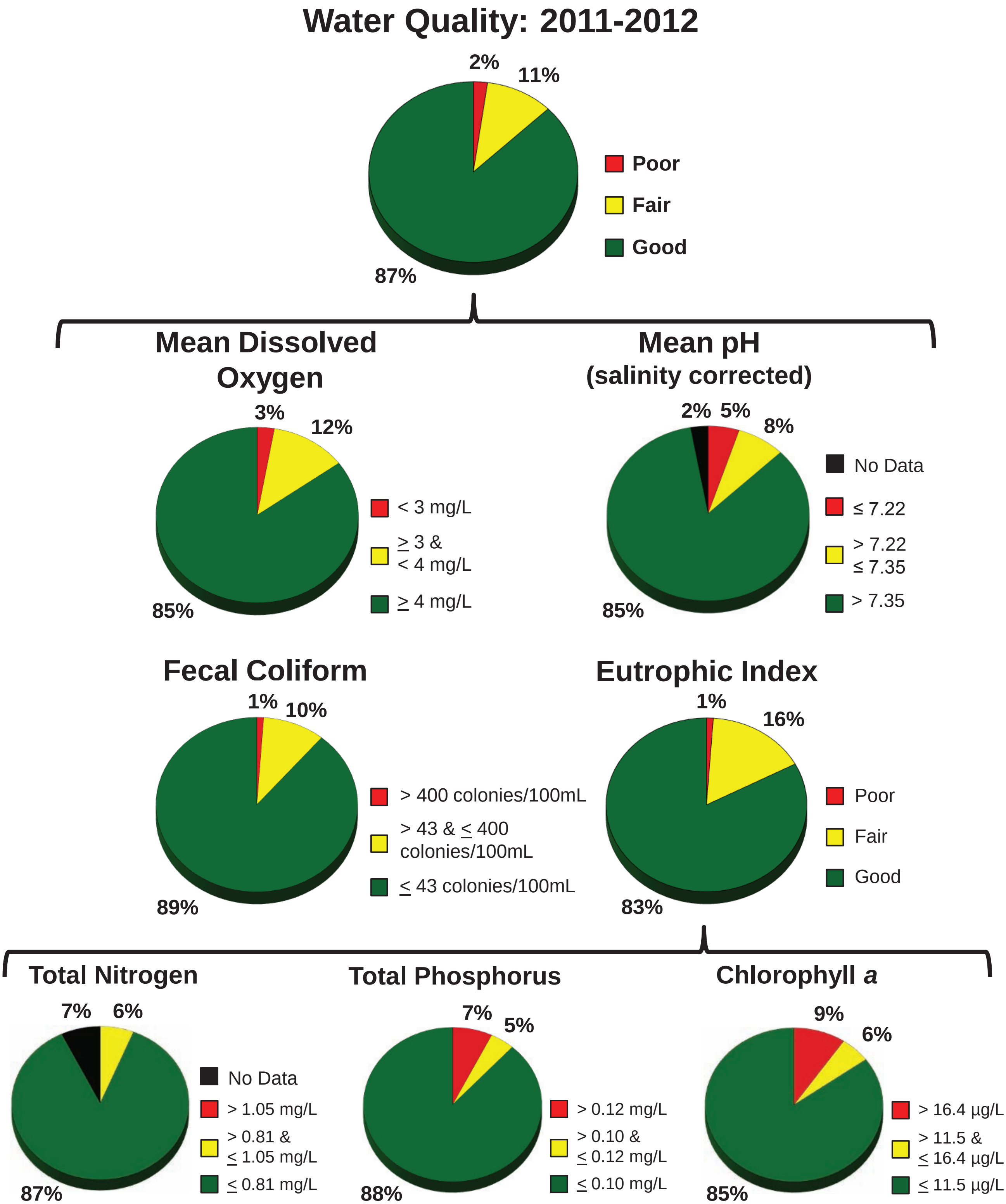


Figure 3.1.1a. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2011 and 2012.

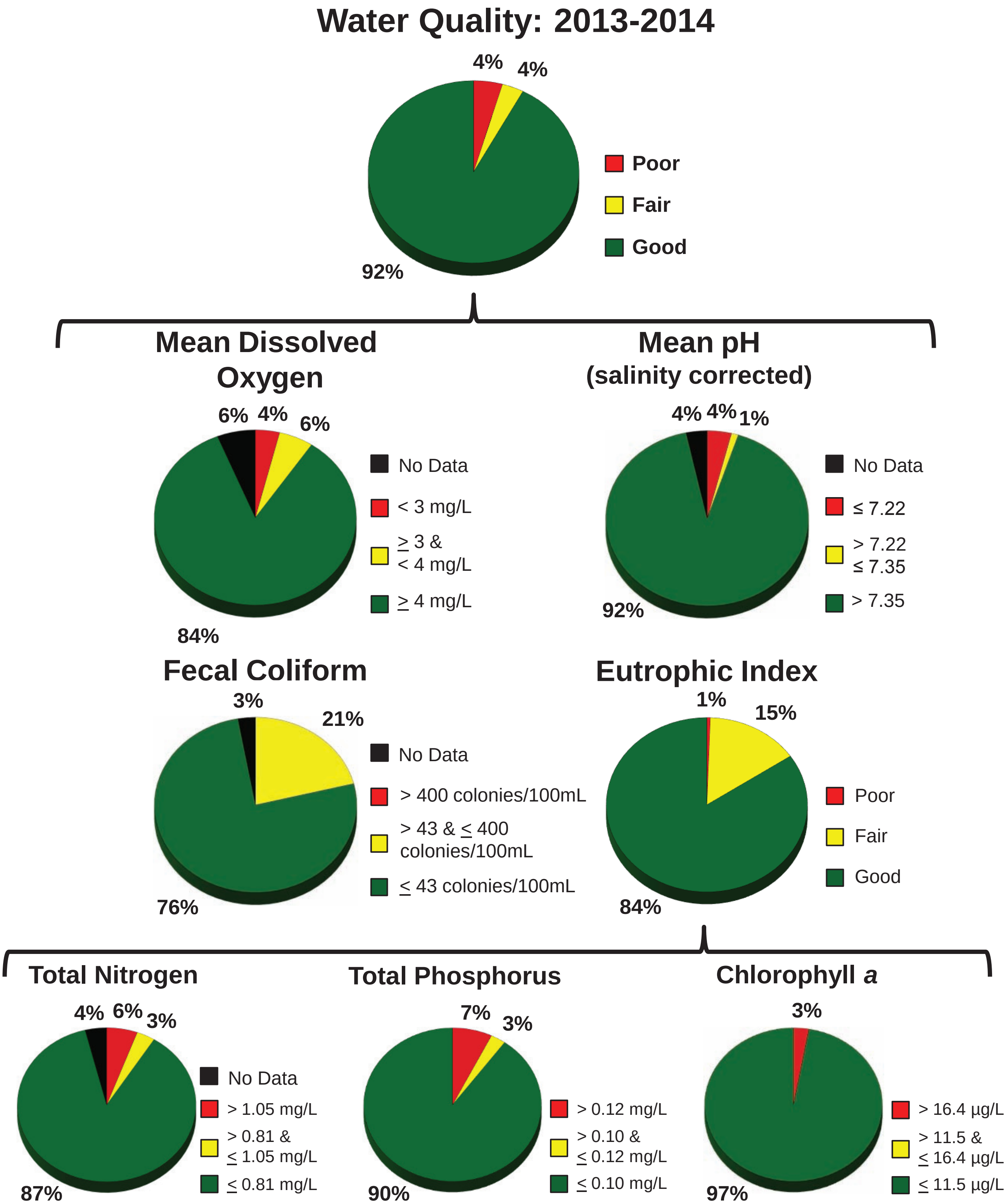


Figure 3.1.1b. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2013 and 2014.

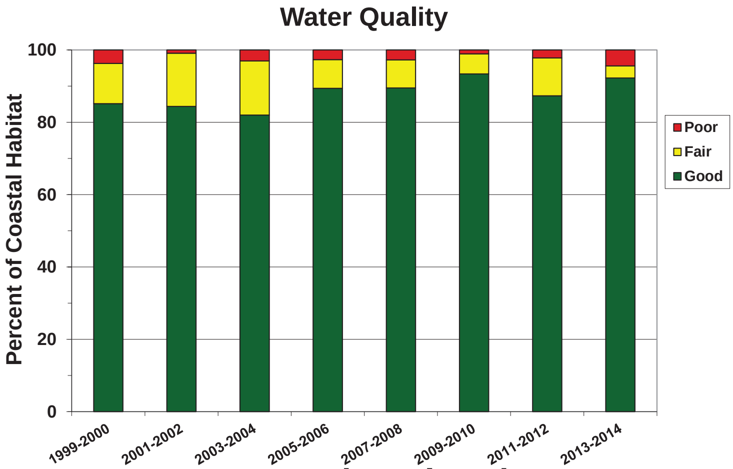


Figure 3.1.2. Water Quality Index values observed by survey period for all coastal habitat.

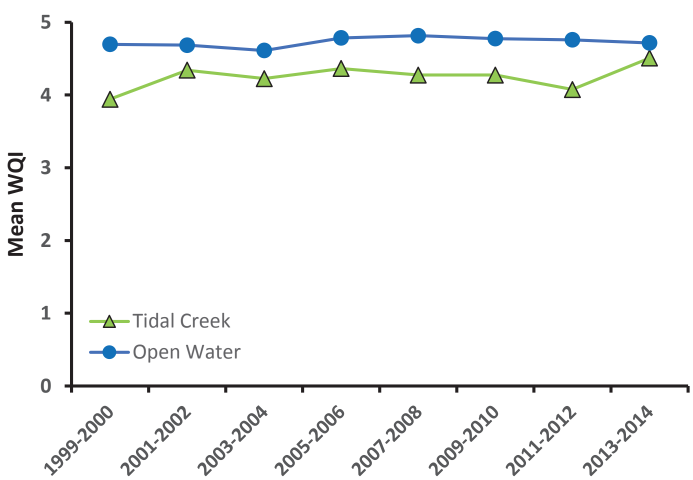


Figure 3.1.3. Water Quality Index values observed by survey period and habitat type.

Bush Island (RO13343). Poor and fair water quality has been observed in Winyah Bay open water sites in previous surveys. The Charleston County stations with poor water quality were a tidal creek along the ICW above Alligator Creek (RT12033), in Summerhouse Creek by the Cape Romain Wildlife Refuge's Bull Island (RT12037), and in Orangegrove Creek, which drains into the Ashley River (RT12020). Every tidal creek along the Ashley River that has been sampled through the SCECAP program has received a WQI score of poor or fair. Two creeks near Summerhouse Creek in Cape Romain have received fair WQI scores, and a subset of creek and open water stations along the ICW near RT12033 have received fair WQI scores. The Colleton County station with poor water quality was in a tidal creek associated with the Chehaw River, northwest of Social Hall Creek (RT13043), an area where tidal creeks have consistently registered as having poor water quality. Two of the Jasper County tidal creek stations with poor water quality were along the Coosawhatchie River (RT12031, 2 miles below Hwy 17; and RT13059, northwest of the Pocotaligo River), near stations sampled in earlier years that showed compromised water quality, and the third was in Hazzard Creek (RT14082), which had not previously been sampled. In 2011-2014, 3 of the 60 open water stations and 10 of the 60 tidal creek stations had fair WQI scores (Appendix 3).

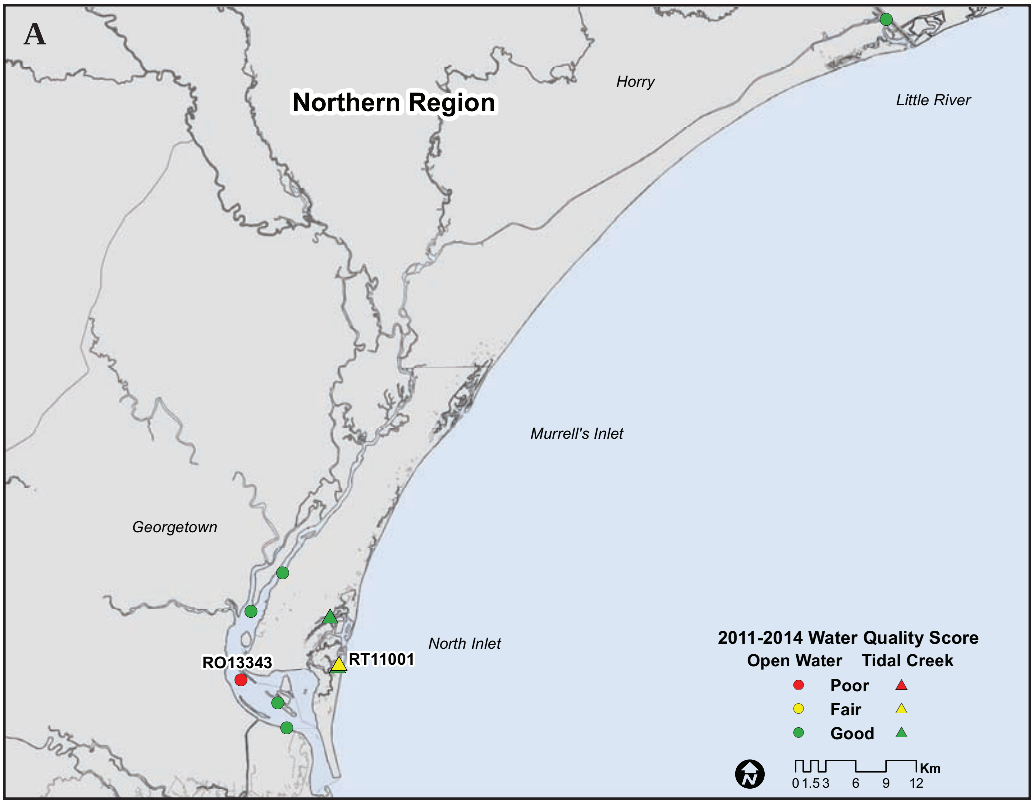
When considering all years (1999-2014), portions of the state with a relatively high incidence of fair to poor water quality are concentrated in Winyah Bay, Santee River, Ashley River, drainages in the vicinity of Dawhoo River, drainage basins associated with the Ashepoo and Combahee Rivers, New River, Coosawhatchie River, and portions of the Wright River (Figures 3.1.4b, 3.1.5b, 3.1.6b).

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 contaminants which can accumulate over time, providing a better measure of long-term exposure to contaminants in an area. Although many sediment quality measures are collected by SCECAP, the three component measures of the Sediment Quality Index (SQI) are considered to be the most indicative of sediment quality. These include: 1) a combined measure of 24 organic and inorganic contaminants that have published biological effects thresholds (ERM-Q; Long et al., 1997; Hyland et al., 1999; 2003), 2) a measure of sediment toxicity based on two bioassays that indicates whether contaminants are present at concentrations that have adverse biological effects, and 3) total organic carbon

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
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
	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
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
	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	4.68
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
	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
Fecal Coliform (col/100mL)	Open	46.52	10.93	14.27	9.20	25.30	16.73	11.68	23.52	16.80	13.13	18.67	9.93	23.20	6.27	21.39	37.89
	Creek	29.69	54.53	34.58	25.47	73.90	86.53	29.40	64.83	14.20	31.73	5.13	26.80	24.53	157.87	57.65	21.05
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
	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
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
	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
Chlorophyll a (µg/L)	Open	10.29	9.08	10.06	10.14	6.86	8.37	7.72	7.44	11.00	9.24	7.18	9.23	8.69	7.61	2.94	6.63
	Creek	12.58	12.54	10.84	9.74	11.59	12.02	8.00	10.11	10.89	8.91	7.85	12.13	9.70	8.64	4.91	5.87
Temperature (°C)	Open	30.20	29.44	29.48	29.10	28.47	29.15	29.96	29.68	29.76	28.99	28.53	30.82	30.13	29.92	28.92	29.14
	Creek	30.07	29.79	29.54	29.03	28.96	29.64	29.92	30.18	30.26	29.91	29.86	31.25	30.68	29.75	29.32	29.59
Salinity (ppt)	Open	26.22	28.13	28.16	31.02	19.93	28.45	25.95	31.08	30.31	31.34	26.40	30.79	30.48	29.14	21.07	24.60
	Creek	31.06	31.47	29.41	32.13	20.76	26.18	23.22	32.27	29.27	31.96	30.90	29.72	34.24	30.69	19.73	28.91



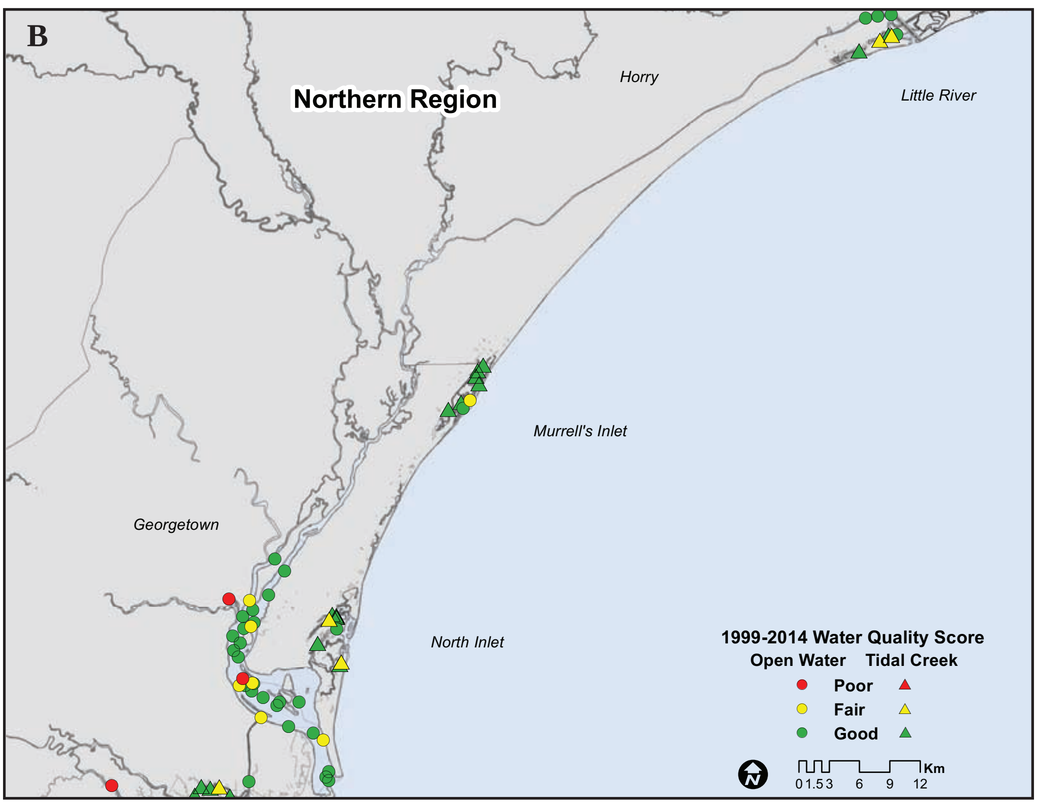
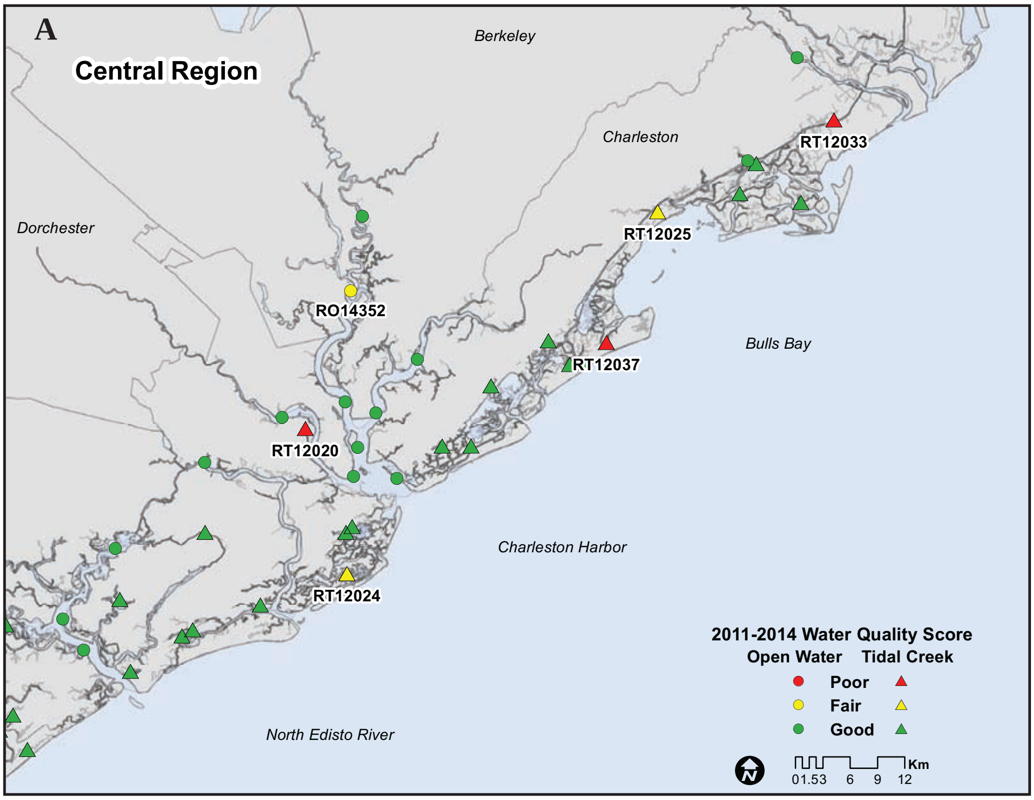


Figure 3.1.4. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2011-2014 (A) and 1999-2014 (B) periods for the northern region of South Carolina.



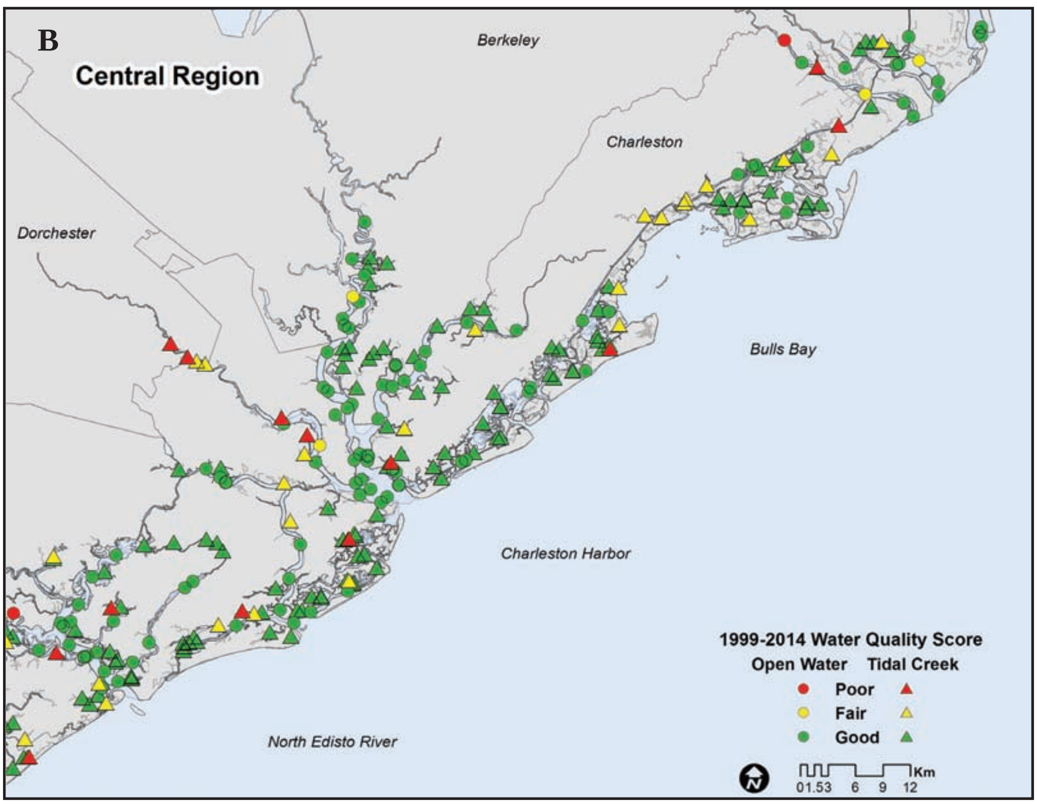
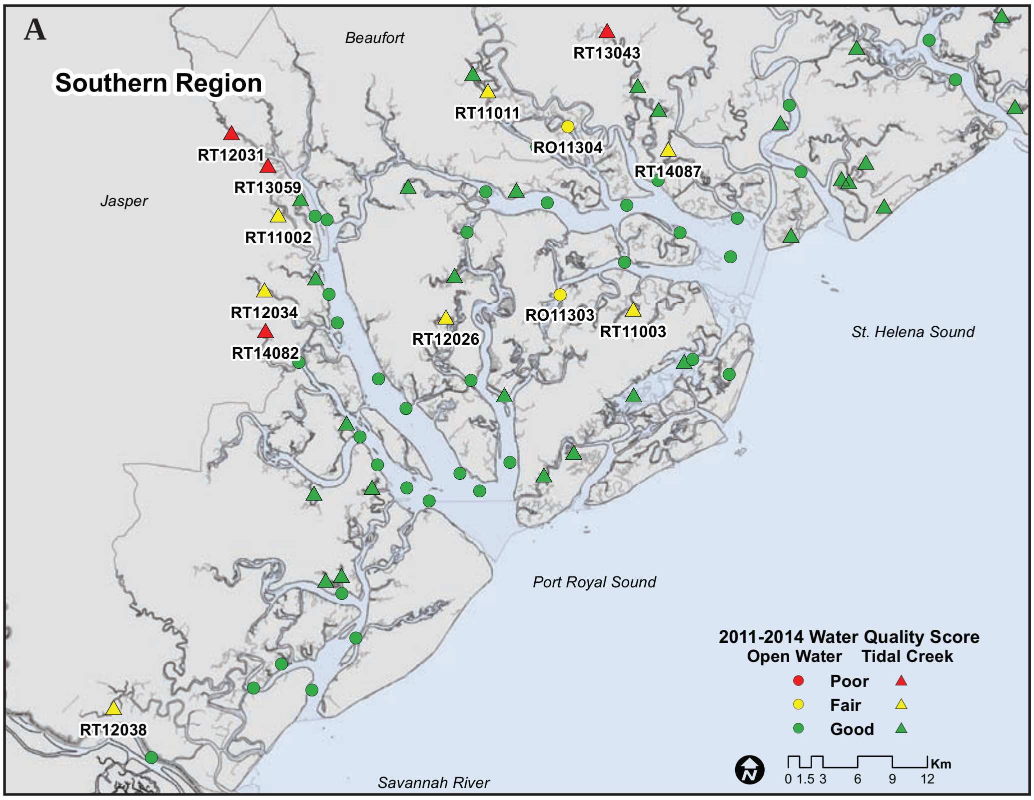


Figure 3.1.5. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2011-2010 (A) and 1999-2014 (B) periods for the central region of South Carolina.



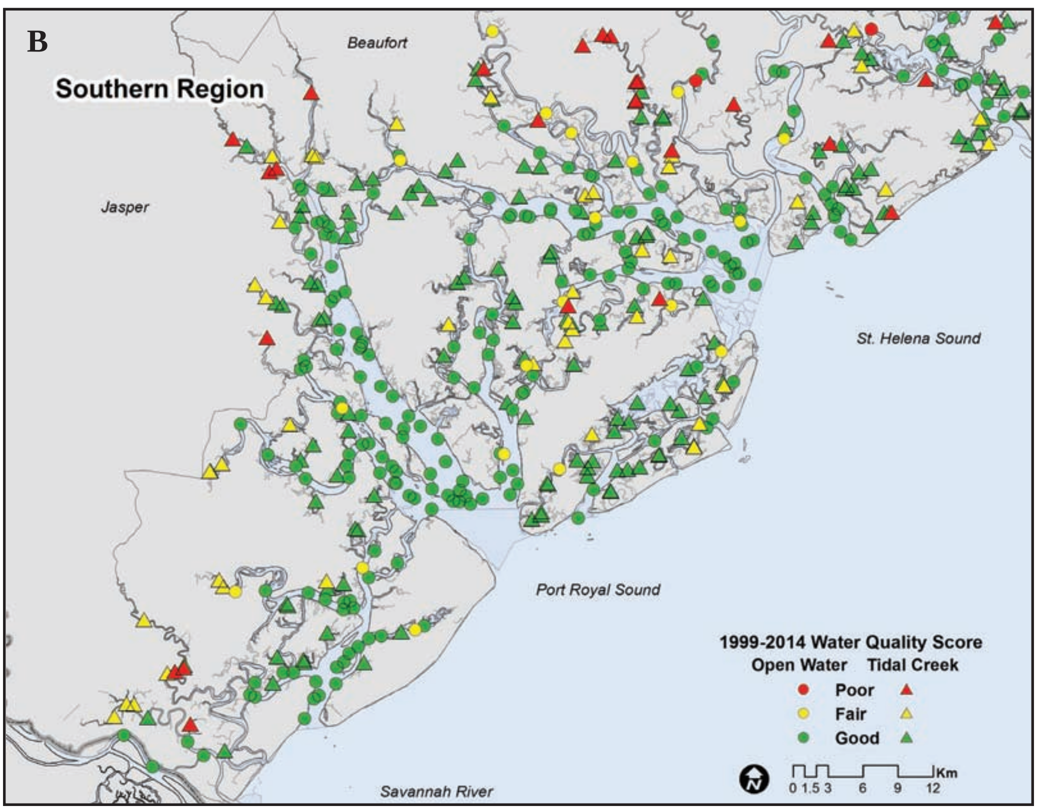


Figure 3.1.6. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2011-2014 (A) and 1999-2014 (B) periods for the southern region of South Carolina.

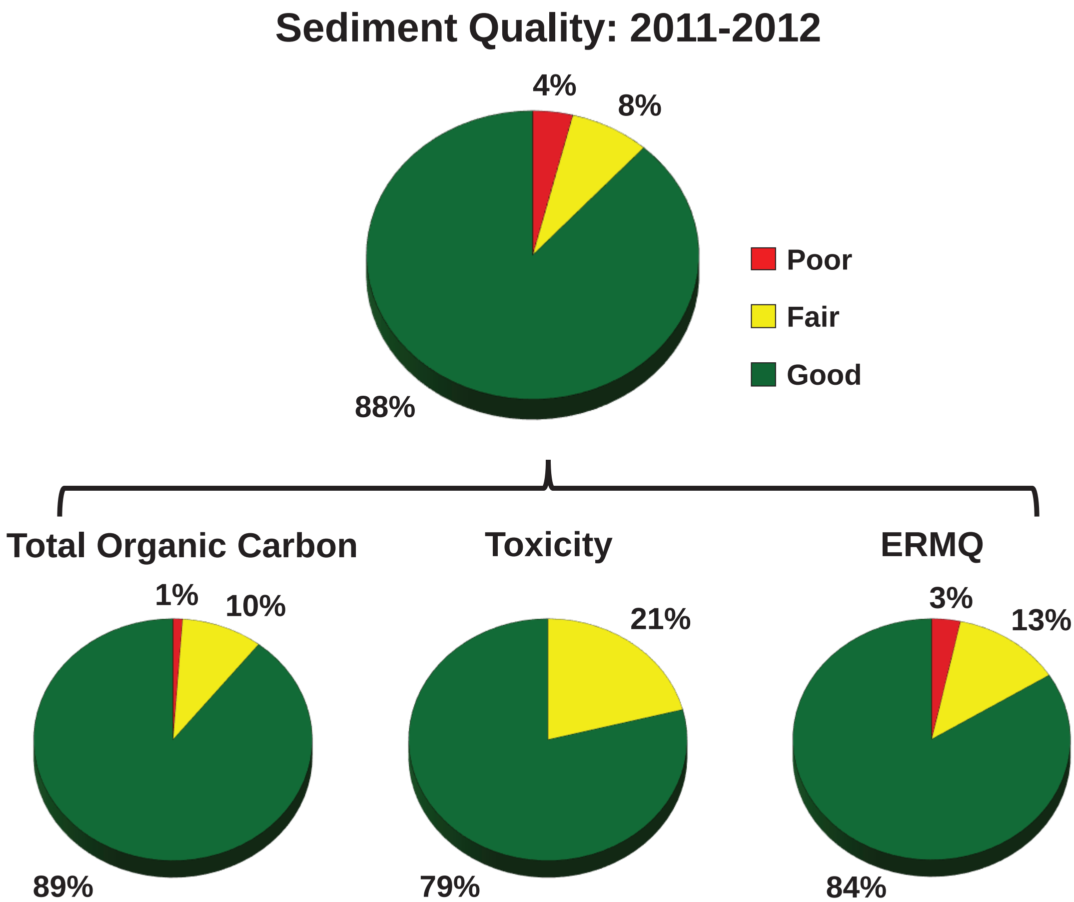


Figure 3.2.1a. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Sediment Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2011 and 2012. Percentage pie values that don't total to 100% indicate a portion of state waters that could not be coded due to missing samples

(TOC), which can have several adverse effects on bottom-dwelling biota and provides a good predictor of benthic community condition (Hyland et al., 2005).

During the 2011-2012 survey using the Sediment Quality Index (SQI) 88% of South Carolina's estuarine habitat had sediment in good condition, with 8% in fair condition and 4% in poor condition (Figure 3.2.1a). The 2013-2014 survey coded 89% of the state's estuarine habitat as having sediment in good condition, 10% in fair condition, and only 1% in poor condition (Figure 3.2.1b). Throughout the 1999-2014 SCECAP timeframe, the percentage of estuarine habitat with good sediment quality has been increasing, from a range of 70-78% in 1999-2004, to a sustained 83% for 2005-2010, to 88-89% for 2011-2014 (Figure 3.2.2). As observed in most years, sediment quality tended to be lower in tidal creek habitats than in open water habitats for both the 2011-2012 and 2013-2014 survey periods (Figure 3.2.3; Appendix 2).

Among the three SQI component measures in 2011-2012, both sediment contaminant (ERM-Q) and toxicity measures showed higher percentages of the state's estuarine waters in only fair or poor condition (16% and 21%, respectively) whereas total organic carbon (TOC) was considered fair or poor for only 11% of the habitat (Figure 3.2.1a). This pattern was also found in 2013-2014, with 33% and 21% of the state's estuarine waters being coded as fair or poor for sediment contamination and sediment toxicity, and only 7% being coded as fair or poor for sediment TOC (Figure 3.2.1b).

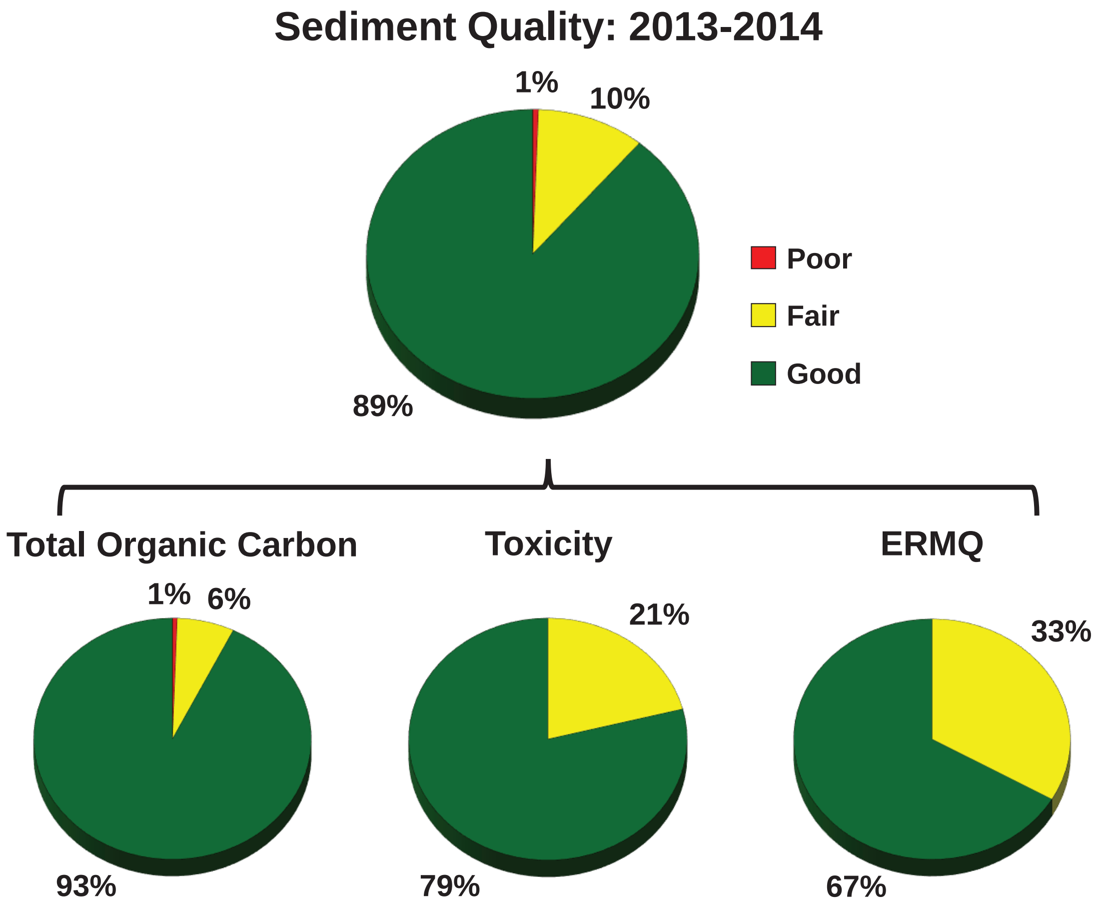


Figure 3.2.1b. Percentage of the state's estuarine habitat that scored as good, fair or poor for the Sediment Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2013 and 2014. Percentage pie values that don't total to 100% indicate a portion of state waters that could not be coded due to missing samples.

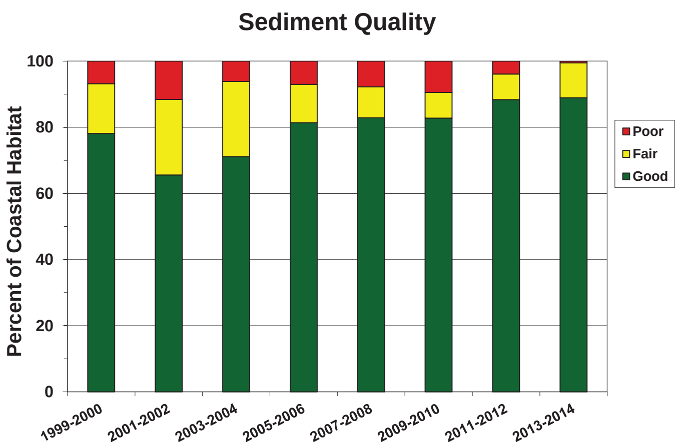


Figure 3.2.2. Sediment Quality Index scores observed by survey period for all coastal waters.

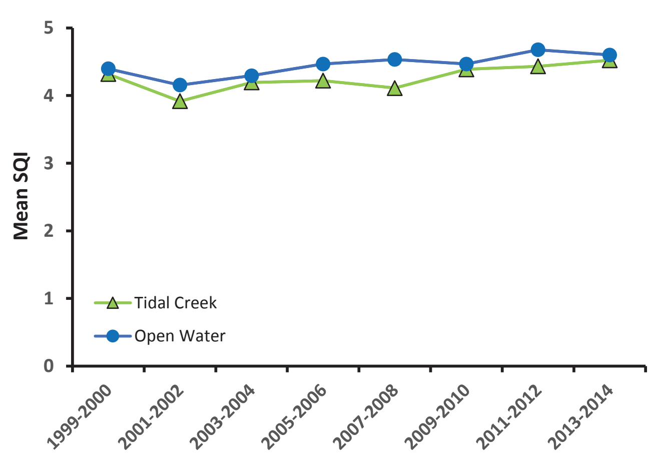
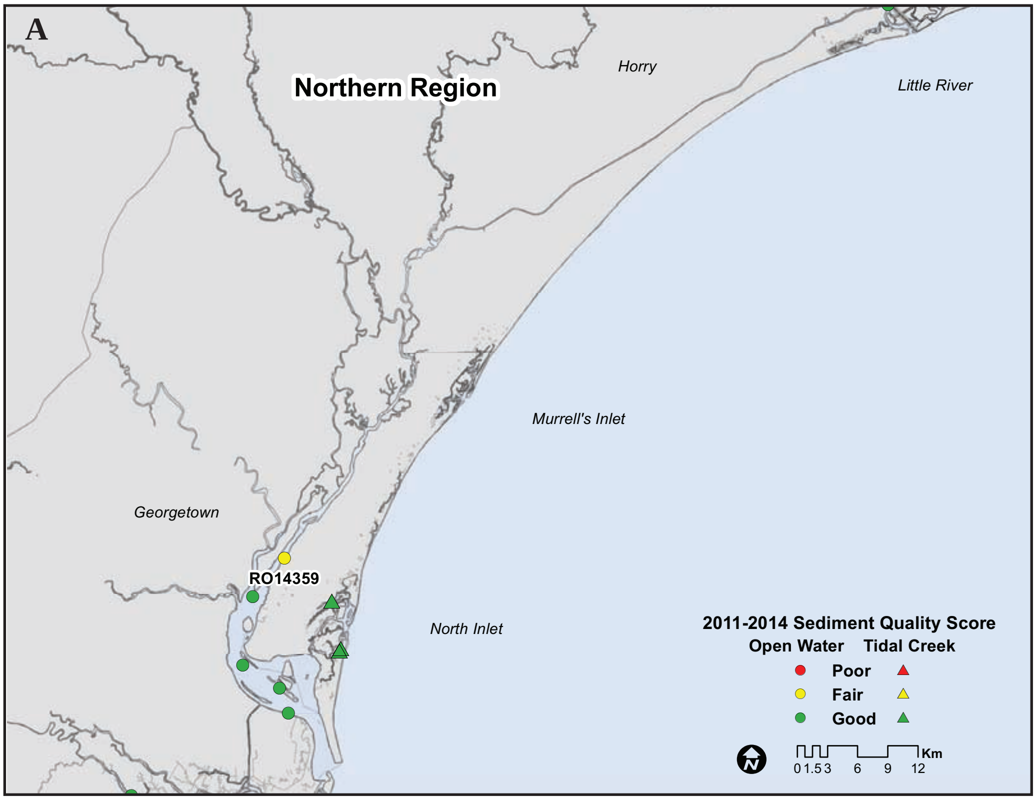


Figure 3.2.3. Sediment Quality Index values observed by survey period and habitat type.



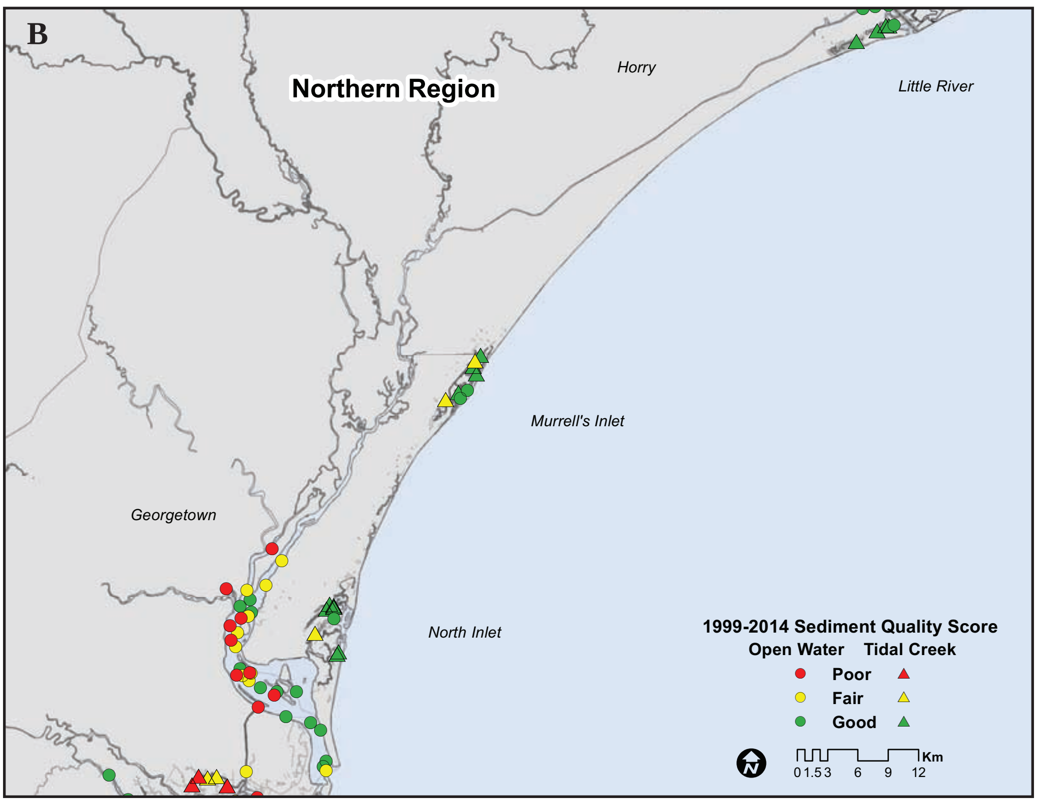
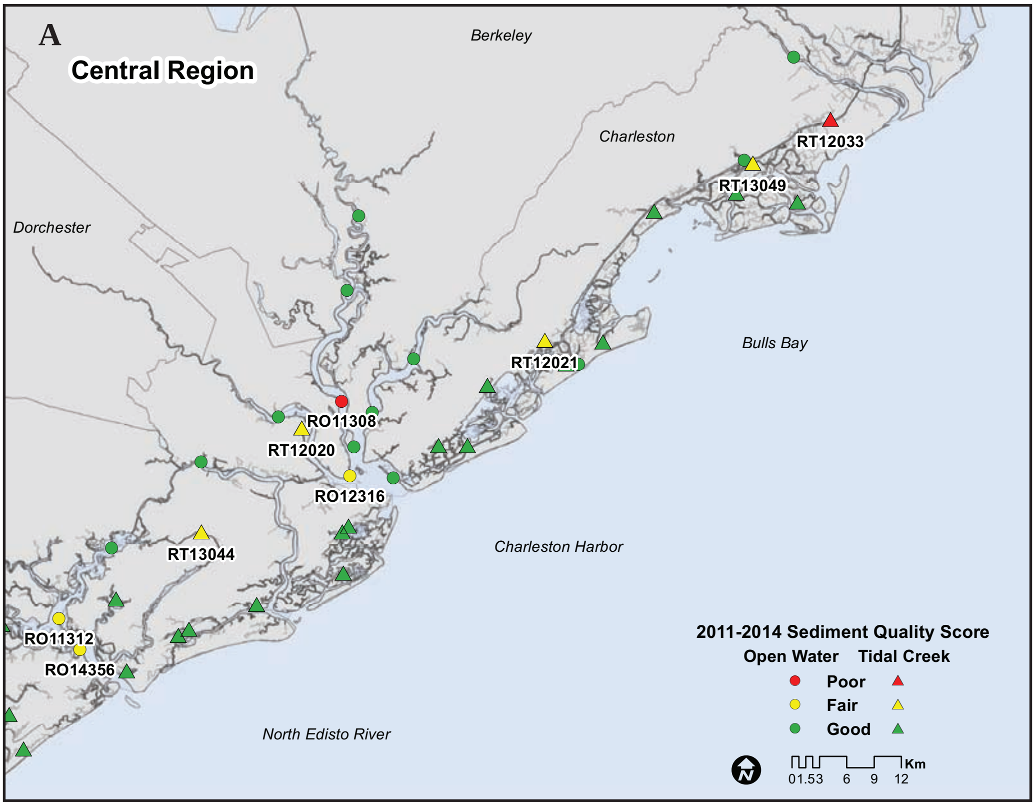


Figure 3.2.4. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2011-2014 (A) and 1999-2014 (B) periods for the northern region of South Carolina.



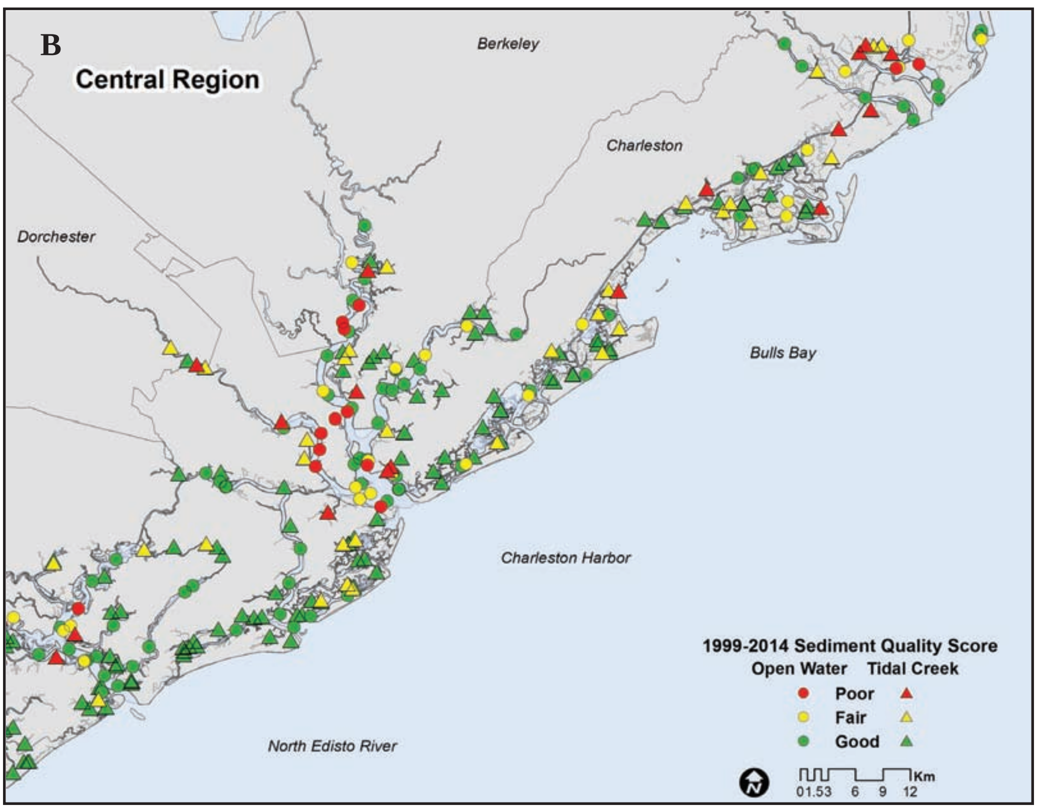
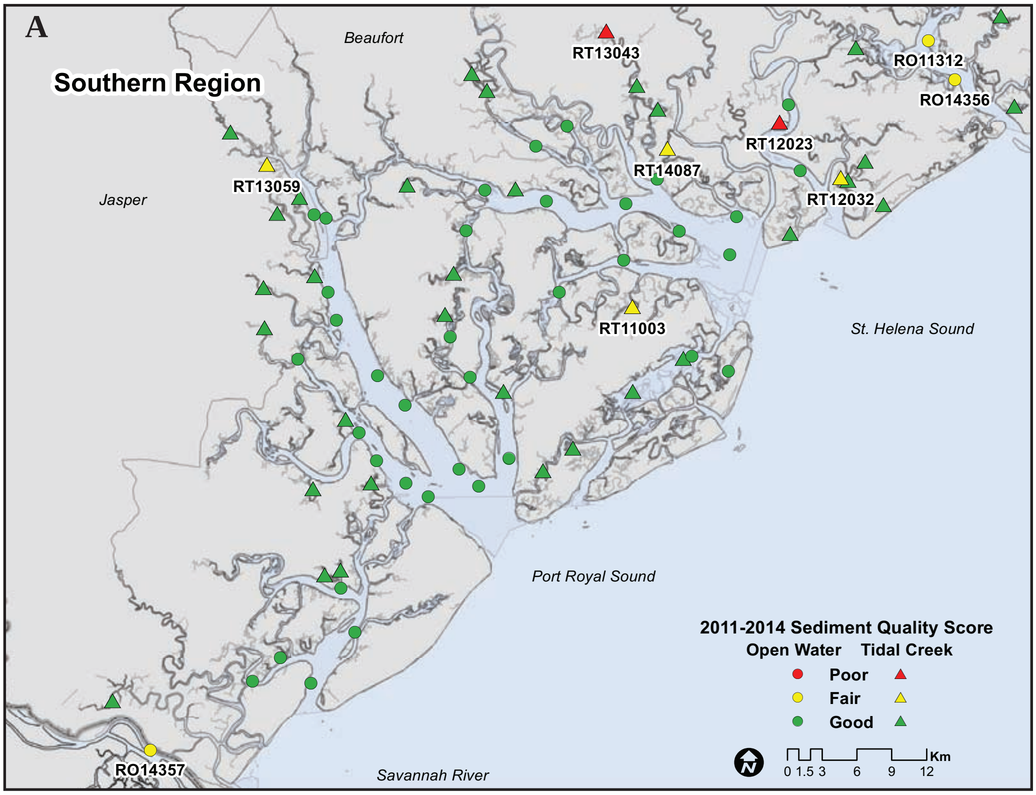


Figure 3.2.5. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2011-2014 (A) and 1999-2014 (B) periods for the central region of South Carolina.



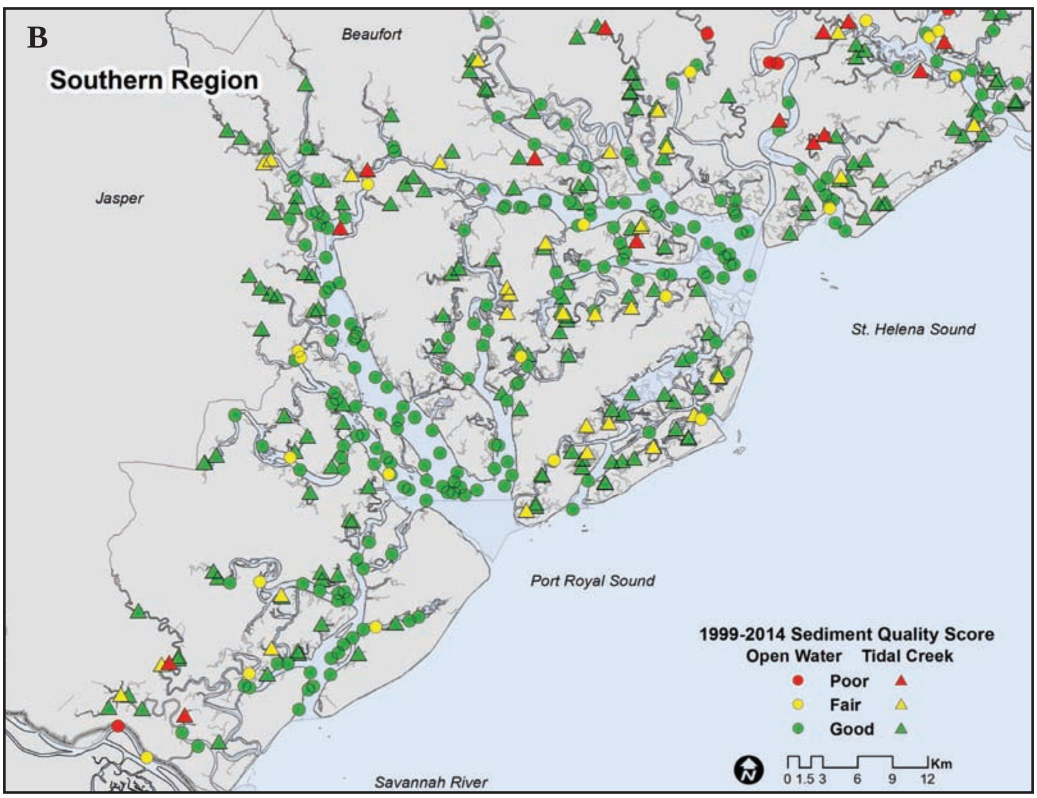


Figure 3.2.6. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2011-2014 (A) and 1999-2014 (B) periods for the southern region of South Carolina.

Stations which contained poor sediment quality in the 2011-2014 surveys included one open water and three tidal creek sites (Figures 3.2.4a, 3.2.5a, 3.2.6a; Appendix 3). The open water site was located in the Cooper River (RO11308), an area where poor sediment quality has been observed in previous surveys. The tidal creek sites were located off the ICW near the Santee River (RT12033) and along the South Edisto River in Alligator Creek (RT12023), where poor sediment quality has been observed previously, and along the Chehaw River northwest of Social Hall Creek (RT13043), an area where only good sediment quality was observed during past SCECAP surveys. Stations with fair sediment quality included five open water and eight tidal creek sites (Appendix 3).

When all survey periods are considered collectively, areas with clusters of poor to fair SQI scores were observed in Winyah Bay, Santee River, Cape Romain area, Ashley and Cooper Rivers, Edisto River, Whale Branch River, New River, and Savannah River (Figures 3.2.4b, 3.2.5b, 3.2.6b).

3.3. Biological Condition

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 serving 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). While most of the benthic community measures shown in Table 3.3.1 do not explicitly identify degraded conditions, they do allow the comparison of community characteristics among habitats and through time. 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 with the more traditional indices above, open water habitats typically supported significantly 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, relative to each other, vary 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). A comparison between tidal creek and open water habitats support these expected patterns, with the densities and proportions of amphipods and mollusks typically being higher in open water habitats and the proportion of polychaetes being higher in tidal creek habitats (Table 3.3.1). The Benthic Index of Biotic Integrity (B-IBI) provides a convenient, broad index of benthic community condition by combining four measures into a single value. The Biological Condition Index (BCI), which is used to score estuarine habitat in terms of benthic community quality, is based upon the B-IBI.

During the 2011-2012 survey, using the Biological Condition Index, 90% of the state's estuarine habitat scored as good condition, 10% as fair, and 0% as poor (Figure 3.3.1a). This was the first survey period in which no estuarine habitat scored as poor. As in all previous surveys, mean BCI was higher in open water habitats than in tidal creeks (Figure 3.3.3). The relatively lower BCI values often seen in tidal creek habitats likely

Our tidal creeks serve as an early warning sentinel habitat. While the elevated contaminant concentrations in our state's tidal creeks are not great relative to known bioeffects levels, continued degradation of these habitats is likely to occur with increasing coastal development.

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.

		Year															
Measure	Habitat	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sediment Quality Index	Open	4.44	4.36	4.17	4.14	4.38	4.21	4.40	4.53	4.49	4.58	4.33	4.60	4.71	4.64	4.73	4.47
	Creek	4.37	4.27	3.67	4.17	4.14	4.24	3.95	4.49	3.87	4.36	4.73	4.04	4.76	4.11	4.22	4.82
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
	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
ERM-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
	Creek	0.015	0.014	0.017	0.015	0.018	0.016	0.018	0.013	0.022	0.015	0.011	0.026	0.016	0.020	0.023	0.013
Sediment Bioassays*	Open	0.48	0.67	0.77	0.73	0.53	0.70	0.56	0.24	0.40	0.33	0.27	0.33	0.07	0.33	0.07	0.33
	Creek	0.59	0.67	1.20	0.63	0.70	0.70	0.84	0.40	0.73	0.53	0.27	0.53	0.13	0.40	0.40	0.07
Silt & Clay (%)	Open	22.31	15.15	23.00	20.50	15.43	24.15	17.66	17.93	22.70	18.74	26.79	15.84	16.38	21.53	12.28	29.14
	Creek	31.95	31.82	30.34	30.89	34.30	25.96	37.36	21.03	40.74	23.37	27.64	26.94	15.24	42.03	36.79	21.32
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	2.84	1.96	1.99	2.46	2.03	2.24
	Creek	2.79	3.06	3.46	2.75	4.74	2.17	2.48	2.16	2.04	2.23	2.75	3.25	1.04	3.86	2.21	1.69

*For each station, a sediment bioassay score of 0 indicates that neither assay was positive for toxic sediment; a score of 1 indicates that 1 assay was positive for toxic sediment; and a score of 2 indicates that both assays were positive for toxic sediment.

reflects the more stressful conditions of shallow tidal creek systems compared to tidal rivers and bays.

During the 2013-2014 survey, the percentage of habitat scoring as good for the BCI was the lowest observed since SCECAP began in 1999, with 69% of the state's estuarine habitat coding as good condition, 27% coding as fair, and 4% coding as poor (Figure 3.3.1b; Figure 3.3.2). In contrast to all previous surveys, a lower percentage of open water habitat scored as good (67%) compared to tidal creek habitat (80%) (Appendix 2), and the mean BCI was slightly lower for open water compared to tidal creek habitat (Figure 3.3.3). In 2014, the lowest BCI for open water stations on record (3.07), and the highest BCI for tidal creek stations on record (3.97) were observed, a reversal of the typical pattern (Table 3.3.1). In general, BCI decreases with increasing total organic carbon (TOC) in sediment, and the mean sediment percent TOC for open water sites in 2014 was the highest observed for open water sites during the course of the study, whereas the 2014 tidal creek sediment percent TOC was unusually low for tidal creek sites (Table 3.2.1). Because the calculation of percent estuarine habitat involves a weighted average of tidal creek (17%) and open water (83%) data, survey years in which open water habitat sites have relatively low BCI values will have lower overall percent good BCI scores.

The distribution of stations with good, fair, or poor BCI scores during the 2011-2014 period is shown in Figures 3.3.4a, 3.3.5a, 3.3.6a, and in Appendix 3. Only three stations scored as poor for the BCI: one station was located in Charleston County's Church Creek, 0.5 miles northwest of the SC 700 bridge (RT13044); the second station was located in Colleton County's Old Chehaw River, upriver of New Chehaw River (RT13055); and the third station was located in Georgetown County's Waccamaw River, in front of Arcadia Plantation (RO14359). Poor to fair BCI values have been associated with the Waccamaw and Old Chehaw Rivers during past surveys. However, tidal creek sites in Church Creek scored as good on the BCI during previous surveys, indicating a recent decline. Fair BCI scores were observed at twenty-four stations throughout the state. Historically, poor to fair BCI scores have been observed in Winyah Bay, other parts of Charleston Harbor, North Edisto River and some of the more inland creeks that drain into St. Helena Sound and Port Royal Sound (Figures 3.3.4b, 3.3.5b, 3.3.6b).

Fish and Large Invertebrate Communities

South Carolina's estuaries provide food, habitat, and nursery grounds for diverse communities of 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 losses 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; Figure 3.3.7). This likely reflects the importance of shallower creek habitats as refuge and nursery habitat for many of these species. Densities of all fauna combined in both tidal creek and open water habitats were consistently relatively high from 1999-2006, followed by a steep decline in 2007-2008, a continuation of low densities in 2009, and a recovery to somewhat higher densities in 2010-2012. In 2013-2014, fish densities declined somewhat while shrimp densities remained relatively high in tidal creek habitats, and in open water habitats the combined density of fish and large invertebrates remained stable although relatively low in comparison to the 1999-2006 period. In general, patterns of changes in density were similar in both estuarine habitat types over time (Table 3.3.2; Figure 3.3.7).

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 fish spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), silver perch (*Bairdiella chrysoura*), and Atlantic spadefish (*Chaetodipterus faber*), and the crustaceans blue crab (*Callinectes sapidus*), white shrimp (*Litopenaeus setiferus*), and brown shrimp

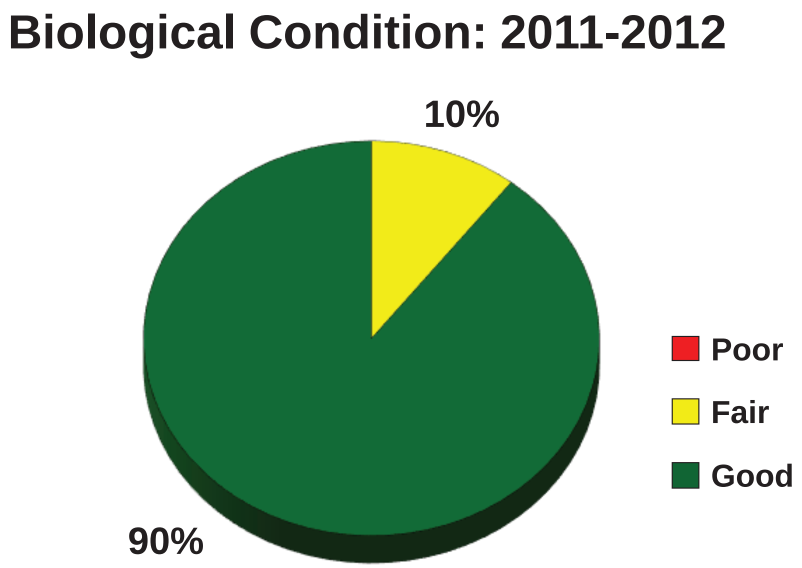


Figure 3.3.1a. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Biological Condition Index. Percentage is based on data obtained from 30 stations for each habitat during 2011 and 2012.

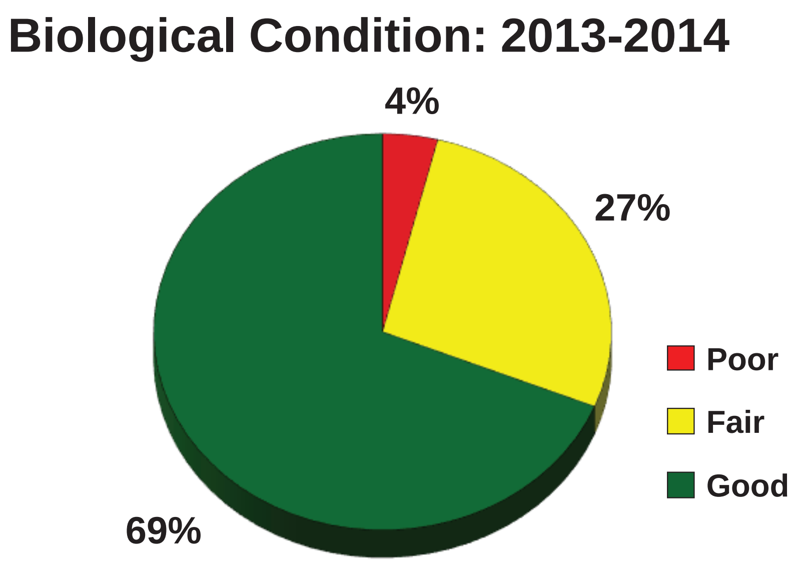


Figure 3.3.1b. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Biological Condition Index. Percentage is based on data obtained from 30 stations for each habitat during 2013 and 2014.

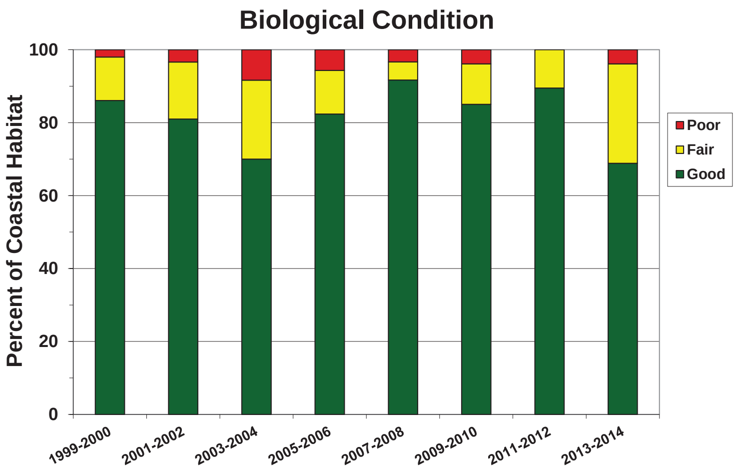


Figure 3.3.2. Biological Condition Index scores observed by survey period for all coastal waters.

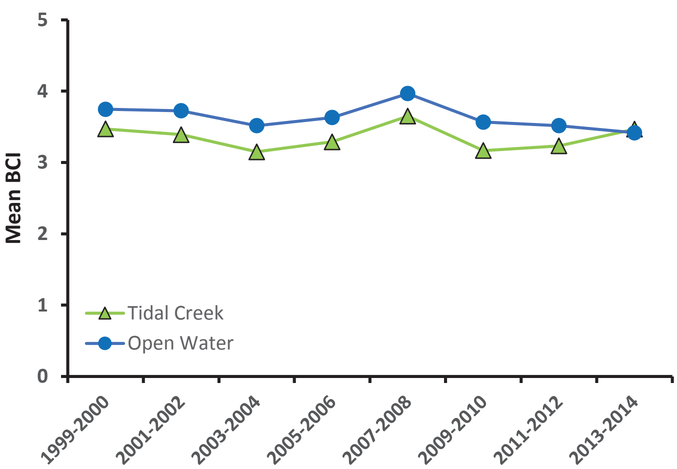


Figure 3.3.3. Biological Condition Index values observed by survey period and habitat type.

(*Farfantepenaeus aztecus*). All of these species, with the exception of weakfish and Atlantic croaker, were generally more abundant in tidal creek habitats (Table 3.3.2). In a recent detailed analysis of spot, Atlantic croaker and weakfish catches, Sanger et al. (2015b) found evidence that Atlantic croaker is remaining constant through time, while both weakfish and spot are decreasing, the former due to decreasing abundances and the latter due to decreasing occurrence. However, in contrast to the overall trend of declining weakfish abundance during the 1999-2014 SCECAP survey period, weakfish abundance in 2014 was higher than in any year since 2004 (Table 3.3.2).

3.4. Incidence of Litter

As the coastline of South Carolina develops 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. Additionally, invasive species can be spread through the movement of litter from one area to another.

During the 2011-2012 survey period, litter was visible in 16% of our state's estuarine habitat. When each habitat type is considered separately, litter was visible in 13% of the state's tidal creek and 17% of the open water habitats. During the 2013-2014 survey period, litter was visible in 13% of our state's estuarine habitat; in 10% of the tidal creek and 13% of the open water habitats. The percentage of estuarine habitat with visible litter has steadily declined since the 2007-2008 survey period, when 35% of estuarine habitat had visible litter, the highest occurrence within the 1999-2014 SCECAP dataset. Litter was observed more frequently in open water than in tidal creek habitats in 2007-2014, a reversal of the pattern seen in 1999-2006.

3.5. Overall Habitat Quality

Using the Habitat Quality Index (HQI) for the 2011-2012 assessment period, 93% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition (Figure 3.5.1a), the highest proportion observed during the 1999-2014 SCECAP project (Figure 3.5.2). Only 1% of the coastal estuarine habitat was considered to be in poor condition and 6% in fair condition. When the two habitats were considered separately, a greater percentage of tidal creek habitat was in fair to poor condition (17% fair, 7% poor) as compared to open water habitats (3% fair, 0% poor) for the 2011-2012 survey (Appendix 2).

Using the HQI for the 2013-2014 assessment period, 82% of South Carolina's coastal estuarine

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
BCI	Open	3.76	3.73	3.55	3.90	3.48	3.55	3.74	3.52	3.93	4.00	3.50	3.63	3.57	3.47	3.77	3.07
	Creek	3.24	3.70	3.38	3.40	3.08	3.22	3.04	3.54	3.37	3.93	3.57	2.77	3.37	3.10	2.97	3.97
Overall Density	Open	5354	6293	4095	7198	4236	4127	5282	4513	6873	8626	2698	3246	4616	2377	5893	2938
(individuals/m^2)	Creek	2363	4659	4710	5001	3198	2863	2282	5060	3008	6395	2843	2133	2222	6328	2267	4563
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	18.8	15.9	14.4	20.0	14.0
	Creek	14.8	19.8	17.5	20.7	14.4	15.8	12.0	22.2	14.1	23.3	15.6	10.6	15.2	14.7	11.0	22.6
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
	Creek	0.72	0.69	0.71	0.70	0.73	0.72	0.75	0.67	0.74	0.72	0.72	0.67	0.76	0.62	0.66	0.75
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	3.16	2.72	2.68	2.70	2.67
	Creek	2.59	2.85	2.78	2.78	2.35	2.65	2.41	2.75	2.64	3.03	2.72	2.05	2.81	2.22	2.07	3.19
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	14.5	14.8	23.3	13.7	11.7
	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
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	15.7	8.7	16.4	12.6	10.4
	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
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
	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
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	61.4	60.9	50.0	62.0	46.6
	Creek	68.8	57.8	69.7	70.9	53.4	70.9	59.4	68.5	59.4	65.0	59.4	74.1	76.3	73.6	62.6	63.6
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	17.8	18.3	24.4	21.5	35.2
	Creek	21.6	24.4	20.0	17.6	31.5	19.7	25.8	16.0	22.4	17.3	27.0	22.3	9.6	17.3	27.1	19.8

habitat was in good condition (Figure 3.5.1b), an amount similar to previous study periods (77-86%) with the exception of 2007-2008 and 2011-2012 (90% and 93%, respectively). During the 2013-2014 survey, only 1% of the state's estuarine habitat was considered to be in poor condition, and 17% in fair condition (Figure 3.5.1b). When the two habitats were considered separately, a greater percentage of tidal creek habitat was in fair to poor condition (20% fair, 3% poor) as compared to open water habitats (17% fair, 0% poor) for the 2013-2014 survey (Appendix 2). This difference between habitat quality in tidal creek and open water habitats observed in both 2011-2012 and 2013-2014 is consistent with previous SCECAP surveys (Figure 3.5.3).

During the 2011-2014 study period, SCECAP stations with fair or poor habitat quality were scattered across the state (Figures 3.5.4a, 3.5.5a, 3.5.6a, Appendix 3). Only three sites had poor HQI scores, all of which were in tidal creek habitats. The poor habitat quality sites were located along the ICW south of the Santee River (RT12033), in Orangegrove Creek along the Ashley River (RT12020), and along the Chehaw River northwest of Social Hall Creek (RT13043). All three of these sites are located in areas where previous surveys have observed fair to poor habitat quality. The ICW and Chehaw River tidal creek sites scored poor for both the WQI and SQI, and fair for the BCI. The Ashley River site scored poor for the WQI, and fair for the SQI and BCI. Seventeen stations with fair habitat quality were observed during the 2011-2014 period. Most of the fair-scoring stations were located in areas noted in previous surveys to have fair to poor habitat quality, with the exception of Hazzard Creek in Jasper County (RT14082) which had not previously been sampled, and Church Creek in Charleston County (RT13044) which had scored as having good habitat quality in past surveys. Hazzard Creek had a poor WQI score, and Church Creek had a fair SQI score and a poor BCI score (Appendix 3).

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

Stations in Winyah Bay, the Santee delta region, the rivers draining into Charleston Harbor, and North Edisto near Dawhoo Creek historically show a persistent pattern of degraded habitat quality (Figures 3.5.4b, 3.5.5b, 3.5.6b). Winyah Bay and Charleston Harbor both 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 areas draining into St. Helena Sound, home to the Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve (NERR), 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. During the past four years, SCECAP data have been used to provide Charleston Harbor baseline information to the U.S. Army Corps of Engineers including data related to sediment composition, distribution of sediment contaminants, benthic community, and near-bottom fish and crustacean community; these data were used for the Charleston Harbor Deepening Feasibility Study. SCDNR staff mined the SCECAP database for updated fishery independent information regarding the status of various crustacean species as part of the Division's annual assessment of stocks. SCECAP benthic data have also been used for a significant

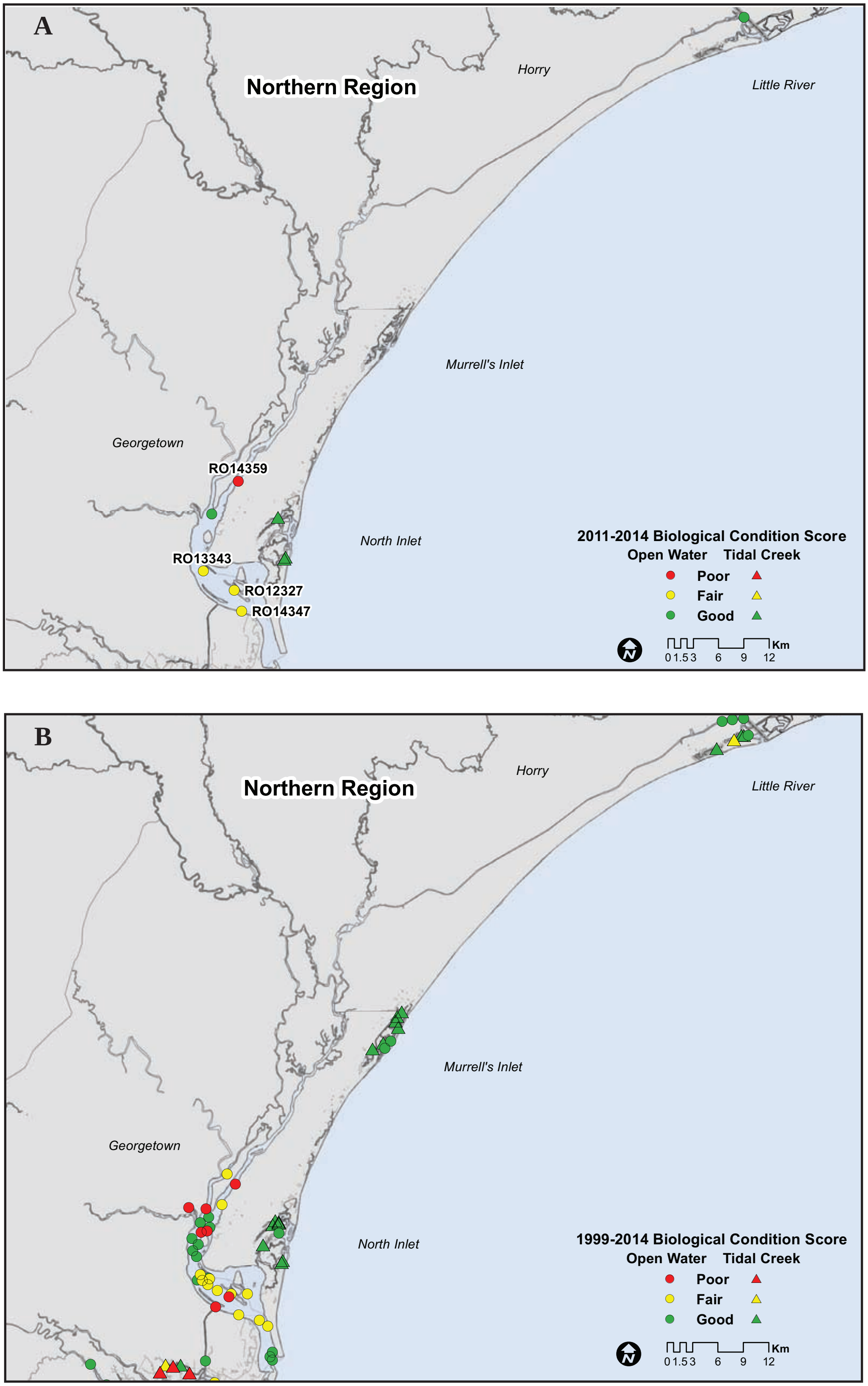
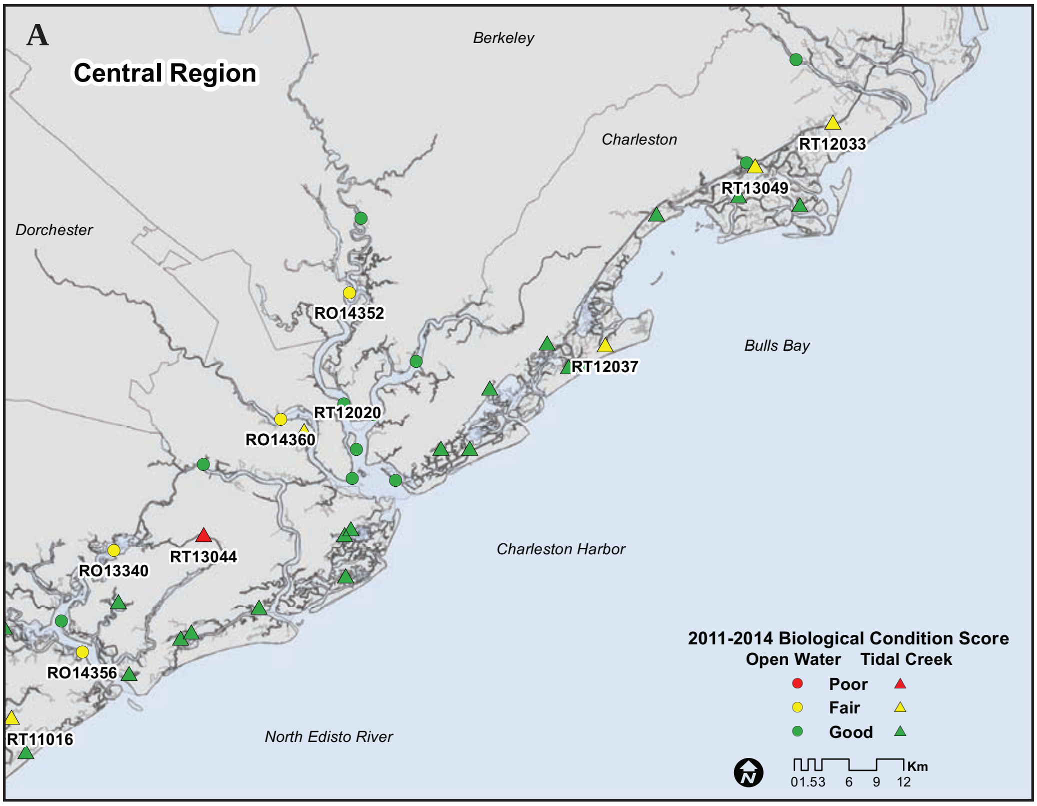


Figure 3.3.4. Distribution of stations with good, fair or poor scores for the Biological Condition Index during the 2011-2014 (A) and 1999-2014 (B) periods for the northern region of South Carolina.



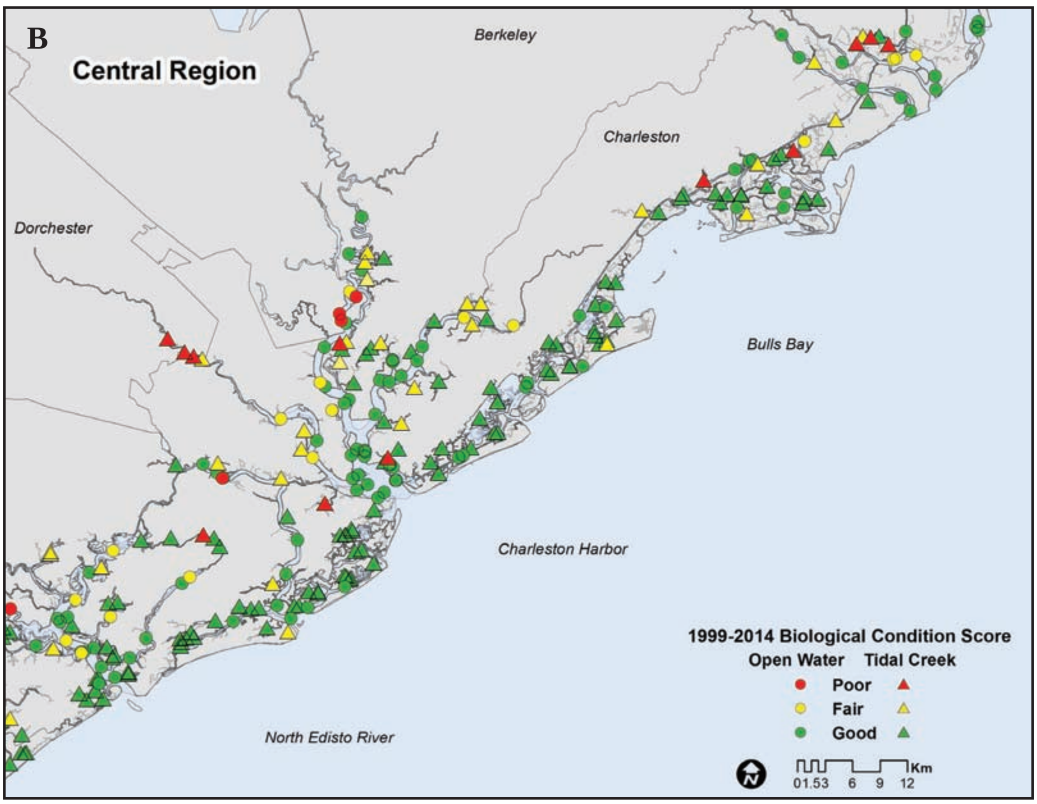
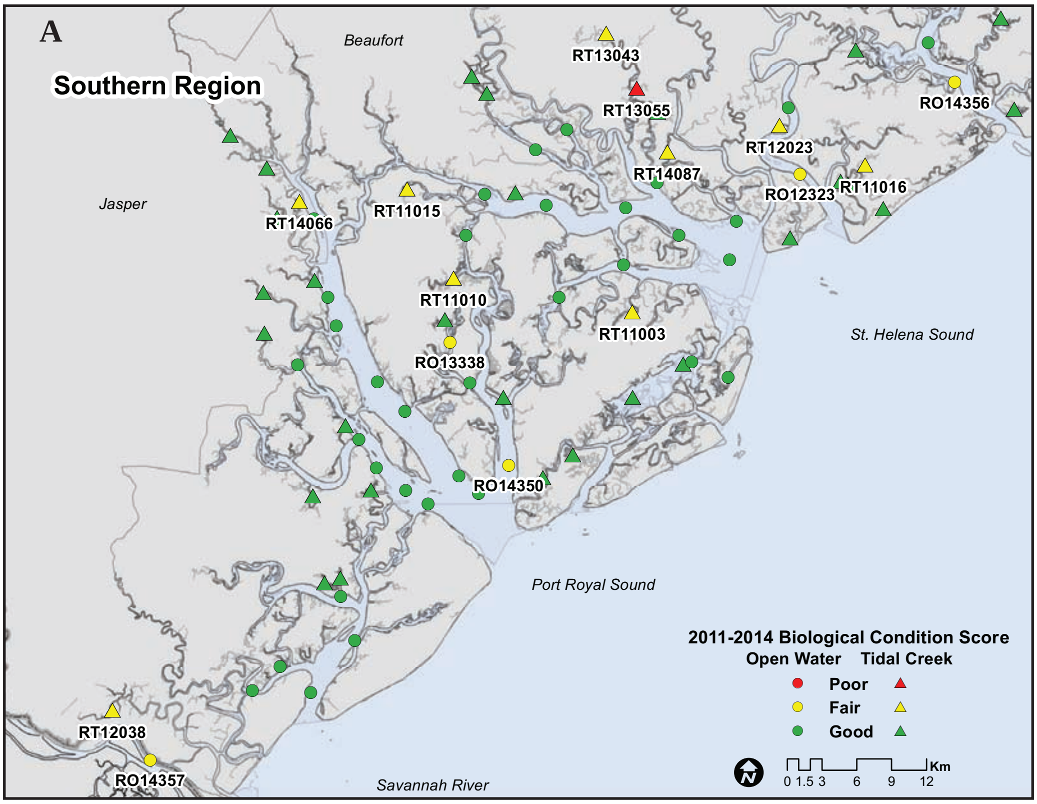


Figure 3.3.5. Distribution of stations with good, fair or poor scores for the Biological Condition Index during the 2011-2014 (A) and 1999-2014 (B) periods for the central region of South Carolina.



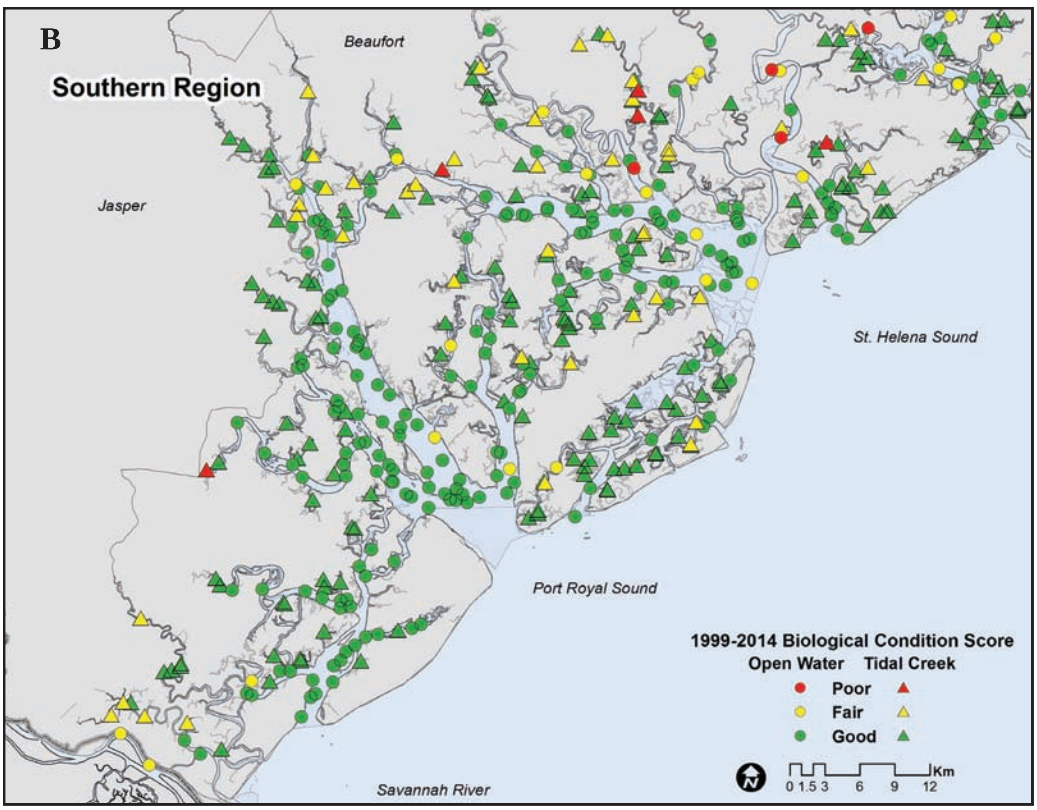


Figure 3.3.6. Distribution of stations with good, fair or poor scores for the Biological Condition Index during the 2011-2014 (A) and 1999-2014 (B) periods for the southern region of South Carolina.

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. All Density and No. Species measures represent mean values, 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
Overall Density: Mean	Open	317	324	376	557	325	453	381	442	281	108	91	247	325	177	155	182
	Creek	800	853	698	1100	760	1321	738	1611	296	295	329	818	387	804	658	528
Overall Density: Median	Open	141	216	174	326	196	197	232	170	123	33	43	112	199	112	58	91
	Creek	536	406	399	560	467	503	500	384	196	116	123	377	384	536	333	167
No. Species	Open	7.5	7.5	7.7	9.2	7.2	8.3	8.2	7.7	8.4	5.3	4.7	7.6	8.5	5.8	5.9	4.9
	Creek	8.3	9.6	8.2	9.2	8.5	9.5	9.3	8.1	7.1	6.1	6.3	8.9	8.4	9.5	7.7	7.2
Fish Density	Open	195	198	196	297	178	218	196	217	154	86	37	99	178	73	85	100
	Creek	302	373	319	264	299	331	308	171	99	196	98	168	184	282	112	157
No. Fish Species	Open	5.1	5.0	5.5	6.5	5.4	5.9	5.7	5.7	6.1	3.9	3.5	4.8	6.3	3.8	4.3	3.4
	Creek	5.6	6.6	5.7	6.5	6.0	6.4	6.4	5.8	4.9	4.0	4.5	5.8	5.7	6.7	5.3	5.5
Decapod Density	Open	86	97	166	248	137	211	166	212	111	14	53	138	138	99	64	81
	Creek	459	425	346	762	429	945	385	1417	182	74	207	633	187	510	539	354
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
	Creek	2.0	2.2	1.8	1.9	2.0	2.4	2.4	1.7	1.8	1.5	1.1	2.4	2.0	2.3	2.0	1.1
Spot Density	Open	6.4	18.2	64.8	26.8	23.2	50.2	56.8	29.1	11.8	19.8	1.0	10.6	52.4	2.4	7.2	4.3
	Creek	69.8	131.0	111.5	37.9	71.0	95.1	146.5	23.6	13.0	44.0	29.0	38.2	32.4	57.6	16.1	51.2
Croaker Density	Open	3.0	48.3	35.8	111.9	71.0	24.6	26.8	26.5	51.0	4.3	4.6	11.1	31.4	13.8	11.1	23.9
	Creek	8.3	7.5	15.7	17.4	12.5	6.3	5.5	1.4	14.0	1.0	10.6	25.1	2.9	9.8	19.8	9.2
Weakfish Density	Open	11.1	23.7	22.4	41.5	2.9	52.3	10.7	13.8	10.9	9.9	1.9	8.2	9.4	4.3	3.1	20.3
	Creek	13.7	6.0	3.8	11.8	3.2	3.5	7.9	2.3	7.8	3.9	3.9	1.4	1.9	5.8	4.8	2.4
Blue Crab Density	Open	1.5	8.3	1.1	1.1	2.5	3.4	3.5	5.7	0.5	0.0	0.5	1.4	3.4	1.0	1.2	2.4
	Creek	4.0	22.4	5.2	5.3	10.5	18.4	20.6	8.5	9.8	3.4	0.5	13.5	4.8	123.1	10.1	1.4
Brown Shrimp Density	Open	8.0	41.8	104.3	69.0	51.3	34.1	45.7	34.3	62.7	8.5	9.9	46.9	22.7	24.9	15.7	69.3
	Creek	122.4	68.6	97.1	130.9	66.8	128.3	150.1	40.7	26.6	37.2	13.0	96.6	34.8	40.0	23.2	9.7
White Shrimp Density	Open	74.6	41.8	54.0	165.7	78.1	172.7	110.9	170.2	42.7	5.6	42.0	88.2	110.1	68.8	46.1	8.6
	Creek	326.1	323.5	238.1	610.3	347.5	792.3	208.3	1364.1	142.6	25.1	192.8	507.7	141.1	342.3	502.3	341.5

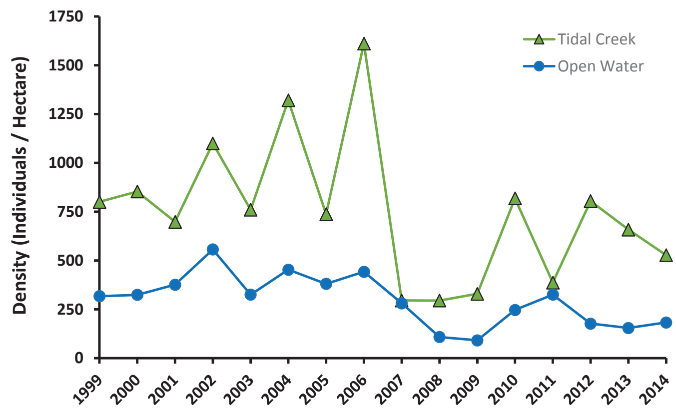


Figure 3.3.7. Mean overall density of fish and large invertebrates observed by year and habitat type.

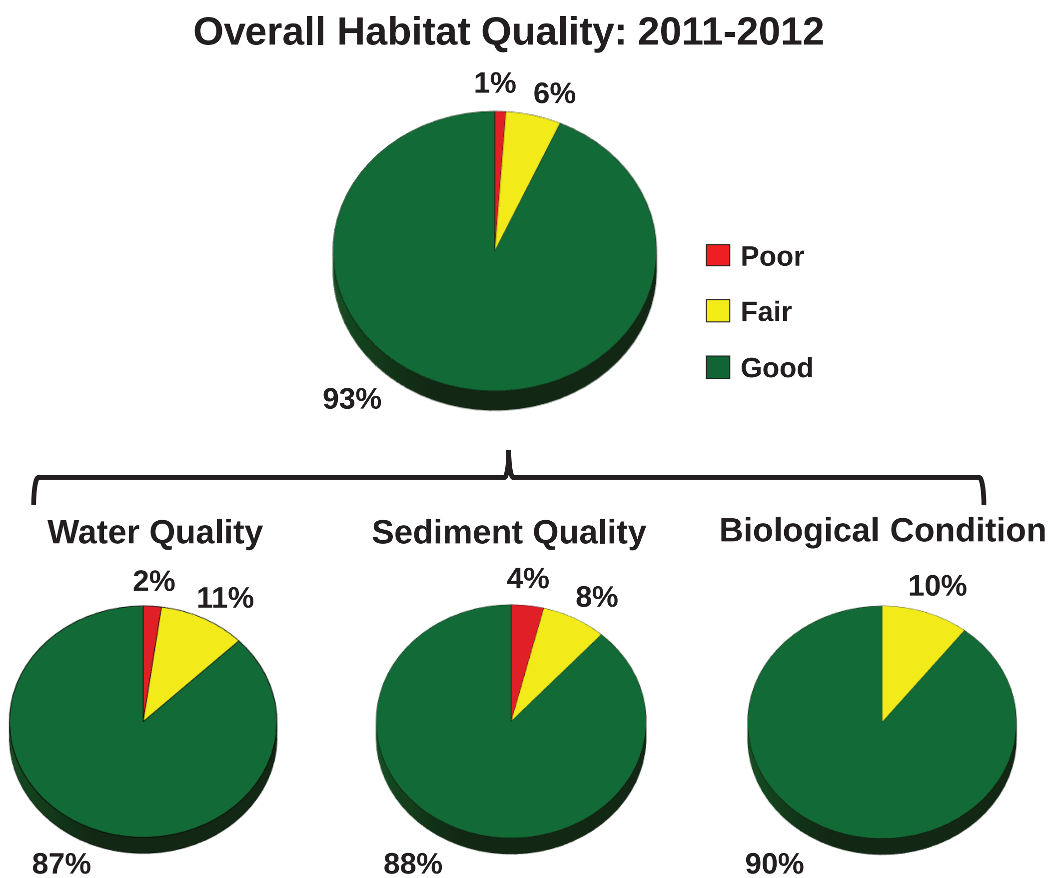


Figure 3.5.1a. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Habitat Quality Index and the component indices that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2011 and 2012.

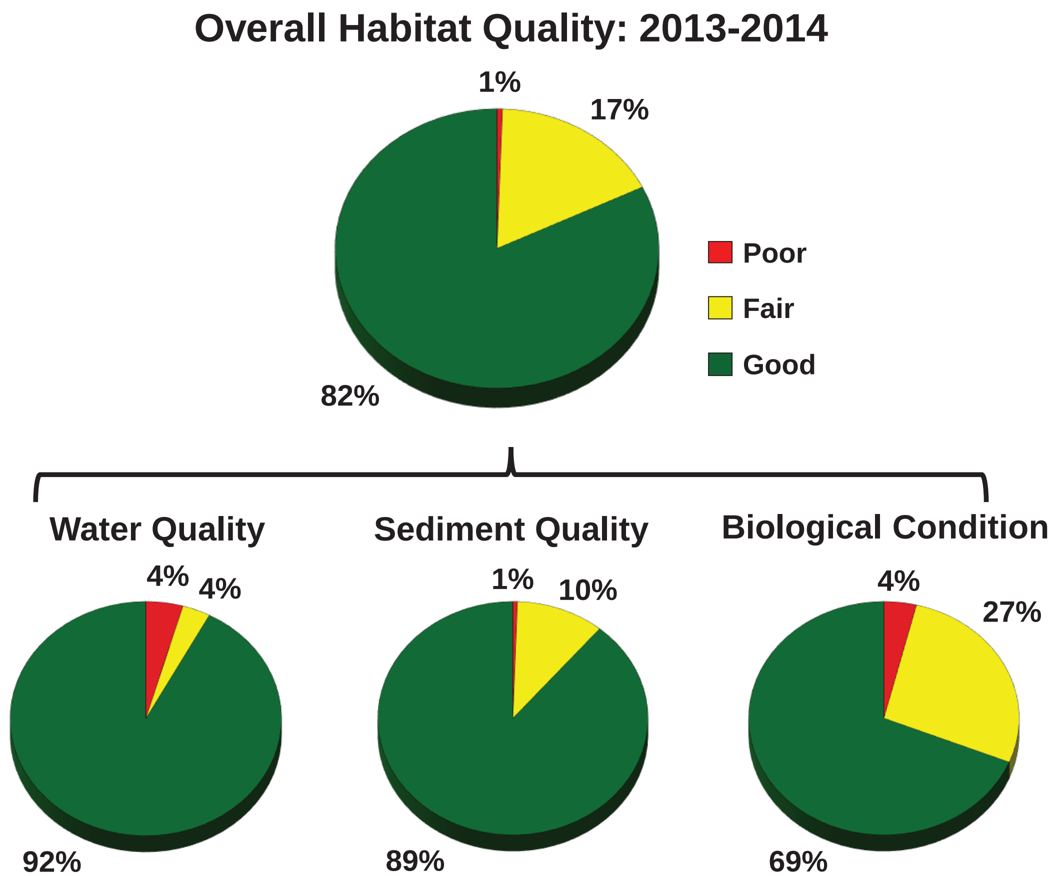


Figure 3.5.1b. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Habitat Quality Index and the component indices that comprise the index. Percentage is based on data obtained from 30 stations for each habitat during 2013 and 2014.

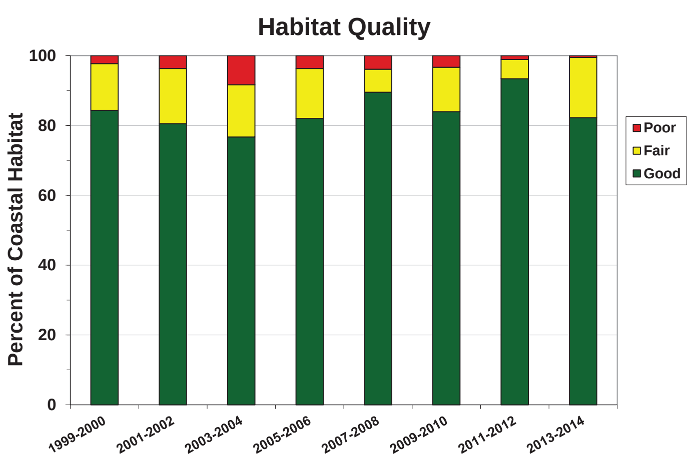


Figure 3.5.2. Habitat Quality Index scores observed by survey period for all coastal waters.

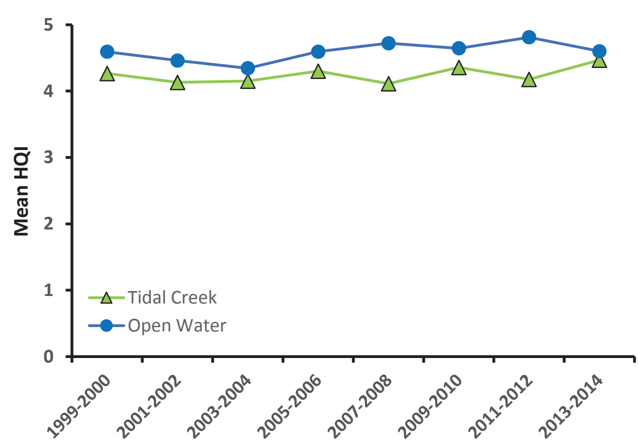
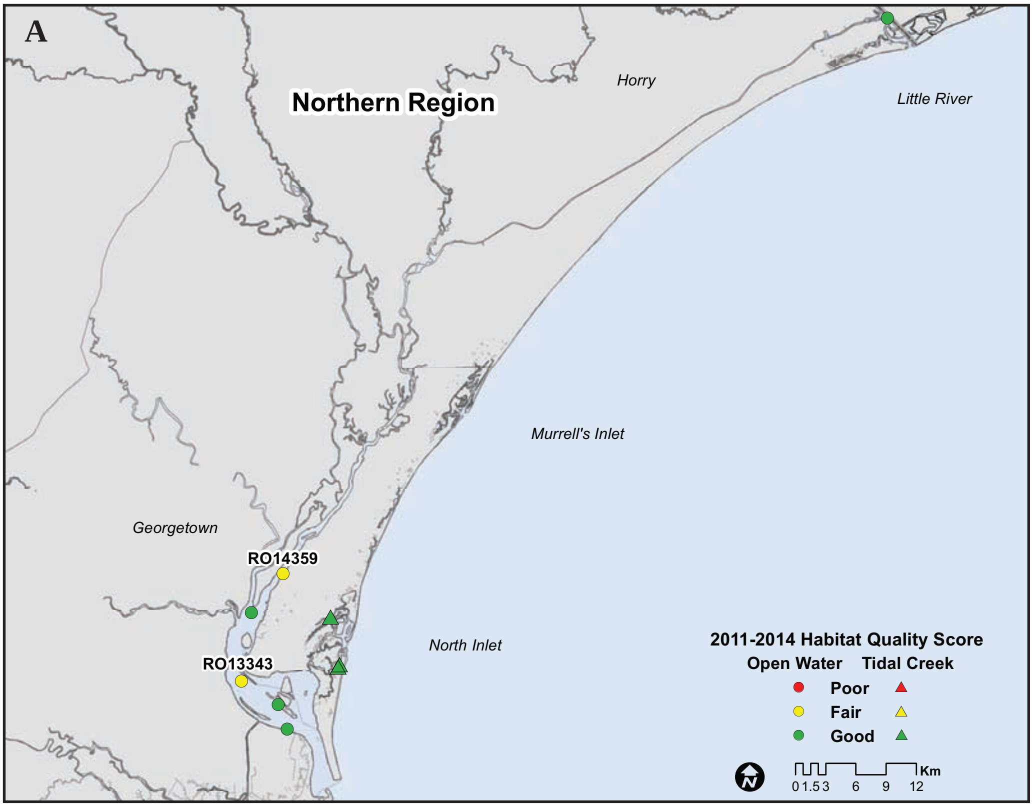


Figure 3.5.3. Habitat Quality Index values observed by survey period and habitat type.

national effort being led by the USEPA to develop a national benthic index. This database provided one of the few detailed empirical databases with species abundance data tied directly to sediment contaminant data, which was critically needed to evaluate pollution sensitivity of various species. Finally, the SCECAP database provides one of the few sources of 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 sites representing tidal creek and open water habitats. These data complement information obtained from other SCDNR programs (e.g., inshore recreational finfish program), 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 and spot abundance data from SCECAP are routinely reported annually in SCDNR Compliance Reports to the Atlantic States Fisheries Management Council (ASFMC).

In previous reports, relationships were observed between coastal rainfall and the percentage of good habitat quality for several of the indices. However, incorporating data from the 2011-2012 and 2013-2014 survey periods reduced the strength of the previously observed relationships. Further analysis will continue for the purpose of improving our understanding of the drivers underlying observed trends. In addition, further analysis of SCECAP fish and shrimp abundance data will be conducted in relation to other long-term SCDNR datasets (e.g., Southeast Area Monitoring & Assessment Program (SEAMAP), Crustacean, and Inshore Fisheries).

During the 2011-2012 and 2013-2014 survey periods, primary funding for this program was obtained from the USFWS Sport Fish Restoration Program. The program maintains sampling at a minimum of 30 sites each year to provide for a total of 60 sites (30 tidal creek, 30 open water) for each two year assessment period. This is considered to be the minimal 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.



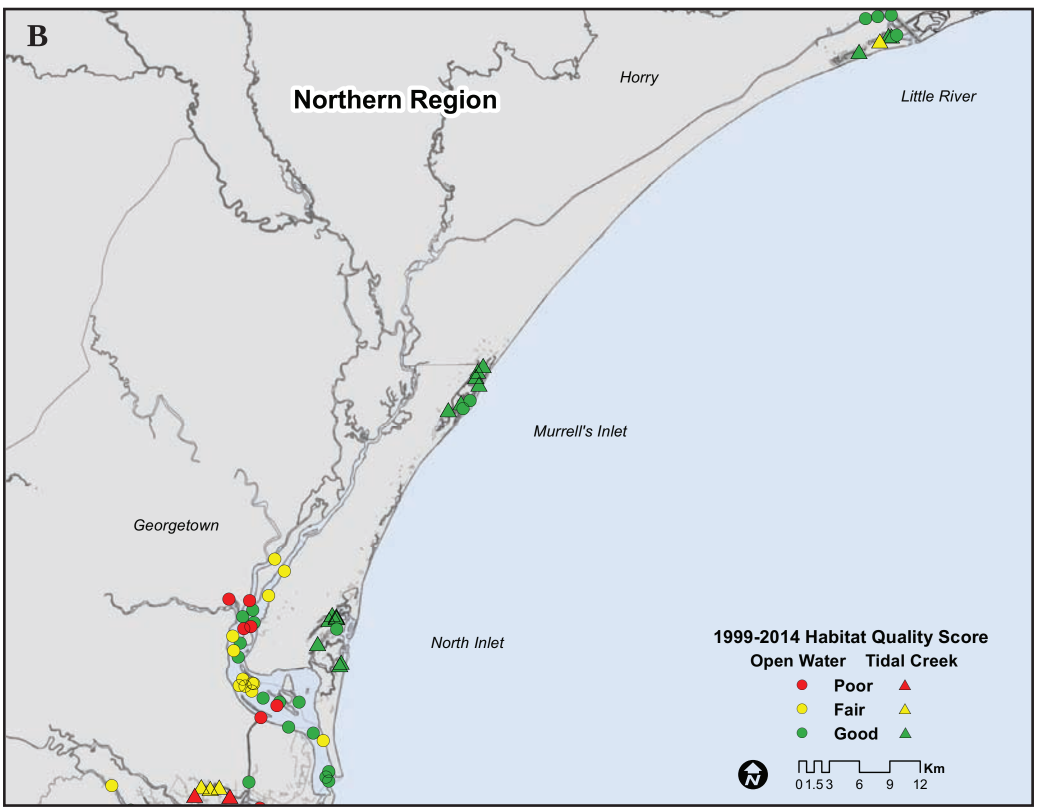
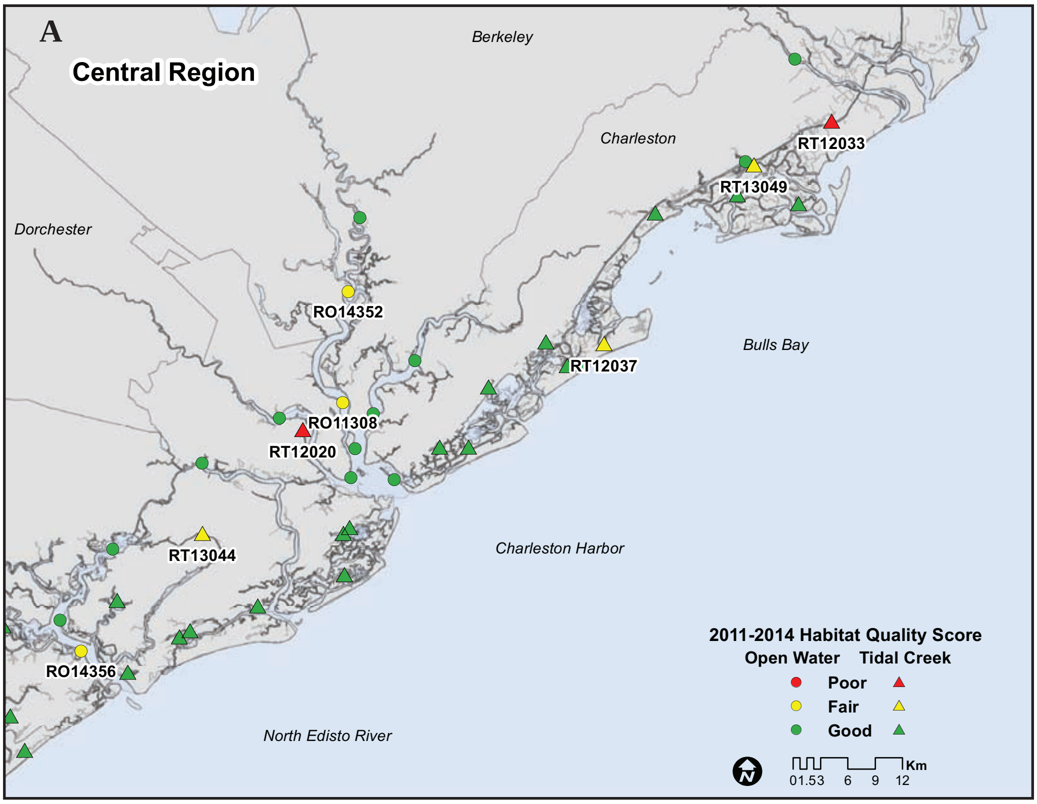


Figure 3.5.4. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2011-2014 (A) and 1999-2014 (B) periods for the northern region of South Carolina.



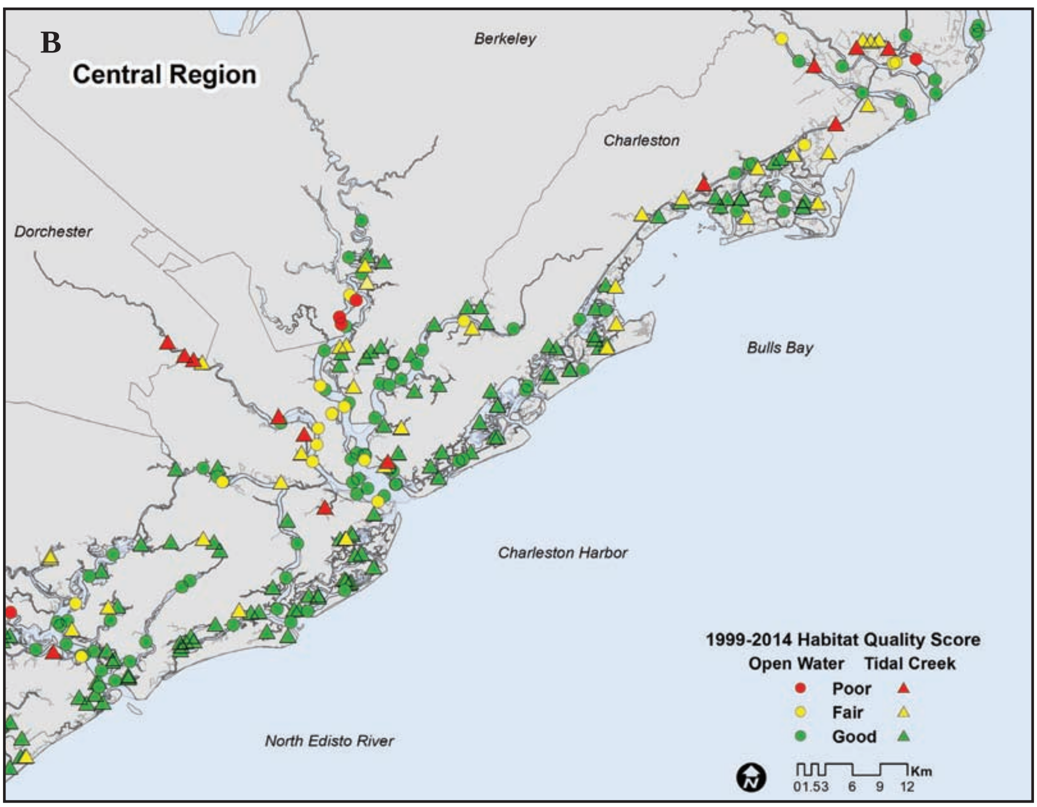


Figure 3.5.5. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2011-2014 (A) and 1999-2014 (B) periods for the central region of South Carolina.

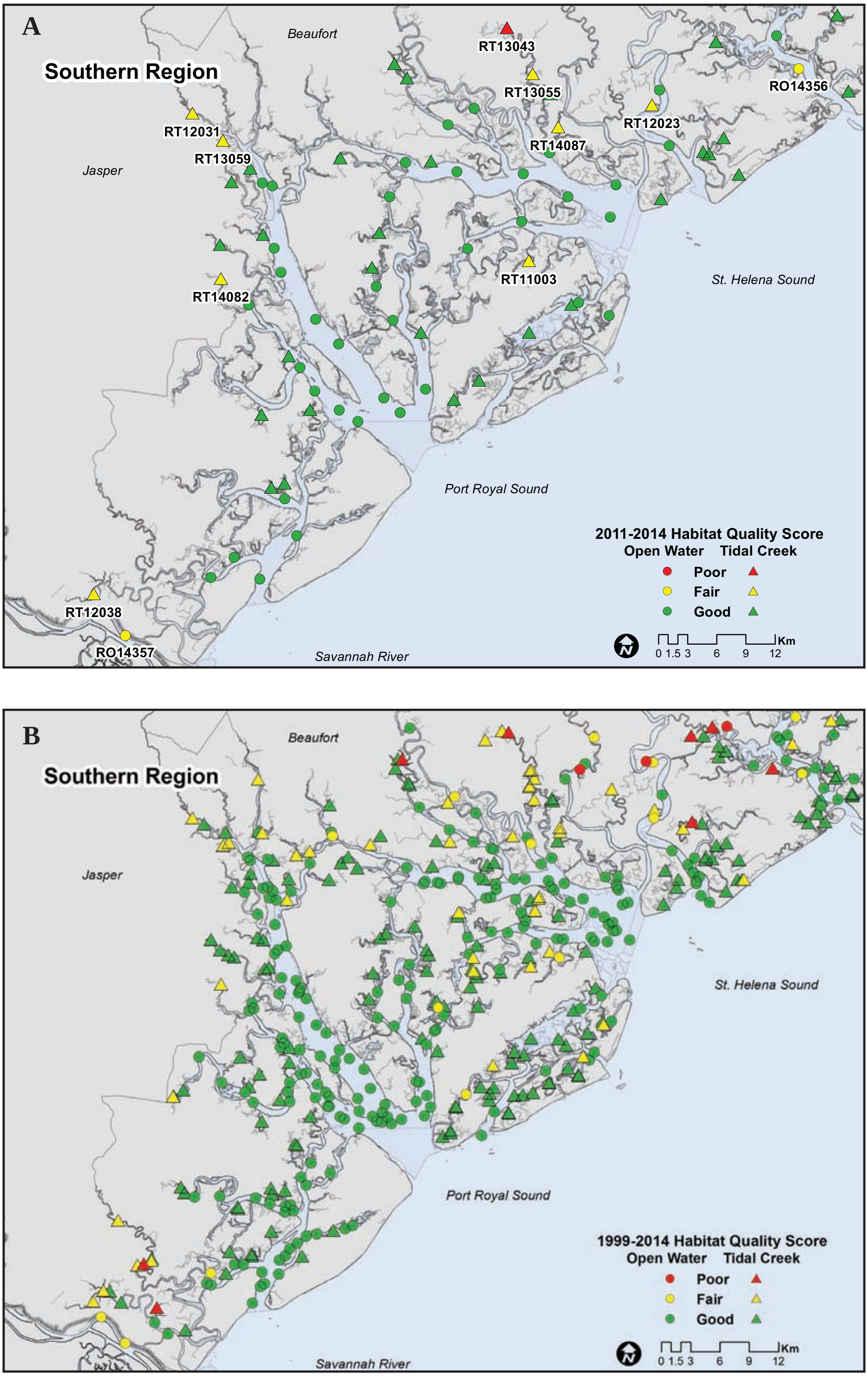


Figure 3.5.6. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2011-2014 (A) and 1999-2014 (B) periods for the southern region of South Carolina.

ACKNOWLEDGEMENTS

The credit for the immense amount of work involved in planning a project of this size, collecting, processing, analyzing the data, 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 Martin Levisen and George Riekerk, who led the SCECAP efforts during the 2011-2014 seasons. Tony Olsen and staff at the USEPA NHEERL, Corvallis, OR assisted in developing the sampling design and CDF routines used during 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 Surface Water Monitoring Section. In addition to the authors, SCDNR field teams included George Riekerk, Dany Burgess, Steve Burns, Michelle Evans, Jordan Felber, Leona Forbes, Brian Hull, Nicole Kozlowski, Marie Moore, Catharine Parker, Mollie Reynolds, and Bree Tomlinson. SCDHEC field staff included David Chestnut, David Graves and Bryan Rabon. Once the diverse array of samples arrived back at the laboratory at the end of a field day, they were distributed to cooperating groups that included the ERS (many named above) which processed benthic community and sediment samples; the NOAA CCEHBR laboratory (Brian Shaddrix, Lynn Thorsell, Brian Thompson, and Katy Chung) which processed sediment chemistry and toxicology assays; the SCDNR Algal Ecology Lab (Dianne Greenfield, Krista DeMattio, Jared Ragland, Sarah Williams, Chuck Keppler, and Lara Brock) which processed the algal samples; and Justin Lewandowski in the SCDHEC Aquatic Biology Section who processed the chlorophyll *a* samples. Staff at the SCDHEC Bureau of Environmental Services, Analytical and Radiological Environmental Services Division who processed the nutrient and fecal samples included Roger Brewer (Central Lab), Sharon Gilbert (Region 7 ECQ Trident Lab), Penny Cornett (Region 8 EQC Low Country Lab), and Leigh Plummer (Region 8 EQC Pee Dee Lab). Jessica L. Elmore with SCDNR Graphics generated the layout of this report.

Funding for many long-term monitoring projects comes from a variety of sources, and this project is no exception. Funding for the 2011-2012 and 2013-2014 survey periods was provided by SCDNR, SCDHEC, and a USFWS Sport Fish Restoration Program grant.

Finally, we wish to thank several individuals who provided technical peer-review of this document. Robert Van Dolah, Jaclyn Daly-Fuchs, and Wallace Jenkins provided valuable comments that improved the quality of this report.

LITERATURE CITED

Balthis, L., J. Hyland, C. Cooksey, E. Wirth, M. Fulton, J. Moore, and D. Hurley. 2012. Support for Integrated Ecosystem Assessments of NOAA's National Estuarine Research Reserve System (NERRS): Assessment of Ecological Condition and Stressor Impacts in Subtidal Waters of the Sapelo Island National Estuarine Research Reserve. NOAA Technical Memorandum NOS NCCOS 150. NOAA Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. 79 pp.

Bergquist, D.C., R.F. Van Dolah, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, L. Brock, D.I. Greenfield, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth, and J. Harvey. 2009. The Condition of South Carolina's Estuarine and Coastal Habitats During 2005-2006: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 106. 60 pp.

Bergquist, D.C., R.F. Van Dolah, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, D.E. Chestnut, W. McDermott, M.H. Fulton, and E. Wirth. 2011. The Condition of South Carolina's Estuarine and Coastal Habitats During 2007-2008: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 106. 64 pp.

Carlton, J., J.S. Brown, J.K Summers, V.D. Engle, and P.E. Bourgeois. 1998. Alabama Monitoring & Assessment Program – Coastal. ALAMAP – Coastal. A Report on the Condition of the Estuaries of Alabama in 1993-1995. A Program in Progress. Alabama Department of Environmental Management, Field Operations Division, Mobile Field Office, Mobile, AL. 20 pp.

Chen, S., Torres, R., Bizimis, M., Wirth, E.F. 2012. Salt marsh sediment and metal fluxes in response to rainfall. Limnology and Oceanography: Fluids and Environments. 2: 54–66.

Chesapeake Bay Foundation. 2007. 2007 State of the Bay. Philip Merril Environmental Center, Annapolis, MD. 11 pp.

Diaz-Ramos, S., D.L. Stevens, Jr., and A.R. Olsen. 1996. EMAP statistical methods manual, EPA/620/R-96/002. U.S. Environmental Protection Agency, Office of Research and Development, Office of Research and Development, NHEERL Western Ecology Division, Corvallis, OR. 13 pp.

Holland, A.F., D.M. Sanger, C.P. Gawle, S.B. Lerberg, M.S. Santiago, G.H.M. Riekerk, L.E. Zimmerman, and G.I. Scott. 2004. Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds. Journal of Experimental Marine Biology and Ecology 298: 151-178.

Hyland, J.L., R.F. Van Dolah, and T.R. Snoots. 1999. Predicting stress in benthic communities of southeastern U.S. estuaries in relation to chemical contamination of sediments. Environmental Toxicology and Chemistry 18(11): 2557-2564.

Hyland, J.L., W.L. Balthis, V.D. Engle, E.R. Long, J.F. Paul, J.K. Summers, R.F. Van Dolah. 2003. Incidence of stress in benthic communities along the US Atlantic and Gulf of Mexico coasts within different ranges of sediment contamination from chemical mixtures. Environmental Monitoring and Assessment 81: 149-161.

Hyland, J., L. Balthis, I. Karakassis, P. Magni, A. Petrov, J. Shine, O. Vestergaard, and R. Warick. 2005. Organic carbon content of sediments as an indicator of stress in marine benthos. Marine Ecology Progress Series 285: 91-103.

Joseph, E.B. 1973. Analysis of a nursery ground. In Pacheco, A.L. (ed) Proceedings of a Workshop on Egg, Larval, and Juvenile Stages of Fish in Atlantic Coast Estuaries. pp 118-121.

Krebs, C.J. 1972. The experimental analysis of distribution and abundance. Ecology. New York: Harper and Row.

Kucklick, J.R., S. Sivertsen, M. Sanders, and G. Scott. 1997. Factors influencing polycyclic aromatic hydrocarbon concentrations and patterns in South Carolina sediments. Journal of Experimental Marine Biology and Ecology 213: 13-29.

Lerberg, S.B., A.F. Holland, and D.M. Sanger. 2000. Responses of tidal creek macrobenthic communities to the effects of watershed development. Estuaries 23: 838-853.

Little, C. 2000. The biology of soft shores and estuaries. In: Crawley, M.J., C. Little, T.R.E. Southwood, and S. Ulfstrand (eds) Biology of Habitats, series, Oxford University Press, USA. 264 pp.

Long, E.R., and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the United Status and trends Program. NOAA Technical Memorandum NOA OMA52. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. 235 pp.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine estuarine sediments. Environmental Management 19: 81-97.

Long, E.R., G.I. Scott, J. Kucklick, M. Fulton, B. Thompson, R.S. Carr, K.J. Scott, G.B. Thursby, G.T. Chandler, J.W. Anderson, and G.M. Sloane. 1997. Final Report. Magnitude and extent of sediment toxicity in selected estuaries of South Carolina and Georgia. NOAA Technical Memorandum NOS ORCA: Technical Summary Report 57. 178 pp.

Mann, K.H. 1982. Ecology of coastal waters. University of California press, Los Angeles, CA. 322 pp.

Microbics Corporation. 1992. Microtox® Manual. Vol. 1. 1992 edition. Carlsbad, CA.

Nelson, D.M., E.A. Irlandi, L.R. Settle, M.E. Monaco, and L. Coston-Clements. 1991. Distribution and abundance of fishes and invertebrates in Southeast estuaries. ELMR Rep. No. 9. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 167 pp.

Partridge, V. 2007. Condition of Coastal Waters of Washington State, 2000-2003: A Statistical Summary. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-051. Available online at: www.ecy.wa.gov/biblio/0703051.html.

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analyses of sediment and water samples. Tech. Rept. EPA ICE-81-1 prepared by Great Lakes Laboratory, State University College at Buffalo, NY, for the U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredge and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ringwood, A.H., M.E. DeLorenzo, P.E. Ross, and A.F. Holland. 1997. Interpretation of Microtox solid phase toxicity tests: The effects of sediment composition. Environmental Toxicology and Chemistry 16(6): 1135-1140.

Ringwood, A.H., and C.J. Keppler. 1998. Seed clam growth: An alternative sediment bioassay developed during EMAP in the Carolinian Province. Environmental Monitoring and Assessment 511: 247-257.

Sanger, D.M., A.F. Holland, and G.I. Scott. 1999a. Tidal creek and salt marsh sediments in South Carolina Coastal Estuaries. I. Distribution of trace metals. Archives of Environmental Contamination and Toxicology 37: 445-457.

Sanger, D.M., A.F. Holland, and G.I. Scott. 1999b. Tidal creek and salt marsh sediments in South Carolina Coastal estuaries. II. Distribution of organic contaminants. Archives of Environmental Contamination and Toxicology 37: 458-471.

Sanger D., Blair A., DiDonato G., Washburn T., Jones S., Riekerk G., Wirth E., Stewart J., White D., Vandiver L., Holland A.F. 2015a. Impacts of Coastal Development on the Ecology and Human Well-being of Tidal Creek Ecosystems of the US Southeast. Estuaries and Coasts 38:S49-S66.

Sanger, D.M., S.E. Crowe, and S.P. Johnson. 2015b. Fishery-Independent Monitoring of Juvenile Nursery Habitat of Key Recreational Fishery Species: Annual Performance Report: July 2014 to June 2015. Prepared for U.S. Department of the Interior, U.S. Fish and Wildlife Service.

South Carolina Budget and Control Board. 2013. South Carolina Statistical Abstract website. Available online at http://abstract.sc.gov/chapter14.html.

South Carolina Department of Health and Environmental Control. a. Water Classifications and Standards (Regulation 61-68) and Classified Waters (Regulation 61-69) for the State of South Carolina. Office of Environmental Quality Control, Columbia, SC.

South Carolina Department of Health and Environmental Control. b. Procedures and Quality Control Manual for Chemistry Laboratories. Bureau of Environmental Services, Columbia, SC.

South Carolina Department of Health and Environmental Control. c. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Office of Environmental Quality Control, Columbia, SC.

South Carolina Department of Health and Environmental Control. d. Laboratory Procedures Manual for Environmental Microbiology. Bureau of Environmental Services, Columbia, SC.

Southwick Associates. 2012. Sportfishing in America: An Economic Force for Conservation. Produced for the American Sportfishing Association (ASA) under a U.S. Fish and Wildlife Service (USFWS) Sport Fish Restoration grant (F12AP00137, VA M-26-R) awarded by the Association of Fish and Wildlife Agencies (AFWA). Available online at http://asafishing.org/uploads/Sportfishing_in_America_January_2013.pdf.

Stevens, D.L. 1997. Variable density grid-based sampling designs for continuous spatial populations. Envirometrics 8: 167-195.

Stevens, D.L., and A.R. Olsen. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological and Environmental Statistics 4: 415-428.

U.S. Census Bureau. 2014. QuickFacts. Available online at: http://www.census.gov/quickfacts/

U.S. Environmental Protection Agency. 2001. National Coastal Condition Report. EPA620-R-01-005. 204 pp.

U.S. Environmental Protection Agency. 2004. National Coastal Condition Report II. EPA620-R-03-002. 286 pp.

U.S. Environmental Protection Agency. 2006. National Coastal Condition Report. EPA842B-06/001. 445 pp.

U.S. Travel Association. 2014. The Economic Impact of Travel on South Carolina Counties 2013. A Study Prepared for the South Carolina Department of Parks, Recreation & Tourism. Washington, D.C. Available online at https://www.scprt.com/files/Research/SC%20 2013%20TEIM%20Report.pdf.

Van Dolah, R.F., J.L. Hyland, A.F. Holland, J.S. Rosen, and T.R. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern United States. Marine Environmental Research 48: 269-283.

Van Dolah, R.F., D.E. Chestnut and G.I. Scott. 2000. A baseline assessment of environmental and biological conditions in Broad Creek and the Okatee River, Beaufort County, South Carolina. Final Report to Beaufort County Council. 281 pp.

Van Dolah, R.F., P.C. Jutte, G.H.M. Riekerk, Levisen, L.E. Zimmernman, J.D. Jones, A.J.Lewitus, D.E. Chestnut, W. McDermott, Bearden, G.I. Scott, and M.H. Fulton. 2002. The Condition of South Carolina's Estuarine and Coastal Habitats During 1999-2000: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 90. 132 pp.

Van Dolah, R.F., P.C. Jutte, G.H.M. Riekerk, M.V. Levisen, L.E. Zimmernman, J.D. Jones, Lewitus, D.E. Chestnut, W. McDermott, Bearden, G.I. Scott, and M.H. Fulton. 2004. The Condition of South Carolina's Estuarine and Coastal Habitats During 2001-2002: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 100. 70 pp.

Van Dolah, R.F., D.C. Bergquist, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, S.B. Wilde, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth, and J. Harvey. 2006. The Condition of South Carolina's Estuarine and Coastal Habitats During 2003-2004: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 101. 70 pp.

Van Dolah, R.F., D.M. Sanger, G.H.M. Riekerk, S.E. Crowe, M.V. Levisen, D.C. Bergquist, D.E. Chestnut, W. McDermott, M.H. Fulton, and E. Wirth. 2013. The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 107. 48 pp.

Appendix 1. Summary of station locations and dates sampled in 2011 through 2014. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2011
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO11301	Open	33.87485	78.57129	2.1	8/10/2011	Horry	R<1	Little River in Millkin Cove
RO11302	Open	32.27607	80.72633	15.5	8/16/2011	Beaufort	R<1	Chechessee River at Port Royal Sound
RO11303	Open	32.43618	80.60584	2.7	7/27/2011	Beaufort	R<1	Morgan River north of Warsaw Flats
RO11304	Open	32.56641	80.59791	3.4	7/19/2011	Beaufort	NDV	ACE Basin in Williman Creek
RO11305	Open	32.32620	80.78939	14.3	8/17/2011	Beaufort	R>1	Chechessee River in the mouth of the Colleton River
RO11306	Open	32.29769	80.69794	11.0	8/17/2011	Beaufort	R>1	Broad River below Parris Island
RO11307	Open	32.51661	80.67360	1.5	7/19/2011	Beaufort	R<1	Whale Branch River below Chisolm Island
RO11308	Open	32.84475	79.93279	3.4	8/2/2011	Charleston	I<1	Cooper River above Shipyard Creek
RO11309	Open	32.37103	80.77222	11.9	8/17/2011	Beaufort	R>1	Broad River below the Broad River Bridge
RO11310	Open	32.38536	80.48444	3.4	7/27/2011	Beaufort	R>1	Harbor River behind Hunting Island
RO11311	Open	33.17886	79.39763	1.2	8/9/2011	Charleston	NDV	South Santee River Near Hwy 17
RO11312	Open	32.63238	80.26546	3.0	8/3/2011	Charleston	R>1	Wadmalaw Sound below Bears Bluff
RO11313	Open	32.13101	80.88721	8.2	8/16/2011	Beaufort	R<1	Cooper River north of Daufuskie Island
RO11314	Open	32.50540	80.54436	10.7	7/19/2011	Beaufort	R>1	Coosaw River above Morgan Island
RO11315	Open	33.35576	79.26485	3.4	8/9/2011	Georgetown	I>1	Winyah Bay below Waccamaw Point

* 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 2011
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT11001	Creek	33.30800	79.17192	2.1	8/10/2011	Georgetown	R>1	North Inlet in Wood Creek
RT11002	Creek	32.49886	80.86406	1.2	7/20/2011	Jasper	R<1	Broad River in West Branch of Boyd Creek
RT11003	Creek	32.42493	80.53858	1.5	7/27/2011	Beaufort	R<1	Morgan River in Eddings Creek
RT11004	Creek	32.85894	79.76194	1.2	8/9/2011	Charleston	R<1	Copahee Sound in Porcher Bluff Creek
RT11005	Creek	33.35067	79.18039	1.8	8/10/2011	Georgetown	R>1	North Inlet in Crab Haul Creek
RT11006	Creek	32.21875	80.80672	1.2	8/16/2011	Beaufort	R<1	May River in Bass Creek
RT11007	Creek	32.31382	80.59380	3.0	8/17/2011	Beaufort	R>1	Station Creek behind St Phillips Island
RT11009	Creek	33.04576	79.46738	4.0	8/9/2011	Charleston	NDV	Bulls Bay in Little Papas Creek
RT11010	Creek	32.45170	80.70233	1.4	7/20/2011	Beaufort	I<1	Beaufort in Albergotti Creek
RT11011	Creek	32.59499	80.67136	3.7	7/19/2011	Beaufort	NDV	Wimbee Creek near mouth of Branford Creek
RT11012	Creek	32.61494	80.12637	0.9	8/2/2011	Charleston	R>1	Kiawah River in Haulover Creek
RT11013	Creek	32.28716	80.77849	5.2	8/16/2011	Beaufort	R>1	Chechessee River east of Victoria Bluff
RT11015	Creek	32.52103	80.74488	0.9	7/20/2011	Beaufort	R<1	Whale Branch River in McCalleys Creek
RT11016	Creek	32.53820	80.32458	1.2	8/3/2011	Charleston	R<1	ACE Basin in tributary of Fishing Creek
RT11018	Creek	32.45007	80.82975	3.0	7/20/2011	Beaufort	R>1	Broad River in Coles 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.

SCECAP 2012
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO12316	Open	32.77076	79.92419	1.5	7/23/2012	Charleston	R<1	Charleston Harbor near the High Battery
RO12317	Open	32.49754	80.83031	4.6	7/17/2012	Jasper	NDV	Broad River across from the Whale Branch
RO12318	Open	32.16965	80.79361	5.8	7/19/2012	Beaufort	R<1	Calibogue Sound near Broad Creek
RO12319	Open	32.48461	80.69112	4.0	8/14/2012	Beaufort	R<1	Brickyard Creek east of the air station
RO12320	Open	32.58255	80.39455	0.9	8/1/2012	Colleton	R>1	South Edisto River above Alligator Creek
RO12321	Open	32.28640	80.74681	8.5	8/14/2012	Beaufort	R>1	Chechessee River northeast of Mackay Creek
RO12322	Open	32.36974	80.68768	7.0	8/14/2012	Beaufort	I<1	Beaufort River at mouth of Battery Creek
RO12323	Open	32.53098	80.38404	3.0	8/1/2012	Colleton	NDV	South Edisto River above St Pierre Creek
RO12324	Open	33.02762	79.91059	5.5	8/21/2012	Berekely	I<1	Cooper River just below the Tee
RO12325	Open	32.41460	80.81000	1.5	7/17/2012	Beaufort	R>1	Broad River above Hwy 170 bridge
RO12326	Open	32.49484	80.44276	1.8	7/31/2012	Colleton	NDV	St Helena Sound near the mouth of Rock Creek
RO12327	Open	33.27320	79.23777	1.2	8/7/2012	Georgetown	NDV	Winyah Bay across from South ICWW entrance
RO12328	Open	32.78629	80.09807	1.5	7/24/2012	Charleston	R<1	Stono River east of Limehouse Bridge
RO12329	Open	32.12943	80.83398	7.6	7/18/2012	Beaufort	R<1	Calibogue Sound across from Harbour Town
RO12330	Open	32.52493	80.51530	4.6	7/31/2012	Colleton	NDV	Cosaw River at mouth of New Chehaw 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.

SCECAP 2012
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT12020	Creek	32.81889	79.97981	1.5	7/23/2012	Charleston	R<1	Ashley River in Orangegrove Creek
RT12021	Creek	32.90292	79.69398	0.9	8/8/2012	Charleston	R>1	Clauson Creek north of Mark Bay
RT12023	Creek	32.56931	80.40272	1.8	8/1/2012	Colleton	NDV	South Edisto River in Alligator Creek
RT12024	Creek	32.67495	79.93295	2.1	8/21/2012	Charleston	R>1	Folly River east of Oak Island
RT12025	Creek	33.02878	79.56393	1.8	8/8/2012	Charleston	NDV	Tidal Creek off the ICWW across from Awendaw Creek
RT12026	Creek	32.41936	80.71051	3.7	8/14/2012	Beaufort	R<1	Battery Creek in the Burton-Grober Creek
RT12028	Creek	32.65143	80.19876	1.5	7/24/2012	Charleston	R<1	Leadenwah Creek middle branch
RT12029	Creek	32.33718	80.80167	3.0	7/18/2012	Beaufort	R<1	Chechessee River above entrance to Colleton River
RT12031	Creek	32.56295	80.90692	3.0	7/17/2012	Jasper	R<1	Coosawhatchie River 2 miles below Hwy 17
RT12032	Creek	32.52551	80.34692	1.5	8/1/2012	Colleton	R<1	South Edisto River in Big Bay Creek
RT12033	Creek	33.11714	79.35549	1.0	8/7/2012	Charleston	NDV	Tidal creek off ICWW above Alligator Creek
RT12034	Creek	32.44060	80.87666	3.0	7/17/2012	Jasper	R<1	Euhaw Creek near the headwaters
RT12037	Creek	32.90052	79.62600	1.5	8/8/2012	Charleston	NDV	Bull Island in Summerhouse Creek
RT12038	Creek	32.11615	81.01504	2.7	7/18/2012	Jasper	NDV	Wright River near headwaters
RT12039	Creek	32.57994	80.51455	6.1	7/31/2012	Colleton	NDV	New Chehaw River near Big 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 2013
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO13332	Open	32.83359	79.89724	8.5	8/6/2013	Berkeley	I<1	Wando River 0.5 miles north of Hobcaw Creek
RO13333	Open	32.49486	80.81934	3.4	7/16/2013	Beaufort	I>1	Broad River northwest of Whale Branch
RO13334	Open	32.28408	80.67992	1.3	7/24/2013	Beaufort	I>1	Port Royal Sound
RO13335	Open	32.50782	80.61710	3.4	7/16/2013	Beaufort	R>1	Coosaw River northwest of Lucy Point Creek
RO13336	Open	32.88566	79.84782	5.2	8/6/2013	Charleston	R<1	Wando River upriver of Horlbeck Creek
RO13337	Open	32.34791	80.74706	1.0	7/24/2013	Beaufort	R>1	Broad River west of Archers Creek
RO13338	Open	32.40146	80.70585	2.1	7/24/2013	Beaufort	R<1	Battery Creek near West Bank
RO13339	Open	33.07789	79.45743	2.7	7/31/2013	Charleston	R<1	ICW between Five Fathom Creek and Jeremy Creek
RO13340	Open	32.70184	80.20341	4.9	8/13/2013	Charleston	R>1	Wadmalaw River upriver of Oyster House Creek
RO13341	Open	32.38428	80.84552	3.4	7/23/2013	Jasper	R<1	Mouth of Hazzard Creek
RO13342	Open	32.46141	80.54639	6.1	7/17/2013	Beaufort	R<1	Morgan River at mouth of Parrot Creek
RO13343	Open	33.29451	79.27686	4.6	7/30/2013	Georgetown	I>1	Winyah Bay northwest of Malady Bush Island
RO13344	Open	32.76831	79.87369	8.8	8/6/2013	Charleston	I>1	Charleston Harbor near Hog Island Channel
RO13345	Open	32.20422	80.80634	2.1	7/23/2013	Beaufort	R>1	May River near mouth of Bass Creek
RO13346	Open	32.46495	80.44908	10.4	7/17/2013	Beaufort	R>1	Saint Helena Sound at mouth of Coosaw 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.

SCECAP 2013
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT13040	Creek	32.71576	79.93385	1.5	8/6/2013	Charleston	R>1	Clark Sound off Oceanview Road
RT13043	Creek	32.64146	80.56161	1.8	7/17/2013	Colleton	NDV	Chehaw River northwest of Social Hall Creek
RT13044	Creek	32.71715	80.09833	1.8	8/13/2013	Charleston	R<1	Church Creek 0.5 miles northwest of SC 700 Bridge
RT13049	Creek	33.07510	79.44732	2.1	7/31/2013	Charleston	NDV	Clubhouse Creek
RT13051	Creek	32.29635	80.62103	1.8	7/24/2013	Beaufort	NDV	Station Creek northeast of mouth at Port Royal Sound
RT13052	Creek	32.64510	80.03472	5.0	8/7/2013	Charleston	NDV	Tributary northeast of Chaplin Creek
RT13053	Creek	33.03584	79.39581	3.0	7/31/2013	Charleston	NDV	Devil's Den Creek
RT13054	Creek	32.51777	80.64548	3.0	7/16/2013	Beaufort	R>1	Coosaw River 2 miles northeast of Brickyard Creek
RT13055	Creek	32.59875	80.53377	4.9	7/17/2013	Colleton	NDV	Old Chehaw River upriver of New Chehaw River
RT13056	Creek	32.62123	80.11382	2.4	8/7/2013	Charleston	R>1	Abbapoola Creek near confluence of Kiawah River
RT13057	Creek	32.50400	80.30798	1.0	8/14/2013	Charleston	NDV	Scott Creek east of SC 174 Bridge
RT13059	Creek	32.53756	80.87344	2.1	7/16/2013	Jasper	R<1	Coosawhatchie River northwest of Pocotaligo River
RT13060	Creek	32.62732	80.33234	1.8	8/13/2013	Charleston	NDV	Whooping Island Creek east of SC 174 Bridge
RT13061	Creek	32.28271	80.83158	1.8	7/23/2013	Beaufort	R<1	Sawmill Creek near confluence of Colleton River
RT13062	Creek	32.48176	80.39371	0.6	8/14/2013	Colleton	NDV	Otter Creek near 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.

SCECAP 2014
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO14347	Open	33.25090	79.22874	3.7	7/22/2014	Georgetown	I>1	Winyah Bay
RO14348	Open	32.79925	79.91892	5.2	7/15/2014	Charleston	I<1	Cooper River south of US 17 Bridge
RO14349	Open	32.43698	80.81750	5.5	8/6/2014	Beaufort	R>1	Broad River south of Boyd Creek
RO14350	Open	32.30572	80.65211	8.5	7/30/2014	Beaufort	R<1	Beaufort River southeast of Ballast Creek
RO14351	Open	32.55114	80.62655	2.1	7/29/2014	Beaufort	NDV	Wimbee Creek northwest of South Wimbee Creek
RO14352	Open	32.95447	79.92518	10.7	7/15/2014	Berkeley	I>1	Cooper River 1 mile south of Back River
RO14353	Open	32.30412	80.77348	4.9	8/6/2014	Beaufort	R>1	Chechessee River 2 miles northwest of Mackay Creek
RO14354	Open	32.37339	80.45091	2.7	7/29/2014	Beaufort	R>1	Johnson Creek 1.4 mile southwest of US 21 Bridge
RO14355	Open	32.87833	79.65501	2.1	7/16/2014	Charleston	NDV	Price Creek southeast of Schooner Creek
RO14356	Open	32.60152	80.24154	3.0	8/13/2014	Charleston	R>1	Westbank Creek near mouth
RO14357	Open	32.07727	80.98048	14.6	8/5/2014	Jasper	I<1	Savannah River 1 mile northwest of Fields Cut
RO14358	Open	32.48375	80.49557	4.6	7/29/2014	Beaufort	NDV	Coosaw River near Morgan Back Creeks
RO14359	Open	33.39017	79.23018	0.4	7/22/2014	Georgetown	I>1	Waccamaw River in front of Arcadia Plantation
RO14360	Open	32.82988	80.00700	1.1	7/15/2014	Charleston	R<1	Ashley River southwest of Brickyard Creek
RO14361	Open	32.14994	80.86176	3.4	8/5/2014	Beaufort	R>1	Cooper River southwest of Bull 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.

SCECAP 2014
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT14063	Creek	32.79969	79.78613	2.1	7/16/2014	Charleston	R<1	Hamlin Creek near Intracoastal Waterway
RT14065	Creek	33.30590	79.17322	4.0	7/23/2014	Georgetown	NDV	Wood Creek north of Double Prong Creek
RT14066	Creek	32.51137	80.84348	2.4	8/6/2014	Jasper	NDV	East Branch Boyd Creek near headwaters
RT14067	Creek	32.38411	80.49208	4.3	7/30/2014	Beaufort	R>1	Harbor River southeast of Horse Island Drive
RT14068	Creek	32.80014	79.82018	0.9	7/16/2014	Charleston	R>1	Inlet Creek southeast of Three Gates Road
RT14070	Creek	32.21487	80.82126	1.1	8/5/2014	Beaufort	R<1	Tributary to Bass Creek 3 miles southeast of Bluffton
RT14075	Creek	32.60847	80.68517	5.2	7/29/2014	Beaufort	NDV	Branford Creek northwest of True Blue Creek
RT14076	Creek	32.58049	80.18708	1.8	8/13/2014	Charleston	R>1	Privateer Creek at split of two main branches
RT14078	Creek	32.35837	80.53879	4.0	7/30/2014	Beaufort	NDV	Harbor River southeast of the end of Bumble Bee Dr.
RT14080	Creek	32.52324	80.34019	1.2	8/12/2014	Colleton	R>1	Big Bay Creek
RT14082	Creek	32.40912	80.87578	1.5	8/6/2014	Jasper	NDV	Hazzard Creek
RT14083	Creek	32.35868	80.65719	2.7	7/30/2014	Beaufort	R<1	Cat Island Creek
RT14085	Creek	32.87910	79.66960	1.5	7/16/2014	Charleston	NDV	Schooner Creek near the confluence of Price Creek
RT14087	Creek	32.54913	80.50591	2.4	8/12/2014	Colleton	NDV	Rock Creek 1 mile southwest of Ashepoo River
RT14088	Creek	32.72171	79.92651	1.5	7/15/2014	Charleston	R<1	Clark Sound south of the end of Lighthouse Road

* 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 the 2011-2014 survey period.

Index / Parameter	Criteria			Percent of Open Water Habitat						Percent of Tidal Creek Habitat					
				2011-2012			2013-2014			2011-2012			2013-2014		
	Poor	Fair	Good	Poor	Fair	Good	Poor	Fair	Good	Poor	Fair	Good	Poor	Fair	Good
WATER QUALITY															
Water Quality Index				0.0	6.7	93.3	3.3	3.3	93.3	13.3	30.0	56.7	10.0	3.3	86.7
Dissolved Oxygen (mg/L)	< 3	3 ≤ x < 4	≥ 4	0	10	90	3**	3**	87**	17	23	60	7*	17*	73*
pH (salinity corrected)	≤ 7.22	7.22 < x ≤ 7.35	> 7.35	3*	3*	90*	3*	0*	93*	13	30	57	7*	7*	83*
Fecal Coliform (cfu/100mL)	> 400	43 < x ≤ 400	≤ 43	0	10	90	0*	20*	77*	7	10	83	0	27	73
Eutrophic Index				0	17	83	0	17	83	7	13	80	3	7	90
Total Nitrogen (mg/L)	> 1.05	0.81 < x ≤ 1.05	≤ 0.81	0*	7*	90*	7*	3*	87*	0***	3***	70***	0**	3**	90**
Total Phosphorus (mg/L)	> 0.12	0.10 < x ≤ 0.12	≤ 0.10	7	3	90	7	0	93	10	10	80	10	17	73
Chlorophyll a (µg/L)	> 16.4	11.5 < x ≤ 16.4	≤ 11.5	10	3	87	3	0	97	7	17	77	0	0	100
SEDIMENT QUALITY															
Sediment Quality Index				3.3	6.7	90.0	0.0	10.0	90.0	6.7	13.3	80.0	3.3	13.3	83.3
Contaminants (ERM-Q)	> 0.058	0.020 < x ≤ 0.058	≤ 0.020	3	10	87	0	33	67	3	27	70	0	33	67
Toxicity	≥ 2	1 ≤ x < 2	< 1	0	20	80	0	20	80	0	27	73	0	23	77
Sediment TOC (%)	> 5	3 ≤ x ≤ 5	< 3	0	10	90	0	7	93	7	7	87	3	7	90
BIOLOGICAL CONDITION															
Benthic-IBI	< 2	2 ≤ x < 3	≥ 3	0.0	6.7	93.3	3.3	30.0	66.7	0.0	30.0	70.0	6.7	13.3	80.0
HABITAT QUALITY															
Habitat Quality Index				0.0	3.3	96.7	0.0	16.7	83.3	6.7	16.7	76.7	3.3	20.0	76.7

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 two stations were missing. *** Data from eight 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 2011 through 2014. Green represents good condition, yellow represent 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		
RO11301							5	5				5	5	5.0	Horry	Little River in Millkin Cove
RO11302							5	5				5	5	5.0	Beaufort	Chechessee River at Port Royal Sound
RO11303							5	3				5	5	4.3	Beaufort	Morgan River north of Warsaw Flats
RO11304							5	3				5	5	4.3	Beaufort	ACE Basin in Williman Creek
RO11305							5	5				5	5	5.0	Beaufort	Chechessee River in the mouth of the Colleton River
RO11306							5	5				5	5	5.0	Beaufort	Broad River below Parris Island
RO11307							5	5				5	5	5.0	Beaufort	Whale Branch River below Chisolm Island
RO11308							5	5				0	5	3.3	Charleston	Cooper River above Shipyard Creek
RO11309							3	5				5	5	5.0	Beaufort	Broad River below the Broad River Bridge
RO11310							5	5				5	5	5.0	Beaufort	Harbor River behind Hunting Island
RO11311							3	5				5	5	5.0	Charleston	South Santee River Near Hwy 17
RO11312							5	5				3	5	4.3	Charleston	Wadmalaw Sound below Bears Bluff
RO11313							5	5				5	5	5.0	Beaufort	Cooper River north of Daufuskie Island
RO11314							3	5				5	5	5.0	Beaufort	Coosaw River above Morgan Island
RO11315							3	5				5	5	5.0	Georgetown	Winyah Bay below Waccamaw Point
RT11001							0	3				5	5	4.3	Georgetown	North Inlet in Wood Creek
RT11002							5	3				5	5	4.3	Jasper	Broad River in West Branch of Boyd Creek
RT11003							5	3				3	3	3.0	Beaufort	Morgan River in Eddings Creek
RT11004							5	5				5	5	5.0	Charleston	Copahee Sound in Porcher Bluff Creek
RT11005							5	5				5	5	5.0	Georgetown	North Inlet in Crab Haul Creek
RT11006							5	5				5	5	5.0	Beaufort	May River in Bass Creek
RT11007							5	5				5	5	5.0	Beaufort	Station Creek behind St Phillips Island
RT11009							5	5				5	5	5.0	Charleston	Bulls Bay in Little Papas Creek
RT11010							3	5				5	3	4.3	Beaufort	Beaufort in Albergotti Creek
RT11011							5	3				5	5	4.3	Beaufort	Wimbee Creek near mouth of Branford Creek
RT11012							5	5				5	5	5.0	Charleston	Kiawah River in Haulover Creek
RT11013							5	5				5	5	5.0	Beaufort	Chechessee River east of Victoria Bluff
RT11015							3	5				5	3	4.3	Beaufort	Whale Branch River in McCalleys Creek
RT11016							5	5				5	3	4.3	Charleston	ACE Basin in tributary of Fishing Creek
RT11018							5	5				5	5	5.0	Beaufort	Broad River in Coles Creek

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		
RO12316							5	5				3	5	4.3	Charleston	Charleston Harbor near the High Battery
RO12317							5	5				5	5	5.0	Jasper	Broad River across from the Whale Branch
RO12318							5	5				5	5	5.0	Beaufort	Calibogue Sound near Broad Creek
RO12319							5	5				5	5	5.0	Beaufort	Brickyard Creek east of the air station
RO12320							5	5				5	5	5.0	Colleton	South Edisto River above Alligator Creek
RO12321							5	5				5	5	5.0	Beaufort	Chechessee River northeast of Mackay Creek
RO12322							5	5				5	5	5.0	Beaufort	Beaufort River at mouth of Battery Creek
RO12323							5	5				5	3	4.3	Colleton	South Edisto River above St Pierre Creek
RO12324							5	5				5	5	5.0	Berekely	Cooper River just below the Tee
RO12325							5	5				5	5	5.0	Beaufort	Broad River above Hwy 170 bridge
RO12326							5	5				5	5	5.0	Colleton	St Helena Sound near the mouth of Rock Creek
RO12327							3	5				5	3	4.3	Georgetown	Winyah Bay across from South ICWW entrance
RO12328							5	5				5	5	5.0	Charleston	Stono River east of Limehouse Bridge
RO12329							5	5				5	5	5.0	Beaufort	Calibogue Sound across from Harbour Town
RO12330							5	5				5	5	5.0	Colleton	Cosaw River at mouth of New Chehaw River
RT12020							3	0				3	3	2.0	Charleston	Ashley River in Orangegrove Creek
RT12021							5	5				3	5	4.3	Charleston	Clauson Creek north of Mark Bay
RT12023							5	5				0	3	2.7	Colleton	South Edisto River in Alligator Creek
RT12024							5	3				5	5	4.3	Charleston	Folly River east of Oak Island
RT12025							0	3				5	5	4.3	Charleston	Tidal Creek off the ICW across from Awendaw Creek
RT12026							5	3				5	5	4.3	Beaufort	Battery Creek in the Burton-Grober Creek
RT12028							5	5				5	5	5.0	Charleston	Leadenwah Creek middle branch
RT12029							5	5				5	5	5.0	Beaufort	Chechessee River above entrance to Colleton River
RT12031							5	0				5	5	3.3	Jasper	Coosawhatchie River 2 miles below Hwy 17
RT12032							5	5				3	5	4.3	Colleton	South Edisto River in Big Bay Creek
RT12033							3	0				0	3	1.0	Charleston	Tidal creek off ICWW above Alligator Creek
RT12034							5	3				5	5	4.3	Jasper	Euhaw Creek near the headwaters
RT12037							5	0				5	3	2.7	Charleston	Bull Island in Summerhouse Creek
RT12038							5	3				5	3	3.7	Jasper	Wright River near headwaters
RT12039							5	5				5	5	5.0	Colleton	New Chehaw River near Big 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		
RO13332							3	5				5	5	5.0	Berkeley	Wando River 0.5 miles north of Hobcaw Creek
RO13333							5	5				5	5	5.0	Beaufort	Broad River northwest of Whale Branch
RO13334							5	5				5	5	5.0	Beaufort	Port Royal Sound
RO13335							3	5				5	5	5.0	Beaufort	Coosaw River northwest of Lucy Point Creek
RO13336							5	5				5	5	5.0	Charleston	Wando River upriver of Horlbeck Creek
RO13337							5	5				5	5	5.0	Beaufort	Broad River west of Archers Creek
RO13338							5	5				5	3	4.3	Beaufort	Battery Creek near West Bank
RO13339							5	5				5	5	5.0	Charleston	ICW between Five Fathom Creek and Jeremy Creek
RO13340							5	5				5	3	4.3	Charleston	Wadmalaw River upriver of Oyster House Creek
RO13341							5	5				5	5	5.0	Jasper	Mouth of Hazzard Creek
RO13342							5	5				5	5	5.0	Beaufort	Morgan River at mouth of Parrot Creek
RO13343							3	0				5	3	2.7	Georgetown	Winyah Bay northwest of Malady Bush Island
RO13344							5	5				5	5	5.0	Charleston	Charleston Harbor near Hog Island Channel
RO13345							5	5				5	5	5.0	Beaufort	May River near mouth of Bass Creek
RO13346							5	5				5	5	5.0	Beaufort	Saint Helena Sound at mouth of Coosaw River
RT13040							5	5				5	5	5.0	Charleston	Clark Sound off Oceanview Road
RT13043							3	0				0	3	1.0	Colleton	Chehaw River northwest of Social Hall Creek
RT13044							5	5				3	0	2.7	Charleston	Church Creek 0.5 miles northwest of SC 700 Bridge
RT13049							5	5				3	3	3.7	Charleston	Clubhouse Creek
RT13051							5	5				5	5	5.0	Beaufort	Station Creek northeast of mouth at Port Royal Sound
RT13052							5	5				5	5	5.0	Charleston	Tributary northeast of Chaplin Creek
RT13053							5	5				5	5	5.0	Charleston	Devil's Den Creek
RT13054							5	5				5	5	5.0	Beaufort	Coosaw River 2 miles northeast of Brickyard Creek
RT13055							5	5				5	0	3.3	Colleton	Old Chehaw River upriver of New Chehaw River
RT13056							5	5				5	5	5.0	Charleston	Abbapoola Creek near confluence of Kiawah River
RT13057							5	5				5	5	5.0	Charleston	Scott Creek east of SC 174 Bridge
RT13059							0	0				3	5	2.7	Jasper	Coosawhatchie River northwest of Pocotaligo River
RT13060							5	5				5	5	5.0	Charleston	Whooping Island Creek east of SC 174 Bridge
RT13061							5	5				5	5	5.0	Beaufort	Sawmill Creek near confluence of Colleton River
RT13062							5	5				5	5	5.0	Colleton	Otter Creek near Fish CreekWater

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		
RO14347							5	5				5	3	4.3	Georgetown	Winyah Bay
RO14348							5	5				5	5	5.0	Charleston	Cooper River south of US 17 Bridge
RO14349							5	5				5	5	5.0	Beaufort	Broad River south of Boyd Creek
RO14350							5	5				5	3	4.3	Beaufort	Beaufort River southeast of Ballast Creek
RO14351							5	5				5	5	5.0	Beaufort	Wimbee Creek northwest of South Wimbee Creek
RO14352							5	3				5	3	3.7	Berkeley	Cooper River 1 mile south of Back River
RO14353							5	5				5	5	5.0	Beaufort	Chechessee River 2 miles northwest of Mackay Creek
RO14354							3	5				5	5	5.0	Beaufort	Johnson Creek 1.4 mile southwest of US 21 Bridge
RO14355							5	5				5	5	5.0	Charleston	Price Creek southeast of Schooner Creek
RO14356							5	5				3	3	3.7	Charleston	Westbank Creek near mouth
RO14357							5	5				3	3	3.7	Jasper	Savannah River 1 mile northwest of Fields Cut
RO14358							5	5				5	5	5.0	Beaufort	Coosaw River near Morgan Back Creeks
RO14359							5	5				3	0	2.7	Georgetown	Waccamaw River in front of Arcadia Plantation
RO14360							3	5				5	3	4.3	Charleston	Ashley River southwest of Brickyard Creek
RO14361							5	5				5	5	5.0	Beaufort	Cooper River southwest of Bull Creek
RT14063							5	5				5	5	5.0	Charleston	Hamlin Creek near Intracoastal Waterway
RT14065							5	5				5	5	5.0	Georgetown	Wood Creek north of Double Prong Creek
RT14066							5	5				5	3	4.3	Jasper	East Branch Boyd Creek near headwaters
RT14067							5	5				5	5	5.0	Beaufort	Harbor River southeast of Horse Island Drive
RT14068							5	5				5	5	5.0	Charleston	Inlet Creek southeast of Three Gates Road
RT14070							5	5				5	5	5.0	Beaufort	Tributary to Bass Creek 3 miles southeast of Bluffton
RT14075							5	5				5	5	5.0	Beaufort	Branford Creek northwest of True Blue Creek
RT14076							5	5				5	5	5.0	Charleston	Privateer Creek at split of two main branches
RT14078							5	5				5	5	5.0	Beaufort	Harbor River southeast of the end of Bumble Bee Dr.
RT14080							5	5				5	5	5.0	Colleton	Big Bay Creek
RT14082							5	0				5	5	3.3	Jasper	Hazzard Creek
RT14083							5	5				5	5	5.0	Beaufort	Cat Island Creek
RT14085							5	5				5	5	5.0	Charleston	Schooner Creek near the confluence of Price Creek
RT14087							5	3				3	3	3.0	Colleton	Rock Creek 1 mile southwest of Ashepoo River
RT14088							3	5				5	5	5.0	Charleston	Clark Sound south of the end of Lighthouse Road

15-10814

Printed on recycled paper.

Total cost	$623.00
Total copies	50
Cost per copy	$12.46