THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2005-2006

AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE

TECHNICAL REPORT NO. 103

The Condition of South Carolina's Estuarine and Coastal Habitats During 2005-2006

Technical Report

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1. INTRODUCTION

Coastal habitats represent important natural resources for residents of and visitors to South Carolina. Almost 450,000 acres of estuarine wetlands lie along the state's coastline (Dahl, 1999) and provide habitat for a diverse array of plants and animals including many recreationally and commercially important fishery species. Together, these resources contribute to the health and well-being of area residents by providing services such as food, livelihoods and recreational opportunities. They also contribute to the economic vitality of the region. For example, the economic impact of the state's saltwater recreational and commercial fisheries alone exceeds 690 million dollars (Southwick Associates, 2008; SCDNR, unpubl. data). Domestic tourism in the state's six coastal counties adds over nine billion dollars to local economies and results in almost 800 million dollars in state and local tax revenue each year (SC Budget and Control Board, 2007).

The southeast Atlantic coast of the United States experienced a 58% increase in the number of people living in coastal counties between 1980 and 2003, the fastest growth rate in the country (Crossett et al., 2004). Within this region, South Carolina's coastal population grew 30% over the last 15 years and, based on recent conservative estimates, will grow another 35% over the next 25 years (SC Budget and Control Board, 2005). Current development patterns in South Carolina consume land at a rate six times that of population growth, resulting in urban sprawl (Allen and Lu, 2003). Water bodies associated with developed watersheds often have degraded habitat quality compared to their non-developed counterparts (Bricker et al., 1999; Kelsey et al., 2004; Nelson et al., 2005; Van Dolah et al., 2007). The close proximity of estuarine tidal creeks, tidal rivers, bays and sounds to human activities means these habitats are typically among the first to show signs of degradation in the marine environment (Holland et al., 2004; Sanger et al., 1999a, b; Lerberg et al., 2000; Van Dolah et al., 2000, 2002, 2004, 2006).

In recognizing the need to monitor the health of the state's coastal zone as development pressures increase, the South Carolina Estuarine and Coastal Assessment Program (SCECAP) was established in 1999. SCECAP represents an ongoing collaborative effort between the South Carolina Department of Natural Resources (SCDNR) and the Department of Health and Environmental Control (SCDHEC) as the lead state agencies and the U.S. Environmental Protection Agency (USEPA) and National Oceanic and Atmospheric Administration (NOAA) as partner agencies. The goals of SCECAP are to 1) monitor the quality of all South Carolina estuaries, 2) develop integrated measures of coastal habitat condition, 3) report findings to the public in understandable formats, and 4) use the data in management and regulatory decisions. This technical report is the fourth in a series of biennial reports documenting the status and trends of South Carolina's coastal habitat since 1999 (Van Dolah et al., 2002, 2004, 2006).

Programs such as SCECAP provide our best mechanism for detecting and addressing human impacts to our valued coastal resources.

2. METHODS

The sampling and analytical methods used for SCECAP are fully described in the first SCECAP report (Van Dolah et al., 2002) and can be viewed and downloaded from the SCDNR's SCECAP website (http://www.dnr.sc.gov/marine/scecap/). This program uses methods consistent with SCDHEC's water quality monitoring programs (SCDHEC, 2001) and the USEPA's National Coastal Assessment (NCA) program (http://www.epa.gov/emap/nca/ index.html).

2.1. Sampling Design

Fifty stations were selected for sampling each year within South Carolina's coastal zone extending from the Little River Inlet at the South Carolina-North Carolina border to the Savannah River at the South Carolina-Georgia border and extending from the saltwater- freshwater interface to near the mouth of each estuarine drainage basin (Appendix 1). Half of the stations were located in tidal creeks (defined as water bodies < 100 m wide from marsh bank to marsh bank), and the other half were located in the larger open water bodies that form South Carolina's tidal rivers, bays and sounds. By surface area, approximately 17% of the state's estuarine water represents creek habitat, and the remaining 83% represents the larger open water areas (Van Dolah et al., 2002).

Stations within each habitat type were selected using a probability-based, random tessellation, stratified sampling design (Stevens, 1997; Stevens and Olsen, 1999), with new station locations assigned each year. All stations were sampled once during the summer (late June through August). The summer period was selected since it represents a period when some water quality variables may be limiting to biota, and it is a period when many of the fish and crustacean species of concern utilize the estuary for nursery habitat. Thirty of the sites sampled each year (15 tidal creek and 15 open water) were also sampled monthly by SCDHEC for most water quality measures (data not reported here).

Most measures of water and sediment quality and biological condition were collected within a 2-3 hr time period around low tide. Observations were made at each site to document the presence of litter (within the limits of the trawled area) and to note the proximity of the site to urban/suburban development or industrial development. A copy of the Quality Assurance Project Plan is maintained at the SCDNR Marine Resources Research Institute and has been approved by the USEPA NCA Program.

2.2. Water Quality Measurements

Time-profile measurements of temperature, salinity, dissolved oxygen and pH were obtained from the near-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. Primary water quality measures were collected from near-surface waters and included total nitrogen (TN; sum of nitrate/nitrite and total Kjeldahl nitrogen (TKN)), total phosphorus (TP), turbidity, chlorophyll-a (chl-a) and fecal coliform bacteria concentrations. Secondary water quality measures were also collected from near-surface waters and included total organic carbon (TOC), total suspended solids (TSS), five-day biochemical oxygen demand (BOD_5) and measures of dissolved nutrients, including dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), dissolved inorganic phosphorus (orthophosphate or DIP), dissolved organic phosphorous (DOP) and dissolved silica (DS). Data for the secondary water quality measures are available on the SCECAP website but are not described in this report since most were collected primarily for the NCA program.

All samples were collected by inserting pre-cleaned water bottles to a depth of 0.3 m and then filling the bottle directly at that depth. Water samples collected for dissolved nutrient quantification were filtered in the field through a 0.45 µm pore cellulose acetate filter. The bottles were then stored on ice until they were returned to the laboratory for further processing. Total nutrients, TOC, total alkalinity, TSS, turbidity, BOD_5, chl-a and fecal coliform bacteria samples were processed by SCDHEC using standardized procedures (SCDHEC, 1998b, 2001, 2005).

2.3. Sediment Quality Measurements

At least seven bottom sediment samples were collected at each station using a stainless steel 0.04 m^2 Young grab deployed from an anchored boat that was repositioned between samples. The surficial sediments (upper 3 cm) of four or more grab samples were homogenized on-site and placed in precleaned containers for analysis of silt and clay content, total organic carbon (TOC), total ammonia nitrogen (TAN), contaminants and sediment toxicity. All sediment samples were kept on ice while in the field and then stored either at 4°C (toxicity, porewater) or frozen (contaminants, silt and clay content, TOC) until analyzed. Particle size analyses were performed using a modification of the pipette method described by Plumb (1981). Pore water ammonia was measured using a Hach Model 700 colorimeter, and TOC was measured on a Perkin Elmer Model 2400 CHNS Analyzer.

Contaminants measured in the sediments included 23 metals, 25 polycyclic aromatic hydrocarbons (PAHs), 79 polychlorinated biphenyls (PCBs), 13 polybrominated diphenyl ethers (PBDEs) and 21 pesticides. All contaminants were analyzed by the NOAA-NOS Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) using procedures similar to those described by Krahn et al. (1988), Fortner et al. (1996), Kucklick et al. (1997) and Long et al. (1997). The sediment contaminants were simplified into an 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 was measured using two bioassays: (1) the Microtox® 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 was 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 were considered toxic if growth (change in dry weight) was < 80% of that observed in control sediments and there was a statistically significant difference ($p < 0.05$).

2.4. Biological Condition Measurements

Three of the samples collected by Young grab were washed through a 0.5 mm sieve to collect the benthic invertebrate fauna, which were then preserved in a 10% buffered formalin-seawater solution containing Rose Bengal stain. Two of these three grab samples were sorted in the laboratory to separate organisms from the sediment remaining in the sample; the third was held in reserve. All organisms from the two grabs were identified to the species level or to the lowest practical taxonomic level if the specimen was too damaged or immature for accurate identification. A reference collection of all benthic species collected for this program is being maintained at the SCDNR Marine Resources Research Institute. The benthic data were incorporated into a Benthic Index of Biotic Integrity (B-IBI; Van Dolah et al., 1999).

Fish and large crustaceans were collected by trawl at each site following benthic sampling to evaluate near-bottom community composition. Two replicate tows were 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 were standardized to 0.5 km for open water sites and 0.25 km for creek sites. Organisms captured were identified to the species level, counted, and checked for gross pathologies, deformities, or external parasites. Up to 25 individuals of each species were measured to the nearest centimeter. Mean abundance of finfish and crustaceans were corrected for the total area swept by the two trawls using the formula described by Krebs (1972). Fish tissue samples for contaminant analyses (targeted species: spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*)) were obtained from trawls, wrapped in foil, and stored on ice in plastic bags until they could be frozen in the laboratory. The fish were sent to the USEPA Gulf Breeze Laboratory for further processing. The results of these analyses are not discussed here, but will be reported by the USEPA.

Water samples for phytoplankton community analysis were collected from near-surface water concurrently with water quality samples. Fresh samples were examined under a microscope for species identifications, and subsamples were filtered and analyzed for taxon-specific biomass determination using CHEMTAX. CHEMTAX is a matrix factorization program that generates a profile of the phytoplankton community based on the pigment ratio detected in the water sample using High Pressure Liquid Chromatography (HPLC) (Lewitus et al., 2005) and is capable of quantifying the biomass of relevant groups of phytoplankton.

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 three integrated indices describing different components of the estuarine ecosystem: water quality, sediment quality and biological condition. The Water Quality Index combines four individual measures (one of which, the Eutrophic Index, is a composite of three other measures), the Sediment Quality Index combines three individual measures, and Biological Condition Index includes only the B-IBI (Table 2.5.1). These three indices are then combined into a single integrated Habitat Quality Index. The integrated indices not only improve public communication of multi-variable environmental data, they also 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 of all 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.

Indices of habitat, water, and sediment quality and biological condition provide simplified statements about the health of our state's coastal resources.

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	Total Organic Carbon	
Eutrophic Index		
Total Nitrogen		
Total Phosphorus		
Chlorophyll *a*		

The methods for calculating the four integrated indices are described in detail in section 2.6. 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." Thresholds for defining conditions as good, fair, or poor are based on state water quality standards (SCDHEC, 2004), published findings (Hyland et al., 1999 for ERM-Q; Van Dolah et al., 1999a for benthic condition; ASTM, 1993; Ringwood et al., 1997, 1998 for toxicity measures), or percentiles of an historical database for the state. These scores are given a numerical ranking (good as highest, poor as lowest) and averaged into an integrated index score (described in general terms in Van Dolah et al., (2004). The integrated indices are likewise given a score of good, fair, or poor using methods described in Van Dolah et al. (2004). 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, individual threshold values and scoring processes. While these changes often do not result in very large changes in data interpretation, the results presented in this report may not match exactly those in previous reports.

2.6. Revisions to Thresholds and Integrated Measures

SCECAP personnel have elected to use new information and a more recently expanded database to improve the computation of various measures and indices of estuarine condition. The goals of this revision were to:

- Modify the scoring process of all measures and indices to improve our ability to detect degraded environmental conditions,
- Extend pH thresholds to include oligohaline and mesohaline waters now that there are sufficient sites to represent those habitats,
- Recalculate thresholds for TN, TP and chl-a using the eight-year SCECAP database that includes both tidal creek and open water habitats,
- Adjust the weighting of the six measures currently used to compute the water quality score to reduce the relative weighting of eutrophication measures to 25% of the total score, and
- Revise the computation of the integrated Sediment Quality Index to include additional measures already collected by SCECAP.

The following sections describe the measures, thresholds, calculations and scoring processes used during this reporting period. Where appropriate, revisions that were implemented are also described.

Changes in the Scoring Process

SCECAP has adopted a new scoring process for rating water quality, sediment quality, biological condition and overall habitat quality. Our goal was to develop indices more sensitive to environmental degradation by adding weight to any measure or index scoring as "poor." Previously, the integrated water and sediment quality indices were calculated by scoring their component measures as "1" for poor, "3" for fair, or "5" for good, then averaging those scores to obtain the overall score. Overall habitat quality was calculated by scoring the overall water and sediment quality and B-IBI scores as above and then averaging those scores.

Revisions to the SCECAP scoring process are meant to create more balanced and sensitive assessments.

Measure					Final
A	B	C	D	Average	Score
0	0	0	0	0.00	Poor (0)
3	0	0	0	0.75	Poor (0)
5	0	0	0	1.25	Poor (0)
3	3	0	0	1.50	Poor (0)
5	3	0	0	2.00	Poor (0)
5	5	0	0	2.50	Poor (0)
3	3	3	0	2.25	Poor (0)
5	3	3	0	2.75	Poor (0)
5	5	3	0	3.25	Fair (3)
5	5	5	0	3.75	Fair (3)
3	3	3	3	3.00	Fair (3)
5	3	3	3	3.50	Fair (3)
5	5	3	3	4.00	Good (5)
5	5	5	3	4.50	Good (5)
5	5	5	5	5.00	Good (5)

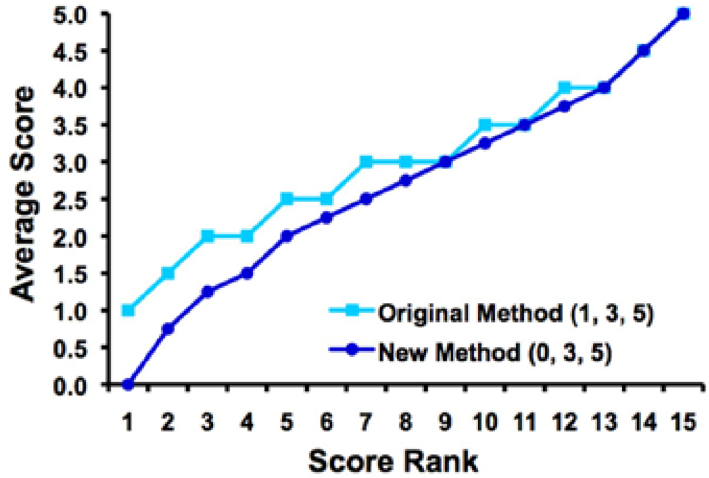

Figure 2.6.1. Summary of possible scores for a generic index using four measures and a graphic illustrating the overlap in scores using the previous scoring process (1,3,5) and the absence of overlap using the new scoring process (0,3,5).

For the new scoring process, the same methods were used, but any measure considered to represent poor conditions was scored with a "0" rather than a "1" used in the original index. This effectively makes the overall scores slightly more conservative and increases the probability of identifying potentially degraded environments (Figure 2.6.1, right graph). This has an added value of eliminating duplication of comparable scores for different permutations of poor, fair and good condition that occurred with using the original scoring of 1, 3, or 5 (Figure 2.6.1).

Water Quality Index

The previous version of the integrated Water Quality Index incorporated six measures: dissolved oxygen, fecal coliform bacteria, pH, TN, TP and chl-a. The new integrated Water Quality Index reduces this to four discrete measures by combining TN, TP and chl-a into a new "Eutrophic Index" prior to averaging it with the other three measures. The Eutrophic Index was deemed necessary to reduce the influence of eutrophication-related measures in the integrated Water Quality Index score. In the previous version, eutrophication measures collectively accounted for 50% of the final score (three of six measures), but in the new version they account for 25% of the score (one of four measures).

Revising the index from six to four individual measures also adds more weight to each of the four individual measures (Figure 2.6.2). For example, when one of four measures scores as poor and the rest score as good, the index score codes as fair, whereas it still codes as good when six measures are included in the index. Similarly, when two of four measures score as poor and the rest score as good, the overall index score codes as poor rather than fair as when six independent measures are used.

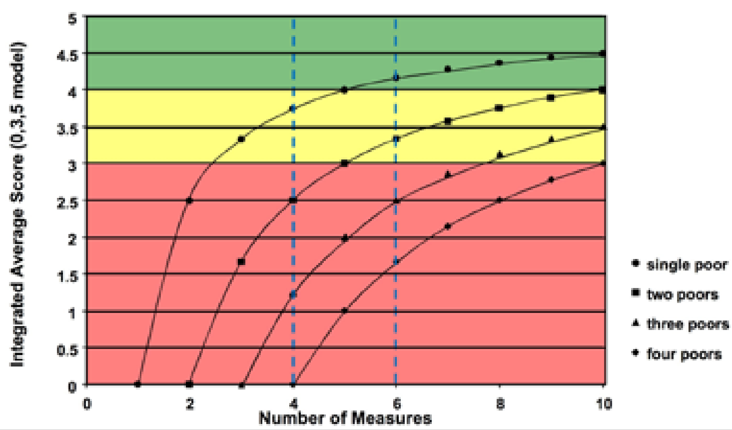

Figure 2.6.2. Possible scores when between one and ten different measures are used to compute a generic integrated index score. The lines show the integrated index score when one, two, three, or four of the component measures score as poor.

For the new integrated Water Quality Index, the thresholds were adjusted to rate overall scores of ≥ 3 as fair and ≥ 4 as good (as in Figure 2.6.1). For the 2001-2002 and 2003-2004 surveys, the overall score had to be > 3 and > 4 to code as fair or good, respectively.

Dissolved Oxygen Thresholds:

The dissolved oxygen (DO) criteria that have been used for all previous surveys remain unchanged in the current survey. DO is a primary measure because low concentrations can limit the distribution or survival of most estuarine biota, especially if these conditions persist for extended time periods (see Diaz and Rosenberg, 1995; USEPA, 2001 for reviews). DO criteria established by the SCDHEC for "Shellfish Harvesting Waters" (SFH) and Class SA saltwaters are a daily average not less than 5.0 mg/L and a minimum not less than 4.0 mg/L (SCDHEC, 2004). Class SB waters should have no DO values less than 4.0 mg/L. Since the SCECAP program was designed to sample only during a summer index period when DO levels are expected to be at their lowest, DO measurements collected in this program probably represent short-term worst-case conditions that may not reflect conditions during other seasons or longer time-averaged periods. Therefore, these measurements should not be used for regulatory purposes. However, SCECAP data provide useful measures of average DO concentrations observed in South Carolina's coastal habitats when DO levels may be limiting, and it identifies areas within the state where this is occurring. Based on the state water quality standards, mean or instantaneous DO concentrations ≥ 4 mg/L are considered to be good for summer time periods, values < 4 mg/L and ≥ 3 mg/L are considered to be fair and average or instantaneous measures < 3 mg/L are considered to be poor and potentially stressful to many invertebrate and fish species.

Fecal Coliform Bacteria Thresholds:

Fecal coliform bacteria criteria remain unchanged from previous SCECAP surveys and are related to SCDHEC's water quality criteria for the state's salt waters. Coliform bacteria are sampled as a measure of potential health hazard in estuarine waters related to primary contact recreation, such as swimming, and shellfish harvesting. State fecal coliform standards to protect primary contact recreation require a geometric mean count that does not exceed 200 colonies/100 mL based on five consecutive samples in a 30-day period and no more than 10% of the samples can exceed 400 colonies/100 mL. To ensure an area is safe for shellfish consumption, the geometric mean shall not exceed 14 colonies/100 mL and no more than 10% of the samples can exceed 43 colonies/100 mL (SCDHEC, 2004). Since only a single fecal coliform count is collected at each site during SCECAP surveys, compliance with the standards cannot be strictly determined, but the data can provide some indication of whether the water body is likely to meet standards. For SCECAP, we consider any sample with ≤ 43 colonies/100 mL to be good. Samples with > 43 colonies/100 mL and ≤ 400 colonies/100 mL represent fair conditions (i.e., potentially not supporting shellfish harvesting) and any sample with > 400 colonies/100 mL represents poor conditions (i.e., potentially not supporting primary contact recreation).

pH Thresholds (revised):

When the Water Quality Index was first developed, pH criteria were limited to polyhaline waters (> 18 ppt) only. This was due to both an insufficient database available for oligo- and mesohaline sites and the known positive

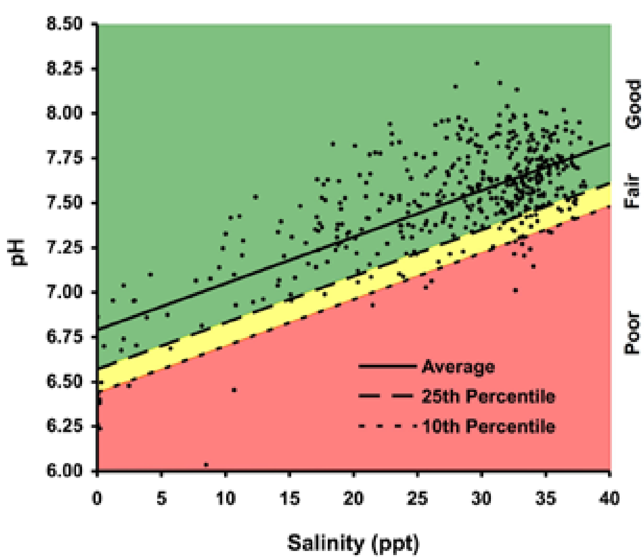

Figure 2.6.3. Relationship between pH and salinity in the 1999-2006 SCECAP dataset. Lines show the average and the percentiles used to determine the thresholds for good, fair, and poor scores.

relationship between pH and salinity. Now that SCECAP has eight years of data representing salinities from 0 to 38 ppt and drought and normal rainfall conditions, we are able to compute the relationship between pH and salinity in South Carolina estuaries and use this to calculate salinity-dependent thresholds (Figure 2.6.3).

Linear regression was used to fit a line and derive an equation describing the relationship between these two measures (Table 2.6.1, Figure 2.6.3). The 10^{th} and 25^{th} percentiles were then calculated for the values falling below the line (negative residuals), and these were subtracted from the equation derived above to create lines describing the thresholds for fair (≤ 25^{th} percentile but > 10th percentile) and poor (≤ 10^{th} percentile) conditions (Table 2.6.1, Figure 2.6.3). This corrects for the natural decrease in pH that occurs with decreasing salinity throughout the range of salinities sampled during SCECAP surveys. Only the lower pH levels are of concern for SCECAP since few stations (only 4) had pH values above 8.0, and none approached SCDHEC's upper criteria of 8.5. Further, our primary concerns are related to the environmental consequences of low pH. Estuarine organisms, especially shellfish, respond negatively to pH levels below 7.5 (Ringwood and Keppler, 2002), and increasing research indicates that acidification of seawater related to elevated CO_2 concentrations will have adverse impacts on many organisms (The Royal Society, 2005; Turley, 2006; Fabry, 2008).

Table 2.6.1. Equations for the lines describing the relationship between pH and salinity and the percentiles used to determine the thresholds for good, fair, and poor pH scores.

Line	Equation
Average	pH = 0.026 X Salinity + 6.79
25^{th} percentile	pH = 0.026 X Salinity + 6.57
10^{th} percentile	pH = 0.026 X Salinity + 6.44

Prior to analysis, all pH values were salinity-corrected by calculating the residual value for each station (the pH difference between the observed value and the predicted average value at that station's salinity) and adding it to the predicted average pH at 30 ppt using the equation in Table 2.6.1 (pH = 7.57). Thus, in the cumulative distribution function (CDF; described in Section 2.7) analysis, salinity-corrected pH values > 7.35 were considered good, values ≤ 7.35 but > 7.22 were considered fair and values ≤ 7.22 were considered poor.

Eutrophic Index: Nutrient and Chlorophyll-a Thresholds (revised):

SCDHEC has not established water quality standards for the three measures comprising the "Eutrophic Index": TN, TP, and chl-a. The USEPA also has no published criteria on these measures for estuarine waters. SCECAP previously utilized SCDHEC's historical water quality data (SCDHEC, 1998a) to define concentrations of TN and TP that are moderately elevated (≥ 75^{th} and < 90^{th} percentile of the historical records) or strongly elevated (≥ 90^{th} percentile of the historical records). SCDHEC did not collect chl-a data for their 1993-1997 assessment, so SCECAP utilized the 75^{th} percentile of all SCECAP chl-a data collected from 1999-2002 to define the threshold between good and fair for the 2003-2004 survey (≤ 12 ug/L for good, > 12 ug/L and ≤ 20 ug/1 for fair) and exceedances of > 20 ug/L chl-a as the poor threshold based on findings by Bricker et al. (1999).

While the historical database (SCDHEC, 1998a) was useful for defining nutrient concentrations that may be problematic, it had several known limitations. These included being limited to data collected from stations located (1) in relatively large water bodies with little if any representation of conditions in tidal creeks, and (2) at sites selected for specific purposes rather than selected to represent the entire coastal zone. The data collected from SCDHEC's water quality monitoring program also represent multiple seasons whereas SCECAP's primary sampling period is constrained to the summer period. SCDHEC's array of fixed stations best meets the goals of the ambient surface water quality monitoring program and is one of the most comprehensive programs in the United States, but its utility to SCECAP was not ideal. The current SCECAP database provides a broader array of sites representing both open water and tidal creek habitats and includes sites from both developed and relatively undeveloped watersheds. It also represents a more contemporary database compared to the 1993-1997 data used previously. Thus, program personnel have elected to use the 1999-2006 SCECAP survey data to define the 75th and 90th percentile thresholds for TP and chl-a, and the 1999-2005 data to define the thresholds for TN. The TN data for 2006 are currently under review due to unusually low TKN values, and until this is resolved, we have chosen to exclude it from the analyses presented here. It is important to note that including the low 2006 data would decrease the 75th percentile by 0.08 mg/L and the 90th percentile by 0.07 mg/L, resulting in more stations scoring as fair or poor for this measure. The adopted thresholds are provided in Table 2.6.2, along with the thresholds derived from the SCDHEC historical data.

The percentiles for each measure show some differences between tidal creek and open water stations, but the values for all stations combined were selected as the best intermediate values to use as thresholds for classifying as good, fair, or poor. It is interesting to note that the 75th percentile for TP differs from the original threshold by only 0.01 mg/L. The 90th percentile threshold is also only 0.05 mg/L lower than the original threshold for TP. TN thresholds are slightly lower than the original thresholds, but both differed by < 0.3 mg/L. The new chl-a thresholds are lower than the values used for previous assessments, but the difference was very small for the 75th percentile threshold. Lower thresholds will provide a more conservative estimate of condition with respect to these measures.

Table 2.6.2. Summary of new thresholds based on the 75th and 90th percentiles of all SCECAP data collected from 1999 to 2006 and comparison with thresholds used in previous SCECAP assessments.

Data Source	TN* (mg/L)	TP (mg/L)	Chlorophyll a (µg/L)
75th Percentiles:			
SCECAP Data (1999-2006)			
All Stations	**0.81**	**0.10**	**11.5**
Tidal Creek Stations	0.84	0.11	13.7
Open Water Stations	0.75	0.09	10.2
SCDHEC Data (1993-1997)	0.95	0.09	Not measured, >12 used
90th Percentiles:			
SCECAP Data (1999-2006)			
All Stations	**1.05**	**0.12**	**16.4**
Tidal Creek Stations	1.12	0.13	17.7
Open Water Stations	1.02	0.11	14.1
SCDHEC Data (1993-1997)	1.29	0.17	Not measured, >20 used
Method Detection Limits (MDL)	0.10**	0.2	

* 2006 data excluded due to unusually low values. Data under review.
** Based on MDL for TKN, which is the least sensitive of the components (TKN+NO_2/NO_3) used to estimate TN.

Sediment Quality Index

SCECAP assesses six characteristics of sediment quality: silt and clay content, total organic carbon (TOC), total ammonia nitrogen (TAN), unionized ammonia nitrogen (UAN), contaminants (a suite of 160 polycyclic aromatic hydrocarbons, PCBs, metals, and pesticides) and toxicity. For SCECAP data collected between 1999 and 2004, the integrated Sediment Quality Index was based on only contaminants and toxicity. The Sediment Quality Index has been revised for the current survey period to include TOC as a third component of the index.

Sediment Contaminant (ERM-Q) Thresholds:

Sediment contaminant criteria used for all previous SCECAP surveys remain unchanged and are related to the probability of observing a degraded benthic community based on a study completed by Hyland et al. (1999). That study demonstrated that ERM-Q provides a reliable index of benthic stress in southeastern estuaries with ERM-Q values ≤ 0.020 representing a low risk, values > 0.020 and ≤ 0.058 representing a moderate risk and values > 0.058 representing a high risk of observing degraded benthic communities.

Sediment Toxicity Thresholds:

Sediment toxicity criteria that have been established for all previous SCECAP surveys also remain unchanged. Sediments may contain a wide range of contaminants, but the ability of these contaminants to negatively impact healthy biological communities depends on their availability to the resident fauna as well as interactive effects among the contaminants. Bioassays provide a means of determining the biological relevance of contaminant loads by examining the performance of living organisms in samples of native sediment (Ringwood and Keppler, 1998). SCECAP currently utilizes two bioassays, Microtox® bacterial growth and seed clam growth, in order to provide a weight-of-evidence estimate of sediment toxicity to benthic fauna. Specifically, positive test results in both assays indicate a high probability of toxic sediments, positive results in only one of the assays indicate possible evidence of toxic sediments, and no positive results indicate non-toxic sediments.

Sediment Total Organic Carbon Thresholds (new measure):

Sediment TOC provides a measure of the amount of organic material present in the sediments of a site and may reflect inputs from both natural and anthropogenic sources. High sediment TOC can increase contaminant bioavailability (Standley, 1997; Skei et al., 2000), may reflect chronic eutrophication of the water body, and in the absence of sufficient oxygen to fuel aerobic respiration, can result in the build-up of potentially toxic reduced chemicals (Pearson and Rosenberg, 1978). Further, analysis of SCECAP data indicates that sediment TOC is a significant predictor of benthic community condition (B-IBI). Taken together, this suggests that TOC should be added to the overall Sediment Quality Index.

The USEPA (2006) developed thresholds for US marine systems of < 2% TOC for good condition, 2 – 5% TOC for fair condition, and > 5% for poor condition. In the Southeast, where inputs from expansive coastal wetlands can be significant, Hyland et al. (2000) determined that

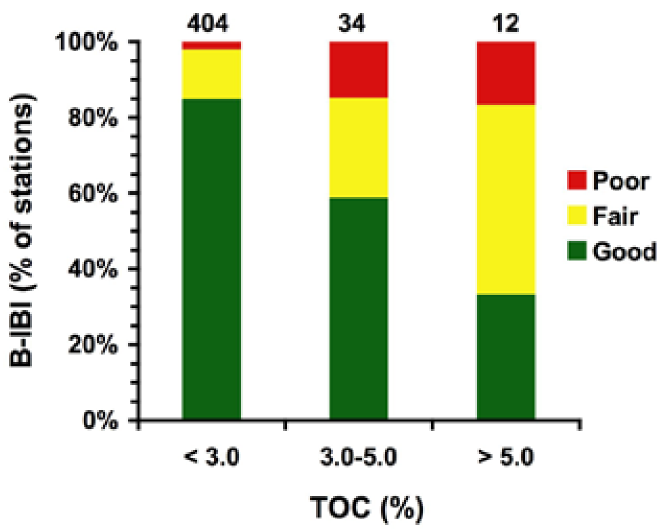

Figure 2.6.4. Relationship between adopted TOC thresholds and the percent of stations that score as good, fair, or poor for B-IBI in the 1999-2006 SCECAP dataset. Numbers above bars indicate number of stations within each TOC threshold range.

decreased benthic abundance and biomass were associated with sediment TOC > 3%. SCECAP has adopted a combination of these criteria for South Carolina in which < 3% TOC indicates good condition, 3-5% TOC fair condition and > 5% TOC poor condition. The adopted thresholds provide a strong predictor of overall benthic community condition (as measured by the B-IBI). Using multiple regression, B-IBI decreases significantly with increasing TOC, and TOC represents the strongest sediment quality predictor of B-IBI (as compared to ERM-Q, silt/clay content, TAN and UAN). Additionally, the percentages of SCECAP sites classified as fair or poor based on B-IBI increase substantially when sites are classified as fair or poor in terms of TOC (Figure 2.6.4). These findings indicate that the new TOC thresholds adopted by SCECAP are biologically-relevant, and that TOC adds an important environmental stressor to the integrated Sediment Quality Index.

Biological Condition Index

As in previous surveys, SCECAP continues to use a single multi-metric benthic index of biological integrity (B-IBI; Van Dolah et al., 1999) in order to calculate the Biological Condition Index. Broadly, the B-IBI combines several measures of the abundance and diversity of various macroinfaunal groups into a single score that reflects environmental quality effects on these communities. Lower values for this score tend to be associated with degraded environments while higher values tend to be associated with undegraded environments.

SCECAP currently has no broad index for analyzing the condition of South Carolina's fish and invertebrate communities sampled by trawl. Indices have been developed for other parts of the US (for example, northeast US and the Gulf of Mexico), but the applicability of these to the southeastern coastal zone is questionable. Consequently, analyses here focus on comparing basic community measures and individual taxonomic and species densities amongst habitats and over time.

Habitat Quality Index

The integrated Habitat Quality Index used by SCECAP has been changed slightly with respect to the scoring process. This index weights each of the three components equally (i.e. Water Quality,

Measure				Final
A	B	C	Average	Score
0	0	0	0.00	Poor (0)
3	0	0	1.00	Poor (0)
5	0	0	1.67	Poor (0)
3	3	0	2.00	Poor (0)
5	3	0	2.67	Poor (0)
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)

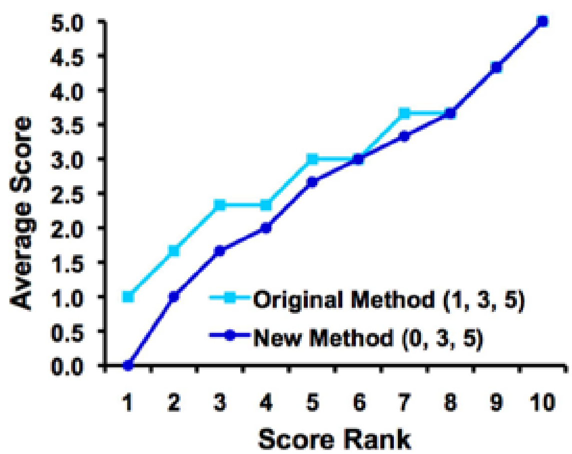

Figure 2.6.5. Summary of possible scores for the integrated Habitat Quality Index using the new scoring process (0,3,5) and a comparison with the previous scoring process using (1,3,5).

Sediment Quality and Biological Condition Indices), but with 0 used as the poor score value for each of these components, instead of 1 as in previous surveys. The possible scores are shown in Figure 2.6.5.

Although the overall score has changed slightly with the new scoring process, SCECAP still considers a site to have poor habitat quality if two or more of the components score as poor, or if one component scores as poor and the other two score only fair. A site is considered to have fair habitat quality if two or more of the habitat quality components score as fair or only one component scores as poor. A site is considered to have good habitat quality if all three components score as good or if only one of the components scores no worse than fair.

2.7. Data Analyses

Use of the probability-based sampling design provided an opportunity to statistically estimate, with confidence limits, the proportion of South Carolina's estuarine habitat classified as being in good, fair, or poor condition based either on (1) state water quality criteria, (2) historical measurements collected by SCECAP between 1999 and 2006, or (3) other thresholds indicative of stress based on sediment chemistry or biological condition (Hyland et al., 1999; Van Dolah et al., 1999). These estimates were obtained through analysis of the cumulative distribution function (CDF) using procedures described by Diaz-Ramos et al. (1996). The percent of the state's overall estuarine habitat scoring as good, fair, or poor for individual measures and each of the indices was calculated after weighting the analysis by the proportion of the state's estuarine habitat represented by tidal creek (17%) and open water (83%) habitat. The proportion of each habitat type (tidal creek and open water) scoring as good, fair and poor was also calculated.

Comparisons of most water quality, sediment quality and biological measures were completed using standard parametric tests or non-parametric tests where the values could not be transformed to meet parametric test assumptions. Individual measures were analyzed by calculating their mean value within habitat type and year, transforming as necessary to meet the assumptions of a general linear model and then applying an analysis of covariance with habitat type as a factor and year as a covariate.

3. RESULTS AND DISCUSSION

3.1. Water Quality

Using the new Water Quality Index developed for the 2005-2006 assessment period, 87% of South Carolina's coastal estuarine habitat, which collectively includes both tidal creeks and larger open water areas, remains in good condition. Only 3% of the coastal estuarine habitat was in poor condition and 10% was in fair condition. When considered separately, tidal creek habitats had a higher percentage of fair to poor water quality conditions (20% fair, 6% poor) as compared to open water habitats (8% fair, 2% poor) in the 2005-2006 survey (Figure 3.1.1). All measures were instrumental in lowering the overall tidal creek scores; whereas, fecal coliform concentrations and the eutrophication score were the key components resulting in reduced water quality in open water habitats. The higher percentage of impaired or potentially impaired tidal creek habitat compared to open water habitat is consistent with previous assessments using the older water quality indices (Van Dolah et al., 2002, 2004, and 2006). That pattern also remains when the new Water Quality Index is applied to the previous survey data (Figure 3.1.2).

The majority of South Carolina's coastal estuarine habitat (87%) remains in good condition, but tidal creek habitats had a higher percentage of fair to poor water quality.

It is interesting to note that the new index showed very similar results to the original index by habitat type, even though the index was significantly modified (Figure 3.1.3). The proportion of open water that coded as good, fair, or poor using the new index never differed by more than 3% from the older index used in previous surveys. Slightly greater variability was observed between the indices in tidal creek habitats (0-8%), with a higher percentage of tidal creek habitat

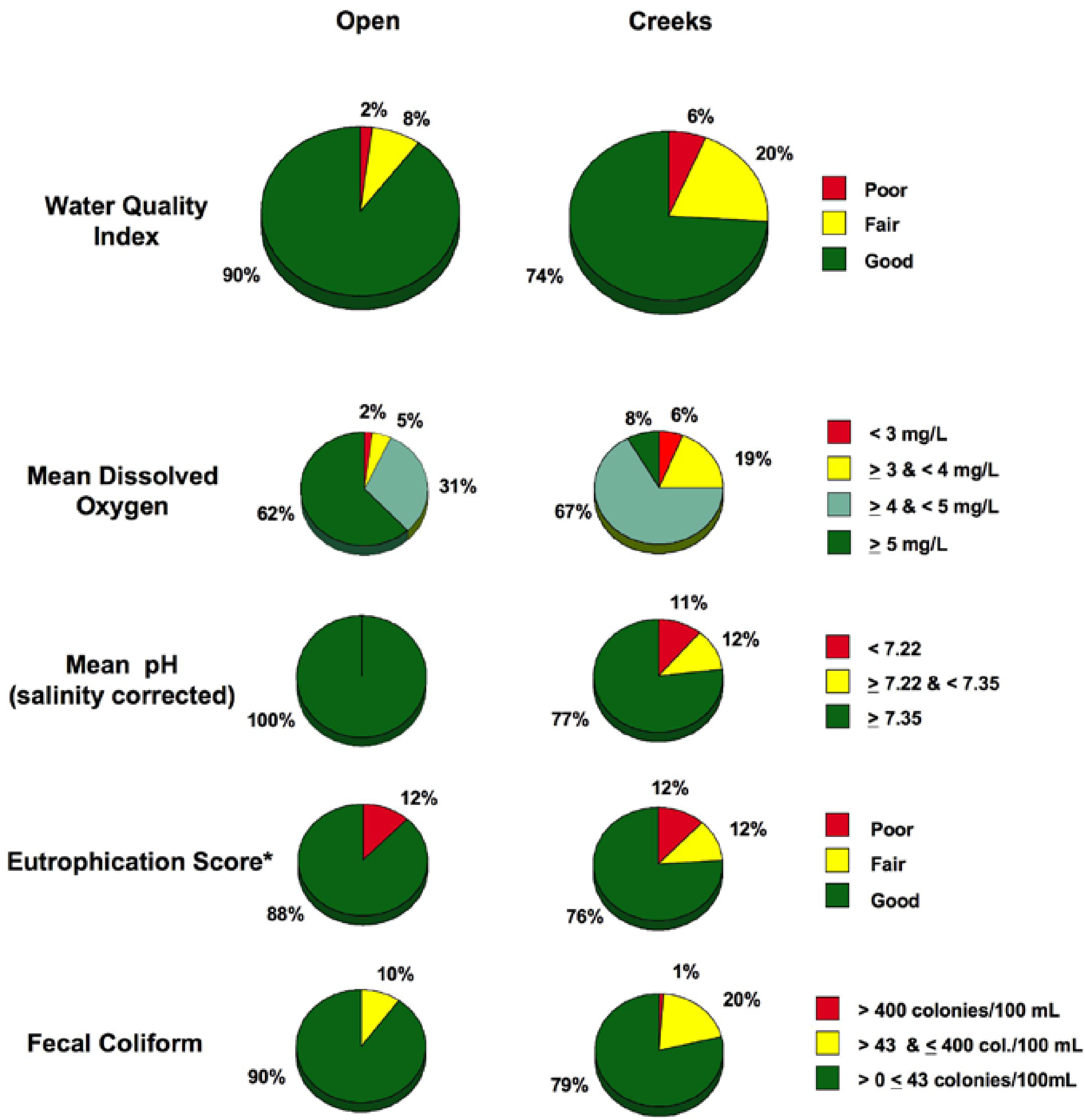

*Figure 3.1.1. Percentage of the state's open water and tidal creek habitat that represent good, fair or poor conditions for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 50 stations for each habitat type except for *TN, which included only the 25 stations for each habitat type sampled in 2005.*

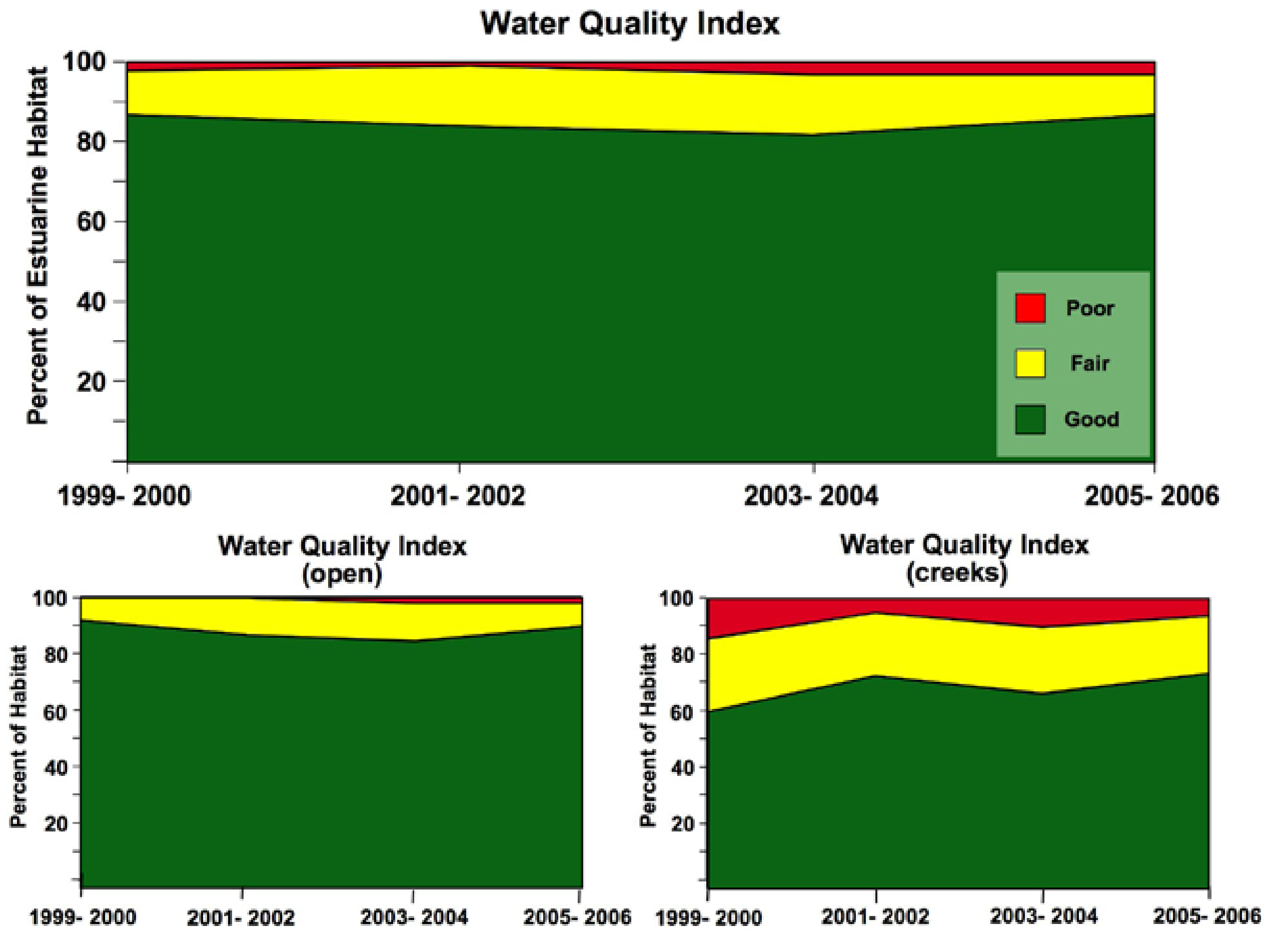

Figure 3.1.2. Water quality condition observed by survey period for all coastal waters and in tidal creeks and open water habitat separately, using the new water quality index.

coding as poor in the 1999-2000 and 2003-2004 surveys, but the differences were not statistically significant. The general consistency among index approaches suggests that our interpretation of the state's coastal water quality condition in the previous surveys would not have changed, even though we are now using a new index.

A summary of the mean values for the water quality measures assessed by SCECAP is provided for each year by habitat type in Table 3.1.1. Results of analyses of covariance indicate that all six of the primary measures used in the Water Quality Index showed highly significant differences between habitat types, with tidal creeks generally showing higher values for TN, TP, chl-a, fecals and lower values for DO and pH. The greatest differences were noted for fecal coliform bacteria. The differences observed between tidal creek and open water habitats confirm that creeks are likely to be more stressful environments for estuarine biota. Comparison of concentrations of the six primary water quality measures over time indicated that only chl-a concentrations changed significantly, with higher values generally observed during the earlier surveys compared to the most recent survey period in both habitats (Table 3.1.1). This did not correspond to a similar difference in the amount of habitat that had elevated (fair to poor) chl-a concentrations.

An evaluation of the new "Eutrophic Index," which averages the scores of TN, TP and chl-a, appears to show a relationship with average rainfall in the coastal counties (Figure 3.1.4). A similar pattern was also observed in open water habitats, but not in the tidal creek habitats.

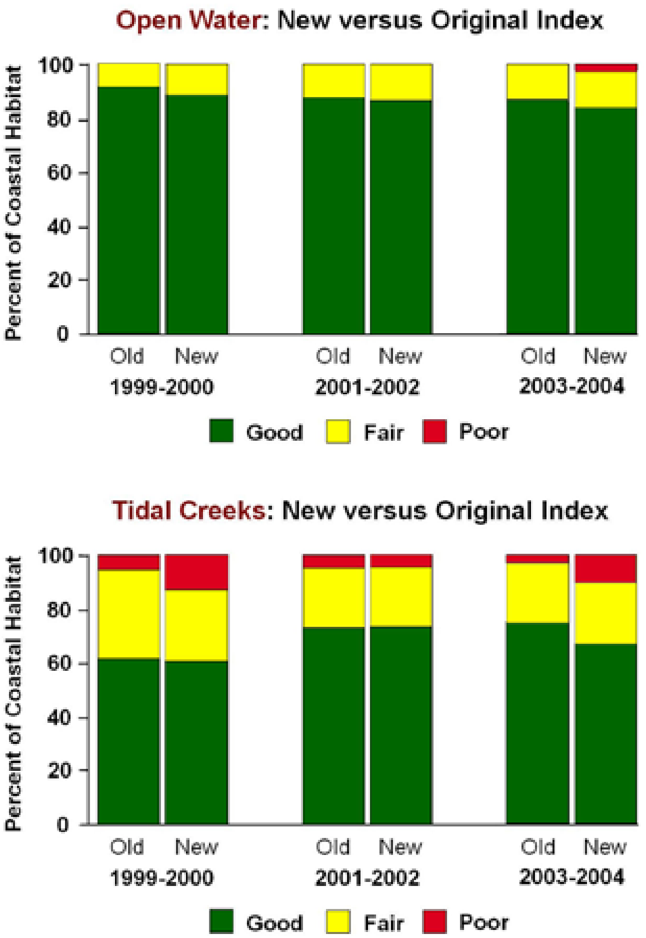

Figure 3.1.3. Comparison of the percent of coastal habitat that coded as good, fair or poor using the original (old) versus revised (new) water quality index.

Among the other water quality measures monitored, only BOD_5, TSS and turbidity values were significantly higher in creeks versus open water habitats (Table 3.1.1). BOD_5 and turbidity values also changed significantly over time in a negative direction, whereas TOC changed significantly over time in a positive direction. In general, the surveys conducted from 2003-2006 had higher concentrations of TOC in both habitats compared to 1999-2002 surveys. Similar increases have not been observed in sediment TOC concentrations, so it is unclear why this apparent trend is being observed. Average rainfall during the survey periods might be expected to have some influence on TOC, but there was no significant correlation between rainfall and TOC for either creek or open water habitats ($p > 0.59$).

The new "Eutrophic Index" appears to show a relationship with average rainfall amongst survey periods in the coastal counties.

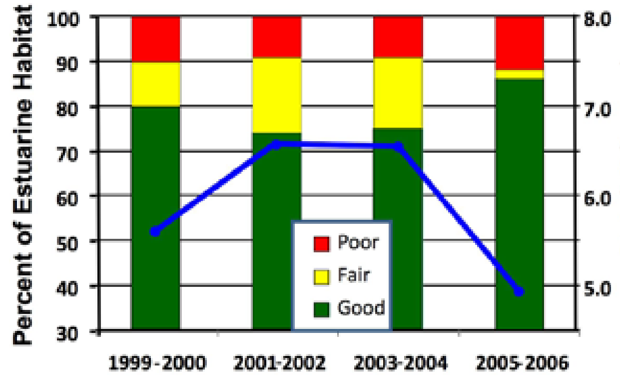

Figure 3.1.4. Comparison of the percentage of overall estuarine habitat with good, fair, or poor Eutrophic Index scores, compared with average rainfall observed during July and August of the survey periods in Beaufort, Colleton, Charleston, and Georgetown Counties. Horry County was not included because only a few stations are located in that county.

The distribution of stations with good, fair, or poor water quality scores is shown in Figure 3.1.5, Appendix 2 and Appendix 3a. Three of the sites with poor water quality were located in the Ashepoo, Combahee, Edisto (ACE) Basin area (RT052109, RT06019, and RO06327) and one was located in the New River (RT052109). A high percentage of the sites considered to be in only fair condition were located in tidal creeks associated with the upper portions of the New River and Port Royal Sound and in both tidal creek and open water habitat in the ACE Basin and Fripp Island areas. The remaining sites were located in tidal creeks of the Wando River, Santee River and North Inlet. There was also one open water site in Winyah Bay that coded as fair. When considered collectively with data from all years sampled to date, portions of the state with a relatively high incidence of fair to poor water quality include the most inland areas of the ACE Basin, the upper Ashley River, the Cape Romain area in or near the Intracoastal Waterway and Winyah Bay (Figure 3.1.6).

Table 3.1.1. Summary of mean water quality measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates those measures included in the Water Quality Index. Statistical p-values identify whether significant differences were observed between habitats and whether a significant change occurred across the eight years; bolded values significant at p < 0.05. na—data not available.

Measure	Habitat	Year 1999	2000	2001	2002	2003	2004	2005	2006	p-values Habitat	p-values Year	Direction of Change
Dissolved Oxygen (mg/L)	Open	4.86	5.01	4.96	5.10	4.97	5.41	5.13	5.11	**<0.001**	0.119	+
	Creek	4.00	4.12	4.45	4.51	4.58	5.10	4.12	4.33			
pH	Open	7.58	7.53	7.67	7.71	7.39	7.75	7.59	7.68	**0.008**	0.708	-
	Creek	7.52	7.43	7.56	7.53	7.31	7.36	7.30	7.48			
Total Nitrogen (mg/L)	Open	0.51	0.58	0.66	0.52	0.84	0.52	0.57	na	**0.004**	0.528	-
	Creek	0.69	0.75	0.72	0.58	0.72	0.64	0.67	na			
Total Phosphorus (mg/L)	Open	0.08	0.06	0.06	0.05	0.06	0.08	0.08	0.07	**0.026**	0.946	-
	Creek	0.09	0.10	0.09	0.06	0.09	0.12	0.08	0.07			
Chlorophyll *a* (ug/L)	Open	10.29	9.08	10.06	10.14	6.86	8.37	7.72	7.44	**0.002**	**0.004**	-
	Creek	12.58	12.54	10.84	9.74	11.59	12.02	8.00	10.11			
Fecal Coliform (col/100mL)	Open	46.52	10.93	14.27	9.20	25.30	16.73	11.68	23.52	**0.008**	0.596	+
	Creek	29.69	54.53	34.58	25.47	73.90	86.53	29.40	64.83			
Temperature (C)	Open	30.20	29.44	29.48	29.10	28.47	29.15	29.96	29.68	0.439	0.917	-
	Creek	30.07	29.79	29.54	29.03	28.96	29.64	29.92	30.18			
Salinity (ppt)	Open	26.2	28.1	28.2	31.0	19.9	28.4	25.9	31.1	0.643	0.594	-
	Creek	31.1	31.5	29.4	32.1	20.8	26.2	23.2	32.3			
BOD_5	Open	2.28	0.92	0.66	0.16	0.00	0.07	0.11	0.10	**0.032**	**<0.001**	-
	Creek	2.63	1.12	0.64	0.62	0.75	0.82	0.49	0.37			
Total Suspended Solids	Open	na	na	28.18	42.03	20.25	21.6	35.26	33.38	**0.016**	0.617	-
	Creek	na	na	52.6	54.15	37.52	38.23	49.82	37.81			
Turbidity	Open	15.81	12.56	16.38	13.49	13.89	10.96	14.50	11.10	**<0.001**	**0.046**	-
	Creek	22.40	19.81	29.47	15.97	25.48	18.46	19.33	14.42			
Total Organic Carbon	Open	3.98	4.10	5.62	4.96	11.57	6.46	8.28	6.55	0.548	**0.003**	+
	Creek	2.61	4.25	5.05	5.77	15.69	9.55	10.00	8.15			
Alkalinity	Open	97.5	96.7	97.6	106.0	75.1	98.8	93.6	107.8	0.475	0.116	-
	Creek	115.6	115.4	108.2	111.8	86.9	100.3	92.9	113.9			

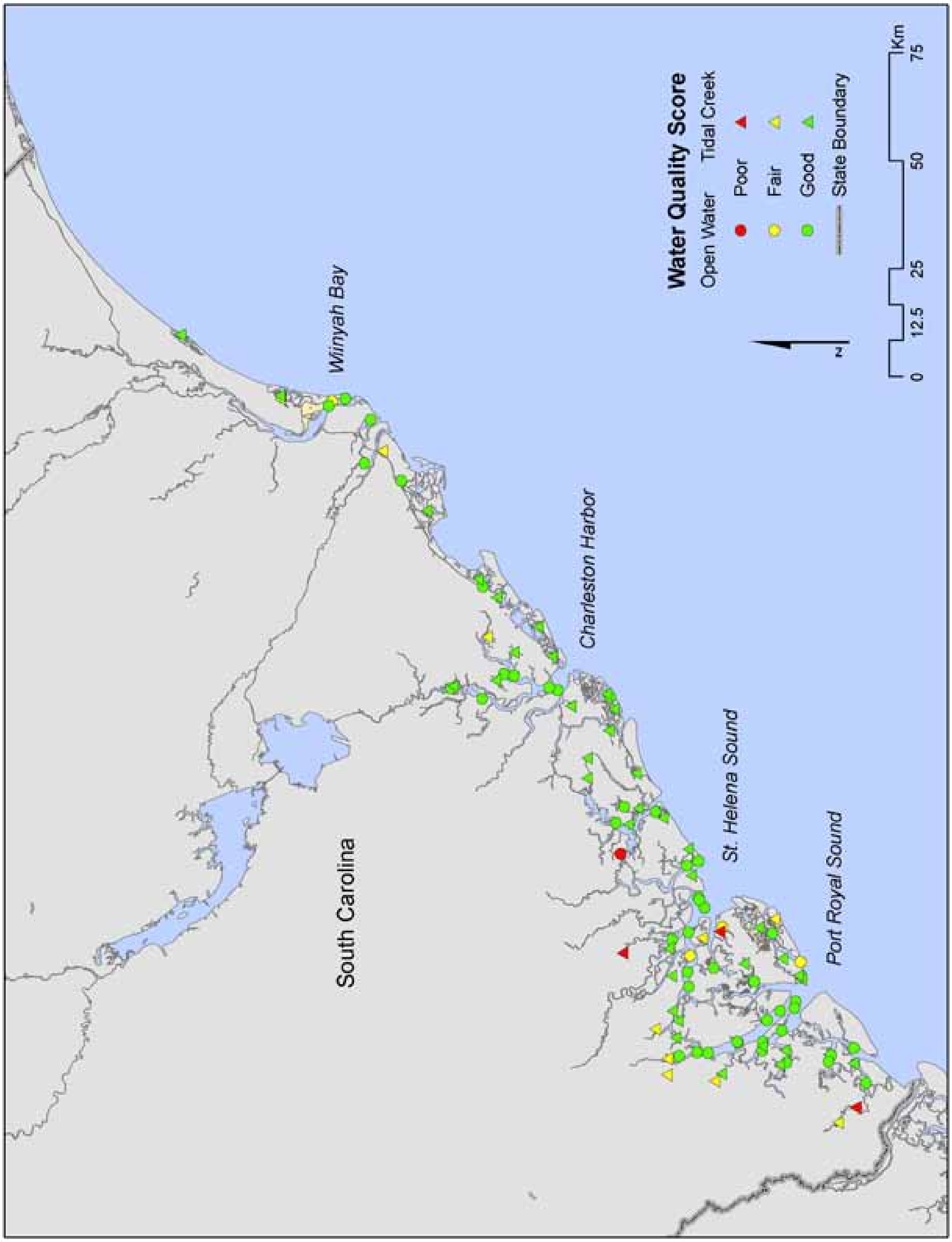

Figure 3.1.5. Distribution of stations having a good, fair, or poor Water Quality Index during the 2005-2006 SCECAP survey period.

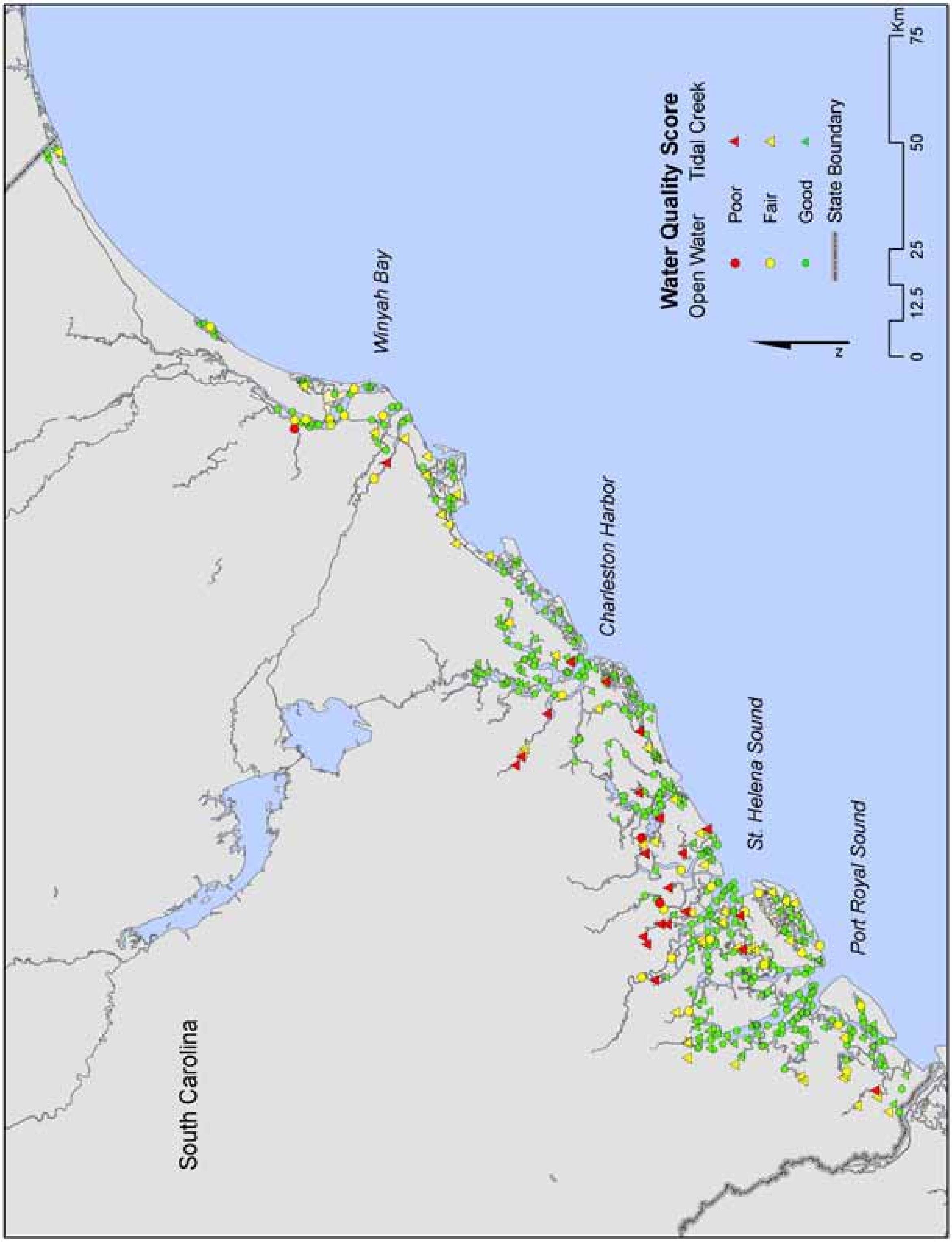

Figure 3.1.6. Distribution of stations having a good, fair, or poor Water Quality Index during the 1999-2006 SCECAP survey period.

3.2 Sediment Quality

Sediments are a critical, and often under-appreciated, component of estuarine ecosystems. They exchange nutrients and gases with overlying water, bind and store contaminants and provide habitat for many of the invertebrates that form the base of the estuarine food web (Gray, 1974; Graf, 1992; Chapman and Wang, 2001). As compared to water, which moves tidally within estuarine systems and mixes with full marine and freshwater sources on short time scales, sediments are more stable. As a result, sediments may integrate impacts such as nutrient runoff or contaminant spills through time providing a history book of local environmental conditions.

Based on the integrated Sediment Quality Index, 84% of South Carolina's open water and 78% of tidal creek habitat had good sediment quality (Figure 3.2.1), with 6% of the open water and 12% of the tidal creek habitat having poor sediment quality. For both habitats, this represents an improvement as compared to conditions during the two previous study periods and a return to conditions more similar to those found during the 1999-2000 period (Figure 3.2.2). This may be related to differences in rainfall in South Carolina's coastal counties between 1999 and 2006. The 1999-2000 and 2005-2006 survey periods had lower rainfall during the summer sampling season than did the 2001-2002 and 2003-2004 sampling seasons (Figure 3.1.4).

The new method for calculating the Sediment Quality Index resulted in similar percentages of habitat scoring as good when compared to the old method (Figure 3.2.3). The most obvious exception to this is the 1999-2000 study period when the new method resulted in additional habitat scoring as good. The greatest change brought about by the new method is additional habitat that had previously scored as fair now scores as poor. This indicates that the new sediment quality score has become somewhat more conservative, primarily by providing better discrimination among fair and poor habitats.

The condition of South Carolina's coastal sediments with respect to each of the three measures comprising the Sediment Quality Index is shown in Figure 3.2.1 and Appendix 2. For ERM-Q, the percent of habitat scoring as good is very similar to the previous two study periods (2001–2002 and 2003–2004) in tidal creek habitats, and better than the previous two study periods in open water habitats (Van Dolah et al., 2002, 2004, 2006). The percent of habitat scoring as good for toxicity and for TOC is higher in both habitats during the current study period than in any previous study period (Van Dolah et al., 2002, 2004, 2006).

Mean values by habitat type and year for the three subcomponents of the integrated Sediment Quality Index are shown in Table 3.2.1. Overall, tidal creek habitats had higher sediment TOC than open water habitats, but average ERM-Q and bioassay score did not differ between habitats. None of the three measures increased or decreased significantly since 1999. However, one apparent trend does stand out: changes in statewide average ERM-Q values in tidal creek and open water habitats were almost perfect mirror images of each other, particularly starting in 2001 (Figure 3.2.4). Furthermore, any change in average ERM-Q between years in tidal creek habitat is reflected one year later in open water habitat (Figure 3.2.4). The reason for this one-year lag is not entirely clear, but it may reflect the entrance of contaminants first into tidal creek habitats which are closer to potential upland sources, followed by the flushing of those contaminants into larger open water bodies the next year.

Two additional measures of sediment quality, mud content (silt & clay) and total ammonia nitrogen (TAN), are also determined by SCECAP, but are not included in the overall Sediment Quality Index. Tidal creek sediments have significantly more silt and clay than open water habitats, but TAN is similar between the two habitats. Mean silt/clay content and TAN concentrations have not increased or decreased significantly since 1999 (Table 3.2.1).

Changes in average ERM-Q between years in tidal creek habitat were apparent one year later in open water habitat. This may reflect the flushing of contaminants through the estuarine system.

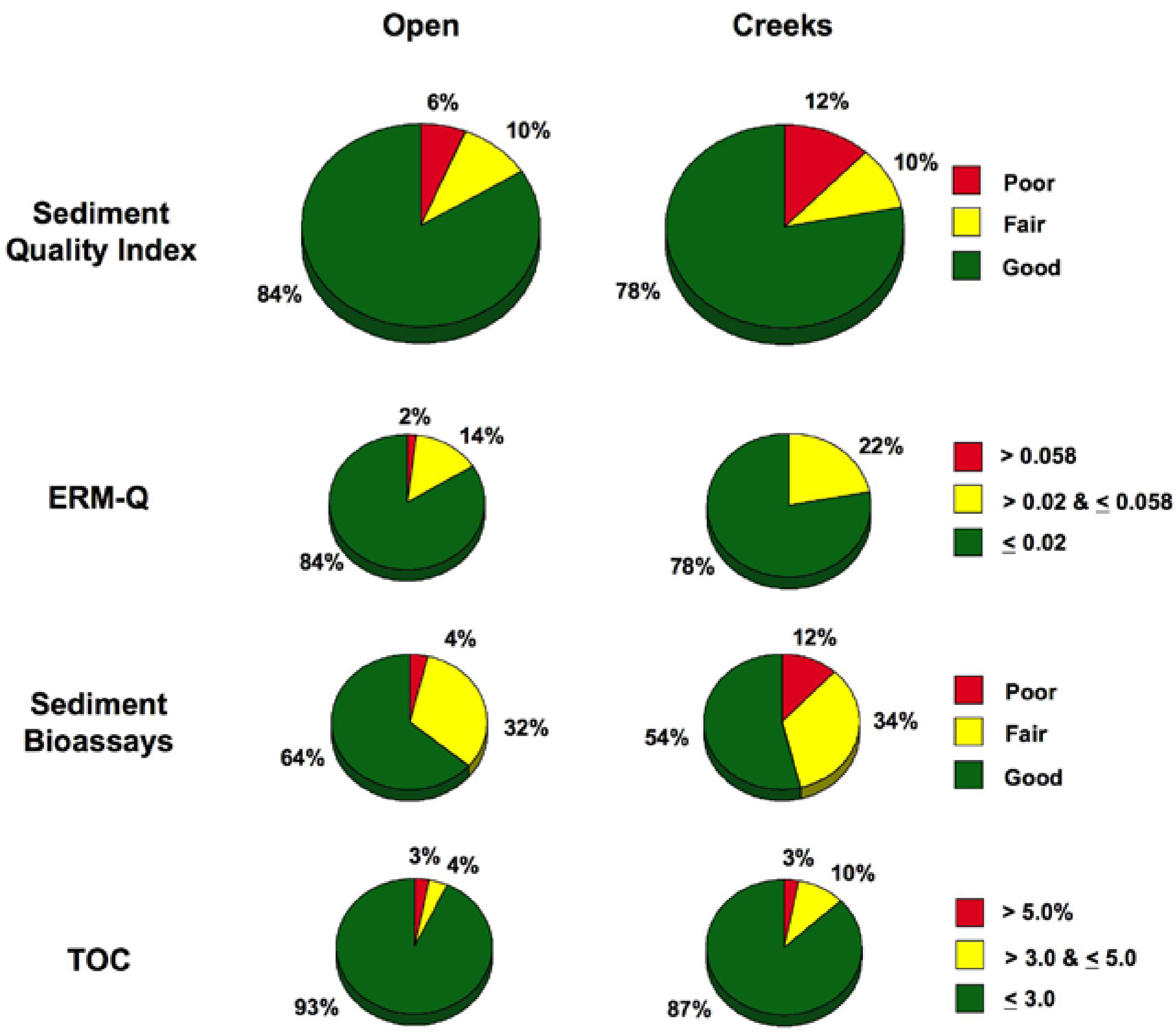

Figure 3.2.1. Percentage of the state's open water and tidal creek habitats that score as good, fair, or poor for the Sediment Quality Index and it's component measures during 2005-2006.

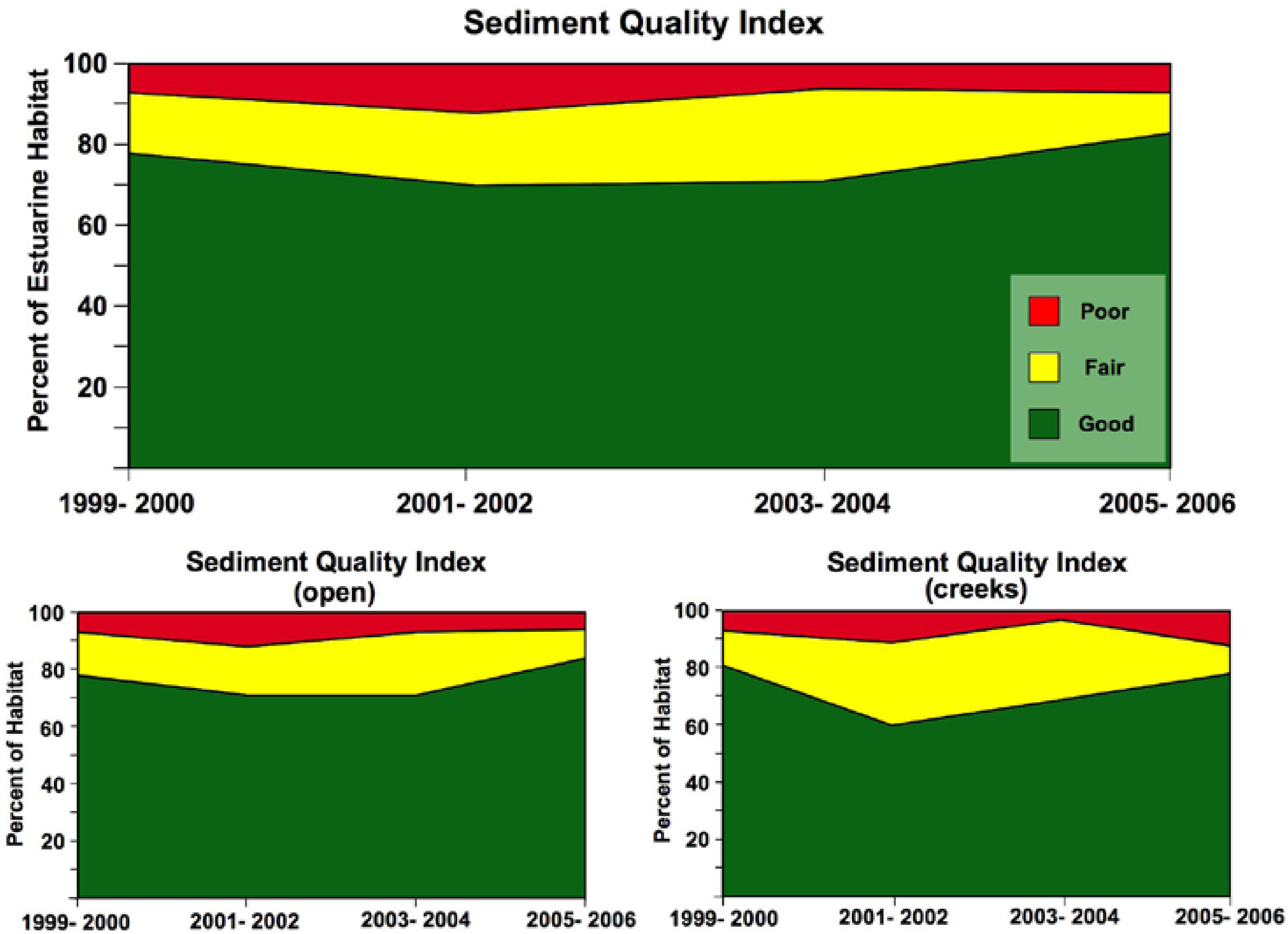

Figure 3.2.2. Sediment Quality Index scores by survey period for all estuarine habitat combined and for tidal creek and open water habitat separately. Revisions in section 2.6 applied to all previous survey periods.

The distribution of stations with good, fair or poor sediment quality scores during the 2005-2006 period is shown in Figure 3.2.5, Appendix 2 and Appendix 3b. The highest concentrations of stations with fair or poor sediment quality are the Santee River complex, Charleston Harbor, the North Edisto and the tributaries of St. Helena Sound. The rather high incidence of stations with fair to poor sediment quality in the North Edisto and St. Helena Sound may be linked to the patterns of degraded water quality, also observed in these areas. When considered collectively with data from all years sampled to date, the persistence of degraded sediment quality becomes apparent in the same areas listed for the current study period, however, Winyah Bay joins that list with a very large proportion of stations with fair to poor sediment quality (Figure 3.2.6).

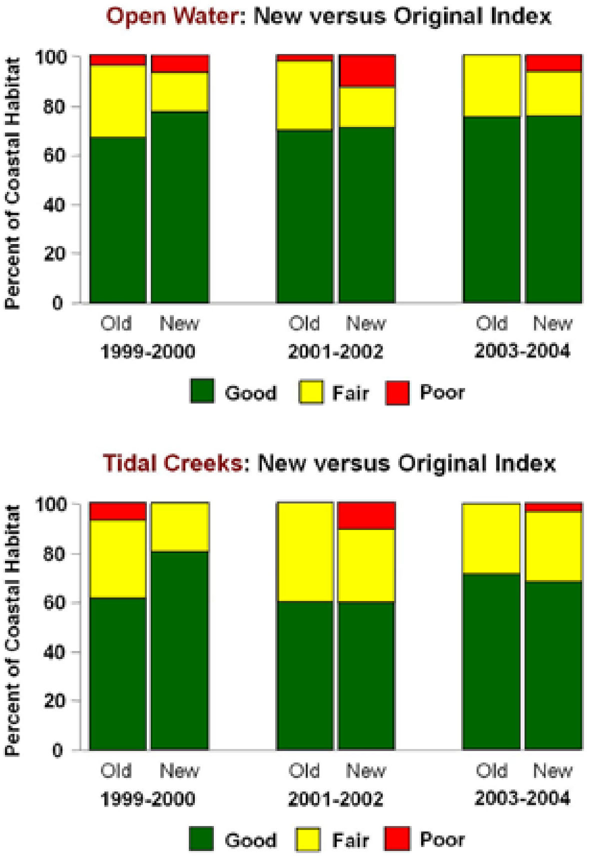

Figure 3.2.3. Comparison of the percent of open water and tidal creek habitats that scored as good, fair, or poor using the original (old) versus revised (new) Sediment Quality Index.

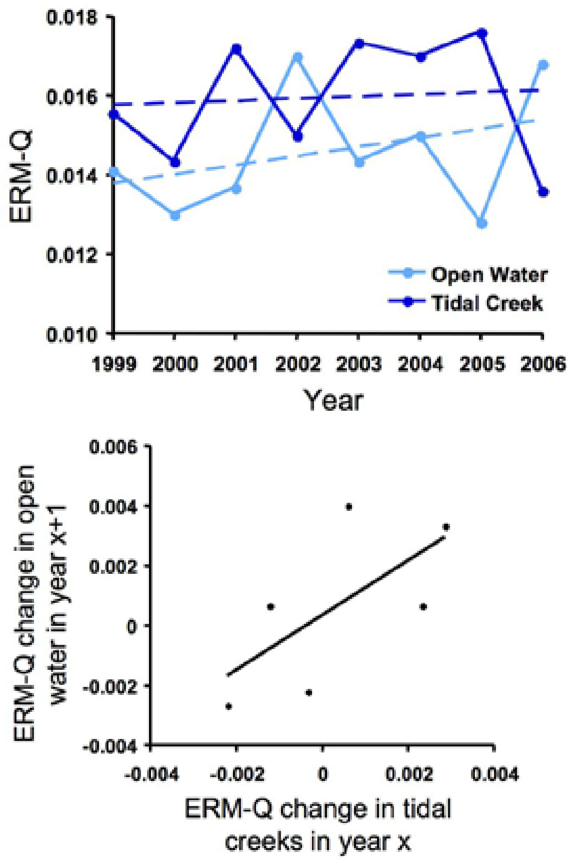

Figure 3.2.4. Mean ERM-Q between 1999 and 2006 for open water and tidal creek habitats and the relationship between the change in ERM-Q in open water and tidal creek habitats in successive years.

Table 3.2.1. Summary of mean sediment quality measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates those measures included in the Sediment Quality Index. Statistical p-values identify whether significant differences were observed between habitats and whether a significant change occurred across the eight years; bolded values significant at $p < 0.05$.

		Year								p-values		Direction of Change
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Habitat**	**Year**	
Total Organic Carbon (%)	Open	0.86	0.63	0.94	0.84	0.74	0.88	0.70	0.77	**<0.001**	0.761	-
	Creek	1.08	1.33	1.30	1.39	1.30	1.12	1.48	1.03			
ERM-Q	Open	0.013	0.013	0.013	0.017	0.014	0.015	0.013	0.017	0.147	0.278	+
	Creek	0.015	0.014	0.017	0.015	0.018	0.016	0.018	0.013			
Sediment Bioassays	Open	0.48	0.67	0.70	0.70	0.53	0.70	0.60	0.20	0.236	0.267	-
	Creek	0.52	0.67	1.16	0.70	0.70	0.70	0.84	0.32			
Silt & Clay (%)	Open	22.3	15.2	23.0	20.5	15.4	24.2	17.7	17.9	**<0.001**	0.341	-
	Creek	32.0	31.8	30.3	30.9	34.3	26.0	37.4	21.0			
Total Ammonia Nitrogen	Open	2.62	2.95	2.46	3.46	2.93	4.07	1.91	2.12	0.710	0.181	-
	Creek	2.79	3.09	3.64	2.68	4.60	2.38	2.31	2.16			

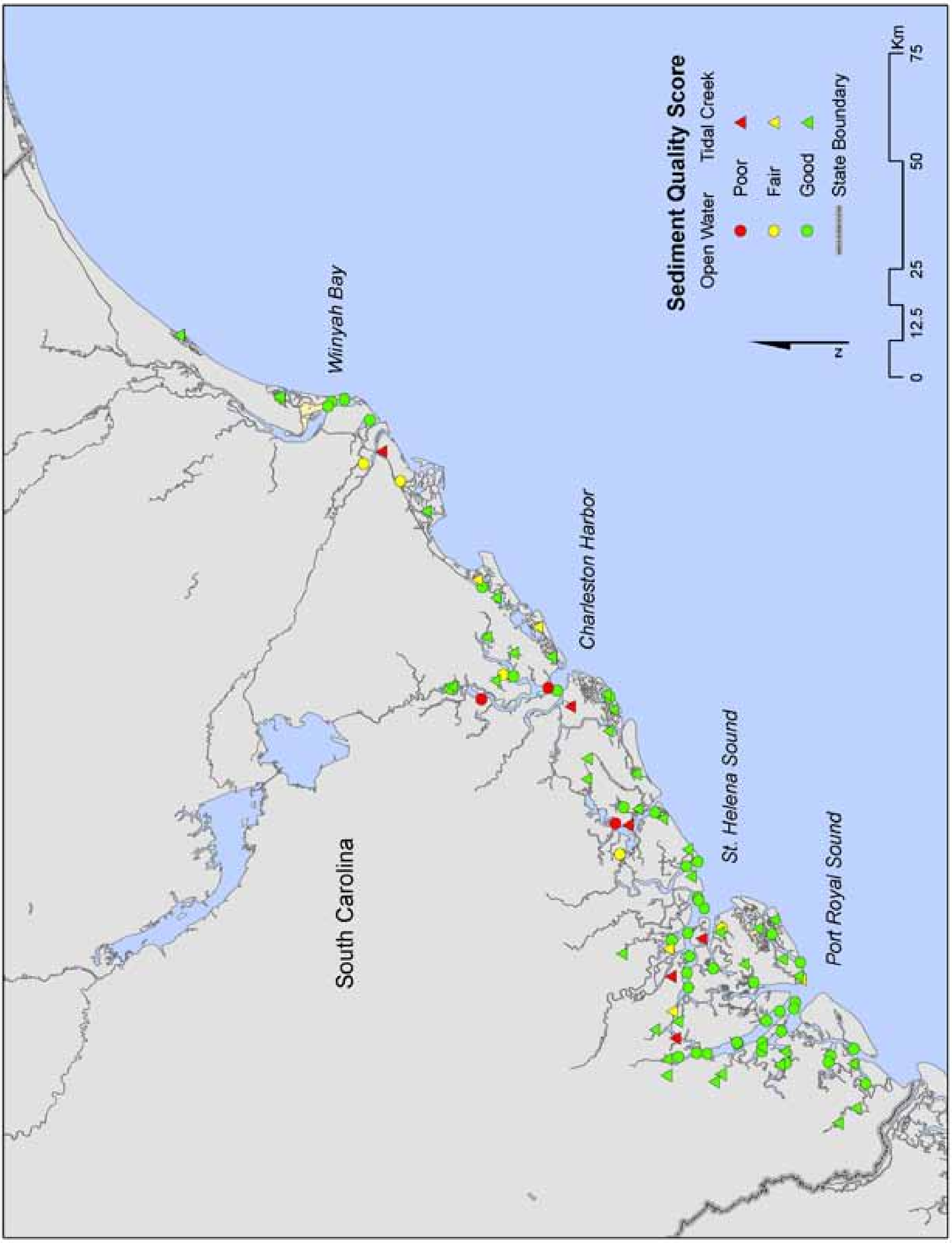

Figure 3.2.5. Distribution of stations having good, fair, or poor scores for the Sediment Quality Index during the 2005-2006 survey period.

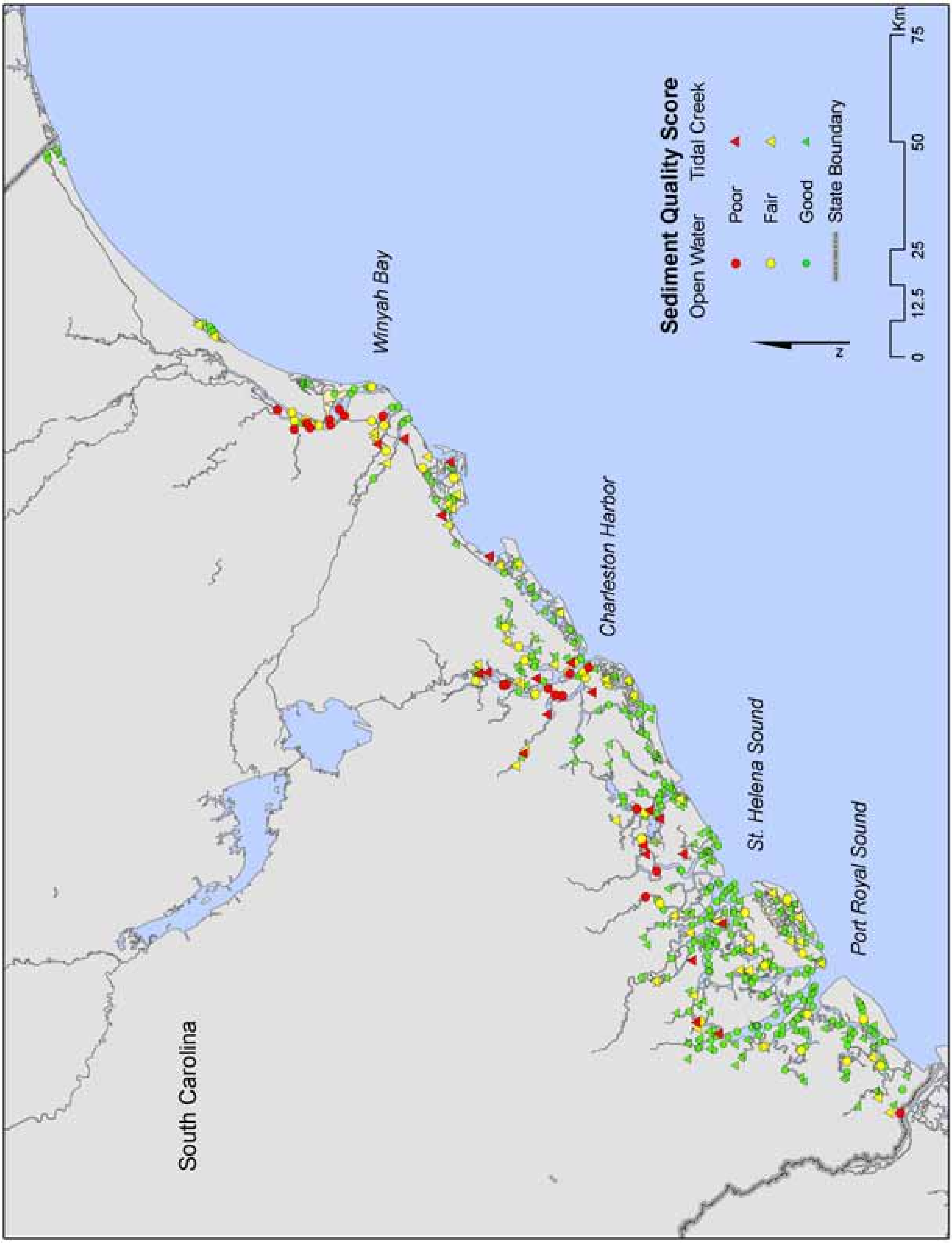

Figure 3.2.6. Distribution of stations having good, fair, or poor scores for the Sediment Quality Index during the 1999-2006 SCECAP survey period.

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 finfish, shrimp and crabs. Benthic macrofauna are also relatively sedentary, and many species are sensitive to changing environmental conditions. As a result, those 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).

Using the Benthic Index of Biotic Integrity (B-IBI), about 84% of South Carolina's open water and 73% of tidal creek habitat supported benthic communities indicative of undegraded (good) environmental conditions (Figure 3.3.1). For open water habitats, this is similar to conditions found between 1999 and 2002 and a distinct improvement as compared to conditions during the 2003-2004 period (Figure 3.3.2). For tidal creek habitats, this is similar to the amount of habitat scoring as good since 2001, but is still much lower than during the 1999-2000 survey period. Average B-IBI scores have not changed significantly in either habitat since monitoring started in 1999 (Table 3.3.1).

Evaluation of bottom dwelling fauna indicates 84% of open water and 73% of tidal creek habitat is in good biological condition.

The B-IBI provides a convenient, broad index of benthic community condition, but because this index combines four measures into a single value, it does not provide much detailed information on community composition. 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') are typically lower in

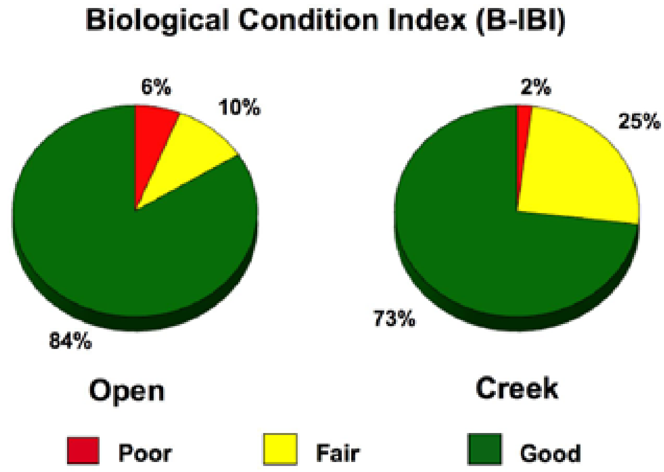

Figure 3.3.1. Percentage of the state's open water and tidal creek habitats that score as good, fair, or poor for the B-IBI during 2005-2006.

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 all SCECAP data collected since 1999, open water habitats tended to have significantly higher values than tidal creeks for all of these measures (Table 3.3.1). This likely reflects a combination of factors including the naturally more stressful conditions of shallower tidal creeks, the closer proximity of tidal creeks to upland development, and the greater influence of high diversity marine communities on open water habitats. While three of these four measures (total faunal density, species richness, and species diversity) decreased in South Carolina's coastal environment since 1999, the changes were not statistically significant in either tidal creek or open water habitat.

Using published literature, species 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 supported significantly higher densities and percentages of sensitive fauna than tidal creek habitats (Table 3.3.1). Sensitive species measures did not change significantly since 1999 (Table 3.3.1).

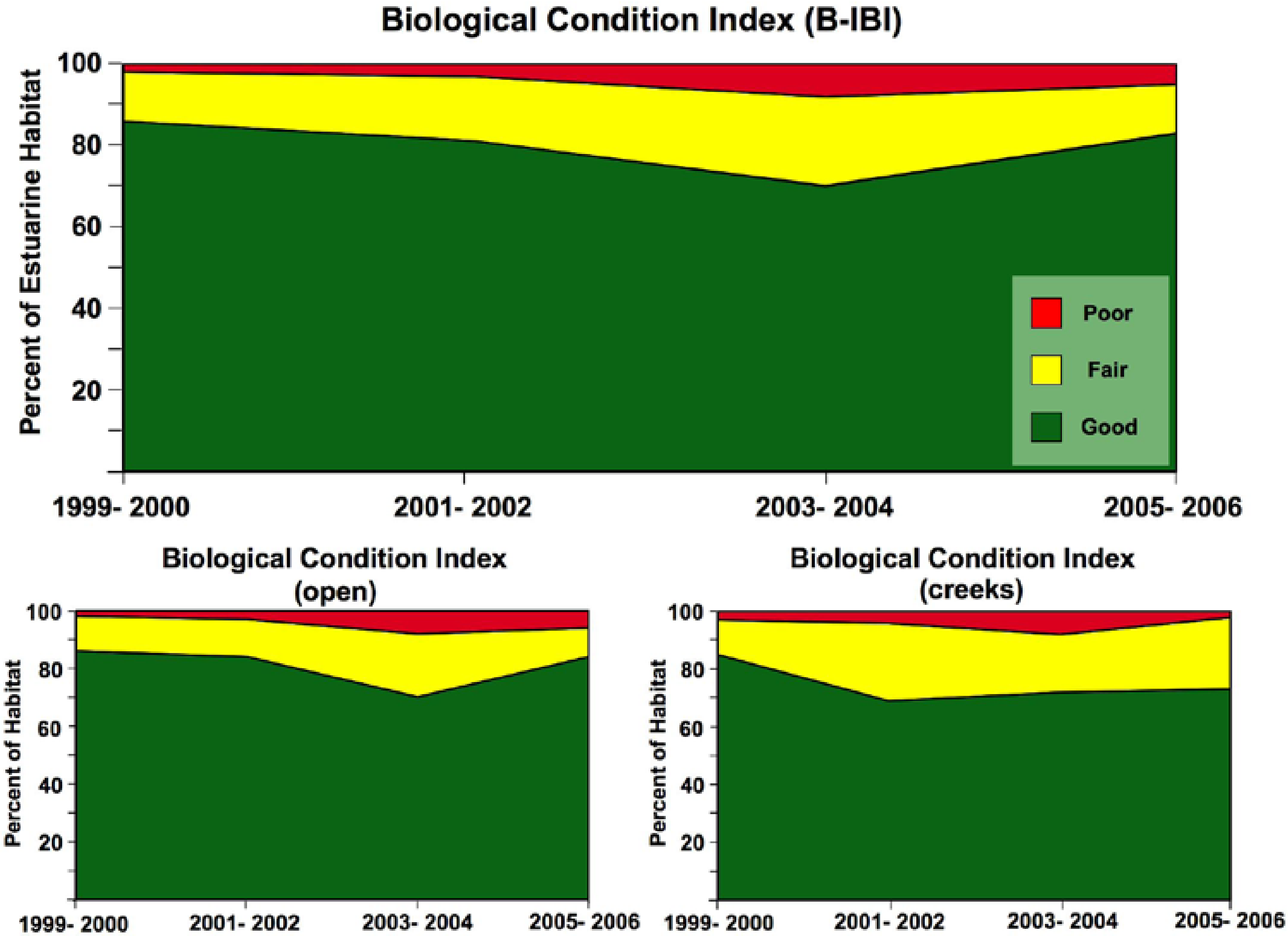

Figure 3.3.2. B-IBI by survey period for all estuarine habitat combined and for tidal creek and open water habitat separately.

Larger taxonomic groups, such as amphipods, molluscs 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 with amphipods and molluscs becoming increasingly more abundant in sandy 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 being higher in open water habitats and the proportion of polychaetes being higher in tidal creek habitats (Table 3.3.1). Since 1999, a slight and non-significant replacement of polychaetes by amphipods and molluscs has been occurring. Whether this trend will continue into the future is uncertain.

The distribution of stations with good, fair or poor B-IBI scores during the 2005-2006 period is shown in Figure 3.3.3, Appendix 2 and Appendix 3c. The highest concentrations of stations with fair or poor B-IBI scores were many of the same locations with degraded water and/or sediment quality: Charleston Harbor, the North Edisto and the tributaries of St. Helena Sound. When considered collectively with data from all years sampled to date, this pattern is confirmed.

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. Statistical p-values identify whether significant differences were observed between habitats and whether a significant change occurred across the eight years; bolded values significant at $p < 0.05$.

		Year								p-values		Direction
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Habitat**	**Year**	**of Change**
B-IBI	Open	3.51	3.73	3.55	3.88	3.48	3.55	3.72	3.50	**0.006**	0.470	-
	Creek	3.24	3.68	3.36	3.37	3.03	3.25	3.04	3.50			
Overall Density	Open	5356	6295	4095	7385	4236	4127	5263	4510	**0.035**	0.574	-
	Creek	2363	4660	4710	4859	3200	2953	2282	5060			
Number of Species	Open	26.0	22.2	17.5	26.8	18.9	18.7	21.0	19.0	**0.032**	0.391	-
	Creek	14.8	19.8	17.5	20.0	14.4	16.0	12.0	22.2			
Species Evenness (J')	Open	0.76	0.70	0.72	0.73	0.73	0.74	0.74	0.77	0.055	0.427	+
	Creek	0.72	0.69	0.71	0.70	0.73	0.72	0.75	0.67			
Species Diversity (H')	Open	3.30	2.81	2.74	3.18	2.67	2.84	2.94	2.99	**0.011**	0.336	-
	Creek	2.60	2.85	2.78	2.74	2.35	2.64	2.41	2.75			
Sensitive Taxa Density	Open	649	1668	615	1045	854	547	519	383	**0.050**	0.199	-
	Creek	313	572	694	528	465	260	338	705			
Percent Sensitive Taxa	Open	15.0	26.7	18.2	15.5	16.3	23.6	19.4	17.6	**0.001**	0.779	+
	Creek	9.8	16.2	10.7	6.5	10.3	8.4	13.3	13.6			
Amphipod Density	Open	416	927	243	954	648	375	341	283	**0.050**	0.627	+
	Creek	113	347	193	248	331	176	346	560			
Mollusc Density	Open	214	258	243	441	302	193	141	207	0.079	0.270	+
	Creek	123	265	193	208	144	91	34	283			
Other Taxa Density	Open	716	837	808	1059	766	605	925	686	**0.030**	0.681	-
	Creek	309	749	924	602	878	525	423	780			
Polychaete Density	Open	2622	3761	2740	4167	2298	1611	2772	1844	0.546	0.296	-
	Creek	1788	2818	2849	3397	1844	2129	1479	3421			
Percent Amphipods	Open	10.9	18.6	13.0	12.8	18.1	35.4	14.0	12.8	**0.004**	0.301	+
	Creek	6.1	11.8	5.0	6.7	8.7	4.0	13.4	12.1			
Percent Molluscs	Open	5.9	7.9	10.0	8.1	7.7	15.9	2.8	10.9	**0.016**	0.766	+
	Creek	3.5	6.0	5.2	5.4	4.6	4.0	1.9	5.6			
Percent Other Taxa	Open	26.7	19.2	16.6	2.1	21.9	42.4	23.2	25.4	0.886	0.622	+
	Creek	21.6	24.4	20.8	15.0	30.8	18.0	25.8	17.4			
Percent Polychaetes	Open	56.4	54.3	60.4	44.3	52.4	41.8	58.0	51.0	**0.005**	0.486	-
	Creek	68.8	57.8	69.0	63.4	52.6	72.6	59.0	64.9			

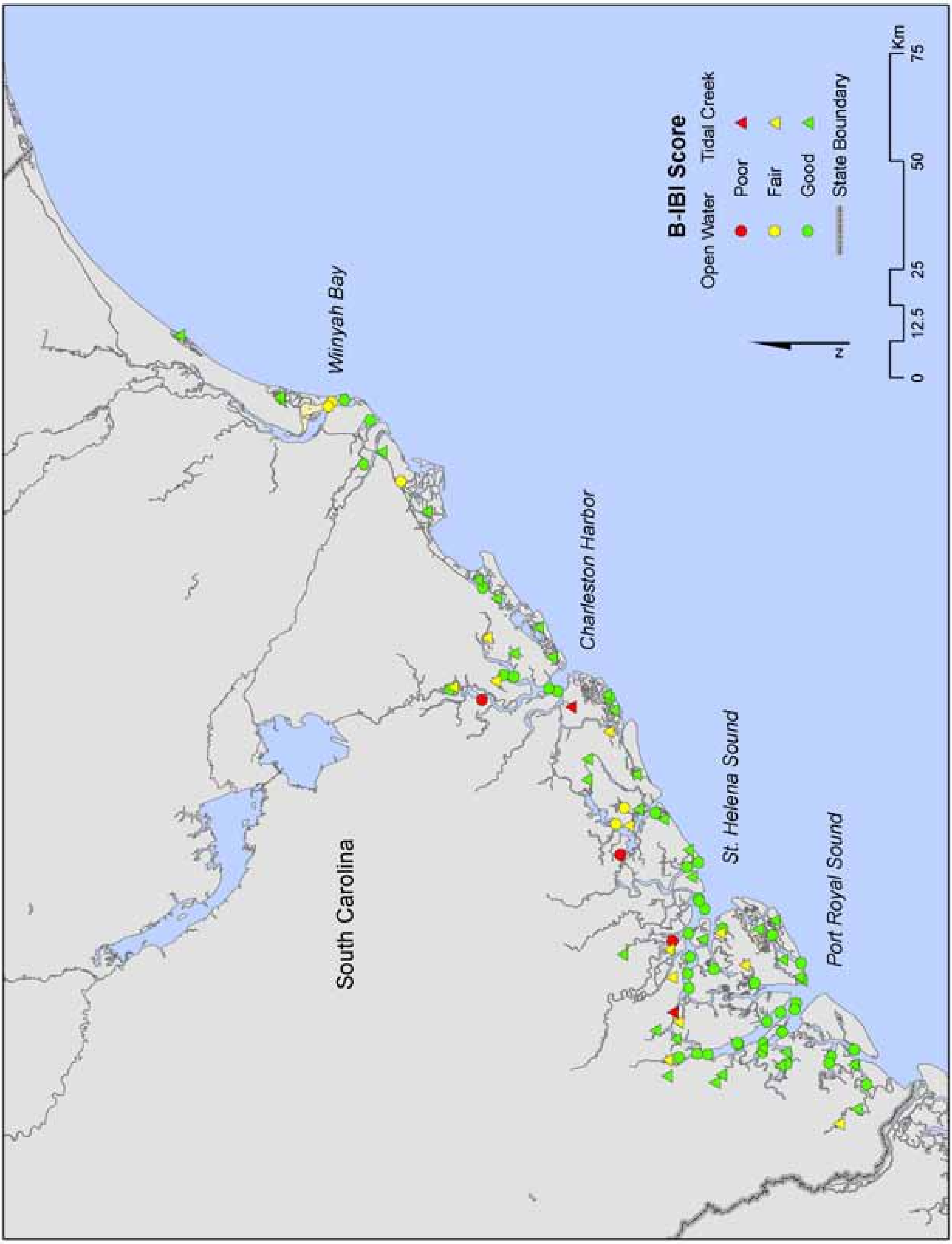

Figure 3.3.3. Distribution of stations having good, fair, or poor scores for the B-IBI during the 2005-2006 SCECAP survey period.

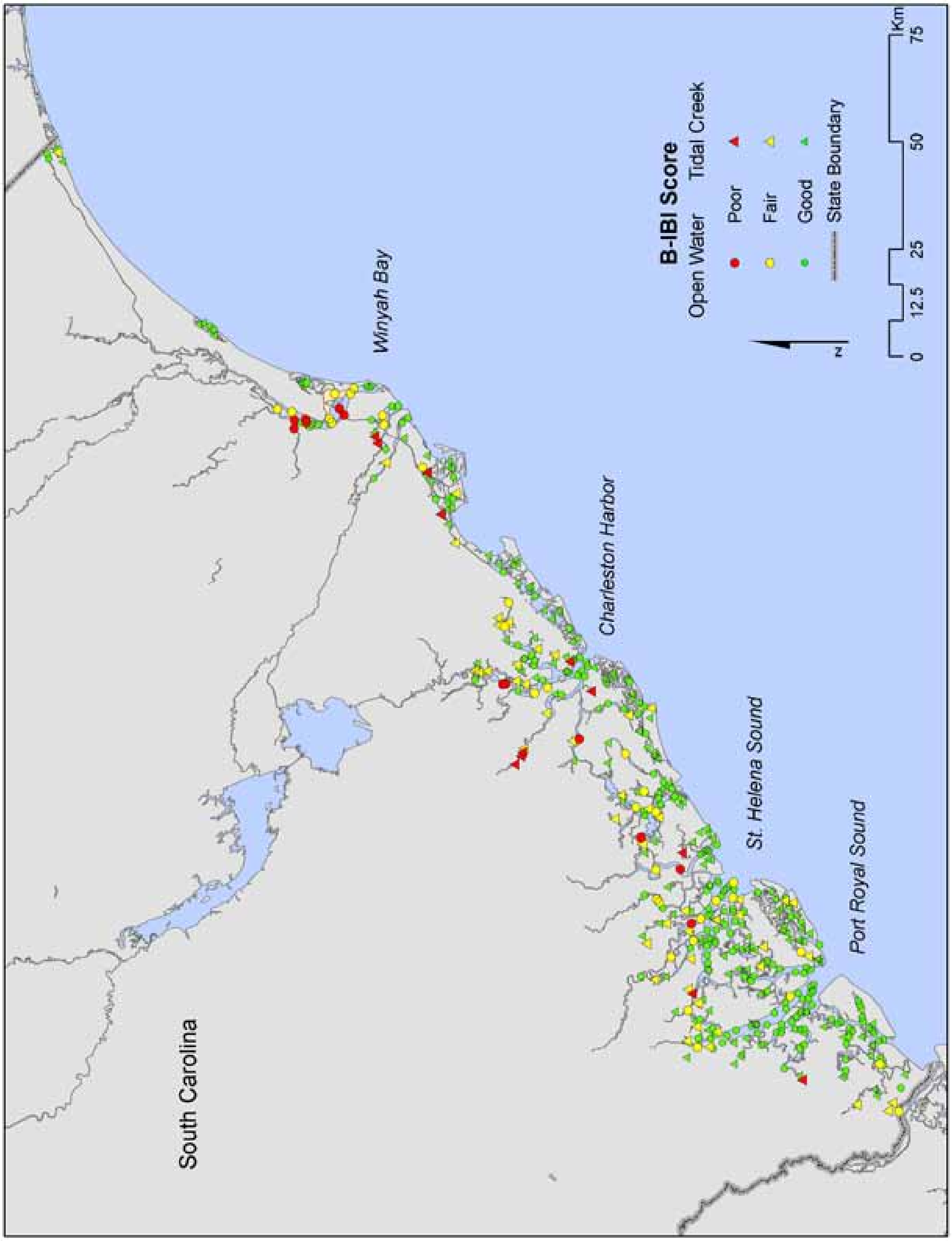

Figure 3.3.4. Distribution of stations having good, fair, or poor scores for the B-IBI during the 1999-2006 SCECAP survey period.

Winyah Bay, Charleston Harbor, the North Edisto River and more inland creeks that drain into St. Helena Sound and Port Royal Sound hosted the most stations with degraded B-IBI scores (Figure 3.3.4). Care should be exercised when interpreting these scores in shallower tidal creeks, however, as the B-IBI was largely derived from and is most accurate in larger water bodies.

Finfish and Large Invertebrate Communities:

South Carolina's estuaries provide food, habitat and nursery grounds for diverse communities of fish and larger epibenthic and pelagic invertebrates (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 invertebrate and fish species.

Broad community measures, such as average densities and numbers of species of fish, decapods (crabs, shrimp, etc.) and all fauna, were significantly higher in tidal creek habitats compared to open water habitats (Table 3.3.2). This likely reflects the importance of shallower creek habitats as nursery habitat for many of these species. Inter-annual variation dominated these measures and resulted in no significant or consistent changes over the eight years analyzed (Table 3.3.2).

SCECAP provides a fishery-independent assessment of several of South Carolina's commercially and recreationally-important fish and crustacean species. Of these species, the most common 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 (*Farfantepenaeus aztecus*). Except for spadefish, densities of all eight species differed significantly between open water and tidal creek habitats. All of these species, with the exception of weakfish and Atlantic croaker, were more abundant in tidal creek habitats (Table 3.3.2). Only brown shrimp showed evidence of a significant change between 1999 and 2006, during which their densities increased on average (Table 3.3.2).

Because average values are susceptible to inflation by unusually large observations, the lowest 10th percentile within each habitat during each year was also examined. The 10th percentiles show the same pattern of higher densities and species numbers in tidal creeks than in open water (Table 3.3.3). However, the 10th percentile of every measure has been decreasing through time with overall fauna density and, to a lesser extent, number of species decreasing significantly (Table 3.3.3), perhaps suggesting that marginal habitats are becoming less favorable. The difference between the temporal trends seen in the average values versus the 10th percentiles also illustrates the influence that unusually large numbers of some species caught at individual locations can have on an assessment of estuarine fish and invertebrate trends.

Phytoplankton Community:

Phytoplankton (algae) are pivotal to aquatic communities because they form the base of coastal food webs as well as produce the majority of water-dissolved oxygen via photosynthesis. Phytoplankton are sensitive to fluctuations in a wide range of environmental parameters and may form blooms in coastal South Carolina waters during spring/summer and occasionally during early autumn. Algal blooms can have a positive effect on an ecosystem by providing energy to higher trophic levels. A subset of taxa categorized as 'harmful', however, may form harmful algal blooms (HABs) that have the potential to cause a wide range of negative effects related to human health (e.g., shellfish poisoning or respiratory problems), ecosystem condition (e.g., fish kills) and the economy (e.g., declines in tourism or aquaculture revenue). HAB species include representatives from all phytoplankton taxa, and both the causes and effects of HABs are species-specific. Given the sensitivity of algal blooms to environmental fluctuations and the potential for deleterious events to occur, monitoring algal communities in South Carolina tidal creeks and open waterways is important for evaluating the health of these systems.

Table 3.3.2. Summary of mean finfish and large invertebrate biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Statistical p-values identify whether significant differences were observed between habitats and whether a significant change occurred across the eight years; bolded values significant at p < 0.05.

		Year								p-values		Direction
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Habitat**	**Year**	**of Change**
Overall Density	Open	329	325	389	557	325	453	381	461	**<0.001**	0.538	+
	Creek	831	676	698	881	759	1174	738	581			
No. Species	Open	7.8	7.6	8.0	9.2	7.2	8.4	8.2	8.0	**0.019**	0.920	+
	Creek	8.6	9.7	8.2	9.5	8.4	9.5	9.3	8.1			
Vertebrate Density	Open	123	195	202	252	127	158	195	226	**0.001**	0.713	-
	Creek	314	255	319	273	291	327	308	171			
No. Vertebrate Species	Open	5.2	4.9	5.7	6.5	5.1	5.9	5.6	5.9	0.054	0.457	+
	Creek	5.8	6.6	5.7	6.6	5.8	6.3	6.2	5.7			
Decapod Density	Open	89	97	171	248	137	211	166	221	**<0.001**	0.230	+
	Creek	476	259	346	536	429	657	385	394			
No. Decapod Species	Open	1.7	1.8	1.7	2.0	1.5	1.6	1.8	1.4	**0.006**	0.612	-
	Creek	2.0	2.2	1.8	2.0	2.0	2.4	2.4	1.7			
Spot Density	Open	7	18	43	27	23	13	57	30	**0.008**	0.866	+
	Creek	72	51	112	39	71	61	106	24			
Croaker Density	Open	3	13	37	56	27	25	27	28	**0.014**	0.995	*
	Creek	9	8	16	18	12	6	6	1			
Weakfish Density	Open	12	24	16	30	3	20	11	7	**0.020**	0.126	-
	Creek	14	6	4	12	3	3	8	2			
White Perch Density	Open	13	9	6	6	5	2	6	9	**<0.001**	0.149	-
	Creek	81	60	32	43	31	35	29	60			
Spadefish Density	Open	5	1	1	1	1	4	6	2	0.066	0.295	+
	Creek	4	3	3	8	1	10	6	6			
Blue Crab Density	Open	2	8	1	1	3	3	3	6	**0.024**	0.955	-
	Creek	4	11	5	5	11	15	13	9			
Brown Shrimp Density	Open	8	42	78	69	51	34	46	36	**<0.001**	**0.046**	+
	Creek	59	69	97	108	67	128	65	41			
White Shrimp Density	Open	77	42	56	166	78	173	111	177	**0.003**	0.132	+
	Creek	339	157	238	374	348	654	208	341			

*-Croaker densities changed significantly differently between tidal creek and open water habitats (ie. interaction term in ANCOVA was significant).

Table 3.3.3. Summary of the lowest 10th percentile of the finfish and large invertebrate biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Statistical p-values identify whether significant differences were observed between habitats and whether a significant change occurred across the eight years; bolded values significant at $p < 0.05$. Those measures appearing in Table 3.2.2 but not appearing here generally had 10th percentiles of zero.

Measure	Habitat	Year 1999	2000	2001	2002	2003	2004	2005	2006	p-values Habitat	p-values Year	Direction of Change
Overall Density	Open	47	48	39	28	21	32	36	12	**<0.001**	**0.005**	-
	Creek	214	78	171	149	159	214	133	93			
No. Species	Open	3.0	2.9	4.0	3.9	2.0	3.0	3.4	2.0	**0.008**	0.087	-
	Creek	5.0	5.9	4.0	3.0	4.9	3.9	4.4	3.4			
Vertebrate Density	Open	7	14	24	17	7	7	29	5	**<0.001**	0.164	-
	Creek	72	43	51	39	36	43	28	28			
No. Vertebrate Species	Open	1.0	1.9	2.6	1.9	1.0	1.9	1.8	1.0	**0.017**	0.227	-
	Creek	3.0	2.9	2.0	2.0	2.9	2.0	2.0	2.0			
Decapod Density	Open	0	0	0	0	0	0	1	0	**<0.001**	0.390	-
	Creek	25	7	3	12	14	20	3	2			
No. Decapod Species	Open	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	**<0.001**	0.536	-
	Creek	1.0	0.9	0.4	0.8	1.0	1.0	0.4	0.4			

Using CHEMTAX (Mackey et al., 1996; section 2.4), the phytoplankton community was divided into three categories based on pigment composition: diatoms, mixed flagellates and harmful taxa. Diatoms are typically most abundant in South Carolina estuaries during the spring, and they support efficient food webs (Lewitus et al., 1998). To date, toxin-producing diatom species have not been found in South Carolina estuarine systems. The mixed flagellate assemblage includes the major taxonomic groups Prasinophyceae, Chlorophyceae, Haptophyceae and Chrysophyceae. For the purposes of the current study the third group, harmful taxa, is composed of certain species of Dinophyceae, Cyanophyceae and Raphidophyceae, since these groups include species that can potentially produce toxins and harm other biota in estuarine systems. The following qualifiers must be noted:

a) Most phytoplankton communities contain a mixture of "non-harmful" and "harmful" species, but it is the relative proportion of each species that influences whether a harmful event may occur. The proportion of "harmful" vs. "non-harmful" species will vary seasonally such that diatoms are more prevalent during spring/fall whereas flagellates tend to be relatively more abundant during summer.

b) Categorization of phytoplankton as "non-harmful" or "harmful" is an overgeneralization because each taxonomic group contains species representing a range of harmful and non-harmful species.

c) Data presented in this study have greatest value for evaluating long-term trends in phytoplankton communities and determining whether particular water bodies are becoming more susceptible to HAB events over time.

During the 2005-2006 study period, diatom pigment biomass did not differ much between the open water and tidal creek sites, representing 48% and 47% of total algal biomass, respectively (Figure 3.3.5). The same is true for the harmful taxa, which contributed to 11% and 9%, respectively, of the total biomass. Compared to the historical data (in the 2001-2002 and 2003-2004 SCECAP reports), incidences of harmful taxa have decreased and the relative contribution of diatoms has remained steady, indicating an increase in the relative proportion of pigments characteristic of the mixed flagellate group (Table 3.3.4).

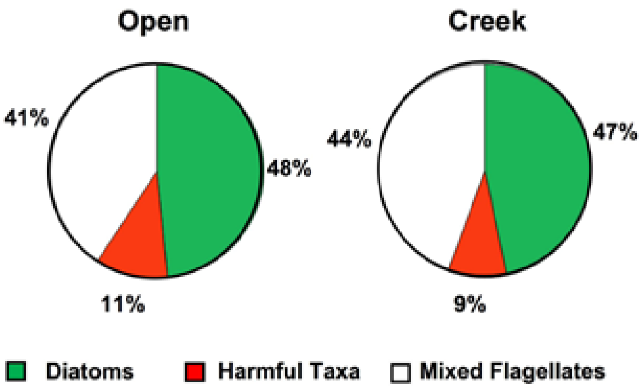

Figure 3.3.5. Percent of algal biomass represented by diatoms, mixed flagellates, and harmful taxa in open water and tidal creek habitats during the 2005-2006 SCECAP survey period.

Table 3.3.4. Percent of algal biomass represented by diatoms, mixed flagellates, and harmful taxa in open water and tidal creek habitats during each survey period between 1999 and 2006.

Phytoplankton		Survey Period		
Group	Habitat	2001-2002	2003-2004	2005-2006
Diatoms	Open	38	48	48
	Creek	48	41	47
Mixed Flagellates	Open	38	39	41
	Creek	33	45	44
Harmful Taxa	Open	24	13	11
	Creek	19	14	9

Although the already low percent contribution of harmful taxa to total algal biomass decreased in open water sites during the study period, seven sites (RO056092, RO056094, RO056098, RO056110, RO06308, RO06310, RO06326) had > 20% of the algal biomass attributed to potentially harmful taxa dominated by either cyanobacteria (three sites) or dinoflagellates (four sites). Two of the above mentioned sites (RO056098 and RO056110) exhibited raphidophyte biomass < 5% of total algal pigment biomass. The relative proportion of diatom biomass was low at all seven sites mentioned above. At four tidal creek sites (RT05209, RT05210, RT05220, RT06001), the relative contribution of potentially harmful taxa was > 20%. At three of these sites (RT05209, RT05210, RT05220), the potentially harmful taxa were mainly dinoflagellates and raphidophytes. Cyanobacteria pigments were not detected at these three sites, however, at RT06001, cyanobacteria were the dominant group of potentially harmful taxa representing 18% of the 27% harmful taxa contribution. As in the open water sites with high relative biomass of potentially harmful taxa, the biomass contribution of diatoms was low.

3.4 Incidence of Litter

The presence of litter, considered by SCECAP to be any solid waste product from plastic shopping bags and water bottles to derelict crab traps and watercraft, in South Carolina's waterways is an common consequence of human use of the coastal zone. Litter is not only an eyesore, but it also represents a wide range of threats to marine and estuarine ecosystems. For example, plastic grocery bags and fishing line can entangle and kill birds, fish and wildlife, and non-biodegradeable materials adrift in the ocean can help spread invasive species. During the 2005-2006 study period, litter was visible in 24% of the state's tidal creek and 14% of the open water habitat. While these percentages tend to be highly variable through time, these are the highest values documented since SCECAP started in 1999.

3.5 Overall Habitat Quality

Using the revised Habitat Quality Index for the 2005-2006 assessment period, 82% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition. Only 4% of the coastal estuarine habitat was considered to be in poor condition and 14% in fair condition. When the two habitats were considered separately, a greater percentage of tidal creek habitat was in fair to poor condition (26% fair, 2% poor) as compared to open water habitats (12% fair, 4% poor) in the 2005-2006 survey (Figure 3.5.1). Appendix 2 shows scores for Habitat Quality Index at each station sampled in 2005 and 2006. When the revised scoring process is applied to the previous survey data, current conditions represent a slight improvement as compared to the 2003-2004 period and similar to the 1999-2002 period (Figure 3.5.2), but the

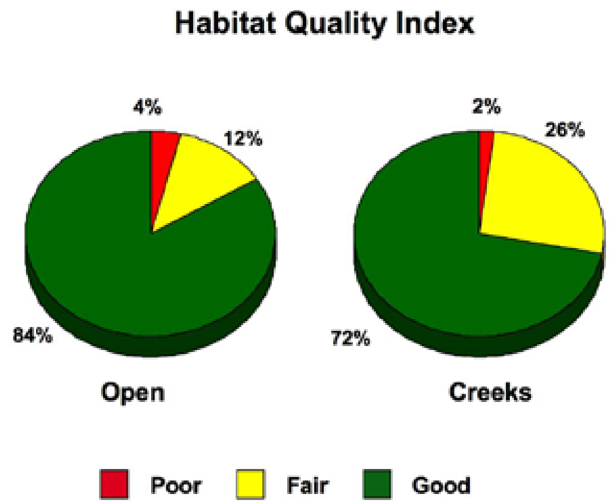

Figure 3.5.1. Percentage of the state's open water and tidal creek habitats that score as good, fair, or poor for the integrated Habitat Quality Index during 2005-2006.

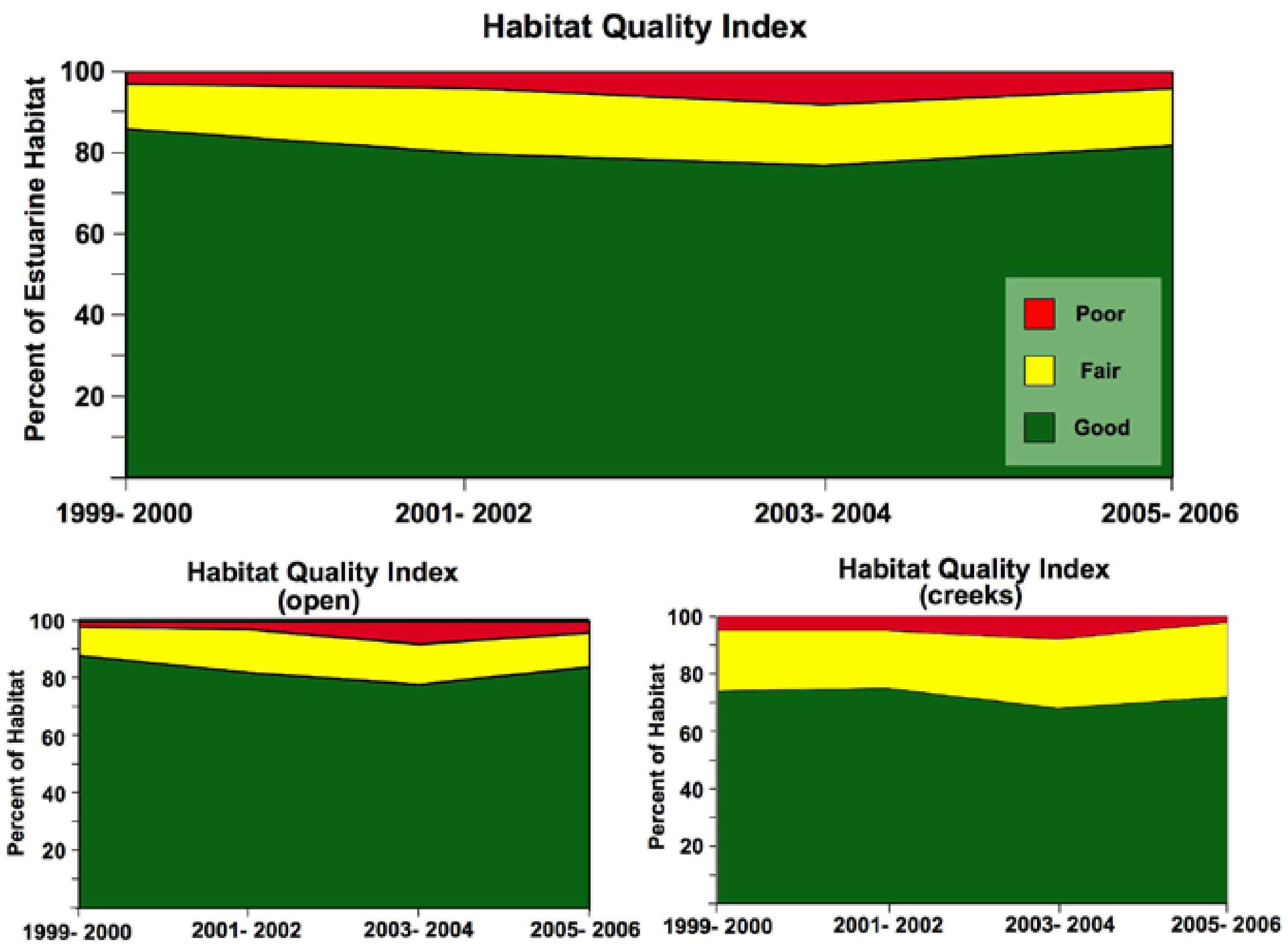

Figure 3.5.2. Habitat Quality Index scores by survey period for all estuarine habitat combined and for tidal creek and open water habitat separately. Revisions in section 2.6 applied to all previous survey periods.

differences were not statistically significant. The small change between the 2003-2004 survey period and the current survey period could reflect the decrease in rainfall and the concurrent change in the Water Quality Index that occurred.

The new method for calculating the integrated Habitat Quality Index resulted in a very slight decrease in the amount of habitat that scored as good for both tidal creek and open water habitats (Figure 3.5.3). The most apparent change was that more habitat previously scoring as fair, now scores as poor. This change was driven by the changes made to the scoring process, component measures, and thresholds of the sediment and water quality indices and the measures that comprise them. One of the goals in modifying the scoring process (in particular, changing poor = 1 to poor = 0) was to make the indices more conservative by providing extra weight to poor scores thus increasing the ability to detect potentially degraded areas. Comparison of the amount of habitat scoring as good, fair, or poor using the old and new calculation methods indicates that this goal was met while not producing unrealistically large changes or invalidating interpretation of the results from previous surveys (Van Dolah et al., 2002, 2004, 2006).

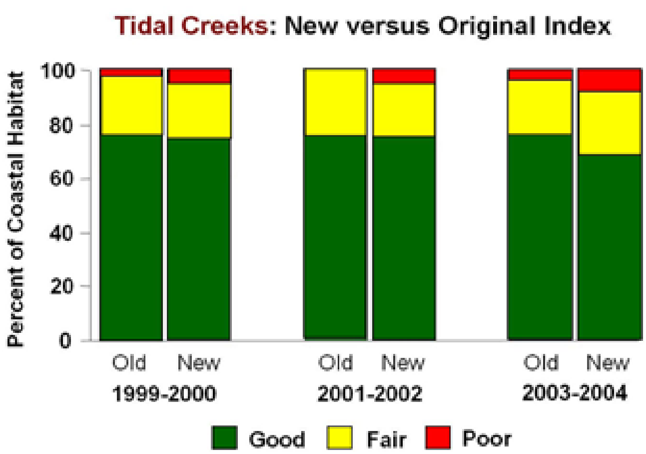

Figure 3.5.3. Comparison of the percent of open water and tidal creek habitats that scored as good, fair, or poor using the original (old) versus revised (new) Habitat Quality Index.

During the 2005-2006 study period, SCECAP stations with fair or poor habitat quality were concentrated primarily in Charleston Harbor, the Dawho River and associated areas of the Intracoastal Waterway, and the upper creeks that drain into St. Helena Sound (Figure 3.5.4, Appendix 2 and Appendix 3d). When combined with the previous six years of data, these same areas as well as Winyah Bay and the Santee delta region show a persistent pattern of degraded habitat quality (Figure 3.5.5). Winyah Bay and Charleston Harbor both have a history of industrial activity and/or high-density urban development that likely contributes 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, are not clear but are currently under study by the SCDNR.

Areas of degraded habitat quality are concentrated in the historically industrialized estuaries of Winyah Bay and Charleston Harbor and, surprisingly, in the Santee delta, parts of Cape Romain, and portions of the ACE Basin.

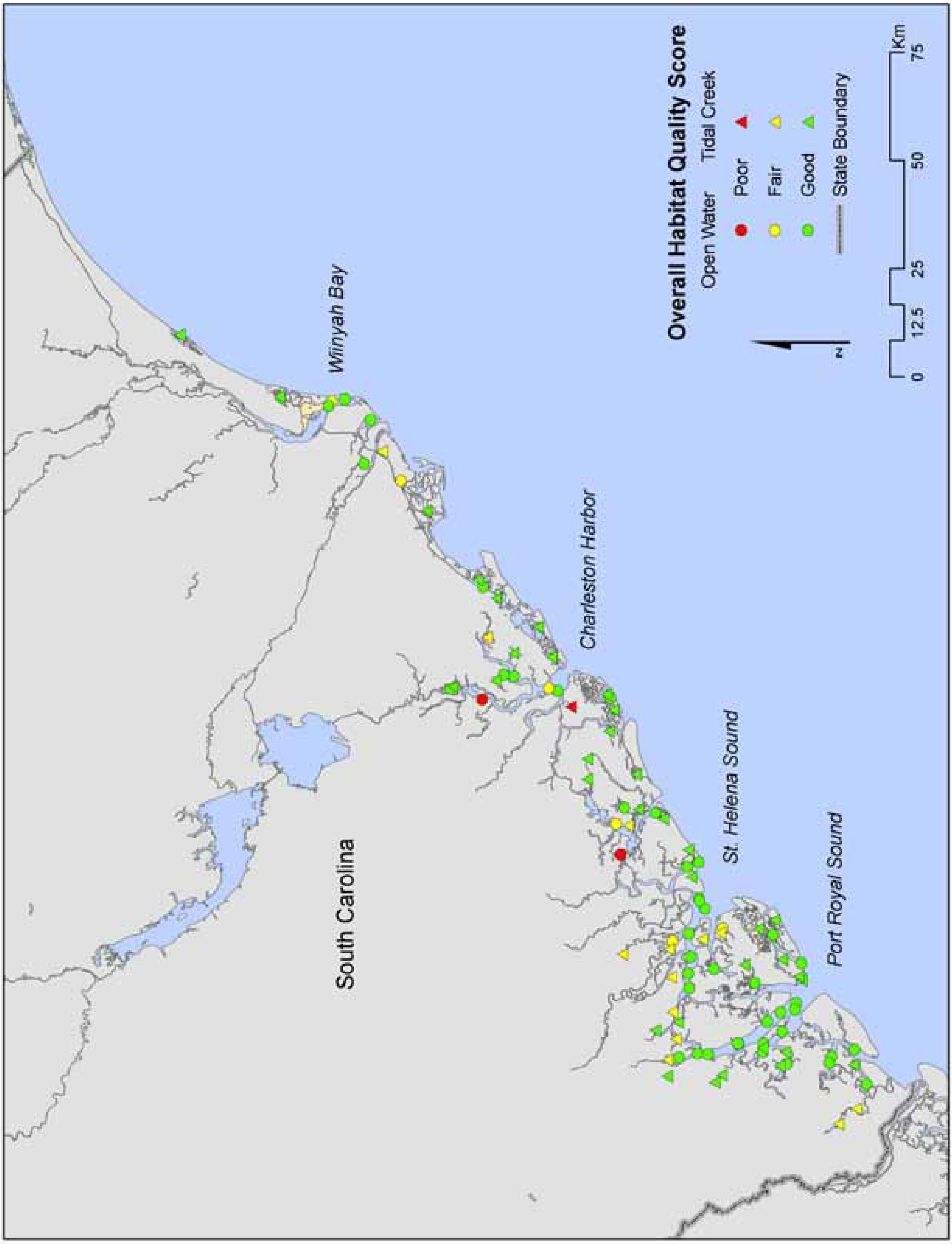

Figure 3.5.4. Distribution of stations having good, fair, or poor scores for the Habitat Quality Index during the 2005-2006 survey period.

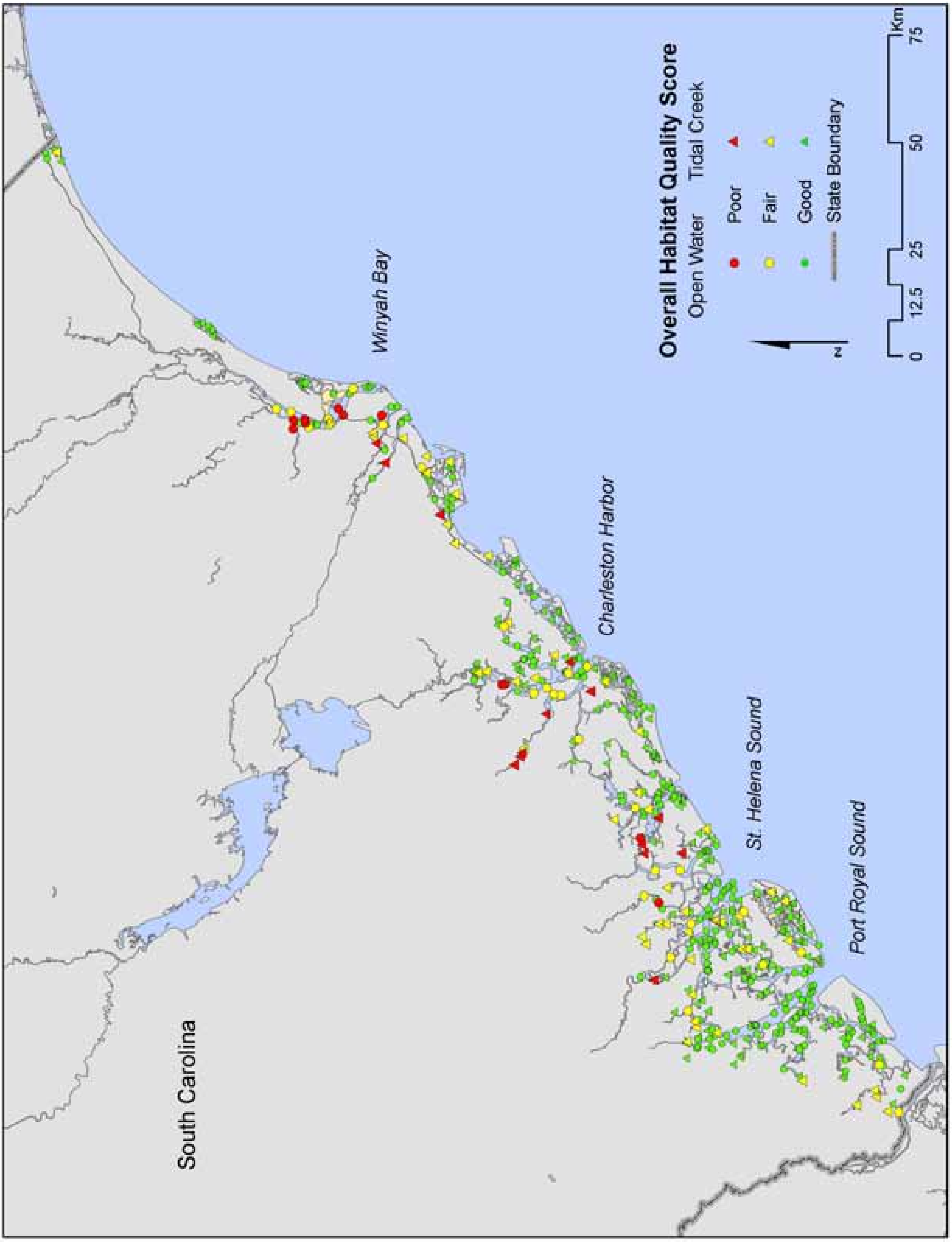

Figure 3.5.5. Distribution of stations having good, fair, or poor scores for the Habitat Quality Index during the 1999-2006 SCECAP survey period.

The Habitat Quality Index synthesizes detailed information on water quality, sediment quality and biological condition. Although it may be convenient to use only a single measure to assess the health of estuarine systems, significant information may be lost. Table 3.5.1 shows the level of agreement between the Habitat Quality Index and each of the indices used to calculate it. Overall, the component indices produce the same score (good, fair, or poor) as the Habitat Quality Index for 80% or less of the stations examined since 1999. For those stations scoring as good for the Habitat Quality Index, the component indices are typically accurate almost 90% of the time. However, for stations with fair to poor habitat scores, the component indices do not accurately predict degradation in the integrated Habitat Quality Index.

Table 3.5.1. Percent of stations surveyed between 1999 and 2006 in which the Water Quality, Sediment Quality, or Biological Condition Index had the same score (good, fair, or poor) as the Habitat Quality Index.

		Index Score Compared to Habitat Quality Index Score		
Score	**Stations**	**Water Quality**	**Sediment Quality**	**Biological Condition**
All	462	78%	80%	80%
Good	357	90%	87%	90%
Fair	57	40%	49%	49%
Poor	48	33%	69%	42%

3.6 Future Program Activities

SCECAP has continued to be an effective collaboration between the SCDNR, SCDHEC, NOAA and the USEPA 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. In the past two years, SCECAP data have been used to examine the impact of land use patterns on water quality (Van Dolah et al., 2007) and biological resources (Van Dolah, unpubl. data), effects on oyster genomics (Chapman), evaluation and status of contamination in North Inlet and Winyah Bay, SC (Ogburn, USC), baseline contaminant concentrations (Wendt, SCDNR), fisheries management (Byrd, SCDNR), invasive species (Knott, SCDNR), oyster resources (Shervette, USC), harmful algal species and phytoplankton communities (Wilde, USC/SCDNR), water quality (Shuford, SCDNR, Van Den Hurk) and trophic transfer of contaminants to marine mammals (Laska/Adams/Schwacke, NOAA) and diamondback terrapin turtles (Blanvillian et al., 2007).

Two currently funded projects emerged directly from issues detected through past SCECAP sampling. One is focused on the potential sources of degraded water quality in the ACE Basin evidently due to nutrient enrichment. The cause of degraded water quality in the area is uncertain, but may be due to a combination of local agricultural practices, abundant waterfowl impoundments, or some other land use. SCDNR researchers are in the second year of a three year assessment of nutrient concentrations and nutrient sources in the ACE Basin. The second project involves utilizing the random array of SCECAP stations for 2008 and 2009 to help evaluate the abundance and distribution of spot and Atlantic croaker in South Carolina's estuaries. Trawl samples and basic water quality measures are being collected during both the spring and summer at all 60 of the 2008 and 2009 SCECAP stations to evaluate the juvenile populations of these two species.

With increasing grassroots attention focusing on issues of coastal urbanization, the user-friendly format of SCECAP also has proven increasingly helpful to local governments and community groups. Beaufort's Friends of the River have used SCECAP assessments to develop a "Report Card" for the Port Royal Sound area and help target areas and resources in greatest need of potential regulatory or restoration activities. A partnership between the Town of Bluffton and the Palmetto Bluff development is using SCECAP and other data to determine whether rapid development in the area poses a risk to the May River system.

As with many programs, the funding for SCECAP has come from state and federal sources. While current funding levels will not allow the program to maintain the 60 stations per year sampling rate as in past years, at least 30 stations are planned for the survey periods that began in 2007.

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Appendix 1. Summary of station locations and dates sampled in 2005 and 2006. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2005
Station Information -- Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO056091	Open	32.65402	80.24790	8.5	7/27/2009	Charleston	NDV	Wadmalaw River south of Meggett
RO056092	Open	32.88686	79.87643	1.5	8/4/2009	Berkeley	R>1	Beresford Creek NE of Wando/Cooper River confluence
RO056093	Open	32.57146	80.22095	4.6	7/27/2009	Charleston	NDV	Ocella Creek northwest of Townsends River
RO056094	Open	33.23833	79.19239	4.0	8/17/2009	Georgetown	NDV	Winyah Bay south of Pumpkinseed Island
RO056095	Open	32.50086	80.57638	2.1	7/20/2009	Beaufort	R>1	Coosaw River west of mouth of Bull River
RO056096	Open	32.32822	80.52306	3.7	8/3/2009	Beaufort	NDV	Story River northeast of Trenchards Inlet confluence
RO056097	Open	32.40047	80.79176	10.0	7/14/2009	Beaufort	R<1	Broad River north of SC 170
RO056098	Open	33.17299	79.34725	4.0	8/17/2009	Georgetown	NDV	North Santee River southeast of North Santee
RO056099	Open	32.43274	80.50748	2.0	7/21/2009	Beaufort	R>1	Village Creek northeast of St. Helena Island
RO056100	Open	33.09634	79.39247	0.9	8/17/2009	Charleston	NDV	Casino Creek east of McClellanville
RO056101	Open	32.50566	80.61729	5.5	7/20/2009	Beaufort	R>1	Coosaw River west of mouth of Bull River
RO056102	Open	32.15794	80.80637	8.0	6/30/2009	Beaufort	R>1	Calibogue Sound west of Hilton Head Island
RO056103	Open	32.48664	80.81559	5.8	7/13/2009	Beaufort	R>1	Broad River west of Cotton Island
RO056104	Open	32.30936	80.76254	10.7	6/29/2009	Beaufort	NDV	Chechessee River southeast of SC 170 near Daws Island
RO056105	Open	32.36655	80.64191	5.5	8/3/2009	Beaufort	R<1	Cowen Creek east of Port Royal
RO056106	Open	32.29963	80.84103	8.0	6/29/2009	Beaufort	R<1	Colleton River northeast of Bluffton
RO056107	Open	32.35050	80.81168	4.0	7/14/2009	Beaufort	R<1	Chechessee River near Spring Island
RO056108	Open	32.28010	80.69114	8.8	6/29/2009	Beaufort	R>1	Port Royal Sound southeast of Davis Island
RO056109	Open	32.34846	80.79033	5.5	7/14/2009	Beaufort	NDV	Cut between Chechessee and Broad Rivers near Daws Island
RO056110	Open	33.24511	79.20297	7.5	8/17/2009	Georgetown	NDV	Winyah Bay south of Pumpkinseed Island
RO056111	Open	32.48276	80.34334	10.1	7/28/2009	Colleton	R<1	South Edisto River at mouth to St. Helena Sound
RO056112	Open	32.99827	79.91013	4.6	8/4/2009	Charleston	I<1	Cooper River south of US 17 near Hog Island Shore
RO056113	Open	32.46965	80.45835	9.8	7/21/2009	Beaufort	NDV	St. Helena Sound northeast of Morgan River confluence
RO056114	Open	32.66459	79.93485	6.7	8/10/2009	Charleston	R<1	Folly River northeast of Folly Island
RO056115	Open	32.48310	80.43246	3.0	7/21/2009	Colleton	NDV	St. Helena Sound southwest of mouth of Ashepoo 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 2005
Station Information -- Tidal Creeks

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT052093	Creek	32.54076	80.62601	1.8	7/20/2009	Beaufort	NDV	South Winbee Creek north of Beaufort
RT052094	Creek	32.93901	79.63921	3.4	8/11/2009	Charleston	NDV	Unnamed creek to Sewee Bay west of Bull's Bay
RT052095	Creek	32.60793	80.21160	5.2	7/27/2009	Charleston	R>1	Adams Creek west of Rockville
RT052096	Creek	32.32364	80.48735	0.5	8/3/2009	Beaufort	I<1	Unnamed creek from Fripp Island to Old House Creek
RT052097	Creek	32.43623	80.86791	3.0	7/14/2009	Jasper	R<1	Euhaw Creek northwest of Bolin Hall Landing
RT052098	Creek	32.74710	79.95673	3.0	8/10/2009	Charleston	R>1	James Island Creek north of White Hall Plantation
RT052099	Creek	32.62918	80.25188	1.5	7/27/2009	Charleston	R<1	Creek near Leadenwah Creek northwest of Rockville
RT052100	Creek	32.86558	79.82256	4.0	8/10/2009	Charleston	R<1	Boone Hall Creek northwest of US 17 and SC 41
RT052104	Creek	32.26831	80.63504	1.8	8/3/2009	Beaufort	R<1	Creek to Morse Island Creek east of Port Royal Sound
RT052105	Creek	32.50414	80.31255	2.4	7/28/2009	Colleton	R>1	Scott Creek near Edisto Beach State Park
RT052106	Creek	32.16005	80.84331	4.9	6/30/2009	Beaufort	NDV	Creek to Cooper River west of Hilton Head
RT052109	Creek	32.15387	80.95190	5.8	6/30/2009	Jasper	NDV	New River west of Page Island
RT052110	Creek	33.55408	79.01981	2.0	8/18/2009	Georgetown	R<1	Main Creek south of Whale Creek
RT052112	Creek	32.66878	80.01811	4.6	8/10/2009	Charleston	R<1	Abbapoola Creek southwest of mouth of Stono River
RT052113	Creek	32.47612	80.53353	3.5	7/21/2009	Beaufort	NDV	Parrot Creek between Coosaw and Morgan River
RT052115	Creek	32.53800	80.71291	2.0	7/20/2009	Beaufort	R<1	Creek to Whale Branch east of US 21
RT052116	Creek	32.90408	79.88995	1.5	8/4/2009	Berkeley	R<1	Martin Creek northeast of Wando and Cooper River
RT052118	Creek	32.71365	80.08588	1.0	7/28/2009	Charleston	R<1	Church Creek southeast of SC 700 Bridge
RT052119	Creek	32.54919	80.83080	2.7	7/13/2009	Beaufort	NDV	Haulover Creek southwest of Sheldon
RT052197	Creek	32.54987	80.87104	2.4	7/13/2009	Jasper	NDV	Creek to Coosawhatchie River southwest of Sheldon
RT052198	Creek	33.34641	79.18391	0.6	8/18/2009	Georgetown	NDV	Bly Creek southwest of Waverly Mills
RT052200	Creek	32.31447	80.84546	4.0	6/29/2009	Beaufort	R<1	Callawassie Creek northeast of Bluffton
RT052201	Creek	32.53202	80.77927	1.5	7/13/2009	Beaufort	R>1	Whale Branch southwest of US 21
RT052202	Creek	32.99311	79.90400	3.4	8/4/2009	Berkeley	NDV	Creek to Cooper River east of Goose Creek
RT052203	Creek	32.71436	80.13643	0.9	7/28/2009	Charleston	R<1	Creek to Church Creek southwest of Cedar Springs

* 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 2006
Station Information -- Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO06301	Open	33.15809	79.23871	2.0	7/12/2010	Georgetown	NDV	North Santee Bay north of confluence of Atlantic Ocean
RO06302	Open	32.28226	80.70673	11.6	8/17/2010	Beaufort	R>1	Port Royal Sound southeast of Daws Island
RO06303	Open	32.50374	80.51888	9.4	6/28/2010	Beaufort	NDV	Coosaw River northeast of SC 802 over Lucy Point Creek
RO06304	Open	32.77402	79.91778	8.2	7/19/2010	Charleston	I>1	Cooper River west of Shutes Folly Island
RO06305	Open	32.13280	80.89194	5.5	8/16/2010	Beaufort	NDV	Cooper River west of Hilton Head Island
RO06306	Open	32.40231	80.79019	6.7	7/26/2010	Beaufort	R>1	Broad River north of SC 170 Bridge over Broad River
RO06308	Open	32.93264	79.93732	13.4	7/20/2010	Berkeley	I<1	Cooper River northeast of mouth of Goose Creek
RO06309	Open	32.46397	80.81709	6.4	8/2/2010	Beaufort	R>1	Broad River north of SC 170 Bridge over Broad River
RO06310	Open	32.26867	80.59306	6.1	7/27/2010	Beaufort	R>1	Trenchards Inlet east of mouth of Morse Creek
RO06311	Open	32.50684	80.35437	1.8	6/29/2010	Charleston	R>1	South Edisto River northwest of Edisto Beach
RO06312	Open	32.92805	79.65802	3.4	7/13/2010	Charleston	NDV	Sewee Bay south of Morse Landing
RO06313	Open	32.20627	80.82351	4.3	8/16/2010	Beaufort	R>1	May River southeast of Bluffton
RO06314	Open	32.50364	80.65349	4.0	8/3/2010	Beaufort	R>1	Coosaw River northeast of Beaufort
RO06315	Open	32.63713	80.20726	2.0	8/9/2010	Charleston	R<1	Leadenwah Creek northwest of Rockville
RO06317	Open	33.21072	79.18711	9.8	7/12/2010	Georgetown	NDV	Winyah Bay south of Lighthouse
RO06318	Open	32.31264	80.71365	5.8	8/17/2010	Beaufort	I>1	Broad River southwest of mouth of Ballast Creek
RO06319	Open	32.53799	80.53780	2.7	6/28/2010	Colleton	NDV	Combahee River northeast of SC 802 over Lucy Point Creek
RO06320	Open	32.79245	79.91029	3.4	7/19/2010	Charleston	I>1	Cooper River northwest of USS Yorktown
RO06321	Open	32.21142	80.83881	3.7	8/16/2010	Beaufort	R>1	May River southeast of Bluffton
RO06322	Open	32.34018	80.73640	9.4	7/26/2010	Beaufort	R>1	Broad River northwest of Ballast Creek
RO06323	Open	32.48106	80.43846	3.7	6/29/2010	Colleton	NDV	St. Helena Sound southwest of mouth of Ashepoo River
RO06324	Open	32.86528	79.88023	6.8	7/20/2010	Charleston	R>1	Wando River northeast of I-526 over Wando River
RO06325	Open	32.52419	80.82480	1.5	8/2/2010	Beaufort	NDV	South Haulover Creek southwest of Sheldon
RO06326	Open	32.45163	80.60735	3.0	8/3/2010	Beaufort	R<1	Lucy Point Creek southeast of SC 802 Bridge
RO06327	Open	32.64556	80.32320	1.2	8/9/2010	Charleston	R<1	Dawho River northeast of SC 174 Bridge over Dawho 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 2006
Station Information -- Tidal Creeks

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT06001	Creek	33.13522	79.31766	0.9	7/12/2010	Charleston	NDV	Alligator Creek southeast of Intracoastal Waterway
RT06002	Creek	32.27398	80.62653	0.3	7/27/2010	Beaufort	NDV	Morse Island Creek northeast of Port Royal Sound
RT06003	Creek	32.54553	80.55760	3.4	8/3/2010	Beaufort	NDV	Unnamed Creek 1 mile northeast of William Creek
RT06006	Creek	32.35752	80.50870	3.4	7/27/2010	Beaufort	R>1	Harbor River southwest US 21 Bridge
RT06007	Creek	32.49724	80.37920	5.5	6/29/2010	Colleton	NDV	Pine Island Creek northwest of Edisto Beach
RT06008	Creek	32.78627	79.83340	3.4	7/19/2010	Charleston	R>1	Conch Creek northeast of Sullivans Island
RT06010	Creek	32.52645	80.73730	1.5	8/2/2010	Beaufort	R<1	McCalleys Creek southeast of US 21 Bridge
RT06012	Creek	32.92123	79.78286	1.5	7/20/2010	Charleston	R<1	Toomer Creek east of SC 41 Bridge over Wando River
RT06013	Creek	32.30275	80.81205	1.5	8/17/2010	Beaufort	NDV	Creek to Colleton River southeast of SC 170 Bridge
RT06014	Creek	32.38805	80.59650	1.8	8/17/2010	Beaufort	R<1	Capers Creek southwest of St. Helena Sound
RT06018	Creek	32.30811	80.58398	2.1	7/27/2010	Beaufort	NDV	Tributary to Trenchards Inlet southeast of Port Royal
RT06019	Creek	32.64292	80.56879	4.0	6/28/2010	Colleton	NDV	Chehaw River northeast of Old Chehaw Boat Landing
RT06020	Creek	32.65852	79.96515	3.7	8/10/2010	Charleston	R<1	Cutoff Reach northwest of Folly Beach
RT06021	Creek	32.19102	80.98819	2.7	8/16/2010	Beaufort	NDV	New River southeast of SC 170 Bridge over New River
RT06024	Creek	32.81405	79.75846	3.0	7/13/2010	Charleston	R>1	Seven Reaches Creek south of Whitehall Terrace
RT06026	Creek	32.57463	80.75729	3.0	8/2/2010	Beaufort	R<1	Creek to Huspa Creek south of Gardens Corner
RT06027	Creek	32.55611	80.23526	1.5	8/9/2010	Charleston	R<1	Creek to Ocella Creek southeast of SC 174 Bridge
RT06028	Creek	32.90037	79.68524	4.6	7/13/2010	Charleston	R<1	Clausen Creek northeast of Whitehall Terrace
RT06029	Creek	32.35064	80.80130	2.4	7/26/2010	Beaufort	R<1	Creek to Chechessee River southeast of SC 170 Bridge
RT06031	Creek	32.61168	80.12521	0.7	8/10/2010	Charleston	R>1	Kiawah River southwest of Legareville
RT06032	Creek	33.04429	79.46753	4.4	7/13/2010	Charleston	NDV	Little Papas Creek southwest of McClellanville
RT06033	Creek	33.34778	79.17606	3.4	7/12/2010	Georgetown	R>1	Old Man Creek southeast of Georgetown
RT06035	Creek	32.43852	80.51772	1.2	8/3/2010	Beaufort	R>1	Creek to Eddings Point Creek northwest of US 21 Bridge
RT06036	Creek	32.67282	79.92780	1.5	8/10/2010	Charleston	R<1	Creek to Folly River northeast of Folly Island
RT06037	Creek	32.45024	80.88676	1.4	7/26/2010	Jasper	R<1	Euhaw Creek southeast of US 278 and SC 462

* 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 Water Quality, Sediment Quality, Biological Condition, and Habitat Quality Index scores and their component measure scores by station for 2005 and 2006. Green represents good condition, yellow represents fair condition, and red represents poor condition. The actual Habitat Quality Index score is shown to allow the reader to see where the values fall within the above general coding criteria. See text for further details on the ranges of values representing good, fair, and poor for each measure and index score.

SCECAP 2005
Integrated Assessment - Open Water

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		
RO056091							5	5				0	3	2.7	Charleston	Wadmalaw River south of Meggett
RO056092							5	5				3	5	4.3	Berkeley	Beresford Creek NE of Wando/Cooper River confluence
RO056093							5	5				5	5	5.0	Charleston	Ocella Creek northwest of Townsends River
RO056094							0	3				5	3	3.7	Georgetown	Winyah Bay south of Pumpkinseed Island
RO056095							0	3				5	5	4.3	Beaufort	Coosaw River west of mouth of Bull River
RO056096							5	5				5	5	5.0	Beaufort	Story River northeast of Trenchards Inlet confluence
RO056097							5	5				5	5	5.0	Beaufort	Broad River north of SC 170
RO056098							5	5				3	5	4.3	Georgetown	North Santee River southeast of North Santee
RO056099							0	3				3	5	3.7	Beaufort	Village Creek northeast of St. Helena Island
RO056100							5	5				3	3	3.7	Charleston	Casino Creek east of McClellanville
RO056101							5	5				5	5	5.0	Beaufort	Coosaw River west of mouth of Bull River
RO056102							5	5				5	5	5.0	Beaufort	Calibogue Sound west of Hilton Head Island
RO056103							5	5				5	5	5.0	Beaufort	Broad River west of Cotton Island
RO056104							5	5				5	5	5.0	Beaufort	Chechessee River southeast of SC 170 near Daws Island
RO056105							5	5				5	5	5.0	Beaufort	Cowen Creek east of Port Royal
RO056106							5	5				5	5	5.0	Beaufort	Colleton River northeast of Bluffton
RO056107							5	5				5	5	5.0	Beaufort	Chechessee River near Spring Island
RO056108							5	5				5	5	5.0	Beaufort	Port Royal Sound southeast of Davis Island
RO056109							5	5				5	5	5.0	Beaufort	Cut between Chechessee and Broad Rivers near Daws Island
RO056110							5	5				5	3	4.3	Georgetown	Winyah Bay south of Pumpkinseed Island
RO056111							5	5				5	5	5.0	Colleton	South Edisto River at mouth to St. Helena Sound
RO056112							5	5				5	5	5.0	Charleston	Cooper River south of US 17 near Hog Island Shore
RO056113							5	5				5	5	5.0	Beaufort	St. Helena Sound northeast of Morgan River confluence
RO056114							5	5				5	5	5.0	Charleston	Folly River northeast of Folly Island
RO056115							5	5				5	5	5.0	Colleton	St. Helena Sound southwest of mouth of Ashepoo River

SCECAP 2005

Integrated Assessment - Tidal 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		
RT052093							3	5				0	3	2.7	Beaufort	South Winbee Creek north of Beaufort
RT052094							5	5				3	5	4.3	Charleston	Unnamed creek to Sewee Bay west of Bull's Bay
RT052095							5	5				5	5	5.0	Charleston	Adams Creek west of Rockville
RT052096							5	3				5	5	4.3	Beaufort	Unnamed creek from Fripp Island to Old House Creek
RT052097							5	5				5	5	5.0	Jasper	Euhaw Creek northwest of Bolin Hall Landing
RT052098							3	5				0	0	1.7	Charleston	James Island Creek north of White Hall Plantation
RT052099							3	5				0	3	2.7	Charleston	Creek near Leadenwah Creek northwest of Rockville
RT052100							5	5				5	5	5.0	Charleston	Boone Hall Creek northwest of US 17 and SC 41
RT052104							5	5				3	5	4.3	Beaufort	Creek to Morse Island Creek east of Port Royal Sound
RT052105							5	5				5	5	5.0	Colleton	Scott Creek near Edisto Beach State Park
RT052106							5	5				5	5	5.0	Beaufort	Creek to Cooper River west of Hilton Head
RT052109							5	0				5	5	3.3	Jasper	New River west of Page Island
RT052110							5	5				5	5	5.0	Georgetown	Main Creek south of Whale Creek
RT052112							5	5				5	3	4.3	Charleston	Abbapoola Creek southwest of mouth of Stono River
RT052113							0	3				0	5	2.7	Beaufort	Parrot Creek between Coosaw and Morgan River
RT052115							5	5				3	0	2.7	Beaufort	Creek to Whale Branch east of US 21
RT052116							5	5				5	3	4.3	Berkeley	Martin Creek northeast of Wando and Cooper River
RT052118							5	5				5	5	5.0	Charleston	Church Creek southeast of SC 700 Bridge
RT052119							0	3				5	3	3.7	Beaufort	Haulover Creek southwest of Sheldon
RT052197							0	3				5	5	4.3	Jasper	Creek to Coosawhatchie River southwest of Sheldon
RT052198							5	3				5	5	4.3	Georgetown	Bly Creek southwest of Waverly Mills
RT052200							5	5				5	5	5.0	Beaufort	Callawassie Creek northeast of Bluffton
RT052201							5	5				0	5	3.3	Beaufort	Whale Branch southwest of US 21
RT052202							5	5				5	3	4.3	Berkeley	Creek to Cooper River east of Goose Creek
RT052203							5	5				5	5	5.0	Charleston	Creek to Church Creek southwest of Cedar Springs

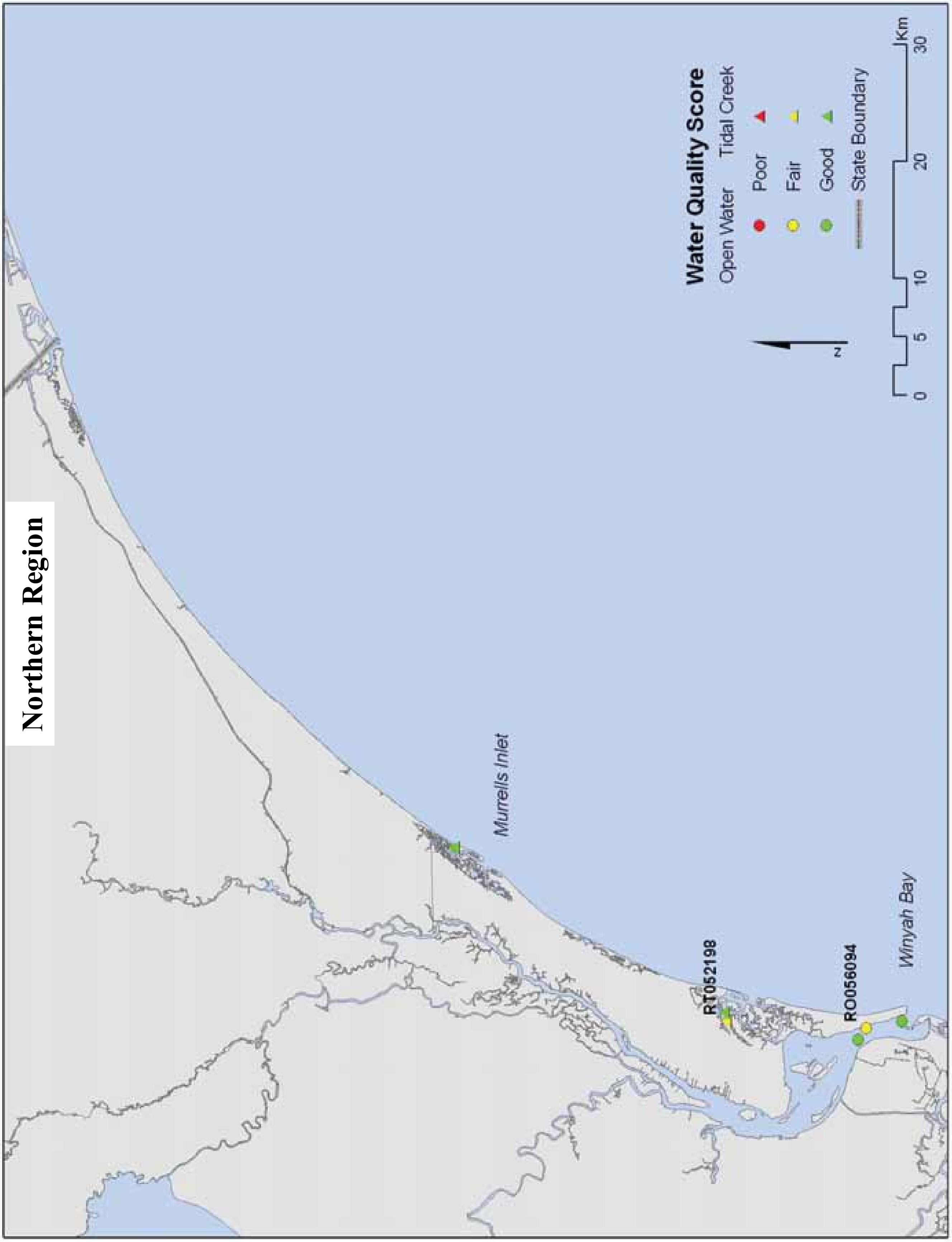
SCECAP 2006
Integrated Assessment - Open Water

Station	Water Quality: Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Sediment Quality: Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Condition: Biological Index (B-IBI)	Habitat Quality: Habitat Quality Index	County	Location
RO06301							5	5				5	5	5.0	Georgetown	North Santee Bay north of confluence of Atlantic Ocean
RO06302							5	5				5	5	5.0	Beaufort	Port Royal Sound southeast of Daws Island
RO06303							5	5				5	5	5.0	Beaufort	Coosaw River northeast of SC 802 over Lucy Point Creek
RO06304							5	5				5	5	5.0	Charleston	Cooper River west of Shutes Folly Island
RO06305							5	5				5	5	5.0	Beaufort	Cooper River west of Hilton Head Island
RO06306							5	5				5	5	5.0	Beaufort	Broad River north of SC 170 Bridge over Broad River
RO06308							5	5				0	0	1.7	Berkeley	Cooper River northeast of mouth of Goose Creek
RO06309							5	5				5	5	5.0	Beaufort	Broad River north of SC 170 Bridge over Broad River
RO06310							0	3				5	5	4.3	Beaufort	Trenchards Inlet east of mouth of Morse Creek
RO06311							5	5				5	5	5.0	Charleston	South Edisto River northwest of Edisto Beach
RO06312							5	5				5	5	5.0	Charleston	Sewee Bay south of Morse Landing
RO06313							5	5				5	5	5.0	Beaufort	May River southeast of Bluffton
RO06314							5	5				5	5	5.0	Beaufort	Coosaw River northeast of Beaufort
RO06315							5	5				5	3	4.3	Charleston	Leadenwah Creek northwest of Rockville
RO06317							5	5				5	5	5.0	Georgetown	Winyah Bay south of Lighthouse
RO06318							5	5				5	5	5.0	Beaufort	Broad River southwest of mouth of Ballast Creek
RO06319							5	5				5	0	3.3	Colleton	Combahee River northeast of SC 802 over Lucy Point Creek
RO06320							5	5				0	5	3.3	Charleston	Cooper River northwest of USS Yorktown
RO06321							5	5				5	5	5.0	Beaufort	May River southeast of Bluffton
RO06322							5	5				5	5	5.0	Beaufort	Broad River northwest of Ballast Creek
RO06323							5	5				5	5	5.0	Colleton	St. Helena Sound southwest of mouth of Ashepoo River
RO06324							5	5				5	5	5.0	Charleston	Wando River northeast of I-526 over Wando River
RO06325							5	5				5	5	5.0	Beaufort	South Haulover Creek southwest of Sheldon
RO06326							5	5				5	5	5.0	Beaufort	Lucy Point Creek southeast of SC 802 Bridge
RO06327							0	0				3	0	1.0	Charleston	Dawho River northeast of SC 174 Bridge over Dawho River

SCECAP 2006
Integrated Assessment - Tidal Creek

Station	Water Quality: Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Sediment Quality: Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Condition: Biological Index (B-IBI)	Habitat Quality: Habitat Quality Index	County	Location
RT06001							0	3				0	5	2.7	Charleston	Alligator Creek southeast of Intracoastal Waterway
RT06002							5	5				5	5	5.0	Beaufort	Morse Island Creek northeast of Port Royal Sound
RT06003							5	5				3	3	3.7	Beaufort	Unnamed Creek 1 mile northeast of William Creek
RT06006							5	5				5	5	5.0	Beaufort	Harbor River southwest US 21 Bridge
RT06007							5	5				5	5	5.0	Colleton	Pine Island Creek northwest of Edisto Beach
RT06008							5	5				5	5	5.0	Charleston	Conch Creek northeast of Sullivans Island
RT06010							5	5				5	3	4.3	Beaufort	McCalleys Creek southeast of US 21 Bridge
RT06012							5	3				5	3	3.7	Charleston	Toomer Creek east of SC 41 Bridge over Wando River
RT06013							5	5				5	5	5.0	Beaufort	Creek to Colleton River southeast of SC 170 Bridge
RT06014							5	5				5	3	4.3	Beaufort	Capers Creek southwest of St. Helena Sound
RT06018							5	5				5	5	5.0	Beaufort	Tributary to Trenchards Inlet southeast of Port Royal
RT06019							0	0				5	5	3.3	Colleton	Chehaw River northeast of Old Chehaw Boat Landing
RT06020							5	5				5	5	5.0	Charleston	Cutoff Reach northwest of Folly Beach
RT06021							5	3				5	3	3.7	Beaufort	New River southeast of SC 170 Bridge over New River
RT06024							5	5				3	5	4.3	Charleston	Seven Reaches Creek south of Whitehall Terrace
RT06026							3	3				5	5	4.3	Beaufort	Creek to Huspa Creek south of Gardens Corner
RT06027							5	5				5	5	5.0	Charleston	Creek to Ocella Creek southeast of SC 174 Bridge
RT06028							5	5				5	5	5.0	Charleston	Clausen Creek northeast of Whitehall Terrace
RT06029							5	5				5	5	5.0	Beaufort	Creek to Chechessee River southeast of SC 170 Bridge
RT06031							5	5				5	5	5.0	Charleston	Kiawah River southwest of Legareville
RT06032							5	5				5	5	5.0	Charleston	Little Papas Creek southwest of McClellanville
RT06033							5	5				5	5	5.0	Georgetown	Old Man Creek southeast of Georgetown
RT06035							0	0				5	3	2.7	Beaufort	Creek to Eddings Point Creek northwest of US 21 Bridge
RT06036							5	5				5	5	5.0	Charleston	Creek to Folly River northeast of Folly Island
RT06037							5	3				5	5	4.3	Jasper	Euhaw Creek southeast of US 278 and SC 462

Appendix 3a. Maps showing the distribution of stations with good, fair, or poor Water Quality Index scores within the northern, central, and southern regions of South Carolina during 2005-2006. Labels for those stations with fair or poor Water Quality Index scores are shown.


Northern Region
Murrells Inlet
Winyah Bay
RT052198
RO056094
Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
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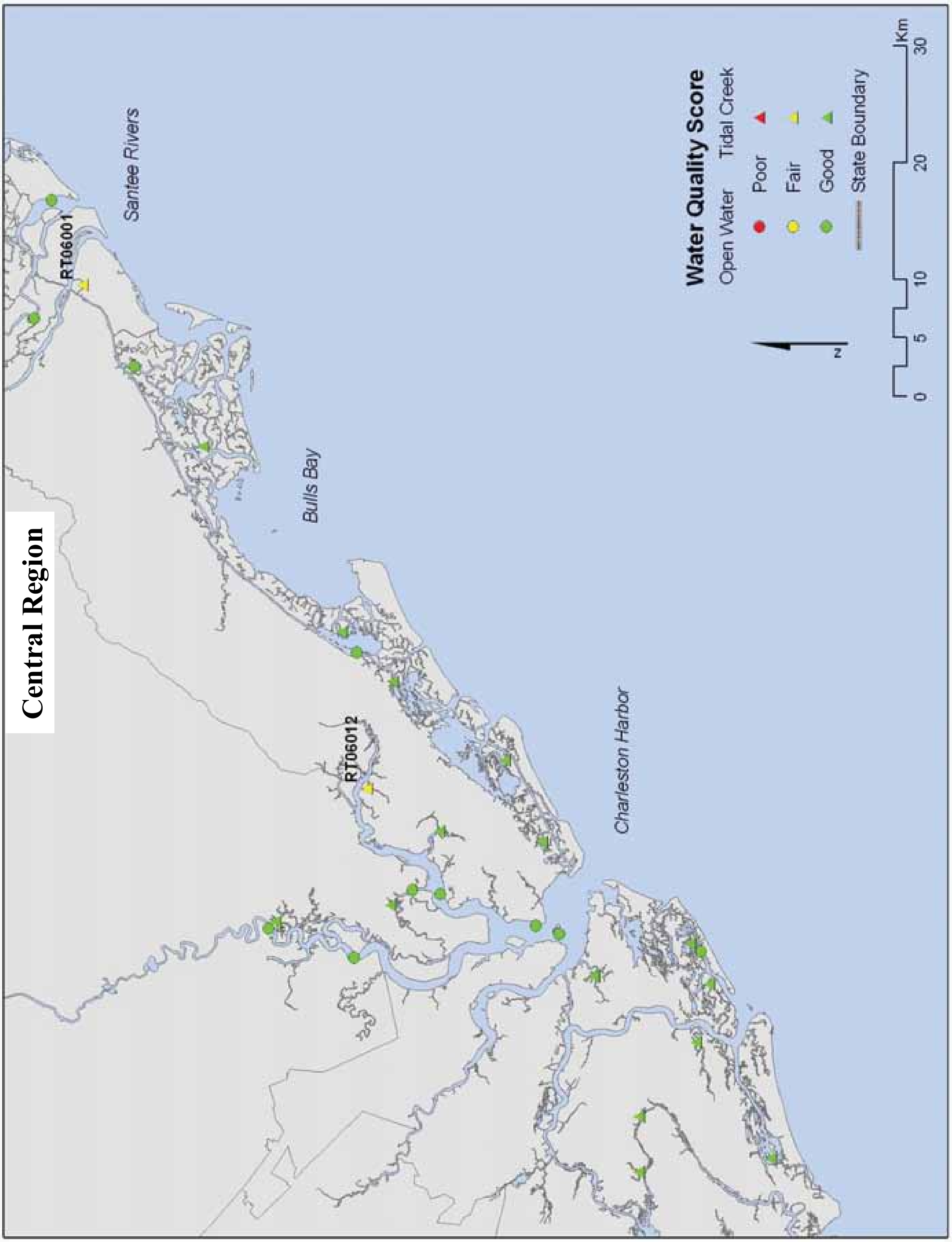
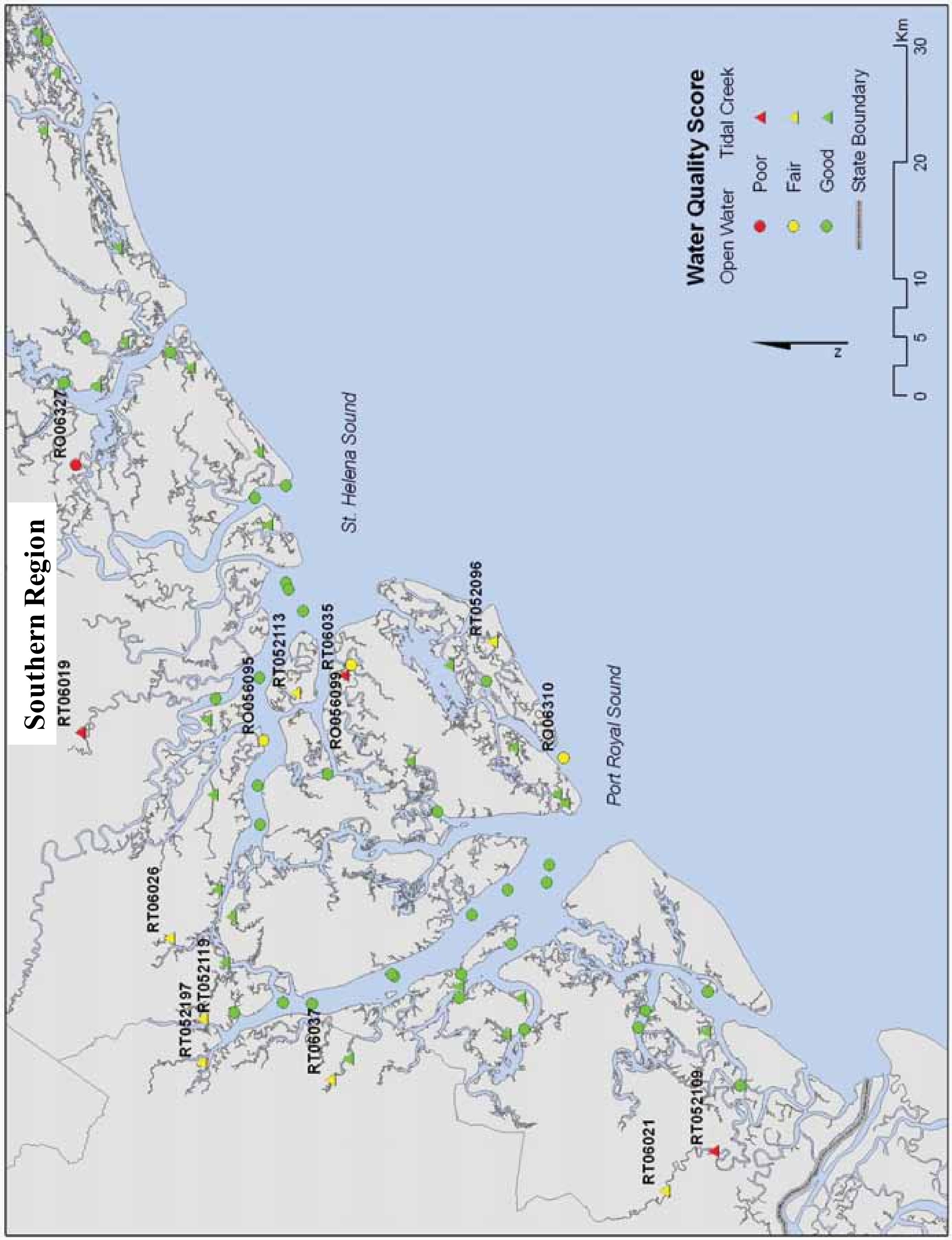
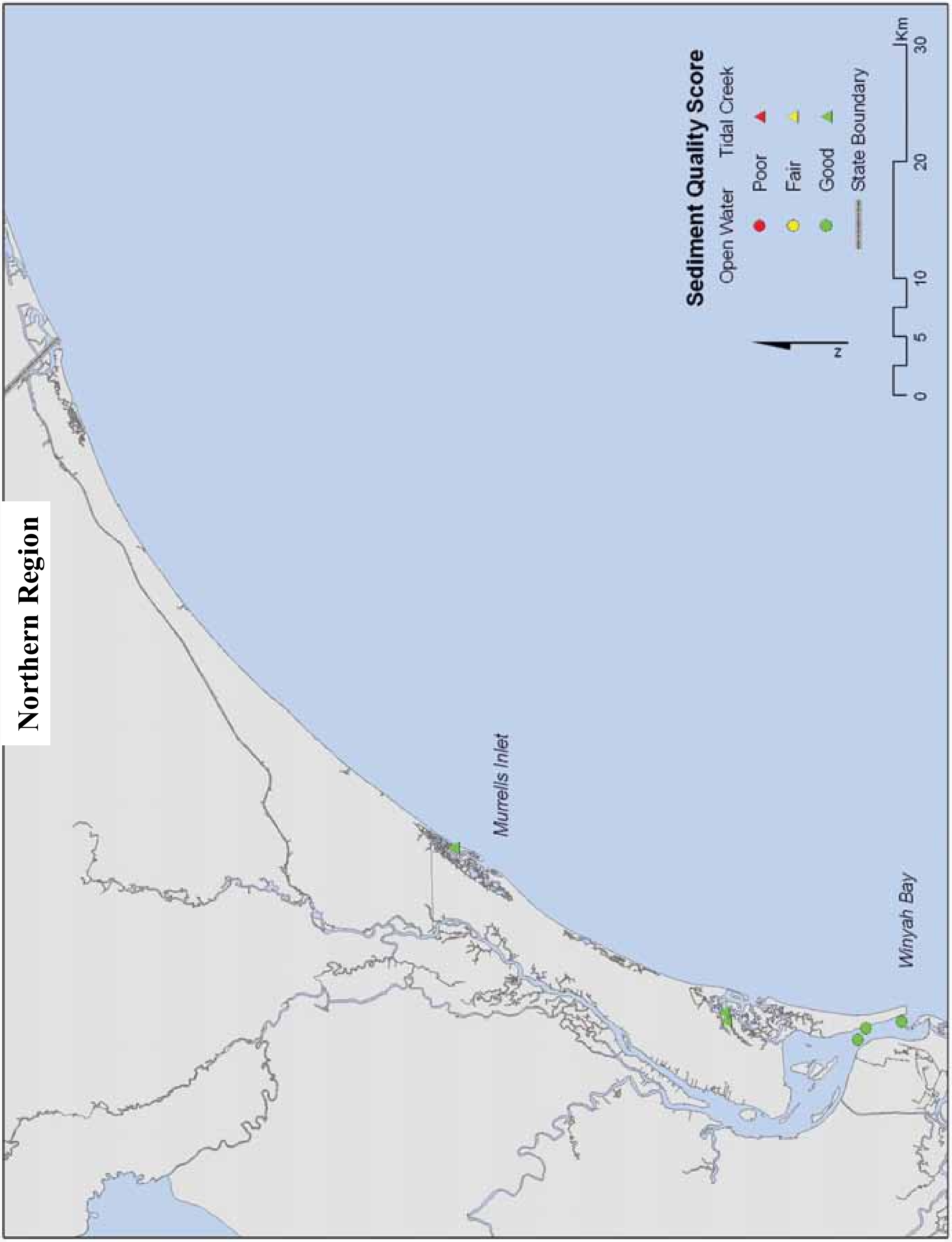
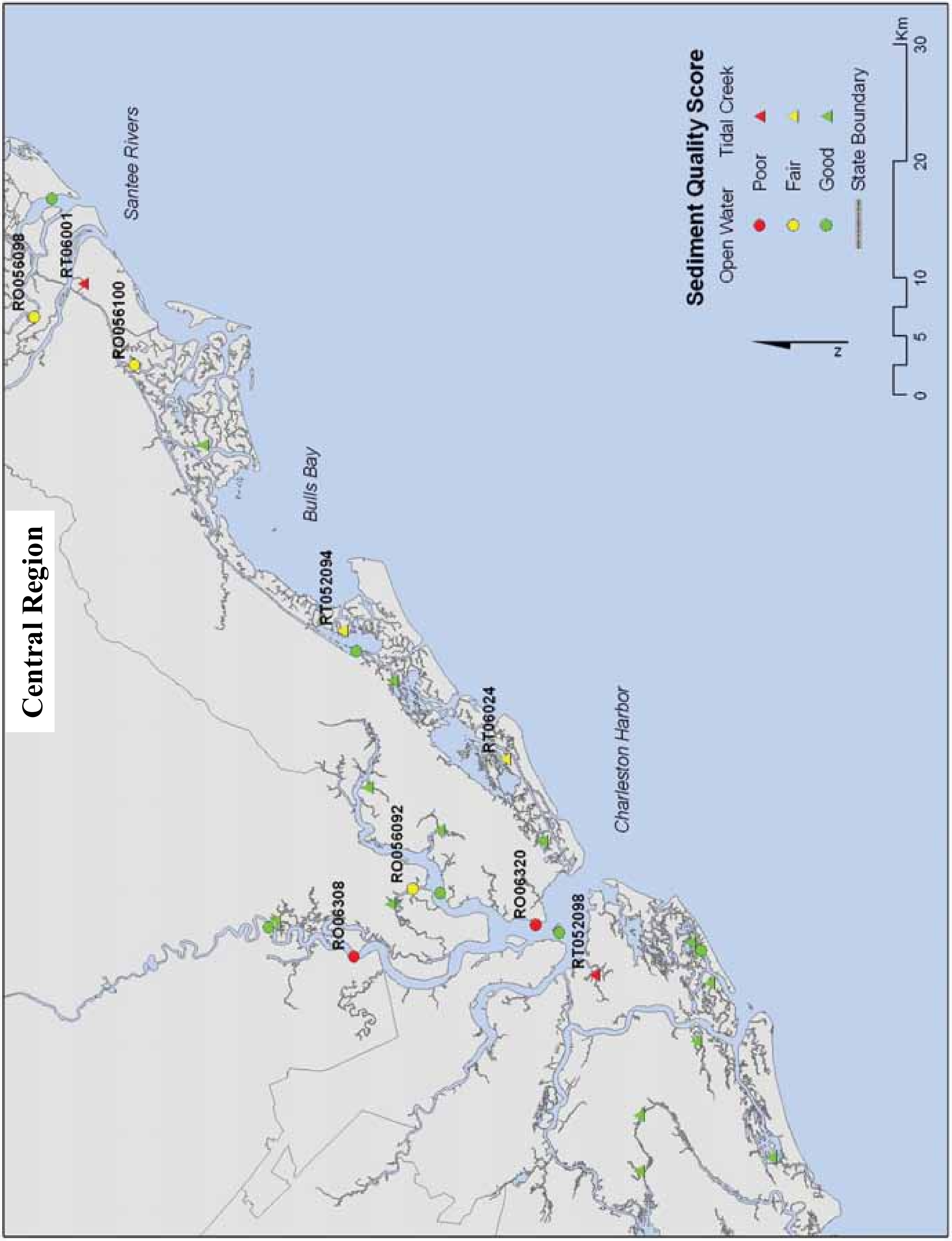
5
10
20
30
Km

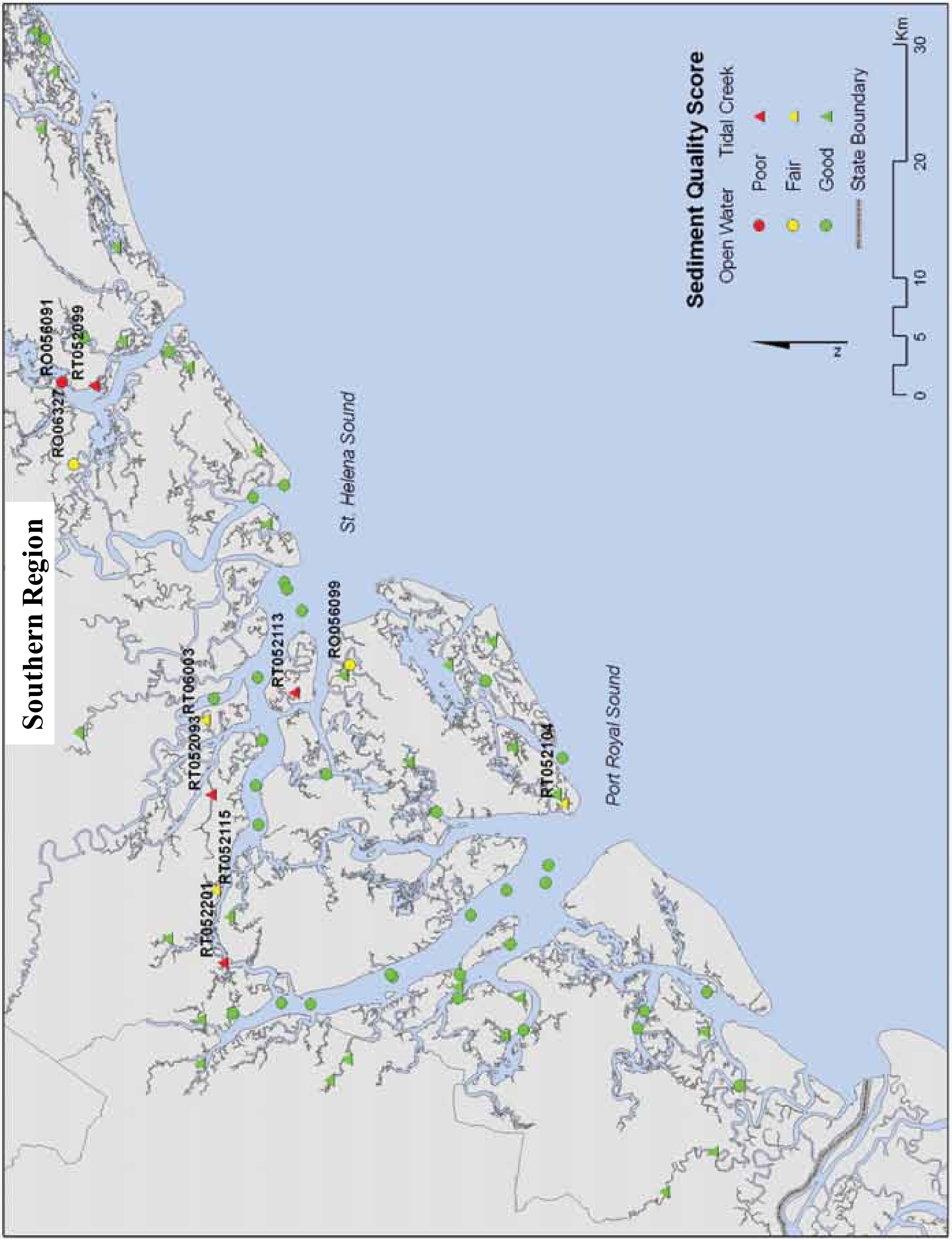

Central Region
RT06001
RT06012
Santee Rivers
Bulls Bay
Charleston Harbor
Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km


Southern Region
RT06019
RO06327
St. Helena Sound
RT052113
RT06035
RO056095
RO056099
RT052096
RO06310
Port Royal Sound
RT06026
RT052197
RT052119
RT06037
RT06021
RT052109
Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km

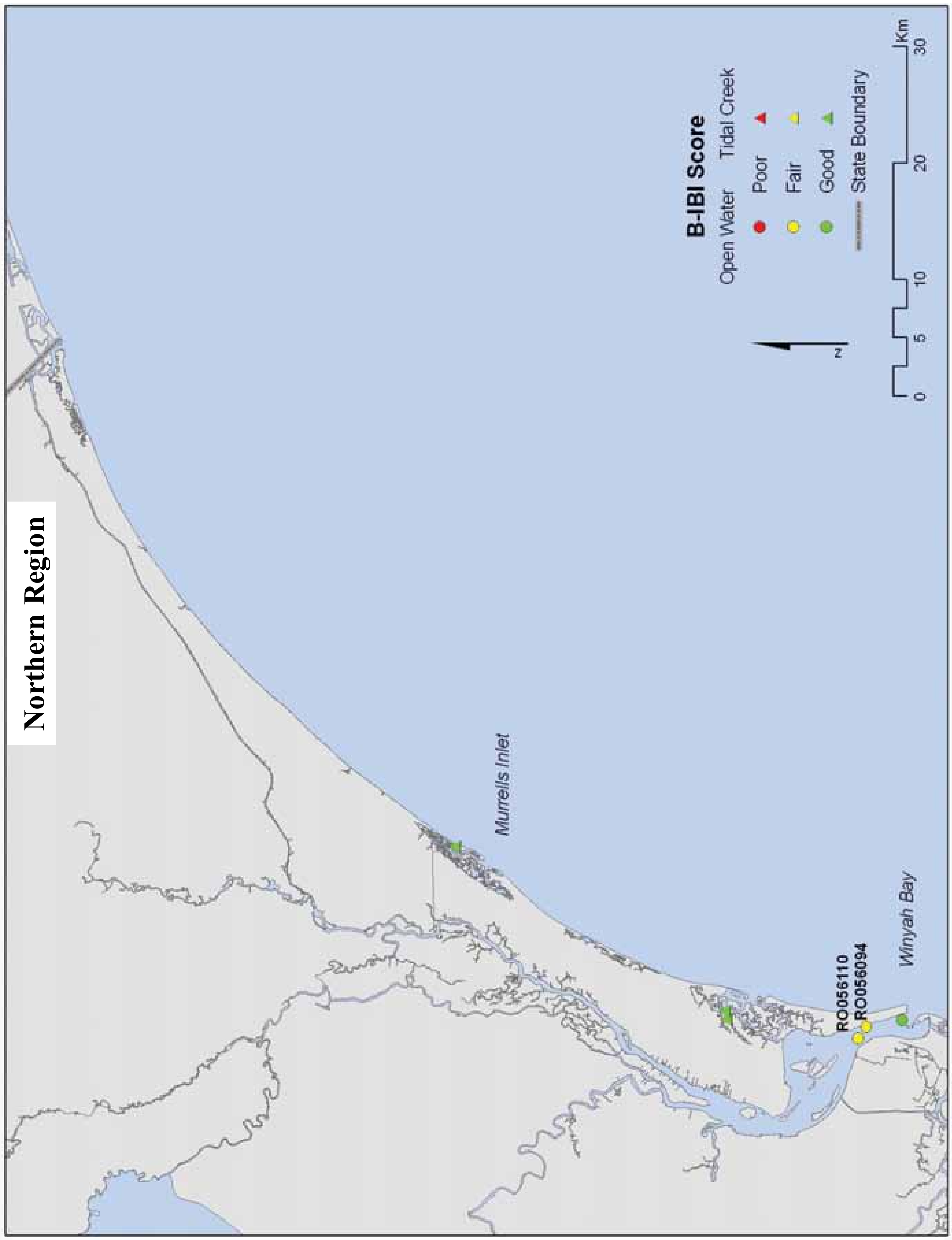
Appendix 3b. Maps showing the distribution of stations with good, fair, or poor Sediment Quality Index scores within the northern, central, and southern regions of South Carolina during 2005-2006. Labels for those stations with fair or poor Sediment Quality Index scores are shown.

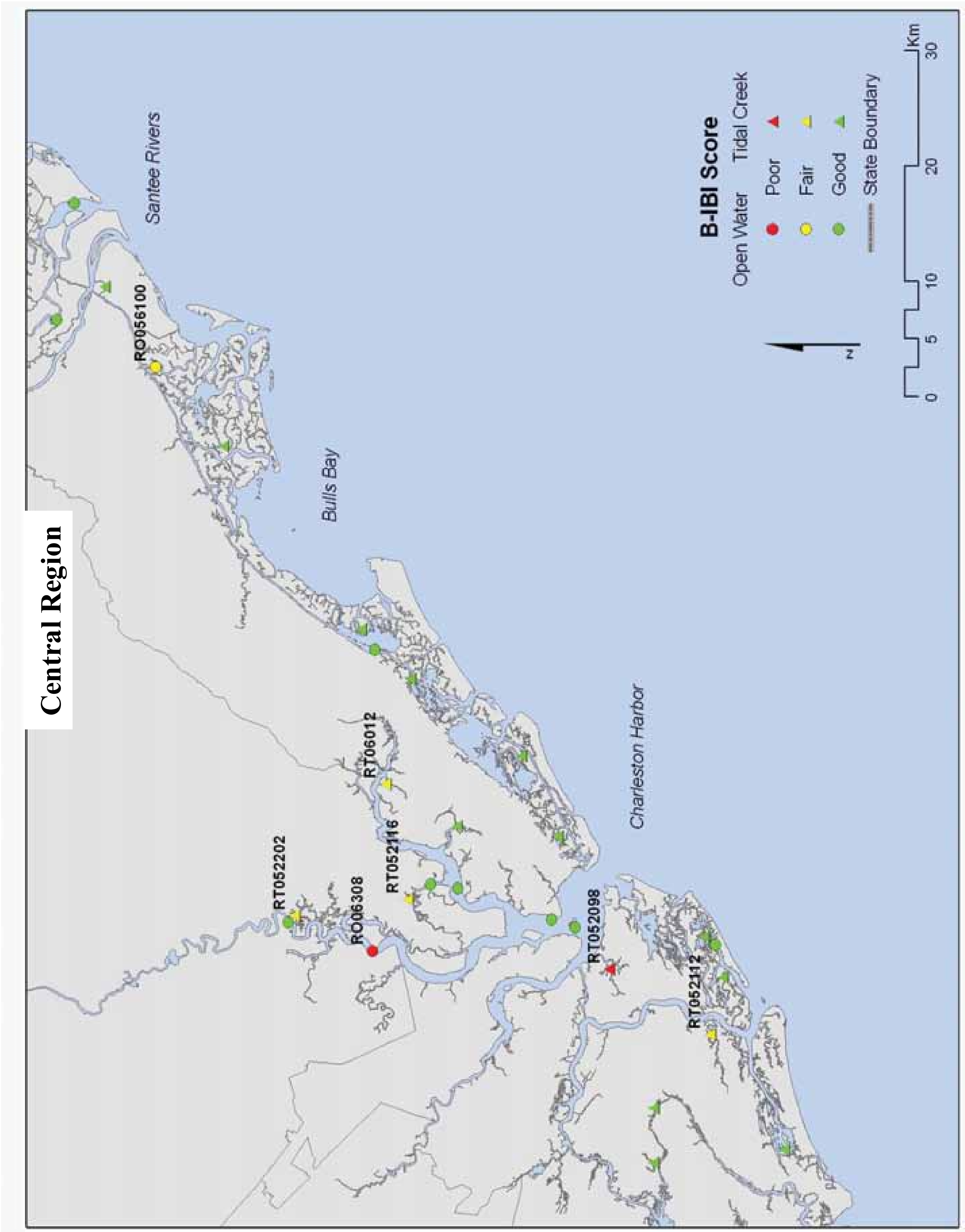

Northern Region
Murrells Inlet
Winyah Bay
Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km

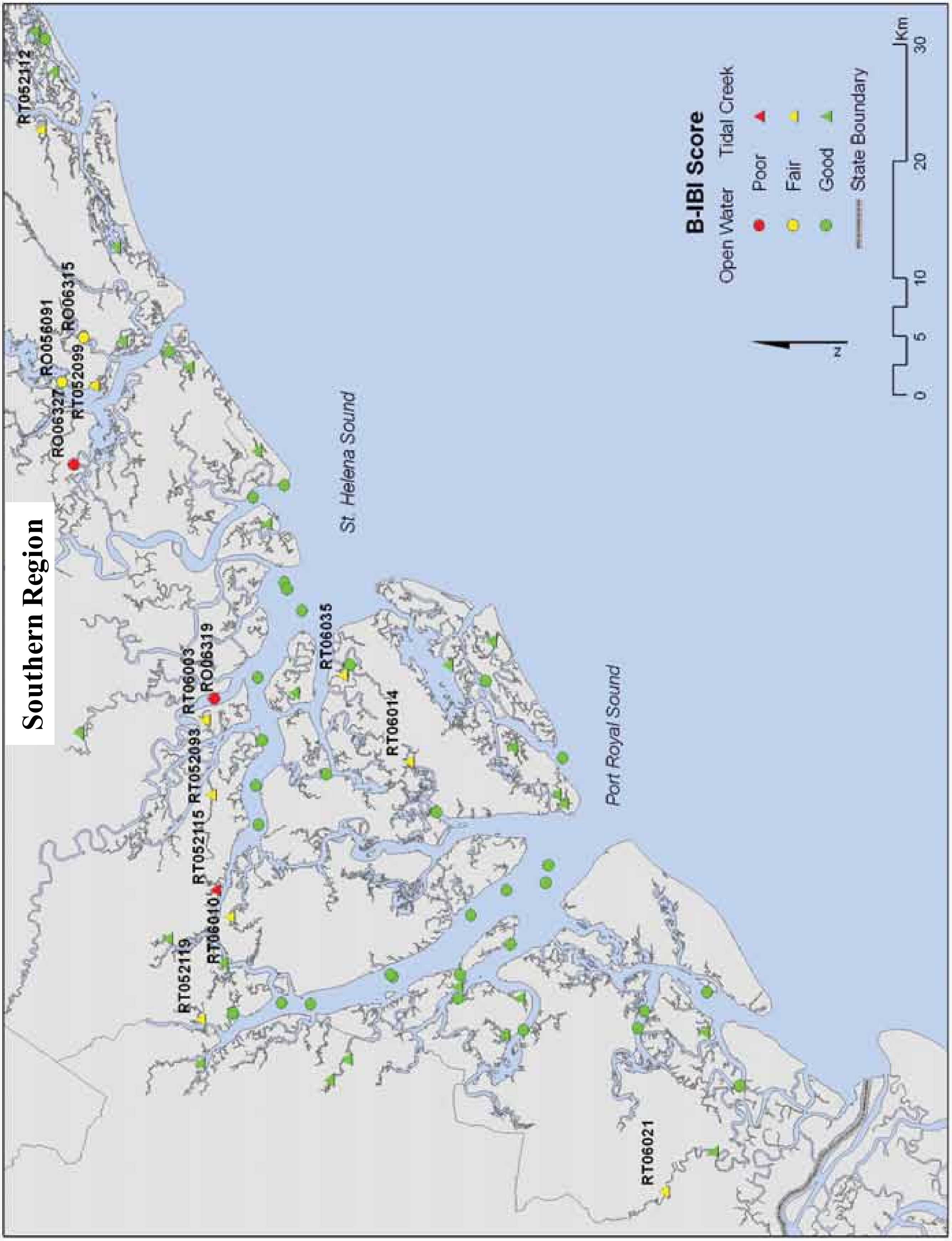

Central Region
Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km
Santee Rivers
Bulls Bay
Charleston Harbor
RO056098
RT06001
RO056100
RT052094
RT06024
RO056092
RO06320
RO06308
RT052098


Southern Region
St. Helena Sound
Port Royal Sound
RO056091
RT052099
RO06327
RO056099
RT052113
RT06003
RT052093
RT052115
RT052201
RT052104
Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0 5 10 20 30 Km

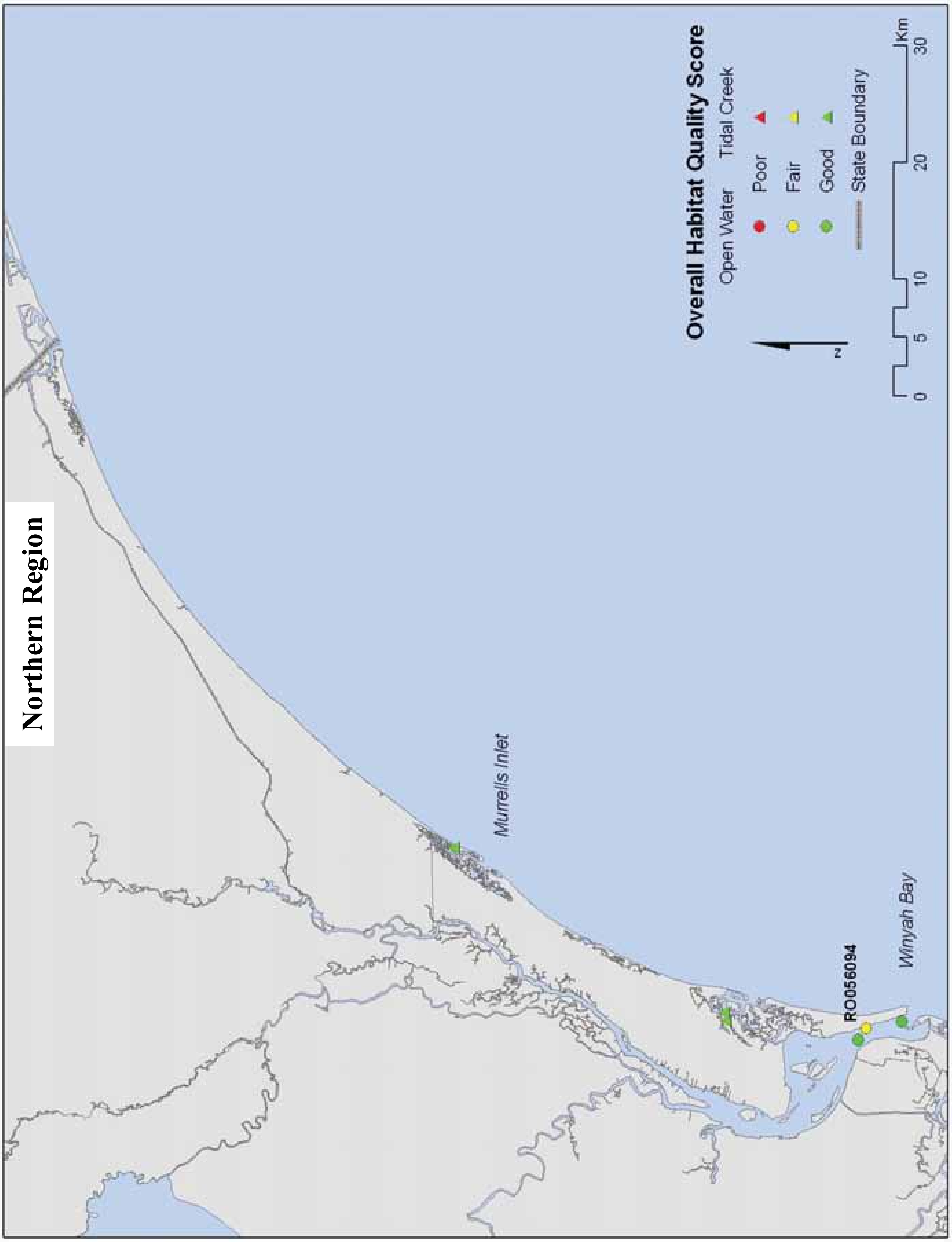
Appendix 3c. Maps showing the distribution of stations with good, fair, or poor Biological Condition Index scores within the northern, central, and southern regions of South Carolina during 2005-2006. Labels for those stations with fair or poor Biological Condition Index scores are shown.

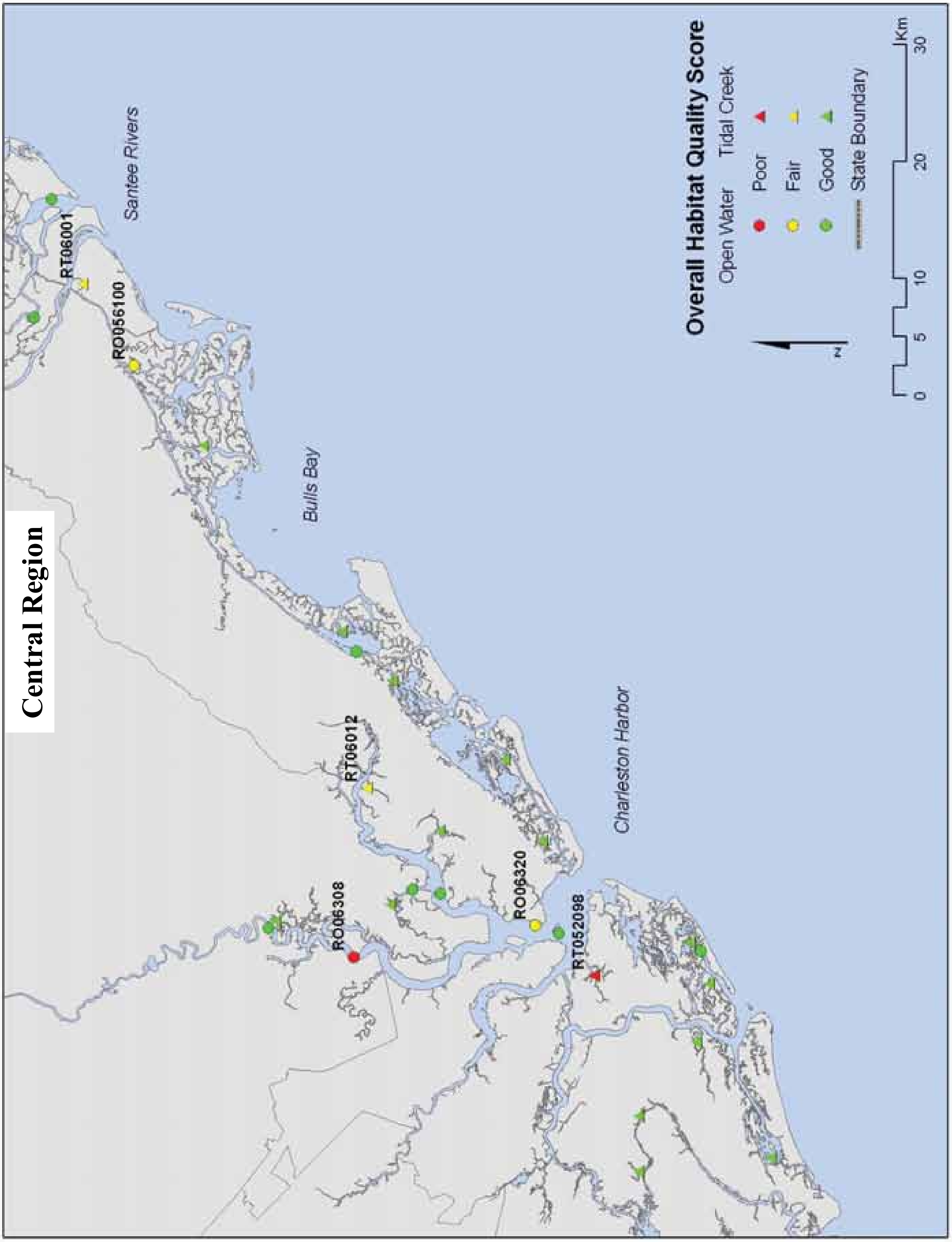

Northern Region
Murrells Inlet
Winyah Bay
RO056110
RO056094
B-IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km

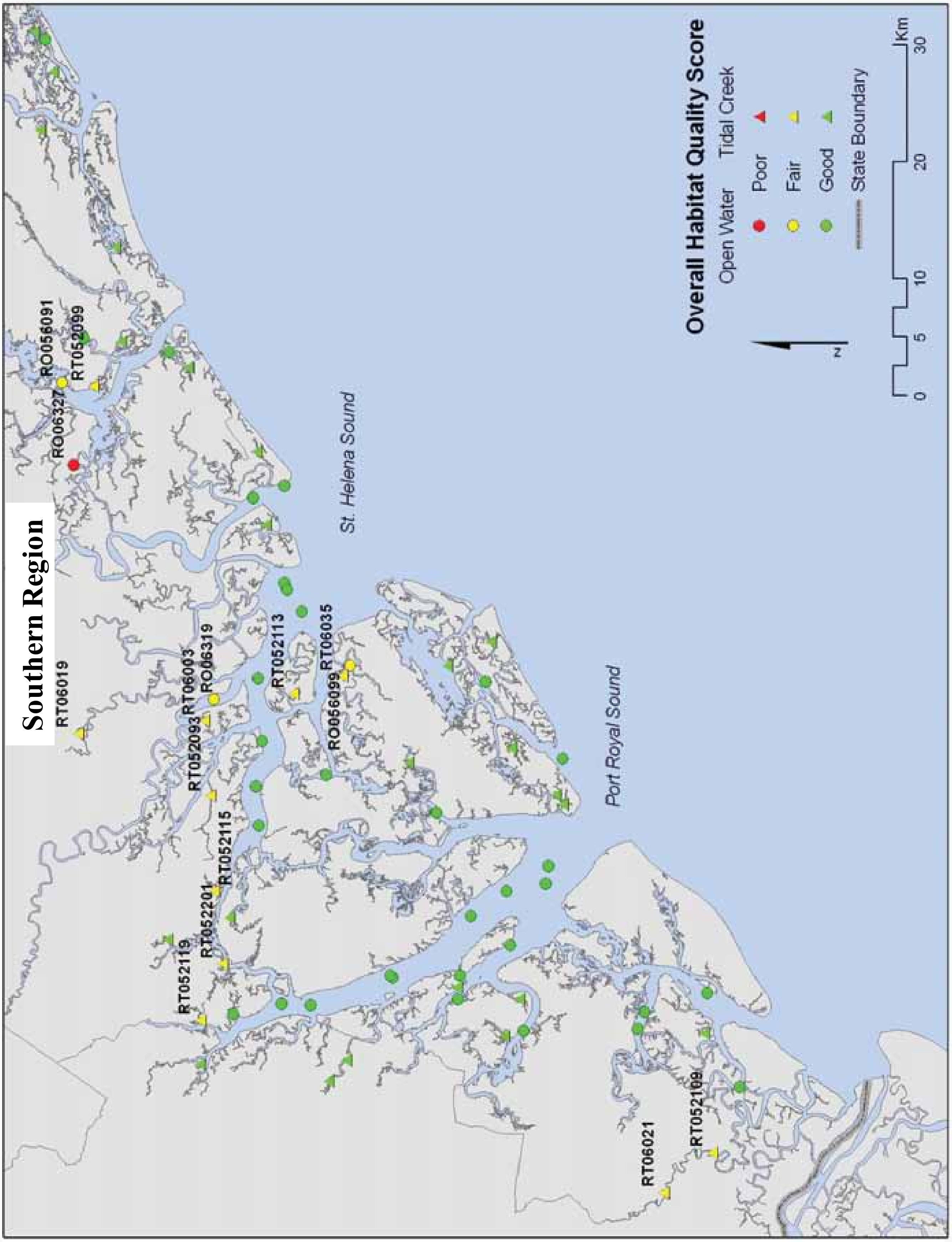

Central Region
Santee Rivers
Bulls Bay
Charleston Harbor
RO056100
RT06012
RT052116
RT052202
RO06308
RT052098
RT052112
B-IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km


Southern Region
RT052112
RO056091
RO06315
RO06327
RT052099
St. Helena Sound
RT06003
RO06319
RT06035
RT052093
RT06014
RT052115
RT06010
RT052119
Port Royal Sound
RT06021
B-IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km

Appendix 3d. Maps showing the distribution of stations with good, fair, or poor Habitat Quality Index scores within the northern, central, and southern regions of South Carolina during 2005-2006. Labels for those stations with fair or poor Habitat Quality Index scores are shown.


Northern Region
Overall Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km
Murrells Inlet
RO056094
Winyah Bay


Central Region
Santee Rivers
Bulls Bay
Charleston Harbor
RT06001
RO056100
RT06012
RO06308
RO06320
RT052098
Overall Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km



Southern Region
Overall Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
Km
0
5
10
20
30
N
St. Helena Sound
Port Royal Sound
RO056091
RT052099
RO06327
RT06019
RT06003
RO06319
RT052093
RT052113
RT06035
RO056099
RT052115
RT052201
RT052119
RT06021
RT052109

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