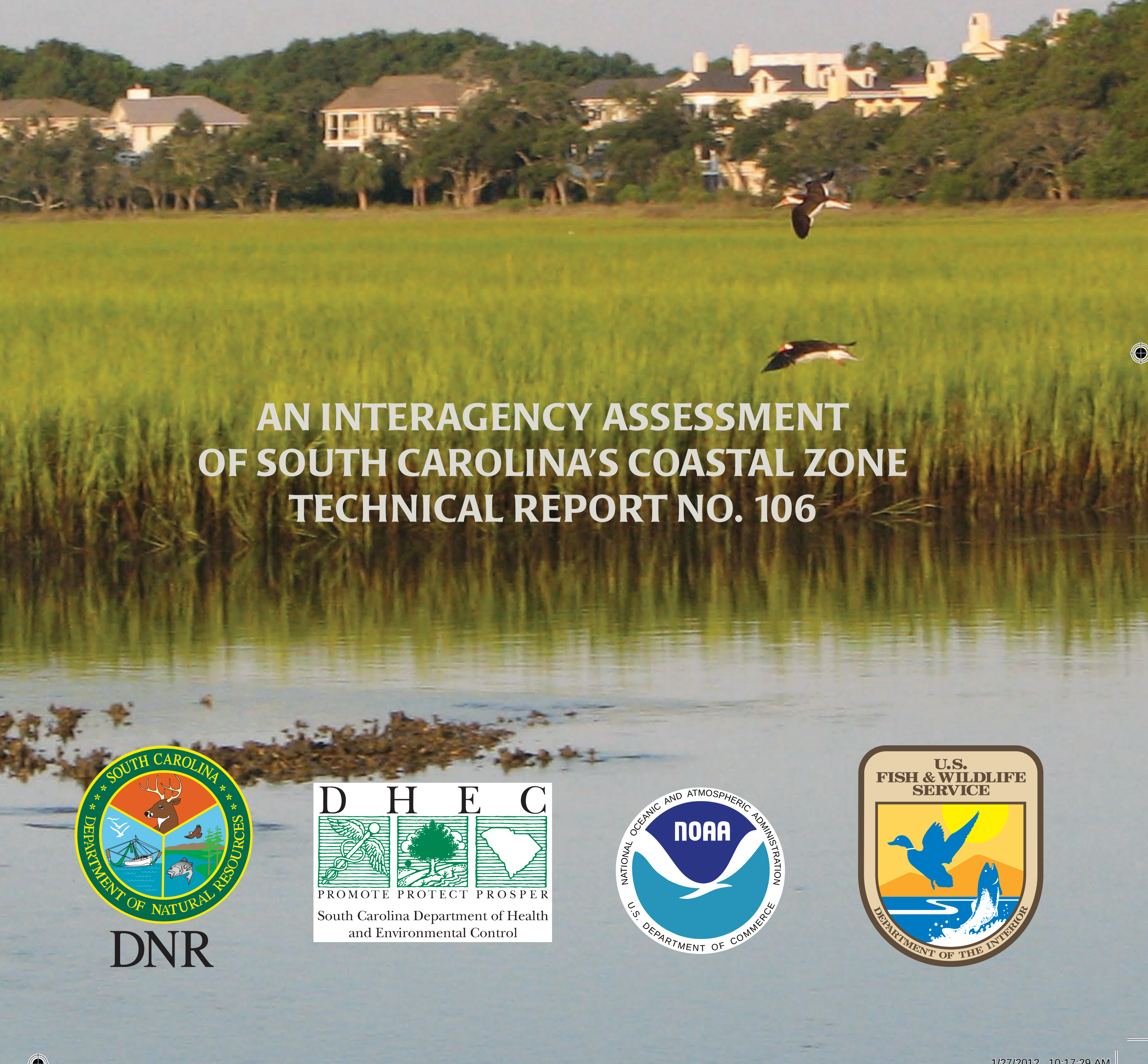
THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2007-2008



AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE

TECHNICAL REPORT NO. 106

South Carolina Department of Natural Resources
DNR

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South Carolina Department of Health and Environmental Control

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

U.S. Fish & Wildlife Service
Department of the Interior

The Condition of South Carolina's Estuarine and Coastal Habitats During 2007-2008

Technical Report

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INTRODUCTION

Estuarine and coastal ecosystems represent important natural resources for residents and visitors of 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 state's commercial fisheries, primarily shrimp, oysters, and crabs, have an economic impact of almost 34 million dollars annually (SCDNR, 2009). When combined with saltwater recreational fisheries, this number exceeds 690 million dollars (Southwick Associates, 2008). Further, coastal tourism employs almost 81,000 residents and accounts for over seven billion dollars in economic activity annually (SCDNR, 2009).

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, the population of South Carolina's eight coastal counties grew 49% between 1980 and 2000, and estimates indicate it has increased another 22% based on the Census 2010 data (SC Budget and Control Board, 2011). 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).

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

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 South Carolina Department of Health and Environmental Control (SCDHEC) as the lead state agencies. The National Oceanic and Atmospheric Administration (NOAA), Charleston laboratories has been a partner agency since the inception of the program and the U.S. Environmental Protection Agency (USEPA) was a major partner and funding source for the program from 2000 through 2006.

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 fifth 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; Bergquist et al., 2009).

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/*). Some of the analytical methods have been modified and are fully described by Bergquist et al. (2009) and in this report. This program uses methods consistent with SCDHEC's water quality monitoring programs (SCDHEC, 2010a) and the USEPA's National Coastal Assessment (NCA) program (*http://www.epa.gov/emap/nca/index.html*).

2.1. Sampling Design

Historically, 50-60 stations were sampled annually, but discontinued funding from the NCA program forced a downsizing of the effort. During the 2007-2008 sampling period, thirty stations were selected for sampling each year within South Carolina's coastal zone (Figure 2.1.1). This region extends from the Little River Inlet at the South Carolina-North Carolina border to the Savannah River at the South Carolina-Georgia border and extends from the saltwater-freshwater interface to near the mouth of each estuarine drainage basin (Appendix 1). Half of the stations each year 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 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. The same sites (15 tidal creek and 15 open water) were also sampled monthly for the calendar year by SCDHEC for selected water quality measures (data not reported here).

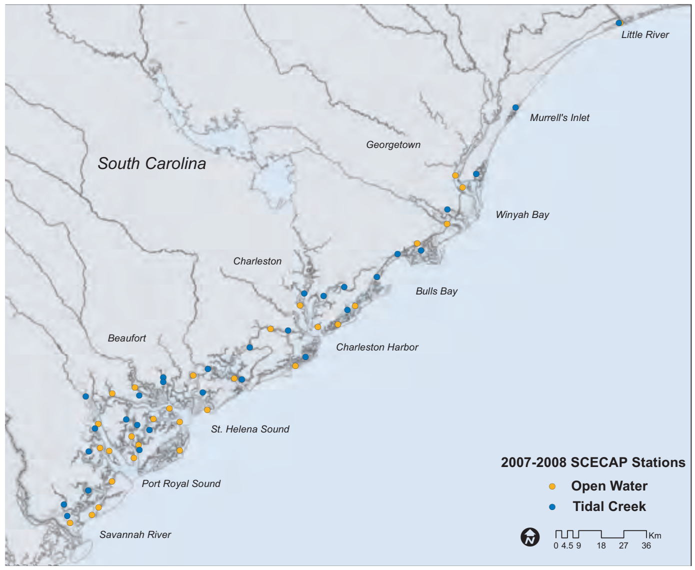

Figure 2.1.1 Locations of stations sampled during 2007 and 2008.

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 and to note the proximity of the site to urban/suburban development or industrial development. All data collected go through a rigorous quality assurance process to validate the data sets. A copy of the Quality Assurance Project Plan is maintained at the SCDNR Marine Resources Research Institute.

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. Other 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), water clarity based on a Secchi disk measurement, and five-day biochemical oxygen demand (BOD_5). Data for the secondary water quality measures are available on the SCECAP website but are not described in this report because these measures are not included in the SCECAP Water Quality Index or have no state water quality standards.

All 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, 2009, 2010a, 2010b).

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 2 cm) of four or more grab samples were homogenized on-site and placed in pre-cleaned containers for analysis of silt and clay content, total organic carbon (TOC), total ammonia nitrogen (TAN), contaminants, and sediment toxicity. All sediment samples 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). Porewater 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 28 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 contaminant concentrations 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).

Placing a sediment composite sample in a container.

Sediment toxicity was measured using two bioassays: 1) the Microtox® solid-phase assay using a photoluminescent bacterium, *Vibrio fischeri*, and protocols described by the Microbics Corporation (1992), and 2) a 7-day juvenile clam growth assay using *Mercenaria mercenaria* and protocols described by Ringwood and Keppler (1998). Toxicity in the Microtox® assay 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 ($p < 0.05$).

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

2.4. 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 was corrected for the total area swept by the two trawls using the formula described by Krebs (1972).

2.5. Integrated Indices of Estuarine Habitat Condition

One of the primary objectives of SCECAP is to develop integrated measures of estuarine condition that synthesize the program's large and complex environmental datasets. Such measures provide natural resource managers and the general public with simplified statements about the status and trends of the condition of South Carolina's coastal zone. Similar approaches have been developed by federal agencies for their National Coastal Condition Reports (USEPA, 2001, 2004, 2006) as well as by a few states and other entities using a variety of approaches (Carlton et al., 1998; Chesapeake Bay Foundation, 2007; Partridge, 2007).

SCECAP computes four integrated indices describing different components of the estuarine ecosystem: water quality, sediment quality, biological condition and an overall Habitat Quality Index. The Water Quality Index combines four individual measures (one of which, the Eutrophic Index, is a composite of three other measures, Table 2.5.1). The Sediment Quality Index combines three individual measures, and the 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 for the majority of water quality measures. If DO were the only measure of water quality used, both locations would be classified as having degraded condition with no basis for distinguishing between the two locations. However, an index that integrates multiple measures would likely not classify the first location as degraded and yet detect the relatively greater degradation at the second location.

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*		

Deploying a grab sampler to collect a sediment sample for chemistry and benthic analysis.

Current methods for calculating the four integrated indices are described in detail in the 2005-2006 SCECAP report (Bergquist et al. 2009). Broadly, each individual measure taken at a sampled station and used to calculate the integrated indices (Table 2.5.1) is given a score of "good," "fair," or "poor." In the various graphics and tables of this report, poor conditions are indicated by red, fair by yellow and good by green. Thresholds for defining conditions as good, fair, or poor are based on state water quality standards (SCDHEC 2008), published findings (Hyland et al. 1999 for ERM-Q; Van Dolah et al. 1999 for benthic condition; ASTM 1993; Ringwood et al. 1997, 1998 for toxicity measures), or percentiles of a historical database for the state based on SCECAP measurements collected from 1999-2006. The thresholds used in this report are listed in Appendix 2. These scores are given a numerical ranking (good as highest (5), fair as intermediate (3), poor as lowest (0)) 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. However, the current report does reflect the updated approach applied to all measures and previous survey periods.

2.6. The Presence of Litter

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

2.7. Data Analyses

Use of the probability-based sampling design provides 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. These estimates were obtained through analysis of the cumulative distribution function (CDF) using procedures described by Diaz-Ramos et al. (1996) and using programs developed within the R statistical package. The percent of the state's overall estuarine habitat scoring as good, fair, or poor for individual measures and for each of the indices 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. In the past, SCECAP used continuous data in these analyses when possible, but this methodology was modified to use only categorical scores in order to improve 1) consistency with reporting by the SCDHEC Ambient Water Quality Monitoring Network, and 2) calculation of the 95% confidence limit for each estimate. Additionally, the difference in scores between tidal creek and open water habitats is now well-established in South Carolina (Van Dolah et al., 2002, 2004, 2006; Bergquist et al., 2009 and Appendix 2). For brevity, graphical summaries in this report are limited to overall estuarine habitat condition (tidal creek and open water combined).

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.

RESULTS AND DISCUSSION

3.1. Water Quality

Water quality measurements are crucial to any estuarine assessment as water supports all functions of the estuarine system as well as dissolves, dilutes, and transports materials (including pollutants). Because of the importance of these factors, measures of water quality are used to regulate recreational use and shellfish harvesting in state waters. SCECAP collects data on a large number of water quality parameters, but the six component measures of the Water Quality Index (WQI) are considered to be the most relevant to assessing estuarine condition. These include: 1) fecal coliform bacteria, which are an indicator of potential human pathogens, 2) dissolved oxygen (DO), which is critical to healthy biological communities and can reflect organic pollution, 3) pH, which measures the acidity of a water body and can indicate the influence of various kinds of human effluents, and 4) a combined measure of total nitrogen (TN), total phosphorus (TP) and chlorophyll a (Chl-a), which provides a composite measure of the potential for a water body to be experiencing nutrient enrichment and/or associated algal blooms. These latter three measures (TN, TP and Chl-a) have been combined into a Eutrophic Index, which equals one quarter of the weight of the overall WQI.

Using the WQI, 89% of South Carolina's coastal estuarine habitat, which includes both tidal creeks and open water habitats, was in good condition during the 2007-2008 survey period (Figure 3.1.1). Based on the WQI, only 3% of the coastal estuarine habitat had poor water quality while 8% had fair water quality. When considered separately, tidal creek habitats had a higher percentage of fair to poor water quality (13% fair, 17% poor) as compared to open water habitats (7% fair, 0% poor) during this period (Appendix 2).

The amount of habitat with good water quality was between 86% and 98% for each of the component measures of the WQI (Figure 3.1.1). The amount of estuarine habitat scoring as good for fecal coliform bacteria was 92%, with 8% scoring as fair and none as poor. For DO, 94% of estuarine water quality scored as good, with only 4% and 2% scoring as fair and poor, respectively. For pH, 92% of estuarine water quality scored as good, 5% scored as fair and 3% scored as poor. Of all the component measures, the eutrophication score identified the least amount of habitat in good condition (86%). Of the three measures comprising the eutrophication score (Chl-a, TN, or TP), Chl-a appeared to drive this outcome with only 73% of estuarine water quality in good, 16% in fair and 11% in poor condition (Figure 3.1.1). Consistent with previous surveys, tidal creek habitats had more area in fair or poor condition with respect to water quality for each component measure than did open water habitats (Appendix 2).

The amount of habitat with a WQI scoring as good during 2007-2008 (89%) was similar to the 2005-2006 (89%) and 1999-2000 (87%) survey periods and higher than the 2001-2002 and 2003-2004 surveys periods (84 and 82%, respectively) (Figure 3.1.2). During all survey periods the amount of habitat scoring as poor remained low (1-3%) with most changes occurring in the amount of habitat scoring as fair. The temporal pattern seen in the WQI appears to reflect patterns of coastal rainfall during July and August from 1999 and 2008 (Figure 3.1.3). During the first survey period, average rainfall for Beaufort, Colleton, Charleston, and Georgetown counties was about five inches. This increased to over seven inches during each of the next two survey periods and decreased to between five and six inches during the latter two survey periods. The primary mode of transport of water-borne pollutants into our coastal systems is stormwater runoff, thus during drier years, fewer pollutants would be expected to enter our waterways.

Results of analyses of covariance indicate that five of the primary measures used in the WQI showed highly significant differences between habitat types, with tidal creeks generally showing higher values for fecal coliform bacteria, TP and Chl-a, and lower values for DO and pH (Table 3.1.1). The greatest differences were noted for fecal coliform bacteria. The differences observed between tidal creek and open water habitats are consistent with creeks being stressful environments for estuarine biota. Comparison of concentrations of the six primary water quality measures over time indicated that only DO and TN changed significantly, with DO increasing and TN decreasing over previous survey periods in both habitats (Table 3.1.1).

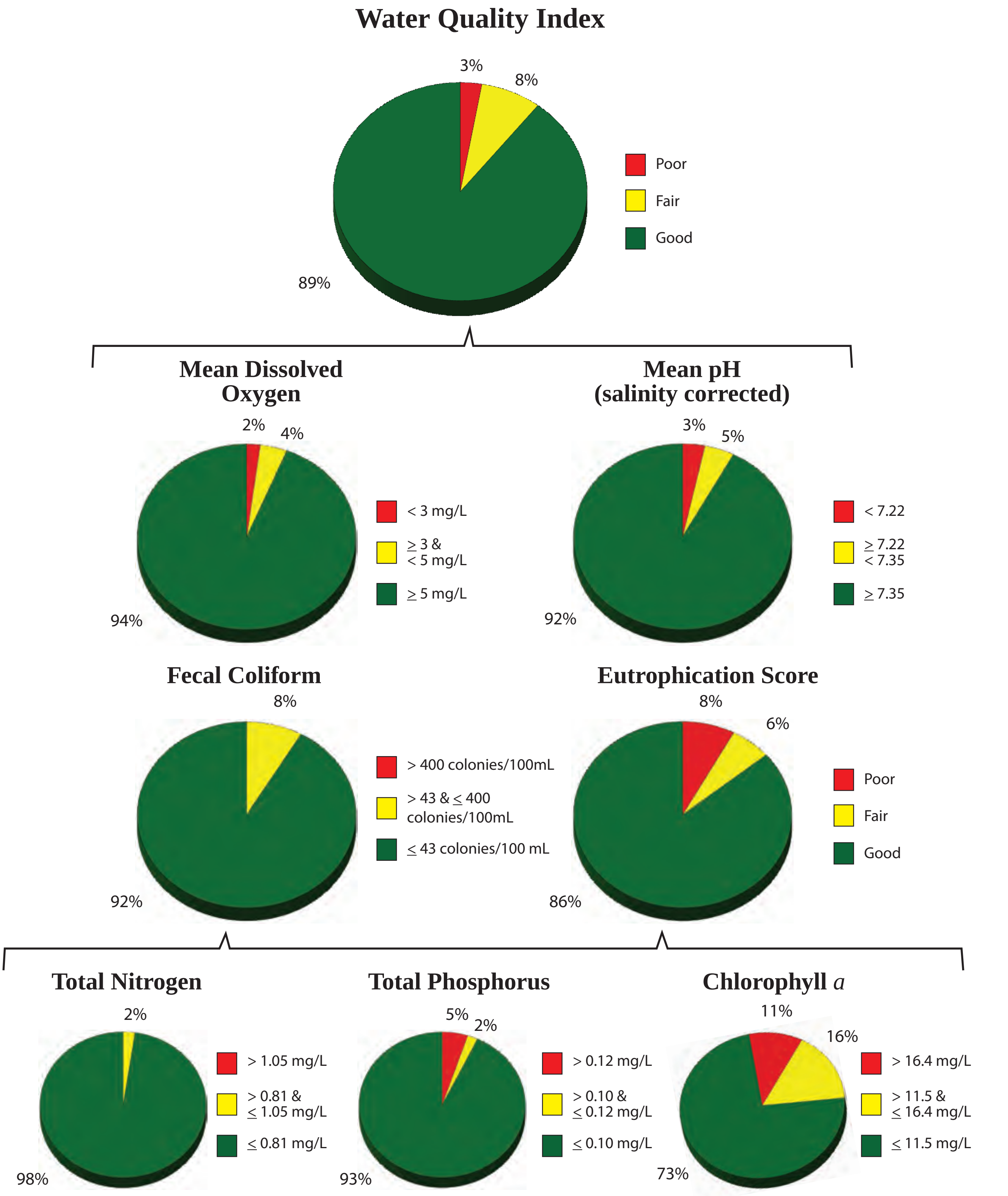

Figure 3.1.1. Percentage of the state's open water and tidal creek habitat that represent good, fair or poor conditions for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat.

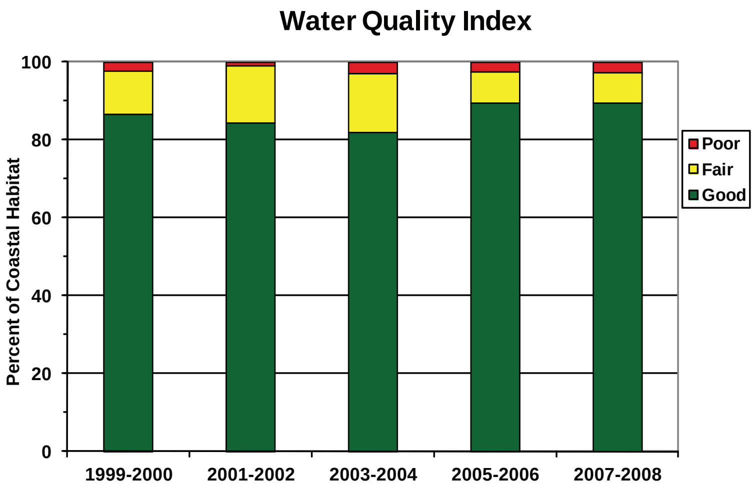

Figure 3.1.2 . Water Quality Index values observed by survey period for all coastal waters.

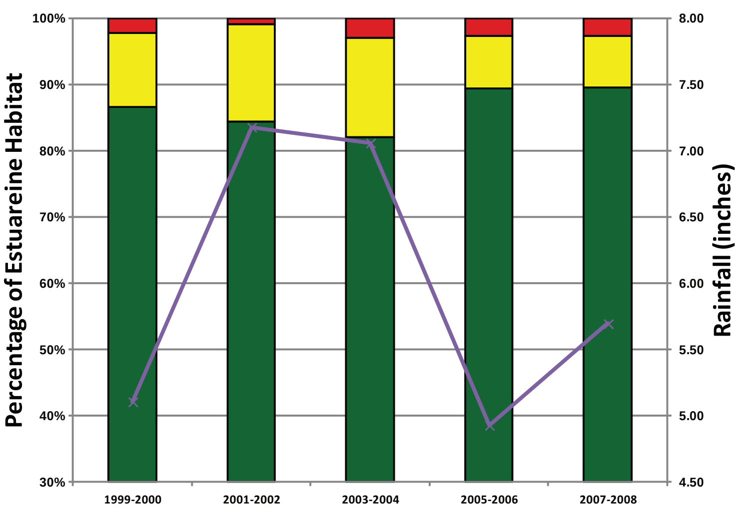

Figure 3.1.3. Comparison of the percentage of overall estuarine habitat with good, fair, or poor Water Quality Index scores, compared with average rainfall observed during July and August of the survey periods in Beaufort, Colleton, Charleston, and Georgetown counties. Horry County was not included because only a few stations are located in that county. Data downloaded from the Southeast Regional Climate Center http://www.sercc.com/.

Although not significant, other measures in the WQI index showed evidence of longer-term improvement, likely related to rainfall patterns since 1999.

Among the other water quality measures monitored, BOD_5, TSS and turbidity values were significantly higher and alkalinity was significantly lower in creeks as compared to open water habitats (Table 3.1.1). BOD_5 values significantly decreased over time, whereas TOC increased significantly over time. The highest BOD_5 was during the 1999-2000 survey period, which then decreased sharply thereafter and has remained low through 2008. This decreasing trend does not correspond with changes in any other parameter measured by SCECAP, so it is not clear why this change has occurred. In general, the surveys conducted from 2003-2006 had higher concentrations of TOC in both habitats compared to 1999-2002 and 2007-2008 surveys. Similar increases have not been observed in sediment TOC concentrations, so it is unclear why this apparent trend is being observed.

The distribution of stations with good, fair, or poor WQI scores is shown in Figure 3.1.4, Appendix 3 and Appendix 4a. Five sites had poor water quality and all were located in the southern portion of the state. Two of the sites with poor water quality were located in the Old Cheehaw River in the Ashepoo-Combahee-Edisto (ACE) Basin area (RT08083 and RT08067), a finding that is consistent with many of the previous surveys in the area (Figure 3.1.5; Van Dolah et al., 2006; Bergquist et al., 2009). The lower WQI in this river system tends to be associated with high levels of TN and TP and low levels of DO. Of the three other sites with poor water quality scores, all were located in Jasper County, one in a tributary of the Coosawhatchie River about 8 miles northeast of Ridgeland (RT07038), one in a tributary of the Wright River (RT07053) and one in the New River about 8.5 mi southwest of Bluffton (RT08085). The poor WQI at all three of these latter sites was driven by low pH and DO and high TP, Chl-a, or fecal coliform bacteria levels. When considering all years (1999-2008), portions of the state with a relatively high incidence of fair to poor water quality include the ACE Basin area, especially the most inland areas, the upper Ashley River, the Cape Romain area in or near the Intracoastal Waterway and Winyah Bay (Figure 3.1.5).

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 ten years; bolded values significant at p < 0.05. na—data not available.

Measure	Habitat	Year										p-values		Direction of Change
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Habitat	Year	
Dissolved Oxygen (mg/L)	Open	4.86	5.01	4.96	5.10	4.97	5.41	5.13	5.11	5.49	5.62	**<0.001**	**0.003**	+
	Creek	4.00	4.12	4.45	4.51	4.58	5.10	4.12	4.33	4.53	4.50			
pH	Open	7.58	7.53	7.67	7.71	7.39	7.75	7.59	7.68	7.68	7.68	**<0.001**	0.832	+
	Creek	7.52	7.43	7.56	7.53	7.31	7.36	7.30	7.48	7.43	7.49			
Total Nitrogen (mg/L)	Open	0.51	0.58	0.66	0.52	0.84	0.52	0.57	0.20	0.26	0.52	0.295	**0.021**	-
	Creek	0.69	0.75	0.72	0.58	0.72	0.64	0.67	0.20	0.32	0.65			
Total Phosphorus (mg/L)	Open	0.08	0.06	0.06	0.05	0.06	0.08	0.08	0.07	0.06	0.05	**0.009**	0.231	-
	Creek	0.09	0.10	0.09	0.06	0.09	0.12	0.08	0.07	0.06	0.09			
Chlorophyll *a* (ug/L)	Open	10.3	9.1	10.1	10.1	6.9	8.4	7.7	7.4	11.0	9.2	**0.012**	0.068	-
	Creek	12.6	12.5	10.8	9.7	11.6	12.0	8.0	10.1	10.9	8.9			
Fecal Coliform (col/100mL)	Open	46.5	10.9	14.3	9.2	25.3	16.7	11.7	23.5	16.8	13.1	**0.004**	0.469	-
	Creek	29.7	54.5	34.6	25.5	73.9	86.5	29.4	64.8	14.2	31.7			
Temperature (C)	Open	30.2	29.4	29.5	29.1	28.5	29.1	30.0	29.7	29.8	29.0	0.182	0.758	+
	Creek	30.1	29.8	29.5	29.0	29.0	29.6	29.9	30.2	30.3	29.9			
Salinity (ppt)	Open	26.2	28.1	28.2	31.0	19.9	28.4	25.9	31.1	30.3	31.3	0.527	0.489	+
	Creek	31.1	31.5	29.4	32.1	20.8	26.2	23.2	32.3	29.3	32.0			
BOD_5	Open	2.28	0.92	0.66	0.16	0.00	0.07	0.11	0.10	0.31	0.31	**0.028**	**<0.004**	-
	Creek	2.63	1.12	0.64	0.62	0.75	0.82	0.49	0.37	0.58	0.52			
Total Suspended Solids	Open	na	na	28.2	42.0	20.3	21.6	35.3	33.4	61.1	45.1	**0.041**	0.135	+
	Creek	na	na	52.6	54.2	37.5	38.2	49.8	37.8	44.1	71.5			
Turbidity	Open	15.8	12.6	16.4	13.5	13.9	11.0	14.5	11.1	14.9	14.1	**<0.001**	**0.224**	-
	Creek	22.4	19.8	29.5	16.0	25.5	18.5	19.3	14.4	19.8	21.3			
Total Organic Carbon	Open	3.98	4.10	5.62	4.96	11.57	6.46	8.28	6.55	6.95	7.30	0.559	**0.009**	+
	Creek	2.61	4.25	5.05	5.77	15.69	9.55	10.00	8.15	7.97	6.90			
Alkalinity	Open	97	97	98	106	75	99	94	108	108	76	**0.042**	0.856	+
	Creek	116	115	108	112	87	100	93	114	107	140			

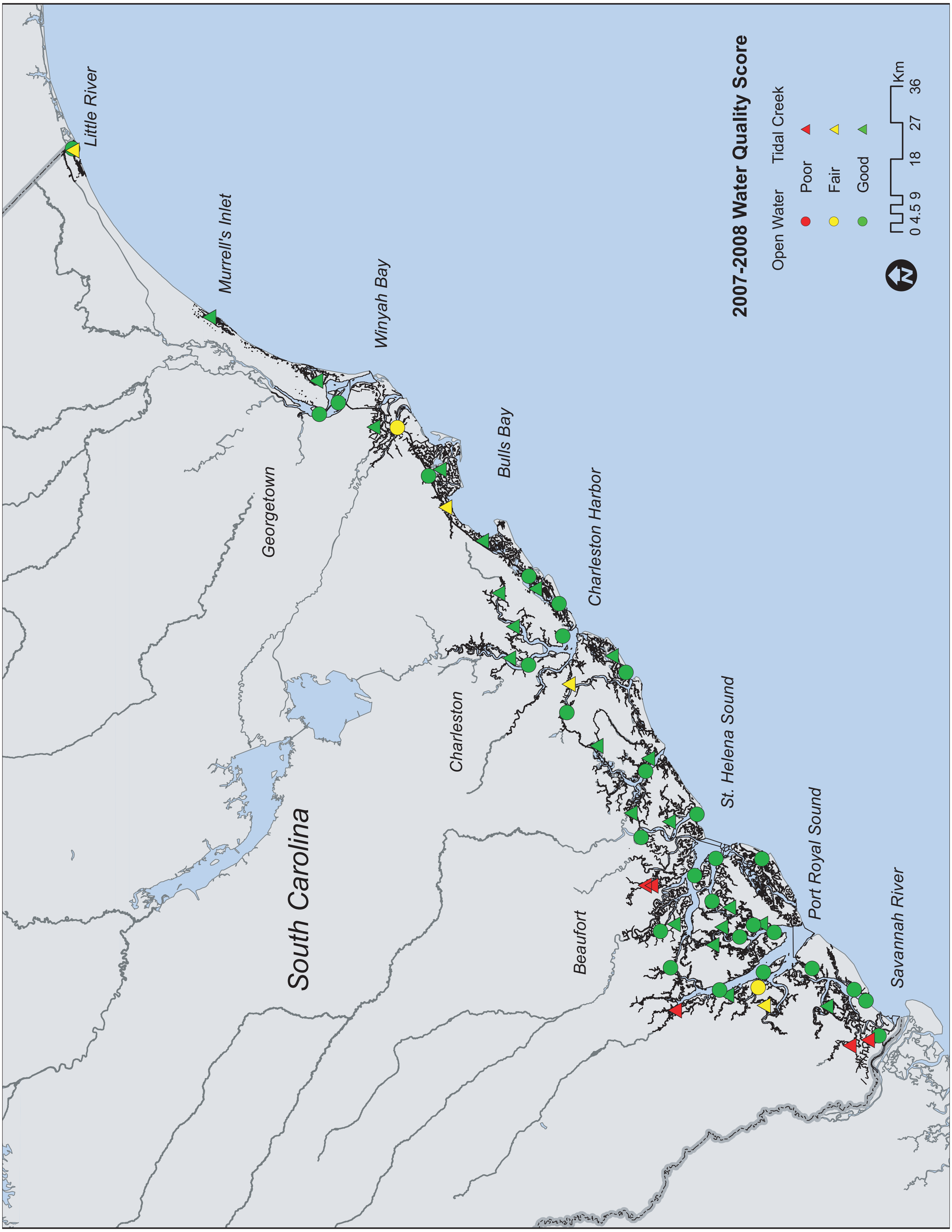

Figure 3.1.4. Distribution of stations having a good, fair, or poor Water Quality Index during the 2007-2008 SCECAP survey period.

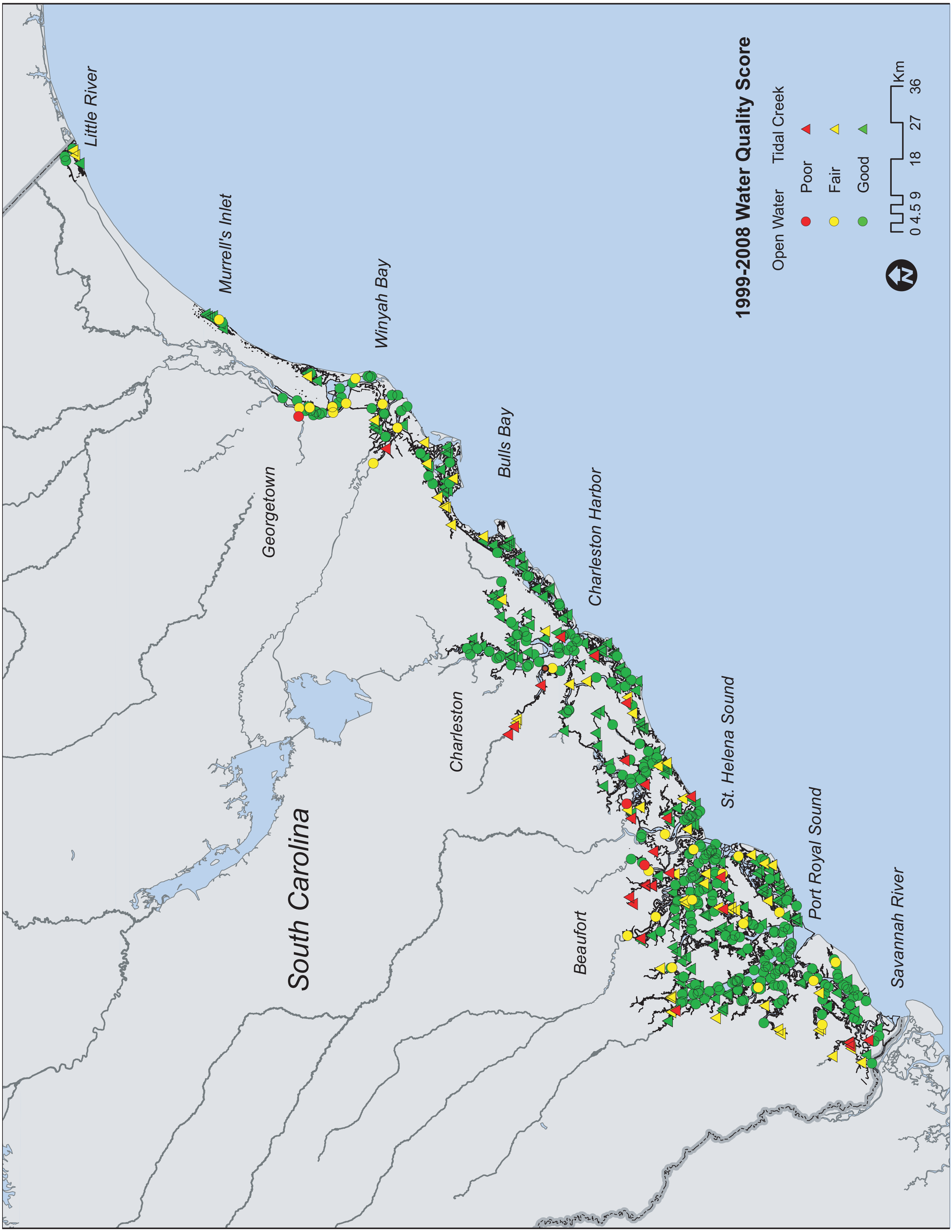

Figure 3.1.5. Distribution of stations having a good, fair, or poor Water Quality Index during the 1999-2008 SCECAP survey period.

3.2 Sediment Quality

Sediment quality measurements are an essential component of our overall estuarine habitat quality assessment because sediments: 1) support invertebrate communities that form the base of food web for many other species of concern, 2) exchange nutrients and gases with overlying water in support of overall estuarine function, and 3) serve as a sink for contaminants which can accumulate over time providing a better measure of long-term exposure to contaminants in an area. Although many sediment quality measures are collected by SCECAP, the three component measures of the Sediment Quality Index (SQI) are considered to be the most important. These include: 1) a combined measure of 24 organic and inorganic contaminants that have published biological effects thresholds (ERM-Q; Long et al. 1997, Hyland et al. 1999, 2003), 2) a measure of sediment toxicity based on two bioassays that indicates whether contaminants are present at concentrations that have adverse biological effects, and 3) total organic carbon (TOC), which can have several adverse effects on bottom-dwelling biota and provide a good predictor of benthic community condition (Bergquist et al., 2009).

Based on the Sediment Quality Index (SQI), 83% of South Carolina's estuarine habitat had good sediment quality, 9% had fair sediment quality, and 8% had poor quality during the 2007-2008 survey period (Figure 3.2.1). As noted in previous surveys, a higher percentage of the state's open water habitat had good sediment quality compared to tidal creek habitats (Appendix 2). During the 2007-2008 survey period, 36% of the state's tidal creek habitat was in fair or poor condition compared to only 14% of the state's open water habitat.

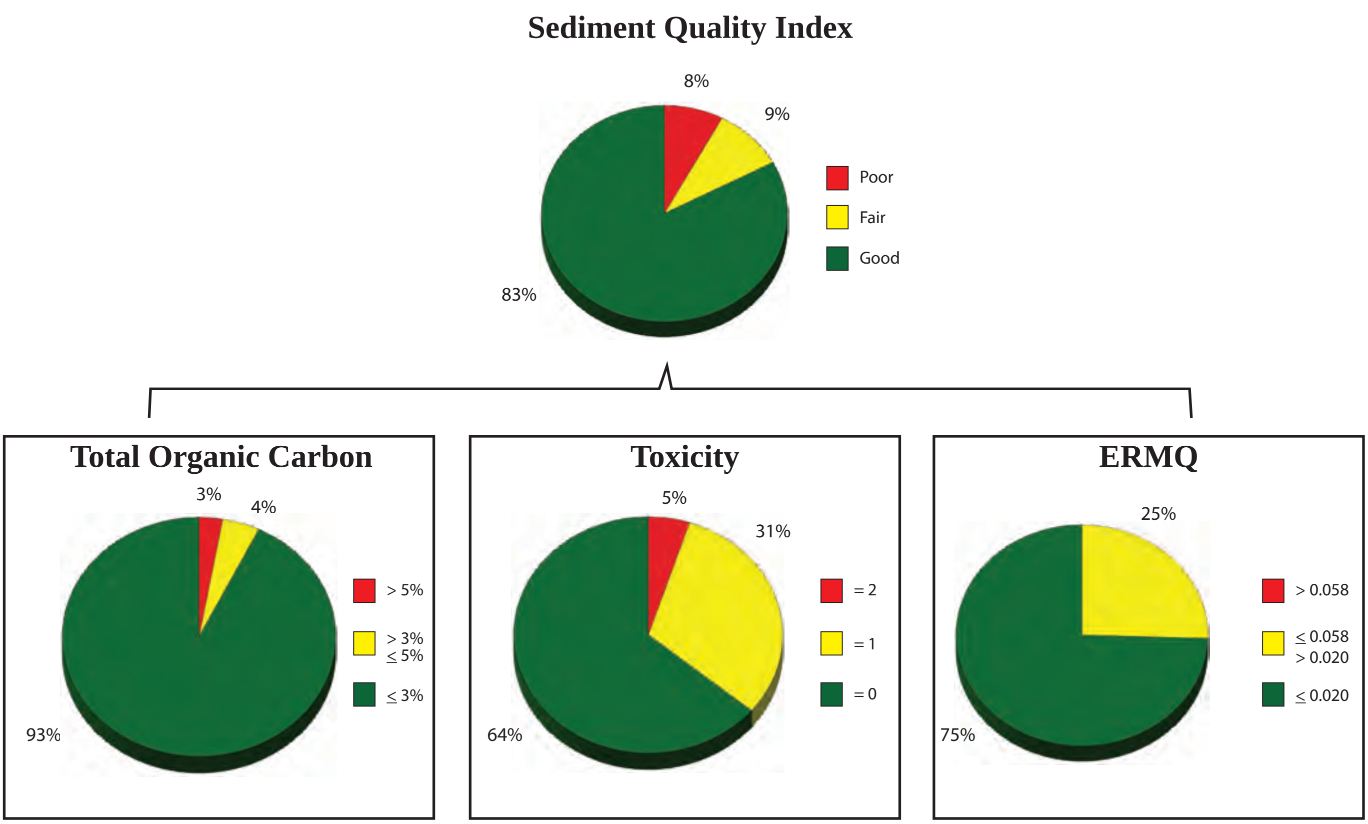

Figure 3.2.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Sediment Quality Index and it's component measures during 2007-2008.

Among the three SQI component measures, both sediment contaminant (ERM-Q) and toxicity measures showed high percentages of the state's waters in only fair or poor condition (25% and 36%, respectively) whereas total organic carbon (TOC) was considered fair or poor for only 7% of the habitat. Since the overall SQI indicated that only 9% of the state's estuarine habitat was in fair condition, most of the sites sampled during this survey did not have both elevated contaminants and toxicity in the sediments (Appendix 3, Appendix 4b). Levels of contaminants that exceed the "fair" threshold are conservative and evidently were not high enough or in a form that was bioavailable to elicit any toxicity responses. The sites that show toxicity in one of the two bioassays (fair rating), may have contained an unmeasured contaminant or may represent a false positive toxicity response, which is common for the Microtox® assay (Van Dolah et al., 2006).

None of the state's coastal habitat had high (poor) contaminant concentrations, and only 5% of the habitat had sediments that showed toxicity in both assays (poor) and/or high (poor) TOC concentrations (3%, Figure 3.2.1).

The high percentage of the state's coastal habitat with good SQI scores is consistent with conditions noted in the previous (2005-2006) survey, and generally better than conditions observed in earlier survey periods (e.g. 2001-2004) (Figure 3.2.2). This may, in part, be due to the lower rainfall observed during more recent survey periods (2005-2008) compared to earlier surveys periods (e.g. 2001-2004, Figure 3.2.3). Lower rainfall results in less runoff from upland sources. Changes in the percentage of the state's habitat that are considered to be fair or poor using SCECAP sediment criteria have also varied among the survey periods, but most of the change was reflected in those sediments coding as fair for the SQI. The percentage of the state's estuarine habitat with poor SQI condition has been fairly consistent among all survey periods, and generally represents < 10% of the estuarine habitat except for the 2001-2002 survey (Figure 3.2.2).

While the overall sediment quality in the state's coastal waters was generally good, it is important to note that during the current survey, 53% of the state's tidal creek habitat had moderately elevated contaminant concentrations (fair condition) compared to only 20% of the state's open water habitat (Appendix 2). This represents a statistically significant increase in the percentage of tidal creek habitat that has coded as fair in sediment contaminant concentrations compared to all previous survey periods (21-36%) except the 2001-2002 survey. Furthermore, while the mean concentrations of ERM-Q has not increased significantly since the inception of SCECAP monitoring, the slope of change in concentration remains positive (i.e. increasing over time) and tidal creek contaminant concentrations are now significantly higher than open water stations ($p = 0.037$) when all survey periods are considered collectively. This was not observed in the 2005-2006 survey (Table 3.2.1). These changes were not expected based on the relatively low rainfall observed during the recent survey periods (Figure 3.2.3) and warrant further consideration if future surveys show this trend continuing. Tidal creeks may serve as an early warning sentinel habitat (Holland et al., 2004) and while the elevated contaminant concentrations are not great relative to known bioeffects levels, continued degradation of the these habitats is likely to occur with increasing coastal development. None of the other sediment quality variables showed significant changes in the percent of the state's tidal creek or open water habitat considered to be good, fair, or poor among the five survey periods completed to date.

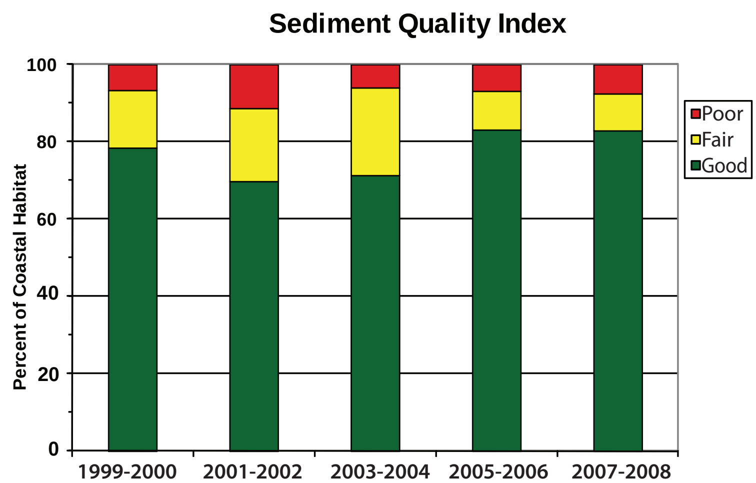

Figure 3.2.2. Sediment Quality Index Scores by survey period for all estuarine habitat combined.

Both silt/clay and TOC concentrations were significantly higher in tidal creeks compared to open water habitats (Table 3.2.1). Contaminants tend to bind with the fine-grained sediments and organic material, which may partially explain the significant difference noted above in ERM-Q concentration. However, significantly higher silt/clay and TOC concentrations were observed in the previous survey without a similar significant difference in ERM-Q concentrations between these two habitats (Bergquist et al., 2009). None of the sediment variables have shown significant changes in annual average values over the 10-year period of SCECAP surveys (Table 3.2.1).

Stations which contained poor sediment quality in the 2007-2008 survey included two open water and four tidal creek sites (Figure 3.2.4; Appendices 3 and 4b). The two open water sites were located in Winyah Bay about 3 km south of the Sampit River and the South Edisto River near the Intracoastal Waterway. Both of these areas have shown habitat quality issues in past surveys. The four tidal creek sites with poor sediment quality were Minum Creek (just north of the North Santee River), Bailey Creek (off the South Edisto River), a creek off the Wright River, and the upper, narrow (< 100 m) portion of the New River. All of these creek sites have had habitat

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

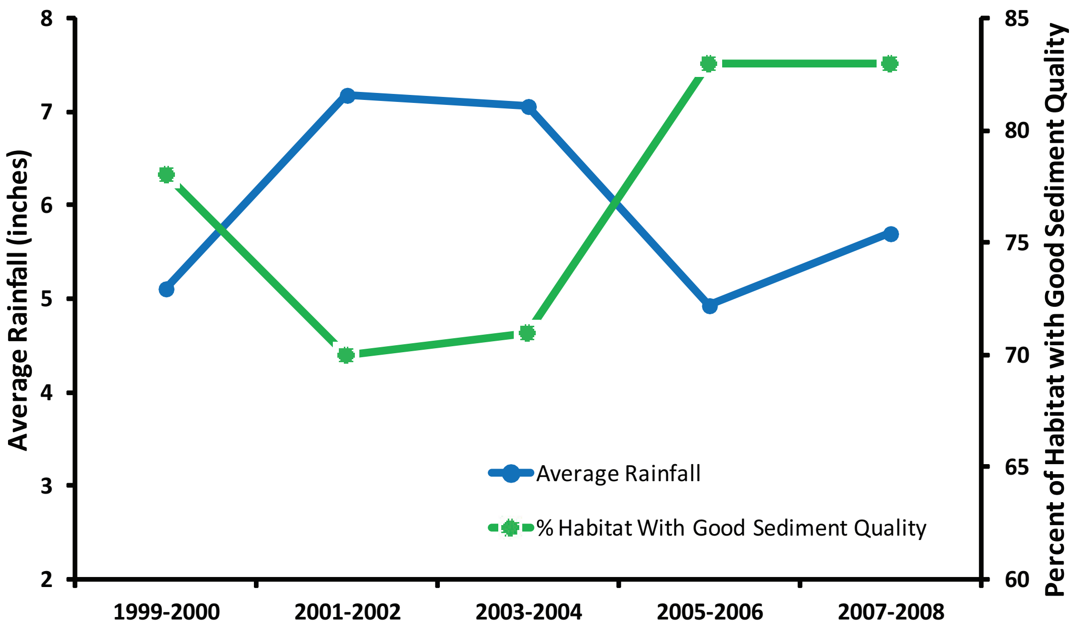

Figure 3.2.3. Average rainfall and the percent of estuarine habitat with the sediment quality index (SQI) coding as "good".

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**	**2007**	**2008**	**Habitat**	**Year**	
Total Organic Carbon (%)	Open	0.86	0.63	0.94	0.84	0.74	0.88	0.70	0.77	0.79	0.70	**<0.001**	0.265	-
	Creek	1.08	1.33	1.30	1.39	1.30	1.12	1.48	1.03	1.71	1.06			
ERM-Q	Open	0.013	0.013	0.013	0.017	0.014	0.015	0.013	0.017	0.013	0.014	**0.037**	0.363	+
	Creek	0.015	0.014	0.017	0.015	0.018	0.016	0.018	0.013	0.022	0.015			
Sediment Bioassays	Open	0.48	0.67	0.70	0.70	0.53	0.70	0.60	0.20	0.40	0.33	0.068	0.077	-
	Creek	0.52	0.67	1.16	0.70	0.70	0.70	0.84	0.36	0.73	0.53			
Silt & Clay (%)	Open	22.3	15.1	23.0	20.5	15.4	24.2	17.7	17.9	22.7	18.7	**<0.001**	0.674	-
	Creek	32.0	31.8	30.3	30.9	34.3	26.0	37.4	21.0	40.7	23.4			
Total Ammonia Nitrogen	Open	2.62	2.91	2.51	3.64	3.22	4.13	1.95	2.09	1.69	3.44	0.935	0.102	-
	Creek	2.79	3.06	3.46	2.75	4.74	2.17	2.48	2.16	2.04	2.23			

quality issues when sampled in previous surveys, with the exception of the creek off the Wright River which has not been sampled previously. Minum Creek is adjacent to extensive waterfowl impoundments and both the Bailey Creek and New River sites are close to agricultural land. Bailey Creek was sampled previously in 1999 and was found to have poor water quality, sediment quality and benthic community condition. The site sampled in 2007 only had poor sediment quality and was more distant from farmland but close to some upland development. Stations which had only fair sediment quality included two open water sites in the Intracoastal Waterway and eight tidal creek sites. There was no consistent land use pattern associated with these creeks that may have contributed to the observed water quality. When all five survey periods from 1999-2008 are considered collectively, areas with the greatest incidence of poor sediment quality are located in Winyah Bay, the Charleston Harbor estuary, and portions of the ACE Basin, particularly near the South Edisto River and Dawhoo Creek (Figure 3.2.5). Continued sampling will provide further evidence of where sediment quality problems are consistently observed, which should help resource managers identify areas to be targeted for more intensive study to identify causes.

Heavy industries in the Winyah Bay area include both paper and steel mills that may be contributing to the pollutants in the watershed.

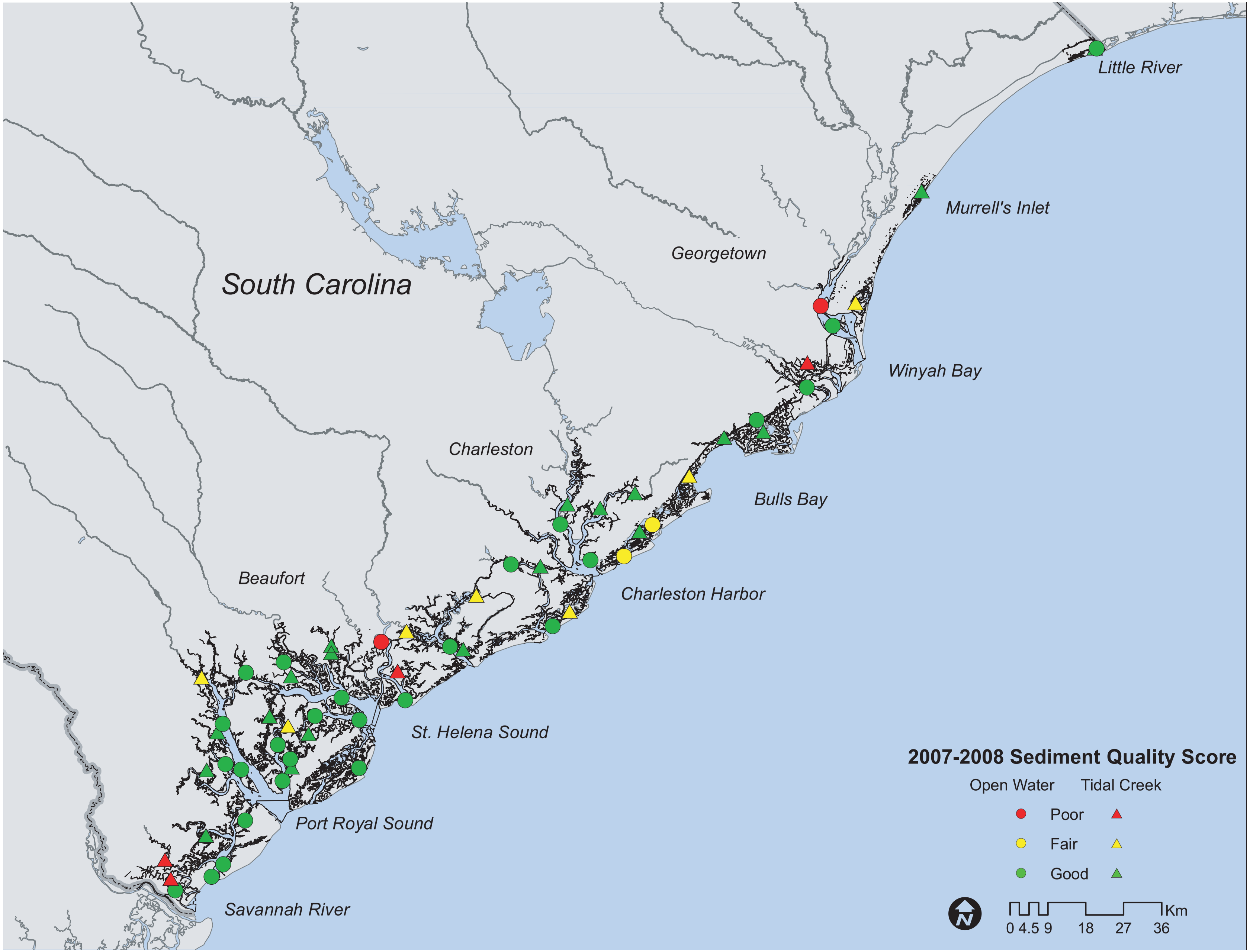

Figure 3.2.4. Distribution of stations having good, fair, or poor scores for the Sediment Quality Index during the 2007-2008 survey period.

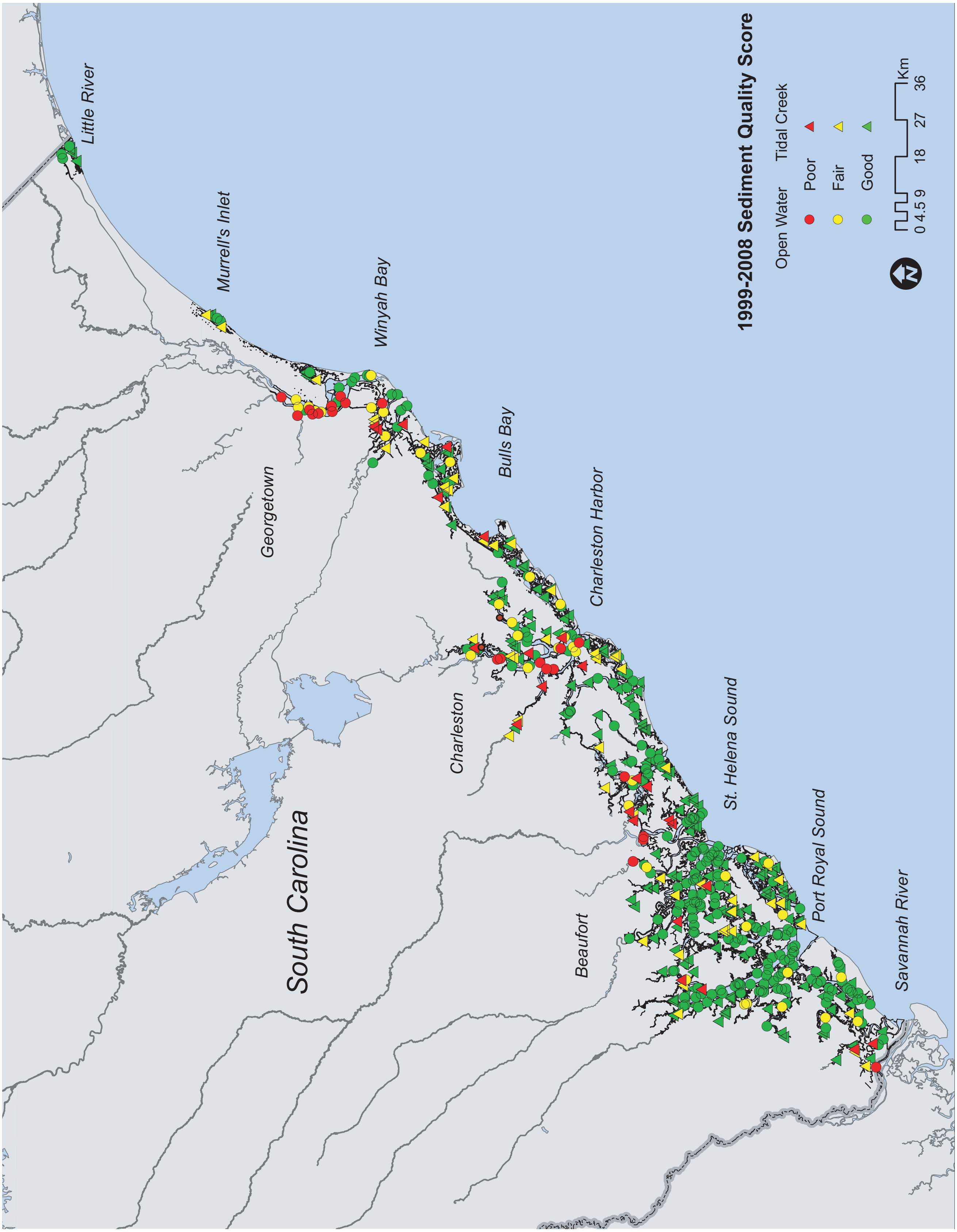

Figure 3.2.5. Distribution of stations having good, fair, or poor scores for the Sediment Quality Index during the 1999-2008 SCECAP survey period.

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 95% of South Carolina's estuarine habitat was in good condition with 2% in fair and 3% in poor condition in terms of benthic community quality during the 2007-2008 survey period (Figure 3.3.1). As in previous surveys, a greater percentage of open water habitat scored as good (97%) compared to tidal creek habitat (84%) (Appendix 2). The greater percentage of fair and poor habitat in the tidal creek habitats may reflect that shallow tidal creek systems are more stressful to the organisms that are indicative of healthy tidal rivers and bays.

The percentage of habitat scoring as good for the B-IBI is the highest observed since SCECAP began in 1999 (Figure 3.3.2). As with the WQI and SQI, the B-IBI shows a clear pattern of greater amount of habitat in good condition during periods of lower rainfall. This likely reflects differences in salinity within the state's estuaries. For example, annual average B-IBI is positively related to annual average salinity (Figure 3.3.3) using data in Table 3.3.1. A primary component of the B-IBI is the number of species by station (Van Dolah et al. 1999). During periods of lower rainfall and higher estuarine salinity, a larger number of marine species can inhabit estuarine systems, thus increasing the number of species present and improving the B-IBI. Although this suggests that salinity represents an important confounding factor in the interpretation of the B-IBI, it is important to note that the B-IBI index thresholds are adjusted for different salinity conditions and the index is still capable of distinguishing habitats of differing stress. This is clearly apparent in the lower B-IBI score of creek habitats for any given salinity (Figure 3.3.3).

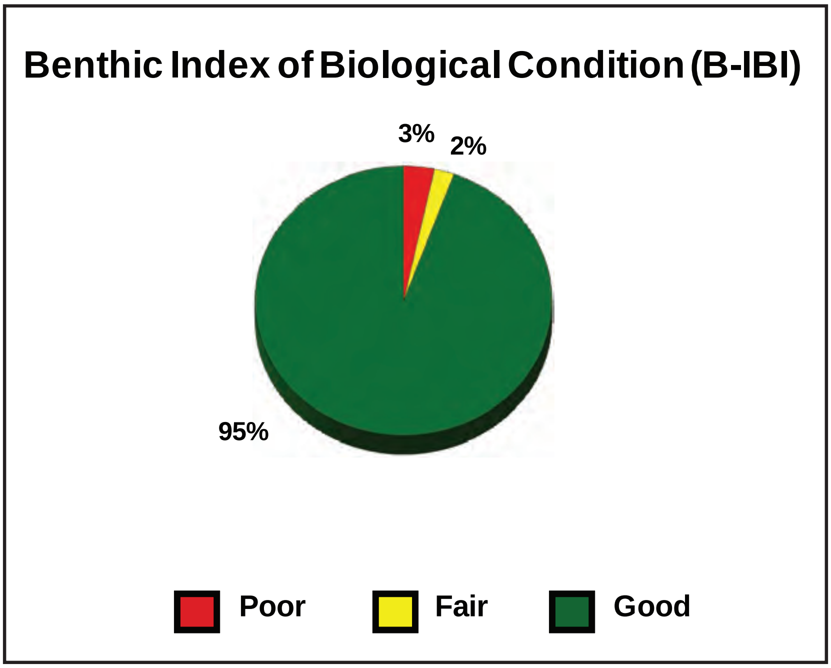

Figure 3.3.1. Percentage of the state's estuarine habitats that score as good, fair, or poor for the B-IBI during 2007-2008.

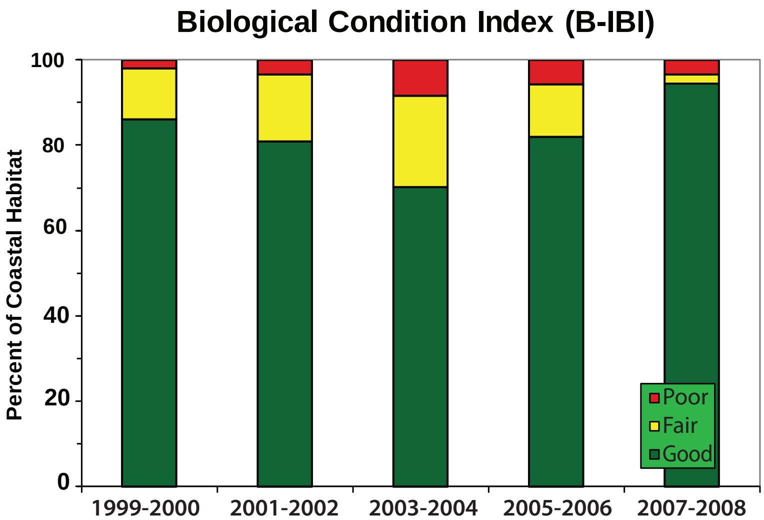

Figure 3.3.2. B-IBI by survey period for the state's estuarine habitats.

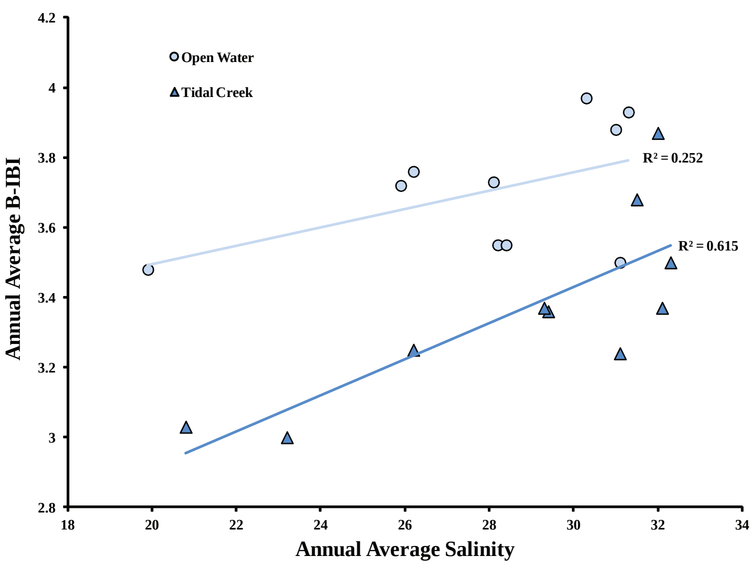

Figure 3.3.3. Annual averages of B-IBI and salinity that show a positive relationship between the two variables.

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') can be lower in more stressful environments. This is because fewer and fewer species within a community can tolerate increasingly stressful conditions, such as those caused by decreasing dissolved oxygen or increasing sediment contamination. Using 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 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, number of species, and species diversity) increased in South Carolina's coastal environment since 1999, the changes were not statistically significant in either tidal creek or open water habitats.

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 have not changed significantly since 1999.

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 whereas amphipods and molluscs become increasingly more abundant in sandier oceanic environments (Little, 2000). A comparison between tidal creek and open water habitats support these expected patterns, with the densities

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**	**2007**	**2008**	**Habitat**	**Year**	**of Change**
B-IBI	Open	3.76	3.73	3.55	3.88	3.48	3.55	3.72	3.50	3.97	3.93	**0.004**	0.340	+
	Creek	3.24	3.68	3.36	3.37	3.03	3.25	3.00	3.50	3.37	3.87			
Density (indiv/m^2)	Open	5354	6294	4095	7198	4236	4127	5282	4513	7230	8634	**0.014**	0.299	+
	Creek	2363	4659	4710	5001	3198	2863	2282	5060	3044	6402			
Number of Species	Open	25.9	22.2	17.5	26.7	18.9	18.7	21.0	19.0	23.1	23.9	**0.020**	0.849	+
	Creek	14.8	19.8	17.5	20.7	14.4	16.0	12.0	22.2	14.5	23.4			
Species Evenness (J')	Open	0.76	0.70	0.72	0.73	0.73	0.74	0.74	0.77	0.69	0.68	0.391	0.741	-
	Creek	0.72	0.69	0.71	0.70	0.73	0.72	0.75	0.67	0.74	0.72			
Species Diversity (H')	Open	3.30	2.81	2.74	3.14	2.67	2.84	2.94	2.99	2.98	3.01	**0.011**	0.838	+
	Creek	2.60	2.85	2.78	2.78	2.35	2.64	2.41	2.75	2.67	3.04			
Sensitive Taxa Density	Open	764	1986	615	1045	854	900	1572	959	1223	1330	**<0.001**	0.799	+
	Creek	313	965	694	528	465	260	338	705	330	680			
Percent Sensitive Taxa	Open	13.3	26.7	18.2	15.5	16.3	23.6	19.4	17.6	18.6	18.0	**<0.001**	0.603	+
	Creek	9.8	16.2	10.7	6.5	10.3	8.4	13.3	13.6	13.9	13.1			
Amphipod Density	Open	687	927	243	979	870	802	1391	283	745	384	0.186	0.250	+
	Creek	113	753	193	248	331	176	346	560	1247	1061			
Mollusc Density	Open	259	327	303	516	302	193	141	627	436	409	0.004	0.470	+
	Creek	123	265	193	208	144	91	34	283	99	246			
Other Taxa Density	Open	1555	1280	808	1059	766	605	925	929	1993	2233	**0.004**	0.532	+
	Creek	339	824	924	684	880	556	423	547	485	868			
Polychaete Density	Open	2855	3761	2740	4644	2298	2182	2772	2481	4057	5608	0.165	0.417	+
	Creek	1788	2818	3401	3861	1844	2129	1479	3421	1213	4228			
Percent Amphipods	Open	10.9	18.6	12.7	13.2	17.5	17.5	16.4	12.7	13.6	9.5	**0.050**	0.258	-
	Creek	6.1	11.8	4.5	5.3	7.8	4.7	12.9	10.4	13.5	14.1			+
Percent Molluscs	Open	5.9	7.9	10.0	9.6	7.8	8.5	2.8	10.5	6.3	6.3	**0.003**	0.285	-
	Creek	3.5	6.0	5.7	6.2	5.6	4.7	1.8	5.0	4.4	3.5			
Percent Other Taxa	Open	26.7	19.2	16.9	20.0	22.4	21.8	23.9	25.4	27.6	24.4	0.500	0.847	+
	Creek	21.6	24.4	20.0	17.6	33.2	19.6	25.8	14.4	23.3	17.6			
Percent Polychaetes	Open	56.4	54.3	60.3	57.2	52.3	50.3	56.4	50.3	52.5	59.6	**<0.001**	0.511	-
	Creek	68.8	57.8	69.7	70.9	53.4	71.0	59.4	68.5	58.7	64.7			

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). The densities of all four of these taxonomic groups increased over the past ten years, but the changes were not significant.

The distribution of stations with good, fair or poor B-IBI scores during the 2007-2008 period is shown in Figure 3.3.4, Appendix 3, and Appendix 4c. Only two stations scored as poor for B-IBI scores: one station was located in Clouter Creek about 0.5 miles from its confluence with the Cooper River in Charleston Harbor (RT07040), and the second station was located in the South Edisto River within the ACE Basin National Estuarine Research Reserve (NERR) (RO07339) (Figure 3.3.4). Poor to fair B-IBI values have been associated with both of these locations during past surveys as well. Historically, poor B-IBI scores have been observed in Winyah Bay, other parts of Charleston Harbor, the North Edisto River. Some of the more inland creeks that drain into St. Helena Sound and Port Royal Sound (Figure 3.3.5) also have poor B-IBI scores. However, care should be exercised when interpreting these scores in shallower tidal creeks as the B-IBI was largely derived from data collected from 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 invertebrates such as shrimp (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.

Densities of vertebrates (fish, rays, etc), decapods (crabs, shrimp, etc) and all fauna combined 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 refuge and nursery habitat for many of these species. Every measure of the finfish and large invertebrate community has been decreasing since 1999 ("- Change" in Table 3.3.2). These changes were significant for several measures including total number of species, vertebrate density and number of decapod species. This could become a significant concern if this trend continues over a longer period.

Finfish , shrimp, crabs and many other species utilize the intertidal oyster and marsh habitats as refuge and feeding areas.

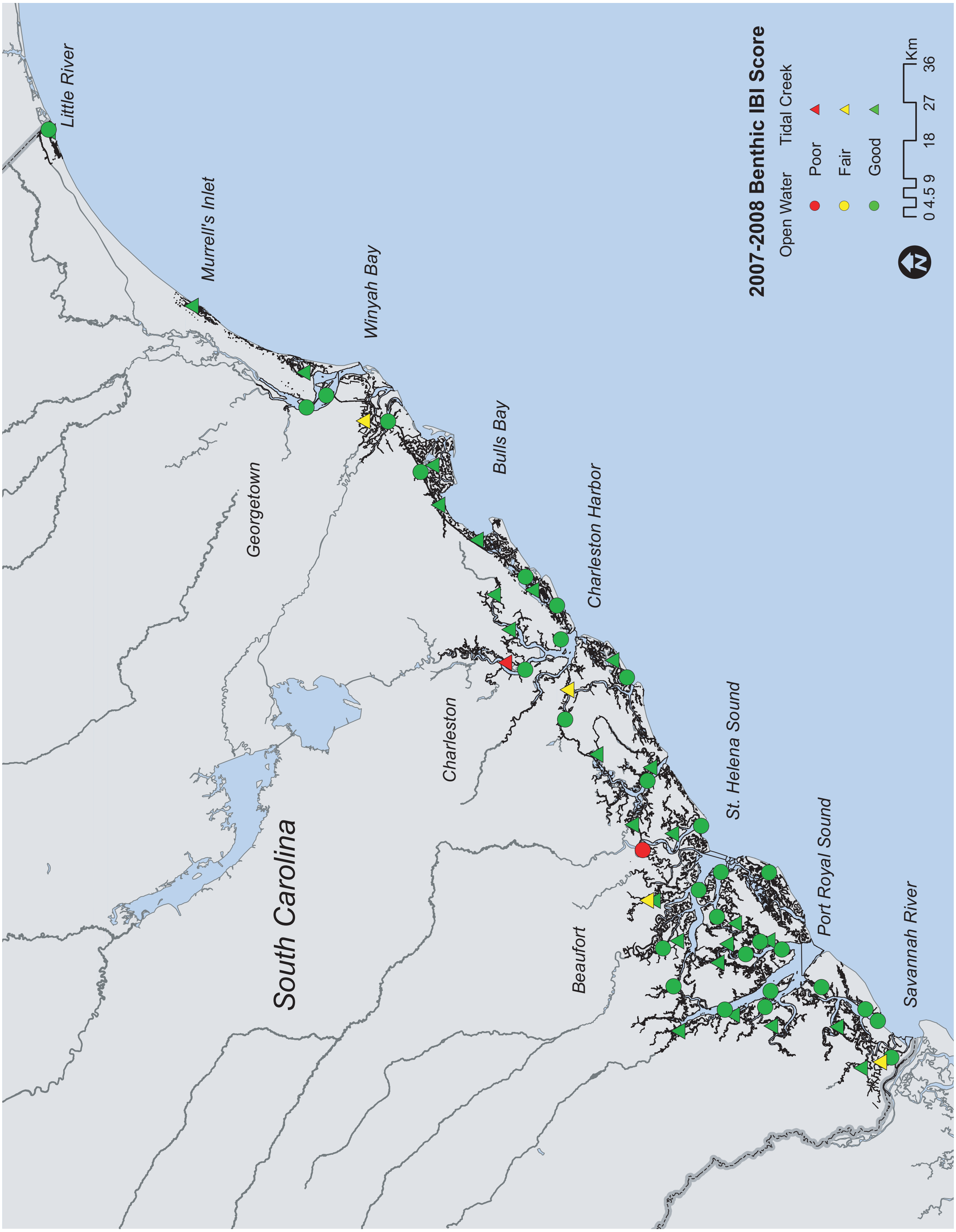

Figure 3.3.4. Distribution of stations having good, fair, or poor scores for the B-IBI during the 2007-2008 SCECAP survey period.

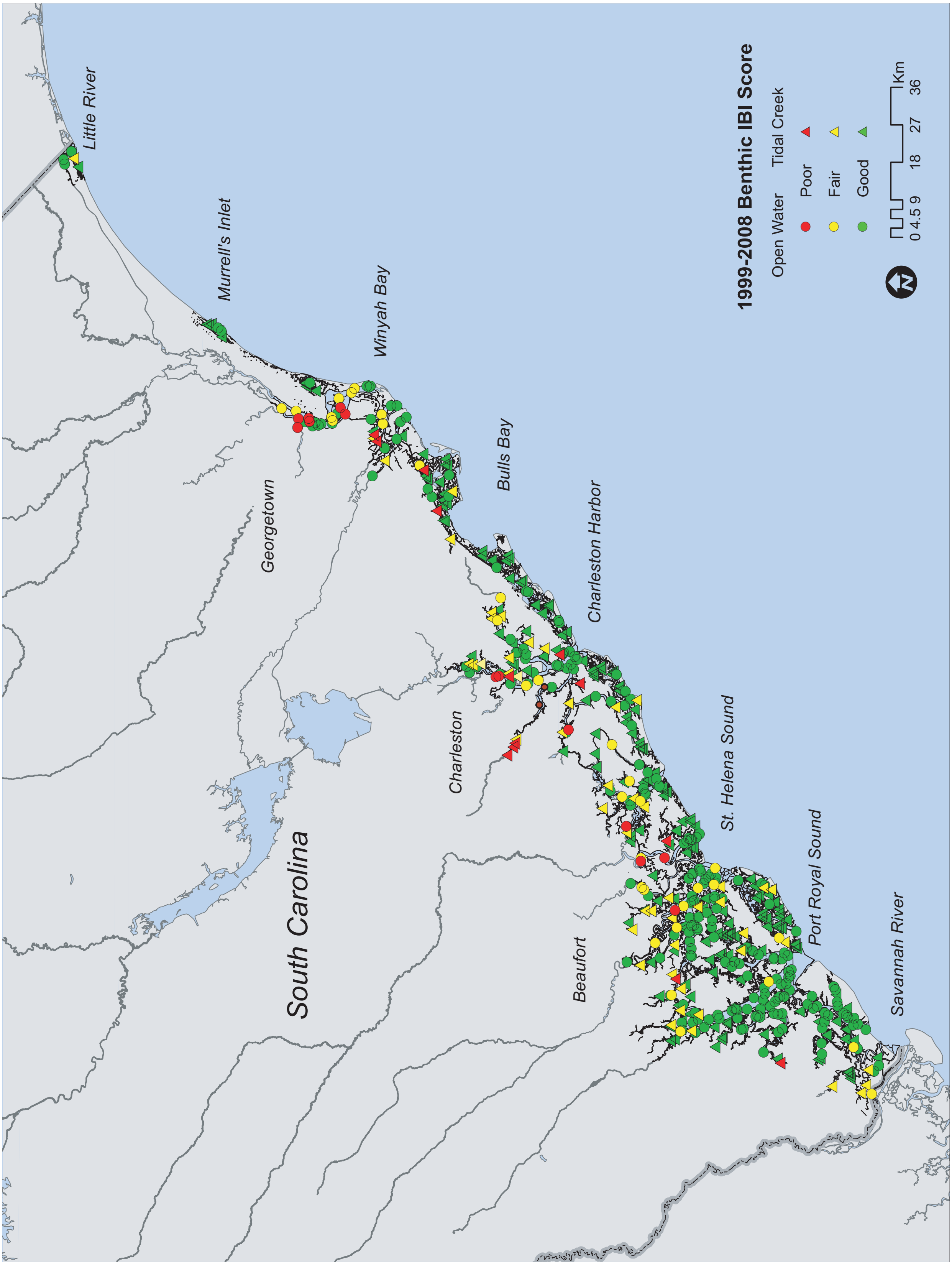

Figure 3.3.5. Distributions of station having poor scores for the B-IBI during the 1999-2008 SCECAP survey periods.

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 of Change
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Habitat**	**Year**	
Overall Density	Open	2.6	2.6	3.0	4.5	2.6	3.6	3.1	3.6	2.3	0.9	**0.001**	0.067	-
	Creek	6.4	6.9	5.6	8.9	6.1	10.6	5.9	12.9	2.4	2.4			
No. Species	Open	8.0	7.8	8.0	9.1	7.4	8.2	8.1	8.0	8.3	6.0	0.148	**0.019**	-
	Creek	8.5	9.9	8.2	9.3	8.4	9.3	9.2	8.0	7.1	6.6			
Vertebrate Density	Open	1.7	1.8	1.7	2.7	1.6	1.9	1.7	1.9	1.4	0.8	**0.034**	**0.003**	-
	Creek	2.7	3.3	2.8	2.4	2.7	3.0	2.8	1.5	0.9	1.7			
No. Vertebrate Species	Open	5.5	5.2	5.7	6.5	5.6	5.9	5.9	6.2	6.1	4.5	0.279	0.277	-
	Creek	5.8	6.8	5.7	6.7	6.0	6.4	6.4	5.9	5.2	5.0			
Decapod Density	Open	10.8	12.0	20.7	30.9	17.1	26.4	20.7	26.5	13.9	1.8	**0.003**	0.146	-
	Creek	57.3	53.0	43.2	95.1	53.6	117.9	48.0	176.0	22.7	9.3			
No. Decapod Species	Open	2.1	2.5	2.0	2.4	2.1	2.0	2.0	1.9	1.9	1.3	0.374	**0.044**	-
	Creek	2.0	2.4	2.0	2.1	2.0	2.4	2.6	1.8	1.8	2.1			
Spot Density	Open	6.4	18.2	64.8	26.8	23.2	49.2	56.8	29.1	11.8	19.8	**0.020**	0.380	-
	Creek	69.8	131.0	111.5	37.9	71.0	95.1	146.5	23.6	13.0	44.0			
Croaker Density	Open	3.0	48.3	35.8	111.9	71.0	24.6	26.8	26.5	51.0	4.3	**0.005**	0.290	-
	Creek	8.3	7.5	15.7	17.4	12.5	6.3	5.5	1.4	14.0	1.0			
Weakfish Density	Open	11.1	23.7	22.4	41.5	2.9	52.3	10.7	13.8	10.9	9.9	**0.005**	0.219	-
	Creek	13.7	6.0	3.8	11.8	3.2	3.5	7.9	2.3	7.8	3.9			
White Perch Density	Open	42.2	8.6	5.8	5.8	4.8	2.1	6.4	8.8	6.4	0.7	**<0.001**	**0.001**	-
	Creek	95.5	93.6	31.5	95.6	31.1	35.3	28.7	59.7	18.3	11.6			
Spadefish Density	Open	4.6	4.0	0.7	5.8	1.0	4.2	6.4	6.8	1.7	0.7	0.324	0.895	-
	Creek	3.8	2.8	2.9	7.7	0.7	12.8	6.1	11.3	1.9	3.9			
Blue Crab Density	Open	1.5	8.3	1.1	1.1	2.5	3.4	3.5	5.7	0.5	0.0	**0.001**	0.449	-
	Creek	4.0	22.4	5.2	5.3	10.5	18.4	20.6	8.5	9.8	3.4			
Brown Shrimp Density	Open	8.0	41.8	104.3	69.0	51.3	34.1	45.7	34.3	62.7	8.5	**0.035**	0.195	-
	Creek	122.4	68.6	97.1	130.9	66.8	128.3	150.1	40.7	26.6	37.2			
White Shrimp Density	Open	74.6	41.8	54.0	165.7	78.1	172.7	110.9	170.2	42.7	5.6	**0.005**	0.149	-
	Creek	326.1	323.5	238.1	610.3	347.5	792.3	208.3	1356	142.6	25.1			

SCECAP provides a fishery-independent assessment of several of South Carolina's commercially and recreationally-important fish and crustacean species. Of these, the most common species collected by SCECAP include the fish: spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), silver perch (*Bairdiella chrysoura*), and Atlantic spadefish (*Chaetodipterus faber*), and the crustaceans: blue crab (*Callinectes sapidus*), white shrimp (*Litopenaeus setiferus*), and brown shrimp (*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). While the densities of all species have decreased since 1999, only silver perch showed evidence of a significantly lower density between 1999 and 2008 (Table 3.3.2). In a recent detailed analysis of spot, Atlantic croaker and weakfish catches, Bergquist et al. (2010) found evidence of potentially decreasing densities and distributions of spot and weakfish and to a lesser extent Atlantic croaker.

3.4 Incidence of Litter

As the coastline of South Carolina develops and more people access our shorelines and waterways, the incidence of litter (plastic bags and bottles, abandoned crab traps, etc.) is likely to increase. The primary sources of litter include storm drains, roadways and recreational and commercial activities on or near our waterways. Beyond the visual impact, litter contributes to the mortality of wildlife through entanglement, primarily fishing line and fishing nets, and through ingestion of plastic bags and other small debris particles. Additionally, invasive species can be spread through the movement of litter from one area to another.

During the 2007-2008 survey period, litter was visible in 35% of our state's estuarine habitat (Figure 3.4.1). When each habitat type is considered separately, litter was visible in 25% of the state's tidal creek and 37% of the open water habitats. This was an increase over all previous study periods covering 1999-2006, and was the first period where more litter was identified in open water than in tidal creek habitats.

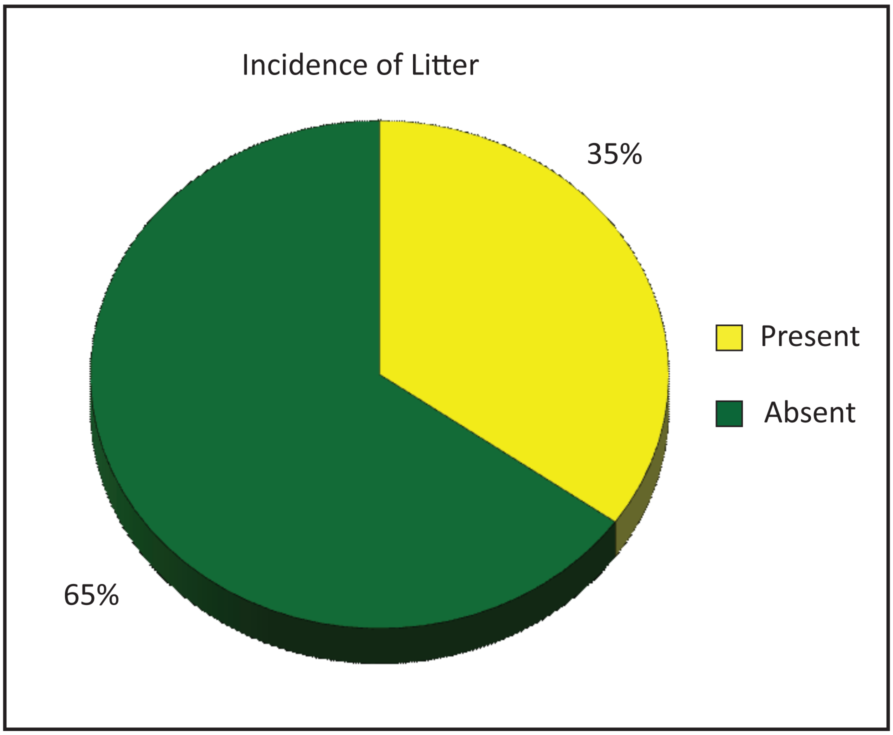

Figure 3.4.1. Percentage of the state's estuarine habitat with litter present.

3.5 Overall Habitat Quality

Using the Habitat Quality Index (HQI) for the 2007-2008 assessment period, 90% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition (Figure 3.5.1). Only 4% of the coastal estuarine habitat was considered to be in poor condition and 6% in fair condition. When the two habitats were considered separately, a greater percentage of tidal creek habitat was in fair to poor condition (23% fair, 7% poor) as compared to open water habitats (3% fair, 3% poor) in the 2007-2008 survey (Appendix 2). This difference between tidal creek and open water habitats is consistent with previous SCECAP surveys.

The amount of habitat scoring as good for the HQI during 2007-2008 (90%) was higher than all previous study periods (77-86%) (Figure 3.5.2). The amount of habitat scoring as poor was similar to previous survey periods (2-8%) but the amount of habitat scoring as fair during the current survey period (7%) was approximately half of that during previous survey periods (12-16%). This increase in the amount of coastal habitat scoring as good for the HQI over previous study periods reflects a consistent increase in habitat scoring as good for all three of the component measures, WQI, SQI and B-IBI, and is likely tied to coastal rainfall patterns.

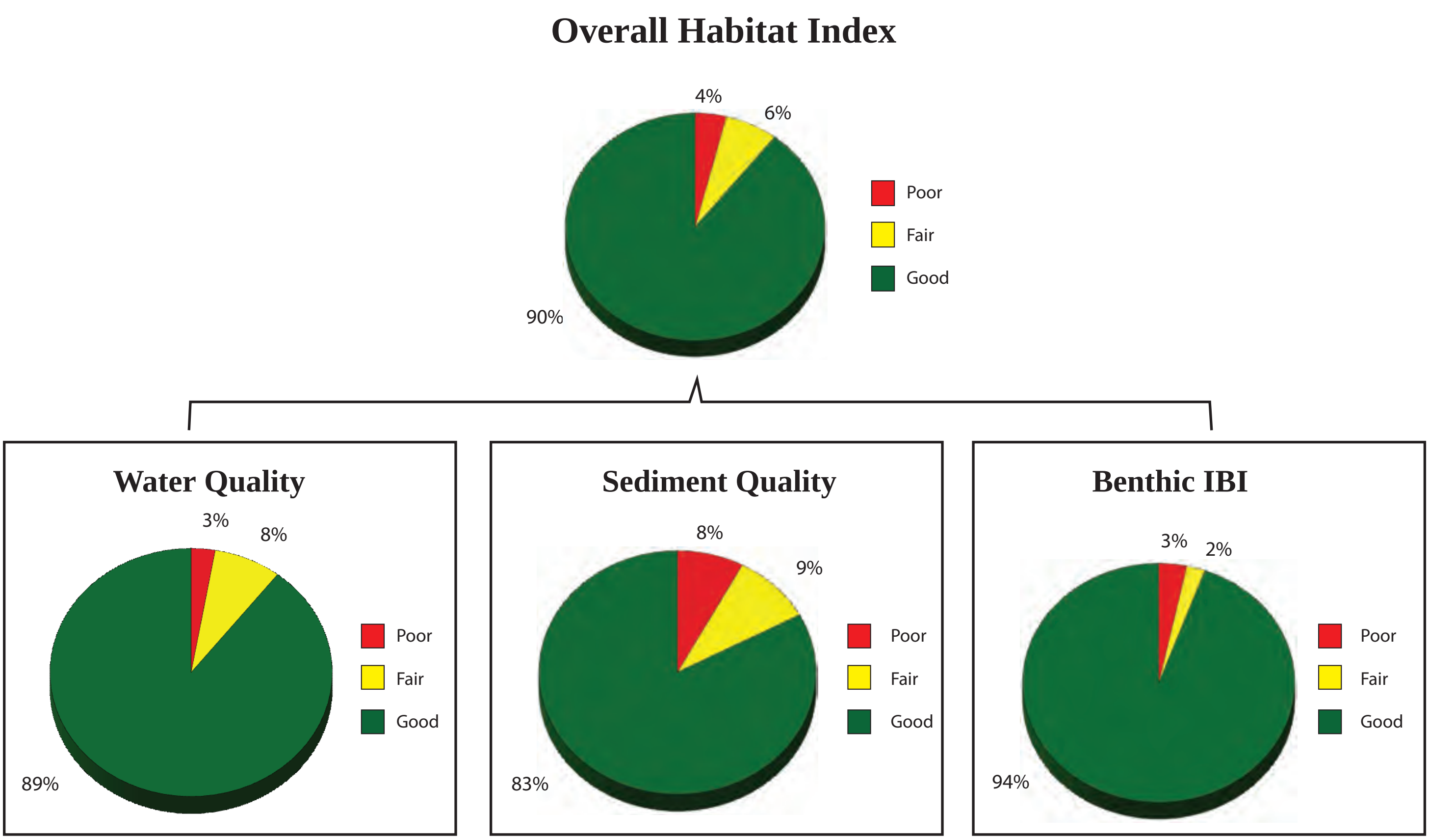

Figure 3.5.1. Percentage of the state's estuarine habitats that score as good, fair, or poor for the integrated Habitat Quality Index during 2007-2008.

During the 2007-2008 study period, SCECAP stations with fair or poor habitat quality were concentrated primarily in the creeks and rivers that drain into St. Helena Sound and in the rivers near the South Carolina-Georgia border (Figure 3.5.3, Appendix 3, and Appendix 4d). Sites with poor HQI scores were located in the South Edisto River within the ACE Basin NERR (RO07339), one in a tributary of the Wright River (RT07053) and the New River about 8.5 mi southwest of Bluffton (RT08085). The stations scoring poor in the Wright and New River systems scored poor for both the WQI and the SQI but either fair or good for the B-IBI. The station in the South Edisto River scored as poor for the B-IBI, fair for the SQI and good for the WQI. The South Edisto and New River systems have had fair to poor habitat quality in previous survey periods as well. Additionally, stations in Winyah Bay, the Santee delta region, the North Edisto near Dawhoo Creek and the rivers draining into Charleston Harbor historically show a persistent pattern of degraded habitat quality (Figure 3.5.4). Winyah Bay and Charleston Harbor both have a history of industrial activity and/or high-density urban development that likely contributed to the degraded conditions in these areas. The causes of degraded habitat quality in the areas draining into St Helena Sound, home to the Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve (NERR), are not clear but are currently under study by the SCDNR.

Bulk handling facilities on the Cooper River in Charleston, SC.

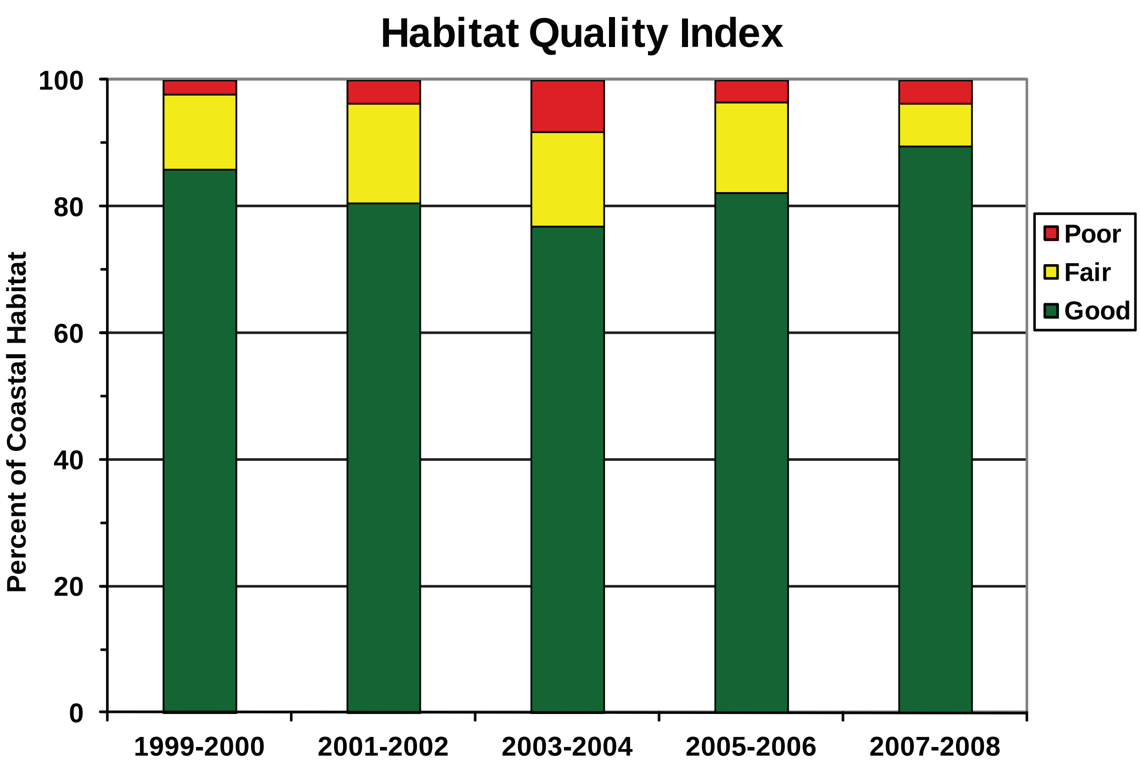

Figure 3.5.2. Habitat Quality Index scores by survey period for all estuarine habitat combined.

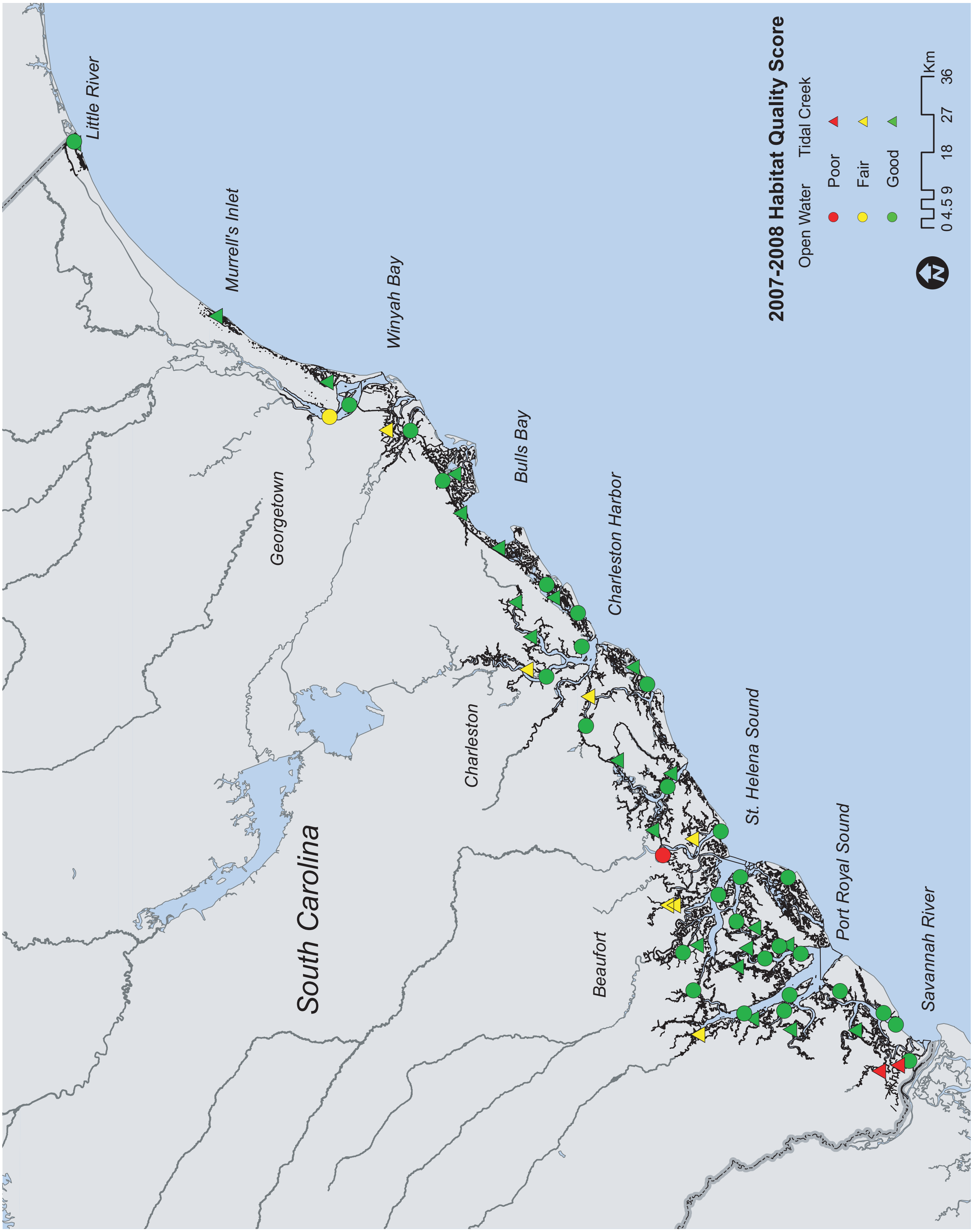

Figure 3.5.3. Distribution of stations state wide good, fair and poor scores for the Habitat Quality Index during the 2007-2008 survey period.

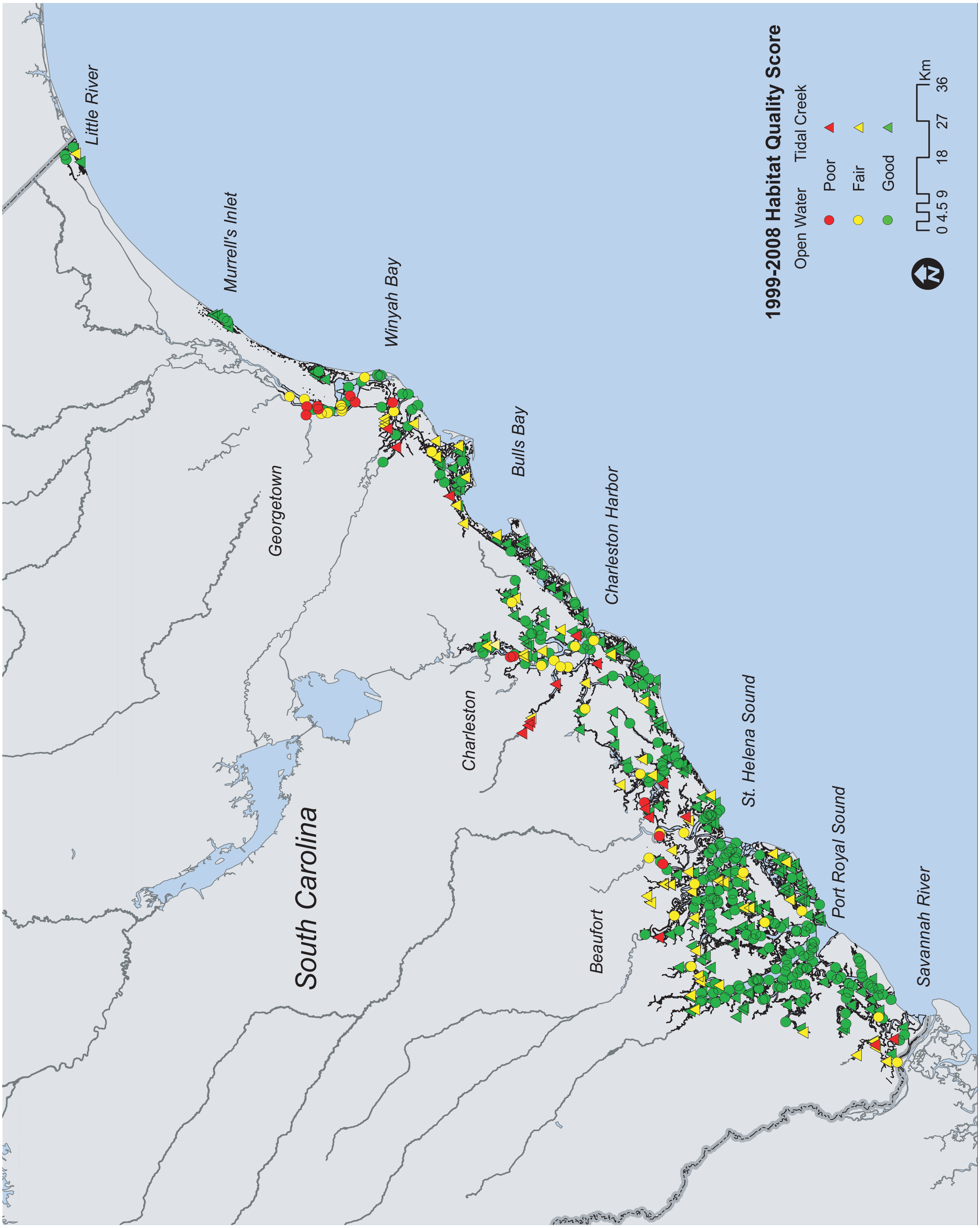

Figure 3.5.4. Distribution of stations having good, fair, or poor scores for the Habitat Quality Index from the 1999-2008.

3.6 Future Program Activities

SCECAP continues as an effective collaboration between the SCDNR, SCDHEC, the EPA, and NOAA to assess the condition of South Carolina's coastal environment. The results of these assessments have been used extensively in research, outreach, and planning by staff from these and other institutions and organizations. During the past two years, SCECAP data have been used to examine the distribution of sediment contaminants (ACOE); shrimp, blue crab and spot abundance data (SCDNR); relationships between nutrients and chlorophyll a (USEPA); relationships between sediment contaminants, fish tissue contaminants, and contaminants in dolphin (NOAA/graduate student at Texas Tech University); and the presence/absence of an algae species (College of Charleston).

Two ongoing 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 organic nutrient enrichment, low dissolved oxygen and potentially elevated fecal coliform bacteria (Figure 3.6.1). The cause of degraded water quality in the area is uncertain, but may be due to a combination of local land use practices and the complex hydrology of the area. SCDNR researchers are in the final year of a three year assessment of nutrient concentrations and nutrient sources in the ACE Basin to resolve this issue. The ability to compare indices across the state allows researchers and managers to identify areas of concern.

The second project involves utilizing the random array of SCECAP stations to help evaluate the abundance and distribution of spot and Atlantic croaker in South Carolina's estuaries. Trawl samples and basic water quality measures have been collected during both spring and summer at all SCECAP stations since 2008 to evaluate the juvenile populations of these two species. A recent analysis found that three target species, spot, Atlantic croaker and weakfish are showing evidence of potentially declining populations in the state's waterways.

The funding for the first eight years of SCECAP originated largely from the USEPA's National Coastal Assessment (NCA) program with supplemental funding coming from several other sources. Those funding levels allowed us to maintain an annual sampling array of 50-60 stations per year. Starting in 2007, the USEPA discontinued funding for the NCA program, but SCDNR was able to maintain a reduced array of 30 stations per year using funds from a combination of state and federal sources. This reduced effort provides us the minimum number of stations necessary to make statistically valid statements about tidal creek and open water habitats using two-year data sets. With recent state budget cuts, it is not clear whether SCDNR will be able to sustain even this minimum effort in coming years.

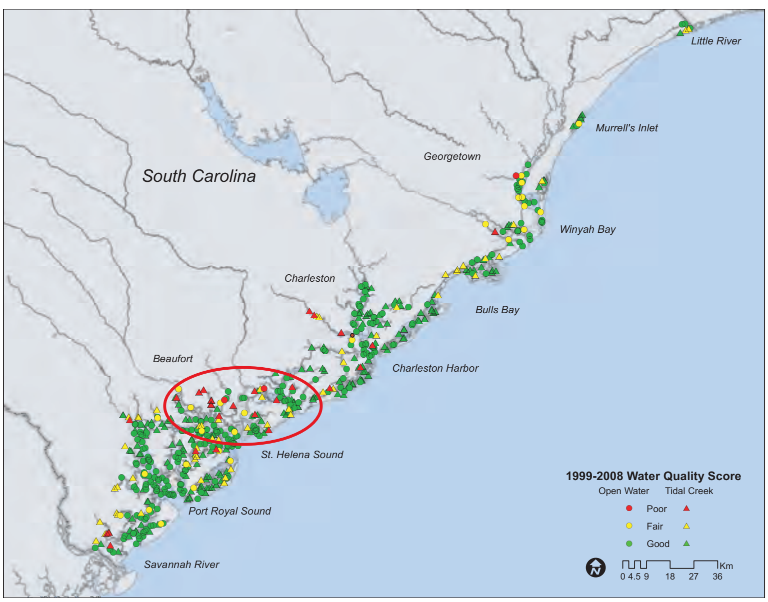

Figure 3.6.1. Distribution of stations in the ACE Basin area having good, fair, or poor scores for the Water Quality Index for 1999-2008.

ACKNOWLEDGEMENTS

A report such as this one is a result of the efforts of many people, from field sampling to laboratory processing to data entry to analysis and writing. Every effort along the way required careful planning and execution, and we wish to thank everyone involved for their dedication to this program over the past ten years. Staff of SCDNR's Environmental Research Section work hard to ensure this project is completed efficiently and accurately, so a very special thanks goes out to Steve Burns, Leona Forbes, Jordan Felber, Patrick Biondo, Dany Burgess, John Heinsohn, Ransom White, Travis Washburn, and Jeremy Grigsby. Many other staff from the DNR and other institutions assisted in field sampling and laboratory processing including: Courtney Brooks, Krista DeMattio, Mark Messersmith, Amanda Powers, Ed Simmons, Lee Taylor, Dana Krizan, and Lani Van de Poel.

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Appendix 1. Summary of station locations and dates sampled in 2007 and 2008. Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2007
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT07038	Creek	32.54018	80.86728	1.5	7/24/2007	Jasper	R>1	Upper Broad River near Dawson Island
RT07039	Creek	32.55165	80.37163	1.0	7/17/2007	Charleston	R<1	Bailey Creek off of the South Edisto
RT07040	Creek	32.90400	79.93735	3.0	7/18/2007	Berkeley	I>1	Cooper River inside the northern end of Clouter Creek
RT07042	Creek	32.45567	80.69588	2.4	8/14/2007	Beaufort	R>1	Albergottie Creek near mouth
RT07043	Creek	32.59730	80.20510	3.7	7/17/2007	Charleston	R<1	North Edisto River near mouth of Westbank Creek
RT07048	Creek	33.05330	79.43705	1.5	7/31/2007	Charleston	R>1	Little Papas Creek just west of Muddy Bay
RT07049	Creek	33.56065	79.02277	2.7	8/8/2007	Georgetown	R<1	Main Creek in Murrell's Inlet south of Flagg Creek
RT07053	Creek	32.11032	80.94600	4.3	7/25/2007	Jasper	NDV	Wright River in the northern branch of the oxbow
RT07055	Creek	32.63700	80.34866	3.7	7/17/2007	Charleston	R>1	Dawhoo River in North Creek
RT07056	Creek	32.89515	79.85456	1.2	7/18/2007	Berkeley	NDV	Wando River in Johnfield Creek behind Juba Island
RT07057	Creek	32.34201	80.85522	2.7	7/24/2007	Beaufort	R<1	Chechessee River near Callawassie Island bridge
RT07058	Creek	32.43567	80.64940	2.7	8/14/2007	Beaufort	R<1	Beaufort River in Factory Creek oxbow
RT07060	Creek	32.96187	79.62690	2.6	7/31/2007	Charleston	R>1	Bulls Bay in Venning Creek
RT07062	Creek	32.54144	80.64095	2.4	8/15/2007	Beaufort	NDV	South Wimbee Creek just North of the Coosaw River
RT07065	Creek	33.19928	79.32259	2.1	8/1/2007	Georgetown	NDV	North Santee River in Minum Creek

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

SCECAP 2008
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO08343	Open	32.60279	80.23824	12.8	7/15/2008	Charleston	R>1	North Edisto River near mouth of West Bank Creek
RO08344	Open	33.14682	79.32433	0.9	7/23/2008	Charleston	NDV	South Santee River just above Intracoastal waterway
RO08346	Open	32.45678	80.58123	2.7	7/30/2008	Beaufort	R<1	Morgan River in the mouth of Boatswain Pond Creek
RO08347	Open	32.64468	79.97774	4.9	7/15/2008	Charleston	R>1	Folly River just north of Bird Key
RO08348	Open	33.31995	79.28568	7.6	7/22/2008	Georgetown	R<1	Winyah Bay east of the Georgetown airport
RO08349	Open	32.08564	80.93409	6.4	8/5/2008	Jasper	NDV	Wright River in the mouth of Fields Cut on the ICW
RO08350	Open	32.34247	80.76785	1.2	8/6/2008	Beaufort	NDV	Broad River on east bank of Dawes Island
RO08351	Open	32.44736	80.46911	7.6	7/29/2008	Beaufort	R>1	Saint Helena Sound just north of Egg Bank
RO08352	Open	32.86133	79.95544	9.8	7/16/2008	Berkeley	I<1	Cooper River at southwestern tip of spoil area
RO08353	Open	32.44070	80.81410	8.2	8/6/2008	Beaufort	NDV	Broad River east of Hogs Neck
RO08354	Open	32.36512	80.64393	4.3	7/30/2008	Beaufort	R<1	Near Beaufort River in Cowen Creek
RO08355	Open	32.48900	80.35242	2.1	7/29/2008	Colleton	R>1	South Edisto River between Otter Island and Edisto Beach
RO08356	Open	32.85873	79.72179	4.3	7/16/2008	Charleston	NDV	In the Intracoastal waterway behind Dewee's Island
RO08357	Open	32.14112	80.81383	4.9	8/5/2008	Beaufort	R<1	Calibogue Sound just northwest of Harbour Town
RO08358	Open	32.54927	80.75554	1.0	8/6/2008	Beaufort	R>1	Whale Branch in the mouth of Huspah Creek

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

SCECAP 2008
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT08067	Creek	32.59093	80.53897	4.6	7/29/2008	Colleton	NDV	Old Chehaw River northwest of Big Island
RT08068	Creek	32.77221	80.00732	1.5	7/16/2008	Charleston	R<1	Stono River near Edgewater Park bridge
RT08069	Creek	33.85659	78.57144	1.5	7/22/2008	Horry	NDV	Little River in mouth of Dunn Sound Creek
RT08073	Creek	32.20195	80.85746	0.9	8/5/2008	Beaufort	R>1	May River behind Potato Island
RT08076	Creek	32.92635	79.76603	1.5	7/16/2008	Charleston	NDV	Wando River in Deep Creek
RT08078	Creek	32.41861	80.59789	4.0	7/30/2008	Beaufort	R<1	Morgan River in Jenkins Creek
RT08079	Creek	32.71206	80.17069	2.1	7/15/2008	Charleston	R>1	North Edisto River near Church Creek
RT08080	Creek	33.04242	79.53744	2.7	7/23/2008	Charleston	NDV	ICW just north of Bulls Bay
RT08081	Creek	33.32506	79.19624	2.1	7/22/2008	Georgetown	NDV	North Inlet in Clambank Creek
RT08082	Creek	32.34723	80.64032	1.5	7/30/2008	Beaufort	NDV	Cowan Creek south of Capers Island
RT08083	Creek	32.60625	80.53867	2.7	7/29/2008	Colleton	NDV	Old Chehaw River near Wiggens
RT08084	Creek	32.67597	79.93475	0.9	7/15/2008	Charleston	R<1	Folly River in creek south of Long Island
RT08085	Creek	32.15097	80.96008	1.5	8/5/2008	Jasper	NDV	New River near Coleman Island
RT08086	Creek	32.42325	80.82816	2.1	8/6/2008	Beaufort	NDV	Broad River in tributary of Euhaw creek
RT08088	Creek	32.84457	79.75466	3.0	7/16/2008	Charleston	R>1	Dewees Creek near Copahee Sound

* 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 2007 and 2008. 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.

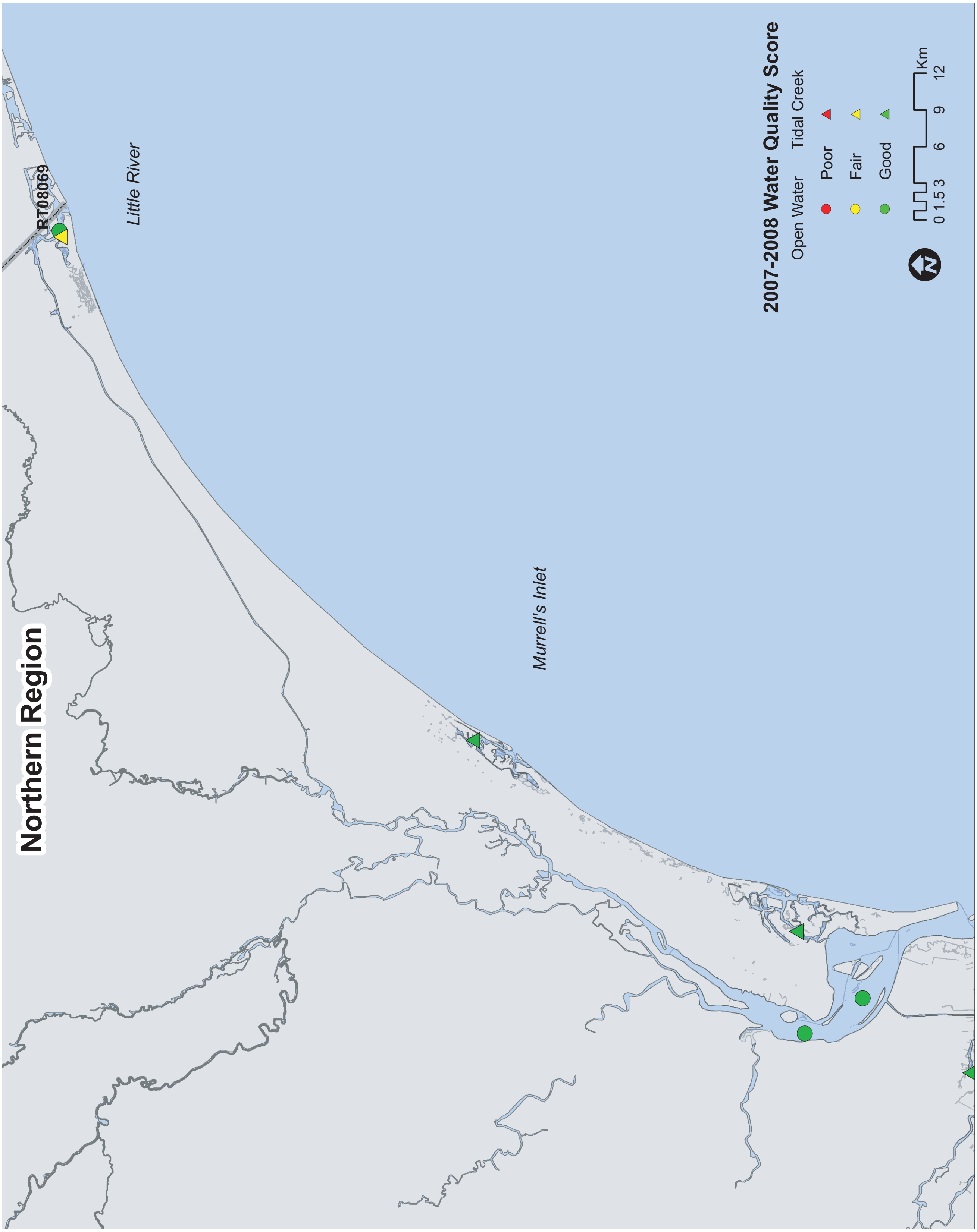
Parameter	Criteria			Percent of Open Water Habitat			Percent of Tidal Creek Habitat		
WATER QUALITY	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**
Water Quality Index				93	7	0	70	13	17
Dissolved Oxygen (mg/L)	≥ 4	≥ 3 & < 4	< 3	97	3	0	83	7	10
pH (salinity corrected)	≥ 7.35	≥ 7.22 & < 7.35	< 7.22	97	3	0	70	10	20
Fecal Coliform	≤ 43	> 43 & ≤ 400	> 400	93	7	0	83	17	0
Eutrophication Score				86	7	7	84	3	13
Total Nitrogen	≤ 0.81	> 0.81 & ≤ 1.05	> 1.05	100	0	0	85	15	0
Total Phosphorus	≤ 0.10	> 0.10 & ≤ 0.12	> 0.12	96	0	4	82	9	9
Chlorophyll a	≤ 11.5	> 11.5 & ≤ 16.4	> 16.4	73	17	10	74	13	13
SEDIMENT QUALITY									
Sediment Quality index				86	7	7	64	23	13
Contaminants ERMQ	≤ 0.020	> 0.020 & ≤ 0.058	> 0.058	80	20	0	47	53	0
Toxicity	< 1	≥ 1 & < 2	≥ 2	67	30	3	50	37	13
TOC	< 3	≥ 3 & < 5	≥ 5	94	3	3	90	10	0
BIOLOGICAL CONDITION									
Benthic IBI	≥ 3	≥ 2 & < 3	< 2	97	3	0	84	13	3
HABITAT QUALITY									
Habitat Quality Index				94	3	3	70	23	7

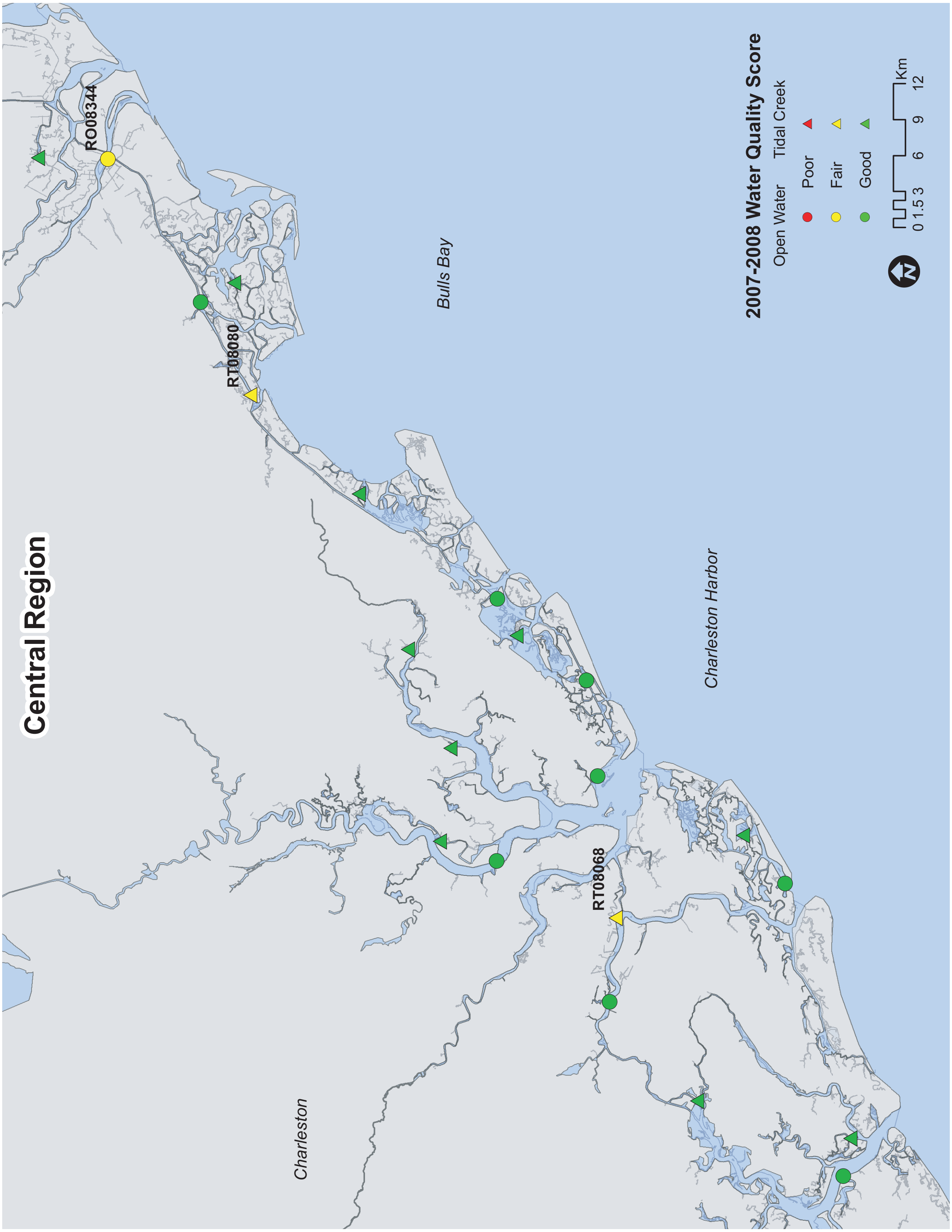
Appendix 3. Summary of the Water Quality, Sediment Quality, Biological Condition, and Habitat Quality Index scores and their component measure scores by station for 2007 and 2008. Green represents good condition, yellow represent fair condition, and red represents poor condition. The actual Habitat Quality Index score is shown to allow the reader to see where the values fall within the above general coding criteria. See text for further details on the ranges of values representing good, fair, and poor for each measure and index score.

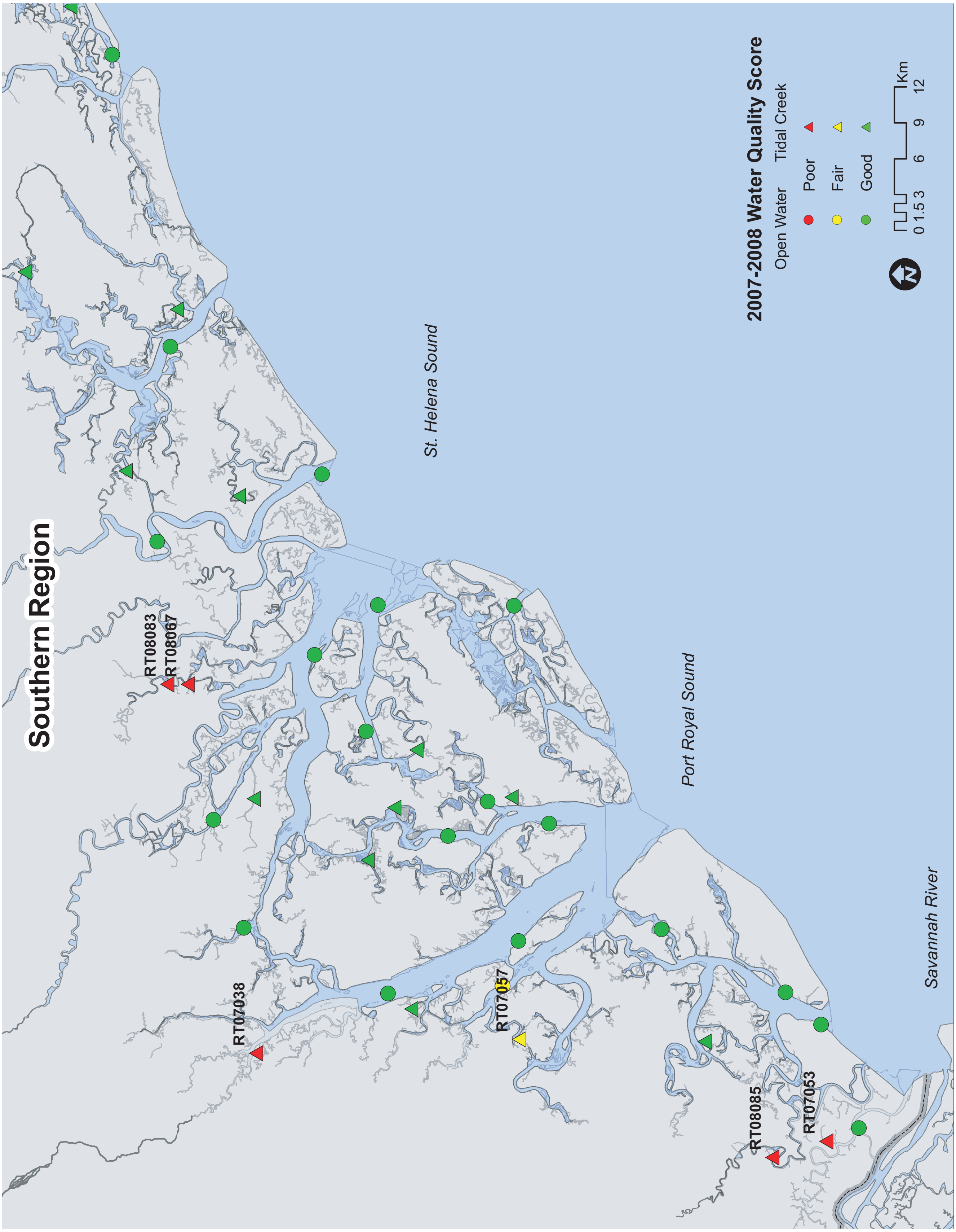
Station	Water Quality								Sediment Quality				Biological Condition	Habitat Quality	County	Location
	Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Index (B-IBI)	Habitat Quality Index		
RO07328	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Charleston	Intracoastal waterway near Jeremy Creek
RO07329	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Beaufort	Skull Creek near Hwy 278 bridge
RO07330	Yellow	Green	Yellow	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Wimbee Creek near Schooner Creek
RO07331	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Charleston	Stono River south of Limehouse bridge
RO07332	Green	Green	Green	Green	Green	Red	3	5	Green	Green	Green	5	5	5.0	Georgetown	Winyah Bay north of entrance to Intracoastal waterway
RO07333	Green	Green	Green	Green	Green	Yellow	5	5	Green	Green	Green	5	5	5.0	Horry	Little River at mouth of Horse Ford Creek
RO07334	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Beaufort River on East side of Parris Island
RO07335	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Beaufort	Coosaw River north of Morgan Island
RO07336	Green	Green	Green	Green	Green	Yellow	5	5	Green	Green	Yellow	5	5	5.0	Charleston	Charleston Harbor near Shem Creek
RO07337	Green	Green	Green	White	Red	Green	0	3	Green	Green	Green	5	5	4.3	Beaufort	Chechessee River near Rose Island
RO07338	Green	Green	Green	Green	Green	Yellow	5	5	Green	Green	Green	5	5	5.0	Beaufort	Beaufort River south of Beaufort
RO07339	Green	Green	Green	Green	Green	Yellow	5	5	Yellow	Red	Yellow	0	0	1.7	Charleston	South Edisto River west of Dawhoo Cut
RO07340	Green	Yellow	Green	Green	Green	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	Intracostal waterway behind IOP near Hamlin Creek
RO07341	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Calibogue Sound on east bank of Daufuskie Island
RO07342	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Fripp Inlet close to Hunting Island
RT07038	Green	Green	Red	White	Red	Green	0	0	Yellow	Green	Yellow	3	5	2.7	Jasper	Upper Broad River near Dawson Island
RT07039	Green	Green	Green	White	Green	Green	5	5	Red	Yellow	Yellow	0	5	3.3	Charleston	Bailey Creek off of the South Edisto
RT07040	Green	Yellow	Green	Green	Green	Yellow	5	5	Green	Green	Yellow	5	0	3.3	Berkeley	Cooper River inside the northern end of Clouter Creek
RT07042	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Albergottie Creek near mouth
RT07043	Green	Green	Green	White	Green	Green	5	5	Green	Green	Green	5	5	5.0	Charleston	North Edisto River near mouth of Westbank Creek
RT07048	Green	Green	Yellow	Green	Green	Green	5	5	Green	Green	Yellow	5	5	5.0	Charleston	Little Papas Creek just west of Muddy Bay
RT07049	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Georgetown	Main Creek in Murrells Inlet south of Flagg Creek
RT07053	Red	Green	Red	Green	Green	Yellow	5	0	Red	Green	Yellow	0	3	1.0	Jasper	Wright River in the northern branch of the oxbow
RT07055	Green	Green	Green	White	Green	Yellow	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	Dawhoo River in North Creek
RT07056	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Yellow	5	5	5.0	Berkeley	Wando River in Johnfield Creek behind Juba Island
RT07057	Green	Green	Red	Green	Green	Green	5	3	Green	Green	Green	5	5	4.3	Beaufort	Chechessee River near Callawassie Island bridge
RT07058	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Beaufort	Beaufort River in Factory Creek oxbow
RT07060	Green	Green	Green	Green	Green	Yellow	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	Bulls Bay in Venning Creek
RT07062	Green	Green	Yellow	Green	Green	Green	5	5	Green	Green	Yellow	5	5	5.0	Beaufort	South Wimbee Creek just North of the Coosaw River
RT07065	Green	Green	Green	Green	Green	Red	3	5	Red	Yellow	Yellow	0	3	2.7	Georgetown	North Santee River in Minum Creek

Station	Water Quality: Dissolved Oxygen	Water Quality: Fecal Coliform	Water Quality: pH	Water Quality: Total Nitrogen	Water Quality: Total Phosphorus	Water Quality: Chlorophyll a	Water Quality: Eutrophic Index	Water Quality: Water Quality Index	Sediment Quality: Toxicity	Sediment Quality: Sediment TOC	Sediment Quality: Contaminants	Sediment Quality: Sediment Quality Index	Biological Condition: Biological Index (B-IBI)	Habitat Quality: Habitat Quality Index	County	Location
RO08343	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Charleston	North Edisto River near mouth of West Bank Creek
RO08344	Green	Green	Green	Green	White	Red	0	3	Green	Green	Green	5	5	4.3	Charleston	South Santee River just above Intracoastal waterway
RO08346	Green	Green	Green	Green	White	Green	5	5	Yellow	Green	Green	5	5	5.0	Beaufort	Morgan River in the mouth of Boatswain Pond Creek
RO08347	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Charleston	Folly River just north of Bird Key
RO08348	Green	Yellow	Green	Green	Green	Red	3	5	Red	Yellow	Yellow	0	5	3.3	Georgetown	Winyah Bay east of the Georgetown airport
RO08349	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Jasper	Wright River in the mouth of Fields Cut on the ICW
RO08350	Green	Green	Green	Green	White	Green	5	5	Yellow	Green	Green	5	5	5.0	Beaufort	Broad River on east bank of Dawes Island
RO08351	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Saint Helena Sound just north of Egg Bank
RO08352	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Yellow	5	5	5.0	Berkeley	Cooper River at southwestern tip of spoil area
RO08353	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Broad River east of Hogs Neck
RO08354	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Near Beaufort River in Cowen Creek
RO08355	Green	Green	Green	Green	Green	Yellow	5	5	Green	Green	Green	5	5	5.0	Colleton	South Edisto River between Otter Island and Edisto Beach
RO08356	Green	Green	Green	Green	White	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	In the Intracoastal Waterway behind Dewee's Island
RO08357	Green	Green	Green	Green	Green	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Calibogue Sound just northwest of Harbour Town
RO08358	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Whale Branch in the mouth of Huspah Creek
RT08067	Red	Green	Red	Yellow	Green	Green	5	0	Green	Green	Green	5	5	3.3	Colleton	Old Chehaw river northwest of Big Island
RT08068	Green	Yellow	Green	Yellow	Red	Red	0	3	Green	Green	Yellow	5	3	3.7	Charleston	Stono River near Edgewater Park bridge
RT08069	Green	Green	Green	Green	White	Red	0	3	Yellow	Green	Green	5	5	4.3	Horry	Little River in mouth of Dunn Sound Creek
RT08073	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	May River behind Potato Island
RT08076	Green	Yellow	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Charleston	Wando River in Deep Creek
RT08078	Green	Green	Yellow	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Morgan River in Jenkins Creek
RT08079	Green	Green	Green	Green	White	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	North Edisto River near Church Creek
RT08080	Green	Green	Green	Green	White	Red	0	3	Green	Green	Green	5	5	4.3	Charleston	Intracoastal Waterway just north of Bulls Bay
RT08081	Green	Green	Green	Green	White	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Georgetown	North Inlet in Clambank Creek
RT08082	Green	Yellow	Green	Green	Yellow	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Cowan Creek south of Capers Island
RT08083	Red	Green	Red	Yellow	Green	Green	5	0	Yellow	Green	Green	5	3	2.7	Colleton	Old Chehaw River near Wiggens
RT08084	Yellow	Green	Green	Green	Yellow	Green	5	5	Yellow	Green	Yellow	3	5	4.3	Charleston	Folly River in creek south of Long Island
RT08085	Yellow	Yellow	Red	Yellow	Green	Green	5	0	Red	Yellow	Yellow	0	5	1.7	Jasper	New River near Coleman Island
RT08086	Green	Green	Green	Green	White	Green	5	5	Green	Green	Green	5	5	5.0	Beaufort	Broad River in tributary of Euhaw Creek
RT08088	Green	Green	Green	Green	Green	Green	5	5	Yellow	Green	Green	5	5	5.0	Charleston	Dewees Creek near Copahee Sound

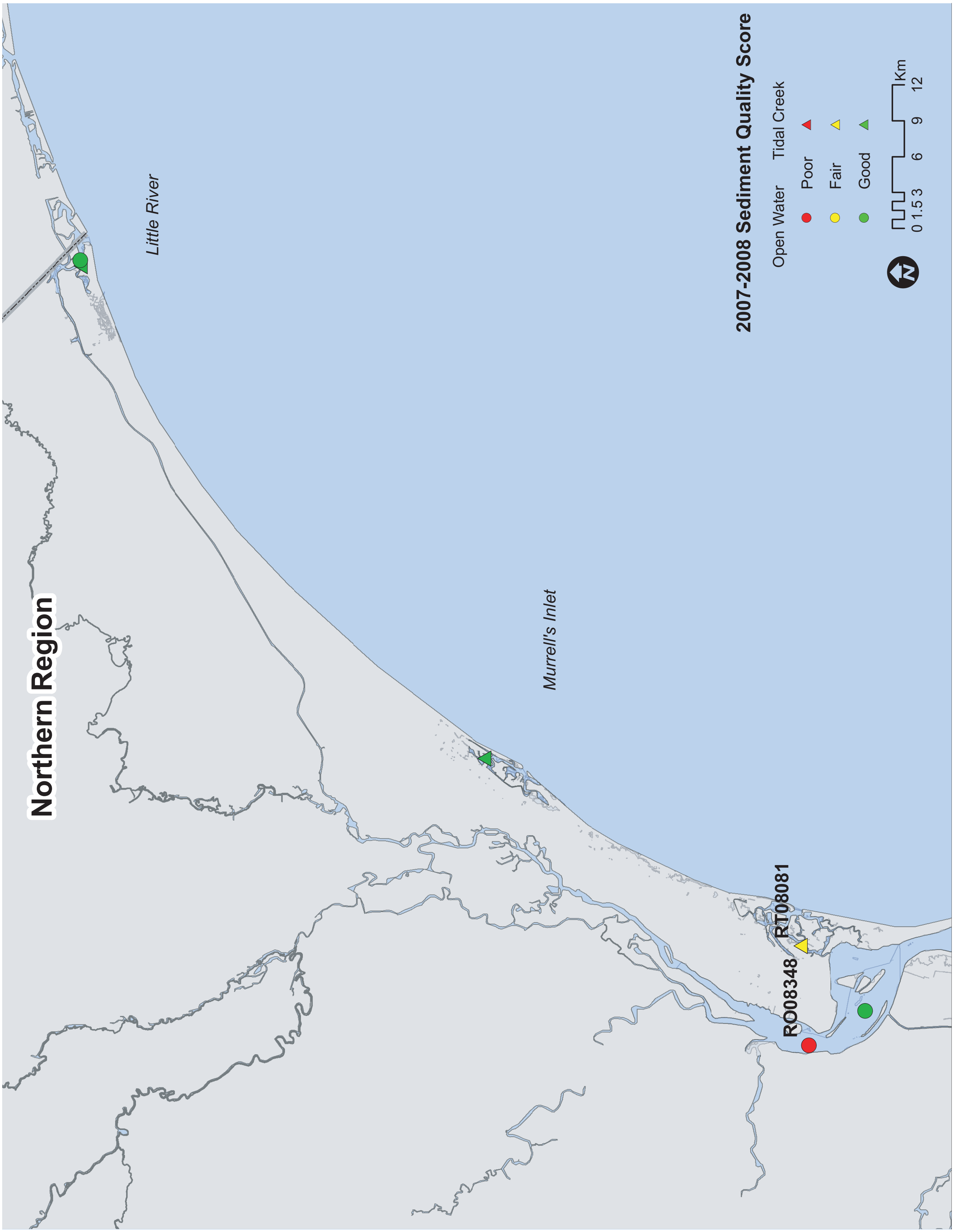
Appendix 4a. Maps showing the distribution of stations with good, fair, or poor Water Quality Index scores within the northern, central, and southern regions of South Carolina during 2007-2008. Labels for those stations with fair or poor Water Quality Index scores are shown.

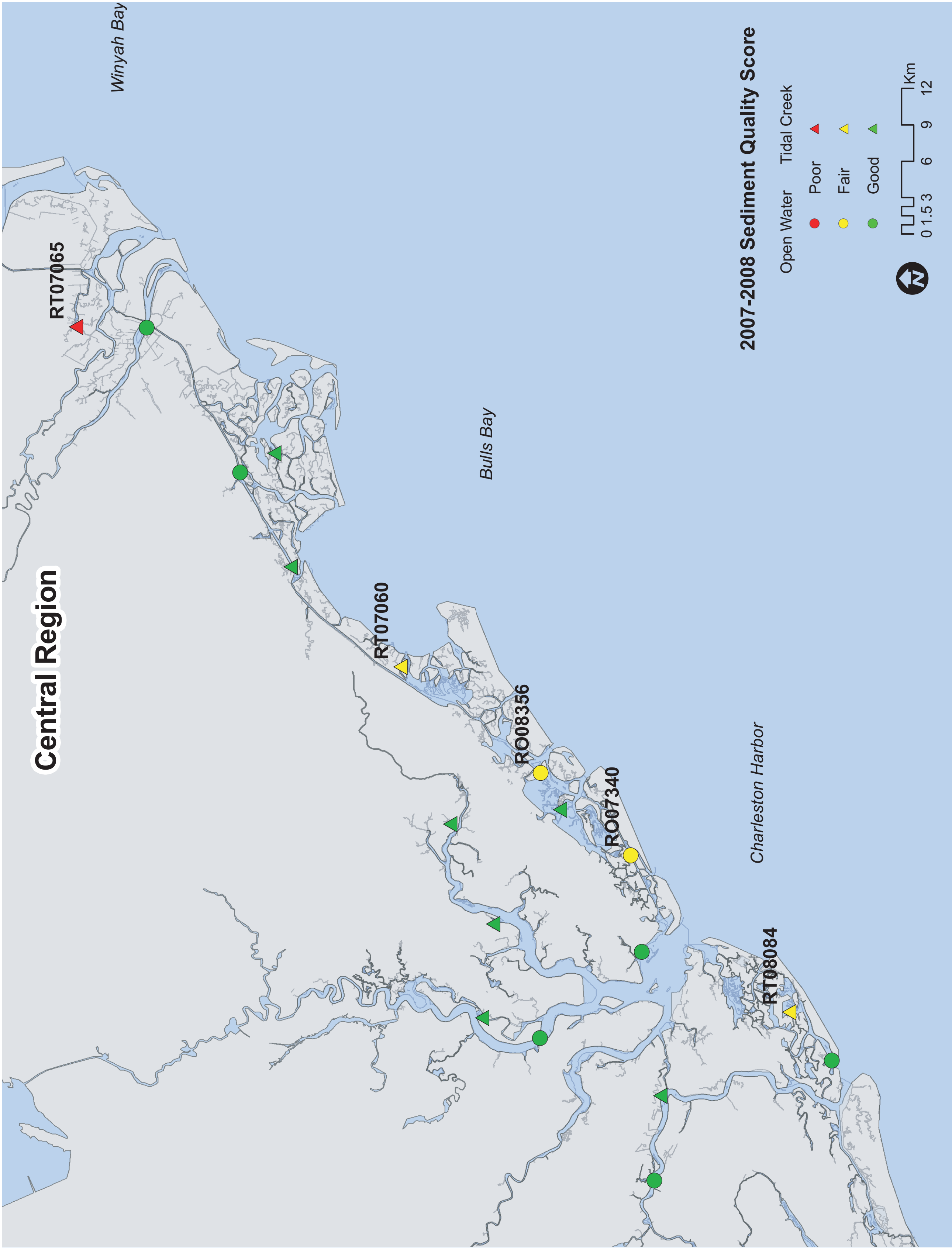

Northern Region
Little River
Murrell's Inlet
RT08069
2007-2008 Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km

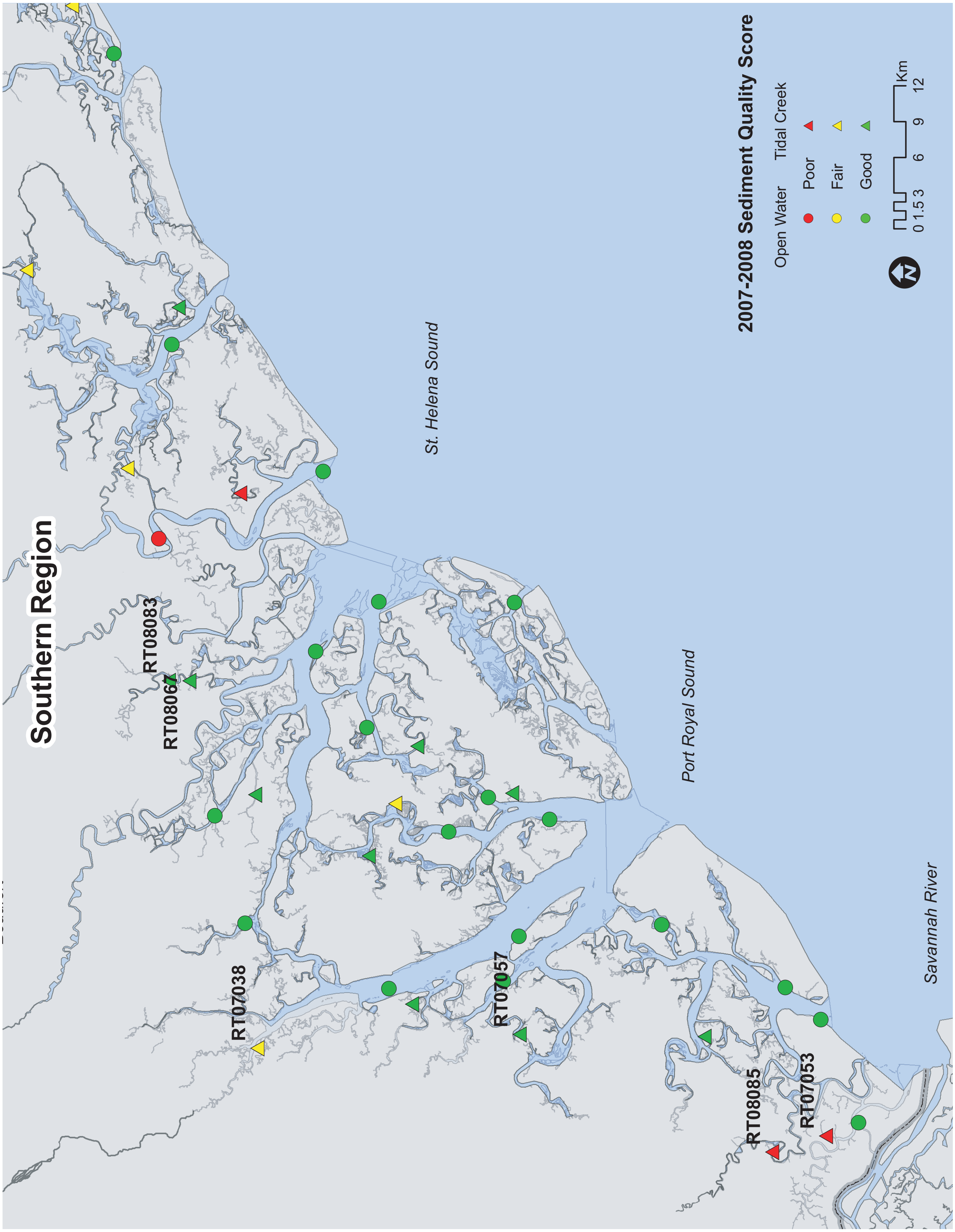

Central Region
RO08344
RT08080
RT08068
Bulls Bay
Charleston Harbor
Charleston
2007-2008 Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km


Southern Region
St. Helena Sound
Port Royal Sound
Savannah River
RT08083
RT08067
RT07038
RT07057
RT08085
RT07053
2007-2008 Water Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km

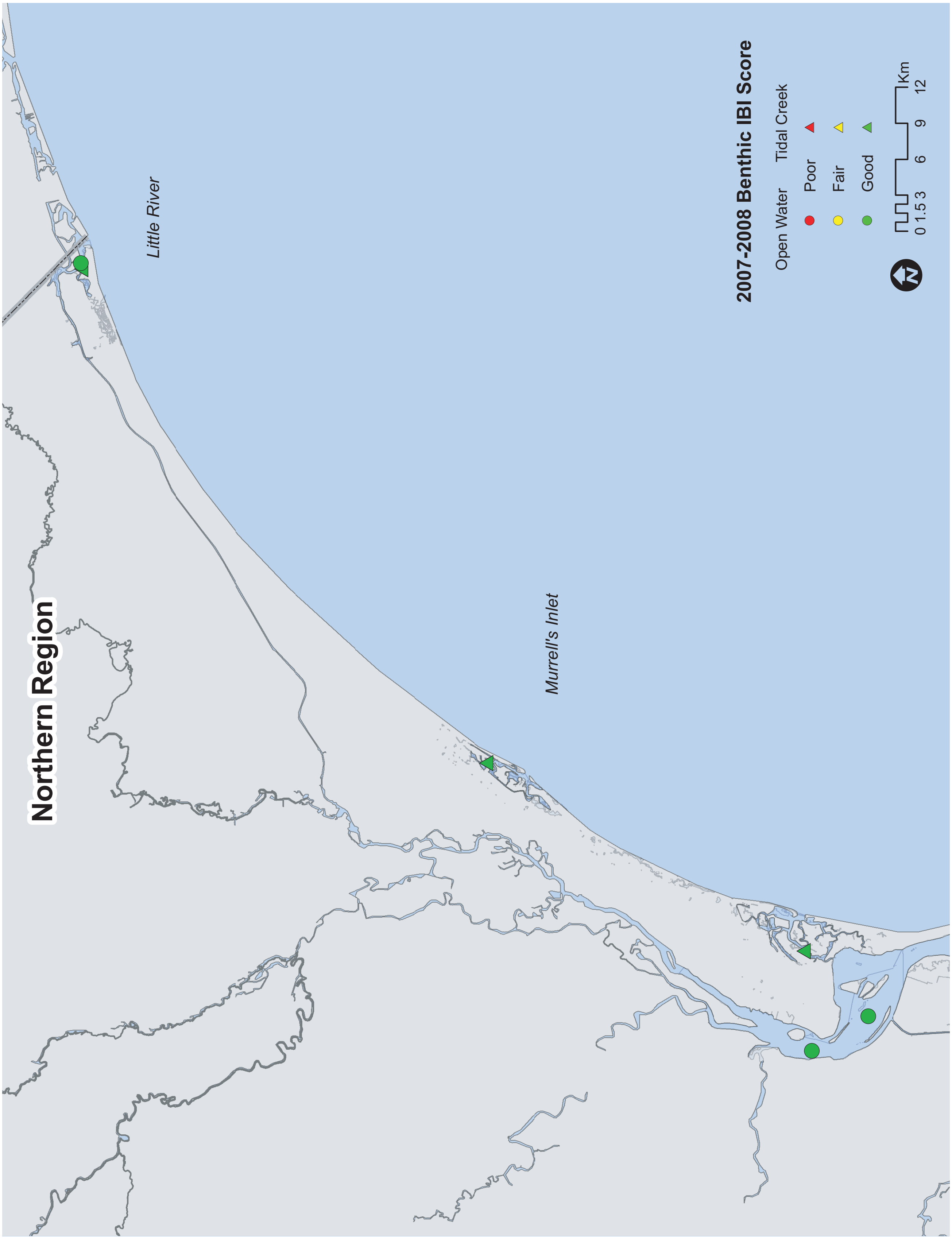
Appendix 4b. Maps showing the distribution of stations with good, fair, or poor Sediment Quality Index scores within the northern, central, and southern regions of South Carolina during 2007-2008. Labels for those stations with fair or poor Sediment Quality Index scores are shown.

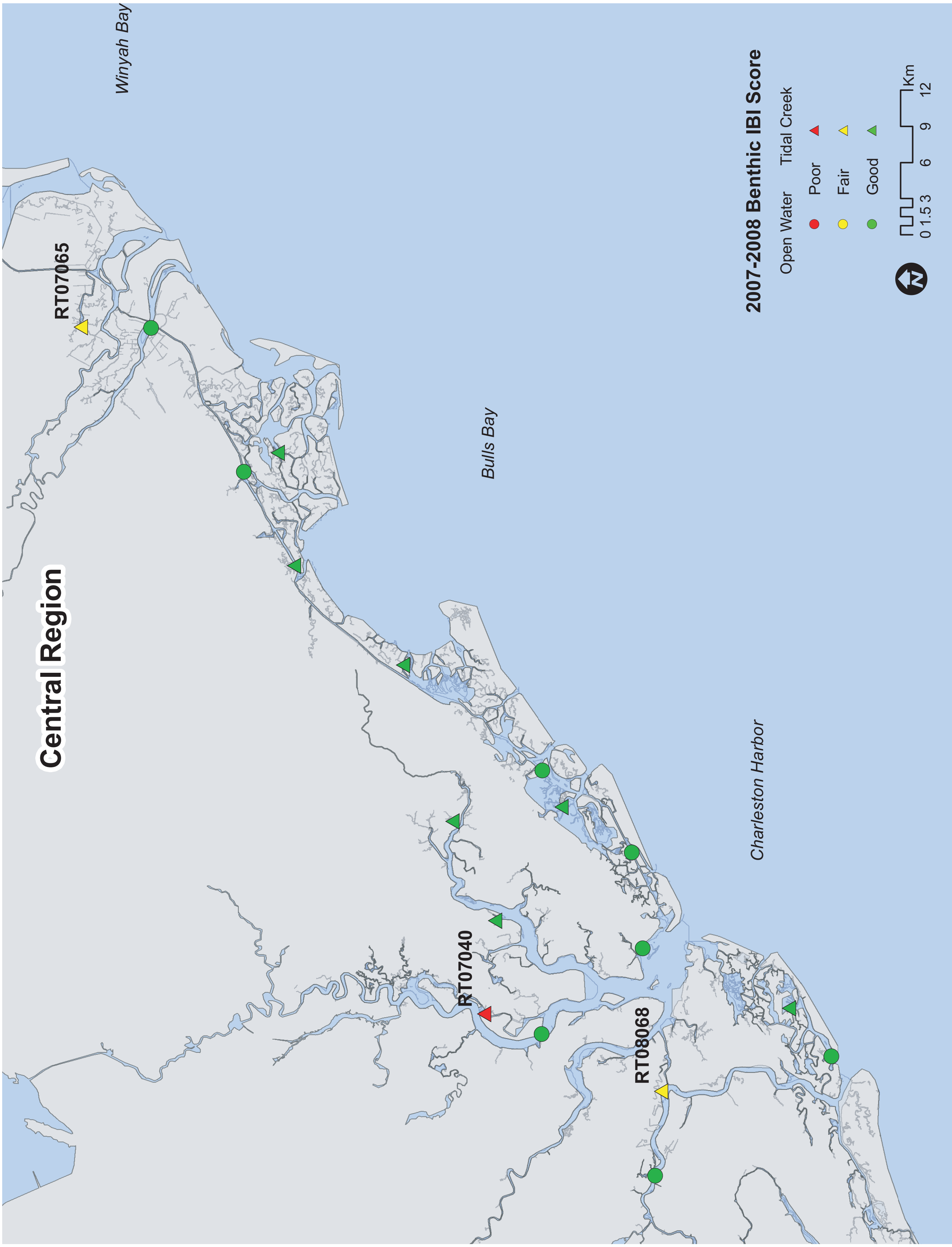

Northern Region
Little River
Murrell's Inlet
RO08348
RT08081
2007-2008 Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km
N

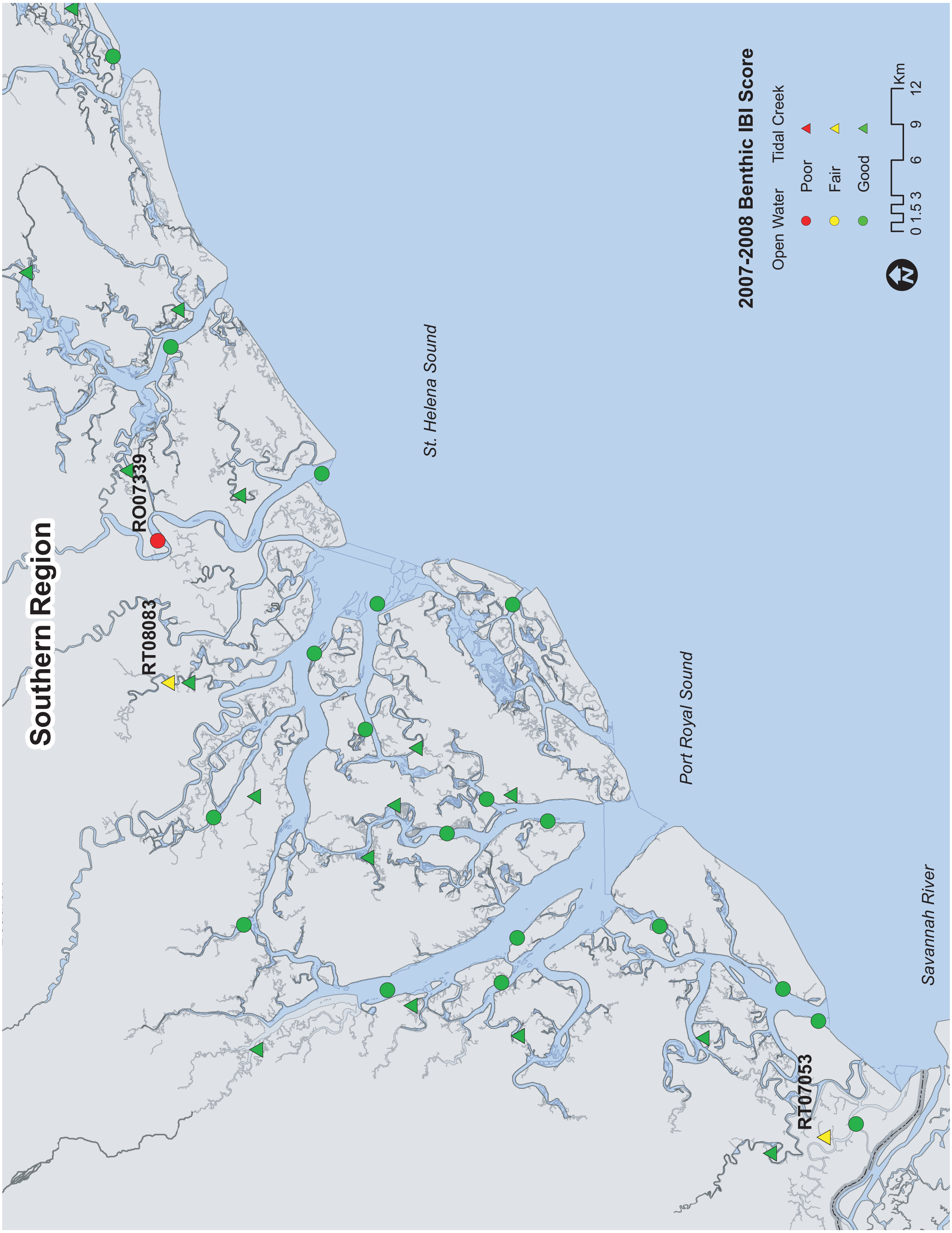

Central Region
2007-2008 Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
Km
0 1.5 3 6 9 12
Winyah Bay
Bulls Bay
Charleston Harbor
RT07065
RT07060
RO08356
RO07340
RT08084


Southern Region
2007-2008 Sediment Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
Km
0 1.5 3 6 9 12
St. Helena Sound
Port Royal Sound
Savannah River
RT08083
RT08067
RT07038
RT07057
RT08085
RT07053

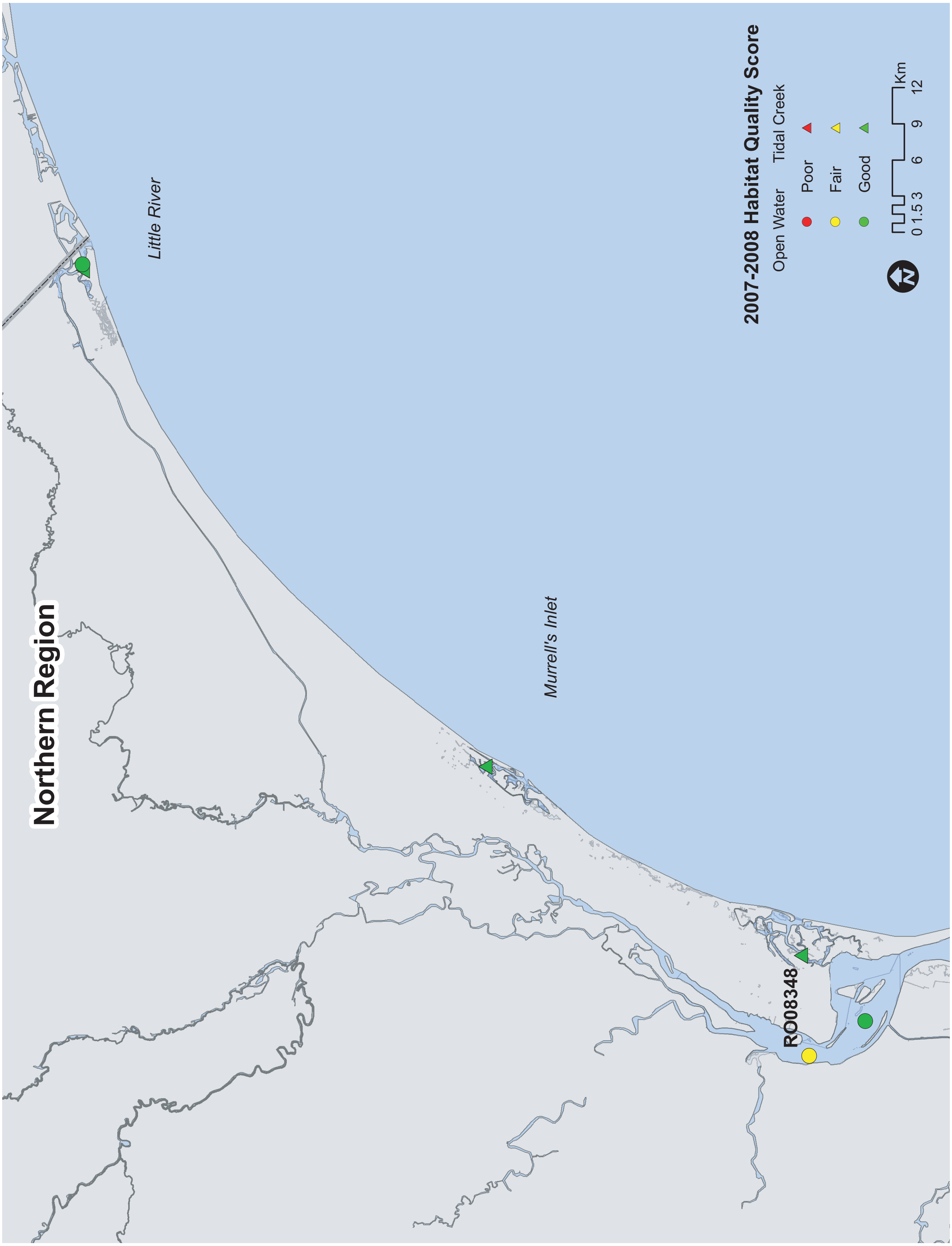
Appendix 4c. Maps showing the distribution of stations with good, fair, or poor Biological Condition Index scores within the northern, central, and southern regions of South Carolina during 2007-2008. Labels for those stations with fair or poor Biological Condition Index scores are shown.

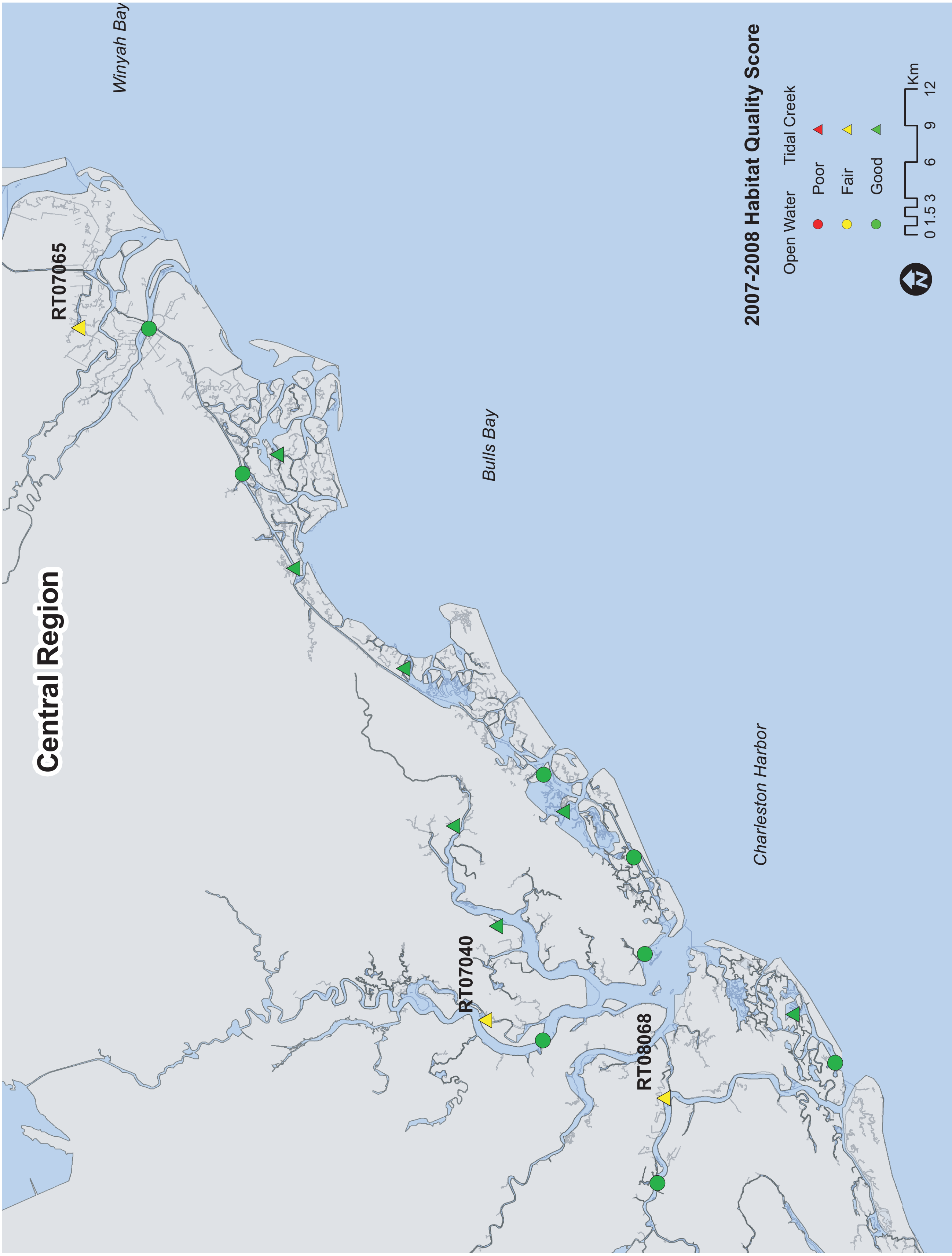

Northern Region
Little River
Murrell's Inlet
2007-2008 Benthic IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km

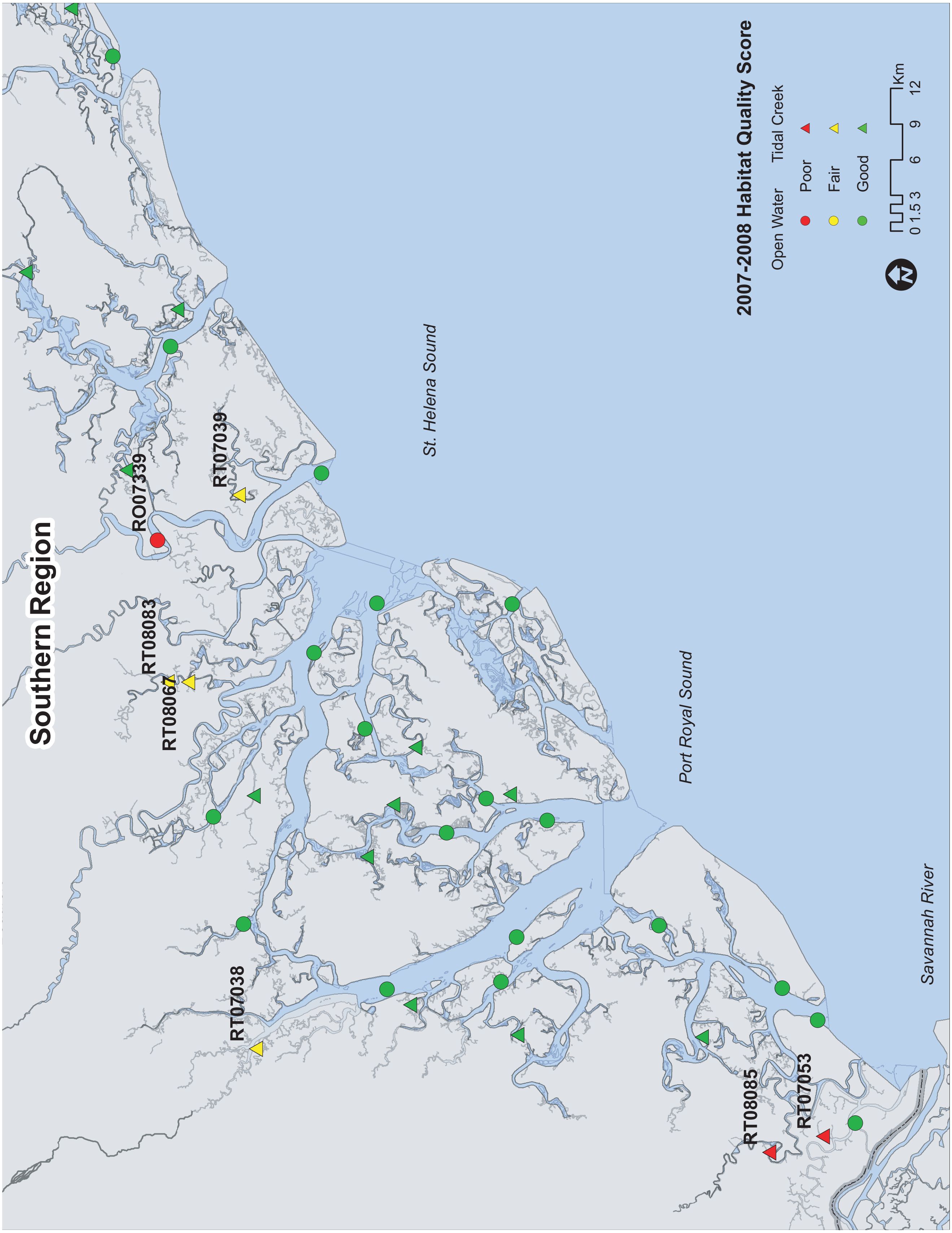

Central Region
Winyah Bay
Bulls Bay
Charleston Harbor
RT07065
RT07040
RT08068
2007-2008 Benthic IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km
N


Southern Region
2007-2008 Benthic IBI Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km
St. Helena Sound
Port Royal Sound
Savannah River
RO07339
RT08083
RT07053

Appendix 4d. 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 2007-2008. Labels for those stations with fair or poor Habitat Quality Index scores are shown.


Northern Region
Little River
Murrell's Inlet
RO08348
2007-2008 Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km


Central Region
Winyah Bay
Bulls Bay
Charleston Harbor
RT07065
RT07040
RT08068
2007-2008 Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km


Southern Region
RO07339
RT07039
RT08083
RT08067
RT07038
RT08085
RT07053
St. Helena Sound
Port Royal Sound
Savannah River
2007-2008 Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
0 1.5 3 6 9 12
Km

DNR

11-7753

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