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Title: South Carolina's Probability Based Approach for Assessing Water Quality and Estuarine Condition using Integrated Indices.

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Abstract: The South Carolina Estuarine and Coastal Assessment Program (SCECAP) has been evaluating the condition of South Carolina's estuaries since 1999. SCECAP was initiated as a joint effort between the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC). Beginning in 2000, SCECAP became part of the National Coastal Assessment Program and uses a sampling design consistent with that program. The program has sampled 50-60 stations a year from 1999-2006 using a probability-based, random tessellation, stratified sampling design (Stevens, 1997; Stevens and Olsen, 1999), with new station locations assigned each year. Two habitat strata are sampled each year with an equal number of stations sampled in each strata. The strata are tidal creek habitat, which is defined as any water body < 100 m from marsh bank to marsh bank; and open water habitat, which represents all larger water bodies such as tidal rivers, bays and sounds (Van Dolah et al., 2002). The primary sampling period is conducted during the summer of each year, but beginning in 2002, a subset of 30 stations (15 in each habitat) is sampled year round for water quality by SCDHEC staff. A comprehensive suite of water quality measures (26 parameters), sediment quality measures (> 85 contaminants, TOC, ammonia, toxicity) and biological condition measures (phytoplankton composition, benthic community composition, finfish and crustacean composition) are collected at each site.

In order to make the findings more useful to resource managers and the public, a series of integrated indices of condition have been developed. Similar approaches have been developed for the National Coastal Condition Reports (USEPA 2001, 2004, 2006) as well as by a few states and other entities using a variety of approaches (e.g., Carlton et al. 1998, Chesapeake Bay Foundation 2007, Partridge 2007). The indices developed and subsequently refined for SCECAP include both a water and sediment quality index, which is then combined with a Benthic Index of Biotic Integrity (B-IBI) that has been developed for the southeastern region (Van Dolah et al., 1999) to form an overall index of habitat quality that is equally weighted for all three components.

A summary of our approach to developing the Integrated Water Quality Score (IWQS) and the findings obtained from that index is the subject of this abstract. The index currently in

use is the third generation of this effort. In developing the refined index, several attributes were considered. These included: selecting parameters that are ecologically relevant; using a measurement scale that is independent of the number of parameters; and ensuring the index is sensitive to poor variables, but resistant to undue weighting of any one parameter score. The IWQS incorporates six measures: dissolved oxygen, pH, fecal coliform bacteria concentrations, total nitrogen (TN), total phosphorus (TP), and chlorophyll-a concentration. Scores for each parameter are based either on state water quality standards (DO, pH, fecal coliform bacteria) or exceedances of the 75th and 90th percentiles of an 8-year database compiled from SCECAP sampling throughout the state in both tidal creeks and larger open water habitats. Scores of the latter three measures (TN, TP, Chl-a) are further averaged into one score for potential eutrophication risk. This score is then averaged with the score of the other three measures (DO, pH, fecals) to compute the final IWQS for a site using equal weighting of the four variables.

Refinements to the third generation IWQS included: using the updated SCECAP database for identifying the 75th and 90th percentile thresholds for defining fair and poor conditions, changing the score values from 1,3,and 5 for poor, fair, and good conditions to 0, 3, and 5 for these conditions which has typically been used in previous indices. The 0 score increases the weight of poor station values and eliminates duplication of equivalent average score values for different permutations. Additionally, we reduced the number of parameters to four from the six parameters originally considered separately in the previous two IWQS. This decreases the weighting of potential eutrophic measures and increases the sensitivity of any one score.

The results of applying the new IWQS to data from all years surveyed by SCECAP indicates that overall water quality in the state's coastal zone is generally very good (< 20% of the habitat is codes as fair or poor in any given year) and there has been little change over time. Comparison of the new index with the previous versions shows a slight increase in the percentage of habitat that codes as either fair or poor for each habitat type, but the differences are not statistically significant. This suggests that all versions of the IWQS were fairly robust and that the minor changes made in the third generation IWQS did not result in a significant modification of our earlier evaluations (Van Dolah, 2002, 2004, 2006). Evaluation of the distribution of water quality scores based on the six years of sampling analyzed to date indicates that a relatively high percentage of the sites in the Winyah Bay estuary, upper Ashley River estuary, and inland portions of the ACE Basin NERR area have fair to poor water quality. Numerous sites in Beaufort County show fair, but generally not poor water quality.

Comparison of the summer only index measurement for the three parameters that are measured year round by SCDHEC and have water quality standards (DO, pH, fecals) indicates that the summer only index is slightly less conservative than collecting year round measures. For example, in the 2003-2004 survey, 8% of the state's coastal waters was considered to be in poor condition and 19% was in fair condition using SCECAP criteria. In contrast, 17% of the state's coastal habitat was rated as poor and 21% of the habitat was rated as fair using SCDHEC criteria of exceeding state water quality standards more than 10% of the time. The SCECAP IWQS was also compared to DHEC's evaluation of the states's coastal waters for 305(b) using a different and more stringent suite of parameters measured at the same SCECAP stations. Those results show that 305(b) measures were more stringent in identifying waters that do not support aquatic life use (poor water quality) and less stringent for identify waters that are partially supporting

aquatic life use (fair) for two of the three survey periods (2001-2002) and (2003-2004) that SCDHEC collected year-round data, but not for the 2005-2006 survey period.

The sediment quality index developed for the SCECAP program has also been modified to include sediment TOC in addition to a combined measure of contaminant concentration and sediment toxicity bioassay results (original index). The scoring process was also changed to use 0, 3 and 5 to be consistent with the water quality score for the reasons noted above. The B-IBI remains unchanged, but the final scores have been altered to 0, 3 and 5 to be consistent with the water and sediment quality indices so that all three variables receive equal weighting in the Overall Habitat Quality Index.

Coastal managers and the public have expressed appreciation for the development of integrated indices, and groups such as the Beaufort County “Friends of the River” have adopted three of the indices into their overall rating of Beaufort County waters. These measures are simpler for the public to understand and the new approach provides improved sensitivity to poor conditions using ecologically relevant measures without radically altering our assessment of the state’s water quality. SCECAP has proven useful to the staff SCDNR, SCDHEC and other agencies and institutions, and is unique to most other state sampling programs. It allows for assessment of temporal trends in habitat quality, and over time, allows for individual basin assessments. The robust database provided by SCECAP includes many condition measures useful for research purposes, even though they may not be incorporated into the indices we have developed.

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