A Comparison of Tidal Creek and Open Water Estuarine Habitats in South Carolina

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Abstract

The South Carolina Estuarine and Coastal Assessment Program (SCECAP) has been monitoring estuarine habitat condition since 1999. The program has sampled 30-60 stations per year, using a probability based sampling design, for which half the stations sampled each year are located in tidal creeks (TC) and the other half are located in larger open water (OW) habitats. The program has developed four indices of estuarine condition using multiple parameters. These include a Water Quality Index (WQI), Sediment Quality Index (SQI), Benthic Condition Index (B-IBI) and an overall Habitat Quality Index (HQI) that integrates the other three indices. These indices are applied at the station level, and then averaged at the the strata level (tidal creek vs open water), and state-wide using both strata combined. Analysis of the indices in each strata indicate that a higher percentage of tidal creek habitats tend to score lower than open water habitats with respect to our thresholds. WQI measures that are significantly ($P < 0.01$) different in tidal creeks include dissolved oxygen, pH, total phosphorus, chlorophyll-a, and fecal coliform bacteria when years are evaluated collectively. SQI variables that are significantly different in tidal creeks include total organic carbon and contaminants (as measured by the ERM-Q). Finally, the B-IBI scores only fair or poor in a greater proportion of the tidal creek habitat, as does the overall HQI. The collective assessment of tidal creek condition relative to open water habitats continues to confirm that tidal creeks serve as a good early warning sentinel habitat for monitoring estuarine condition.

Introduction

Tidal creeks provide valuable habitat for many commercially and ecologically important species of plants and animals, and act as "filters" that process or capture nutrients and contaminants coming from both upland as well as oceanic sources. While tidal creek habitats reflect their proximity to "downstream" habitats, the primary influence to tidal creeks comes from the associated upland habitats and the changes that occur in these habitats. The proximity to upland habitats is what makes tidal creeks an ideal sentinel habitat as changes in the upland are often reflected in changes in the associated tidal creeks (Holland *et al*., 2004; Mallin *et al*., 2004; Van Dolah *et al*., 2008).

SCECAP has been documenting responses of the subtidal creeks, rivers, and sounds of South Carolina since 1999. Strong environmental and biological gradients exist between the habitats for most of the parameters measured through the years of the program. While many of these gradients are a natural result of the transitions between the habitats, other gradients are influenced (salinity, hydrology) or created (a suite of contaminants) by anthropogenic changes in the upland habitats.

WQI Parameters	Good-Fair	Fair-Poor
pH	>7.35	≤7.22
Dissolved Oxygen	<4.0 mg/L	<3.0 mg/L
Fecal Coliforms	≤43 cfu	>400 cfu
Total Nitrogen	≤0.81 mg/L	>1.05 mg/L
Total Phosphate	≤0.10 mg/L	>0.12 mg/L
Chlorophyll-*a*	≤11.5 mg/L	>16.4 mg/L

SQI Parameters	Good-Fair	Fair-Poor
Total Organic Carbon	<3%	>5%
ERMQ	≤0.02	>0.058
Toxicity	1	2
BQI Parameter	**Good-Fair**	**Fair-Poor**
Benthic IBI	≥3	<2

Thresholds used for the 10 parameters that make up the Water Quality Index, Sediment Quality Index and Benthic Quality Index. Values distinguish between good and fair and fair and poor respectively, e.g. pH > 7.35 = good, pH ≤ 7.35 but > 7.22 = fair, pH ≤ 7.22 = poor.

Methods

Each summer, SCECAP samples a suite of water and sediment quality and biotic condition measures at a random array of stations in each of two estuarine habitats: tidal creek (<100 m from marsh bank to marsh bank) and open water (>100 m from marsh bank to marsh bank).

The proportion of each estuarine habitat that falls within ranges of values considered to be unimpaired (good), potentially or marginally impaired (fair), or impaired (poor) for the parameter is then calculated. These ranges are determined from a combination of state water quality criteria, historical data, or published stress thresholds. By combining ratings for each parameter, water quality and sediment quality indexes, a Benthic Index of Biological Integrity (B-IBI) index, and an integrated habitat quality index is calculated for each station. These values are then used to characterize the percentage of the total habitat that fall in good, fair or poor categories.

Example of tidal creek (dark blue) and open water (light blue) habitats in the Wando River, Charleston, SC.

Measure	Habitat	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	1999-2008	Habitat	Year	Change
Dissolved Oxygen (mg/L)	Open	4.86	5.01	4.96	5.1	4.97	5.41	5.13	5.11	5.49	5.62	5.2	**<0.001**	**0.003**	+
	Creek	4	4.12	4.45	4.51	4.58	5.1	4.12	4.33	4.53	4.5	4.4			
pH	Open	7.58	7.53	7.67	7.71	7.39	7.75	7.59	7.68	7.68	7.68	7.6	**<0.001**	0.832	+
	Creek	7.52	7.43	7.56	7.53	7.31	7.36	7.3	7.48	7.43	7.49	7.4			
Total Nitrogen (mg/L)	Open	0.51	0.58	0.66	0.52	0.84	0.52	0.57	0.2	0.26	0.52	0.5	0.295	**0.021**	-
	Creek	0.69	0.75	0.72	0.58	0.72	0.64	0.67	0.2	0.32	0.65	0.6			
Total Phosphorus (mg/L)	Open	0.08	0.06	0.06	0.05	0.06	0.08	0.08	0.07	0.06	0.05	0.07	**0.009**	0.231	-
	Creek	0.09	0.1	0.09	0.06	0.09	0.12	0.08	0.07	0.06	0.09	0.09			
Chlorophyll a (ug/L)	Open	10.3	9.1	10.1	10.1	6.9	8.4	7.7	7.4	11	9.2	9.0	**0.012**	0.068	-
	Creek	12.6	12.5	10.8	9.7	11.6	12	8	10.1	10.9	8.9	10.7			
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	18.8	**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	44.5			
Total Organic Carbon (%)	Open	0.86	0.63	0.94	0.84	0.74	0.88	0.7	0.77	0.79	0.7	0.8	**<0.001**	0.265	-
	Creek	1.08	1.33	1.3	1.39	1.3	1.12	1.48	1.03	1.71	1.06	1.3			
ERM-Q	Open	0.013	0.013	0.013	0.017	0.014	0.015	0.013	0.017	0.013	0.014	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	0.016			
Sediment Bioassays	Open	0.48	0.67	0.7	0.7	0.53	0.7	0.6	0.2	0.4	0.33	0.5	0.068	0.077	-
	Creek	0.52	0.67	1.16	0.7	0.7	0.7	0.84	0.36	0.73	0.53	0.7			
B-IBI	Open	3.76	3.73	3.55	3.88	3.48	3.55	3.72	3.5	3.97	3.93	3.7	**0.004**	0.34	+
	Creek	3.24	3.68	3.36	3.37	3.03	3.25	3	3.5	3.37	3.87	3.4			

Average values for the 10 measures that go into the indices and ANOVA results by parameter, year and habitat for 1999-2008.

Findings

•Dissolved oxygen, pH, total phosphorus, fecal coliform bacteria, sediment total organic carbon, ERM-Q and the Benthic IBI are all significantly different in tidal creek versus open water habitats (2-Way ANOVA, $p<0.05$).

•Dissolved oxygen concentrations have increased significantly over the 10-year period while total nitrogen concentrations have decreased significantly over the same period.

References

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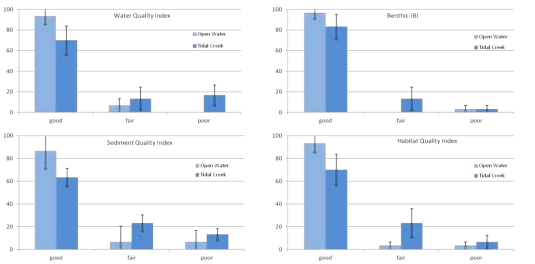
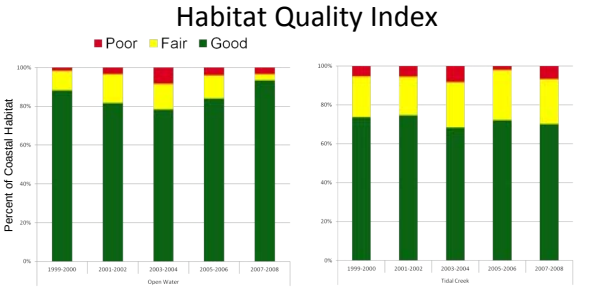


Percent of good, fair and poor habitat condition by habitat (OW and TC) and by index type for the 2007-2008 survey period. Error bars represent the 95% confidence interval around the mean index value (N=30 per habitat).

Findings

•During the 2007-2008 survey period, indices were not significantly lower in TC habitats versus OW (N=60).

•When all years are combined, there are significant differences between OW and TC habitats for the Water Quality, Sediment Quality and Habitat Quality indices (Mann-Whitney, N=543, $p<0.01$) but not the Benthic Quality index.



Percent of habitat in good, fair and poor condition for open water and tidal creek habitats by two year survey period.

Findings

•Tidal creek and open water habitats have responded differently over the 5 survey periods with the percentage of tidal creek habitat in the three categories remaining fairly constant.

Conclusions

There are significant natural and anthropogenic gradients in many environmental measures between tidal creek and open water habitats. Based on these measures, tidal creek habitats are under more "stress", from both of these sources. Using the indices developed by SCECAP, the percentage of tidal creek habitat in fair or poor condition is greater than the percentage of open water habitat.

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Additional Information can be found on the SCECAP website http://www.dnr.sc.gov/marine/scecap