Patterns of Coastal Land Cover and Estuarine Habitat Quality: Application of Long-term Monitoring Data

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Abstract: The coastal zone of the southeastern US is experiencing increasing pressure from urbanization (Crossett *et al*., 2004), and South Carolina is no exception, with its coastal population expected to grow 35% over the next 25 years (SC Budget and Control Board, 2005). Increases in urban land cover necessarily accompany a growing population, and 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; Van Dolah *et al*., 2007).

As impacts do not manifest rapidly, long-term monitoring represents a critical tool for detecting the impacts of changing land cover patterns on estuarine systems. The South Carolina Estuarine and Coastal Assessment Program (SCECAP) was established in 1999 to address concerns about potential degradation of natural resources as the state's coastline becomes increasingly developed. SCECAP has established independent indices of water quality, sediment quality, biological condition, and overall habitat quality, each of which encompasses multiple indicators, to assess the health of the state's coastal waters on a recurring basis (Van Dolah *et al*., 2006). The growing database for this program has provided a unique platform to examine spatial patterns and temporal trends in estuarine habitat quality.

Statewide, SCECAP has identified two regions of elevated estuarine habitat degradation associated with historically urbanized/industrialized water bodies: Charleston Harbor and Winyah Bay. Although the pattern was expected, it illustrated the effectiveness of the SCECAP approach for detecting land use impacts in estuarine systems on broad spatial scales. More quantitatively, Van Dolah *et al*. (2007) used SCECAP data in addition to several other data sources and documented consistent correlations between upland development and degraded water and sediment quality at the 14-digit HUC watershed scale.

SCECAP monitoring also identified a large number of areas with degraded water quality in the ACE Basin NERR, an area prized for conservation, recreation, and eco-tourism. Upon closer examination, the water quality degradation was driven primarily by elevated nutrients (total nitrogen and total phosphorus) and depressed dissolved oxygen. The ACE Basin NERR and surrounding areas include a range of land uses from urban/suburban to agriculture and waterfowl impoundments that may be influencing water quality on a finer, creek-by-creek scale. These observations led directly to an ongoing study to more specifically identify areas of degradation, link those to surrounding land uses/land cover, and recommend management actions to improve water quality. However, during this study several questions have arisen concerning how best

to link estuarine quality at a random array of stations to surrounding land use/land cover: 1) do environmental conditions in tidal estuarine water bodies more closely reflect upland land cover within associated watersheds or within a specific distance of the location sampled?, 2) at what spatial scales are the relationships between environmental conditions and upland land cover strongest?, and 3) how do the physical characteristics of the water bodies influence these relationships?

The recent addition of land cover data and water body characteristics (for example, width and creek order) to the SCECAP database has provided a means to more explicitly address the scales at which coastal development impacts estuarine habitat quality. To do this, the area surrounding a sampling location was defined in one of two broad ways: 1) as the fine scale Elevation Derivatives for National Applications (EDNA) watershed within which the station occurred, and 2) as that area falling within a given radius (50, 100, 250, 500, 750, 1000, 2000, and 4000 m) of the station (buffer approach). Land cover data was derived by intercepting the area surrounding each station with the National Land Cover Database (NLCD) and calculating percent of total upland area and percent of upland area as each land cover category (the focus here on developed land cover categories: open space, low, med and high development).

The relationships between parameters measured at each station and the developed land cover where examined using Pearson's r correlations. The strength of these correlations in a series of preliminary analyses were then compared across the two area approaches (EDNA watersheds and buffers) and spatial scales (50-4000 m radii) in two broad estuarine habitat types (tidal creeks and open water bodies). These analyses suggested that at least for some parameters, the buffer approach resulted in stronger relationships between estuarine quality and developed land cover than the ENDA watershed approach; however, this was somewhat dependent upon the size of the water body examined. For many SCECAP stations, the smallest buffer radii (50 and 100 m) did not include any upland in the area they encircled, indicating they provide little value in examining potential upland land cover impacts. Correlations tended to be strongest for buffer radii in the 750-1000 m scale and in analyses where only those buffers that included some upland were included. The strengths of the correlations were also dependent upon the size of the water body examined.

Long-term estuarine monitoring in South Carolina has provided a critical tool for identifying areas of degraded environmental quality in the state's coastal zone. These data have allowed the documentation of potential land cover/use impacts at spatial scales from large estuaries to finer than EDNA watersheds. The linking of estuarine quality with land cover/use at finer scales is particularly critical as these are the scales at which management actions intended to improve environmental quality would be most effective.

Literature Cited

Crossett, K.M., T.J. Culliton, P.C. Wiley, and T.R. Goodspeed. 2004. Population trends along the coastal United States: 1980-2008. Technical Report. Prepared by NOAA, National Ocean Service, Management and Budget Office. 54pp.

Holland, A.F., D.M. Sanger, C.P. Gawle, S.B. Lerberg, M.S. Santiago, G.H.M. Riekerk,

L.E. Zimmerman, and G.I. Scott. 2004. Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds. J. Exp. Mar. Biol. & Ecol. 298: 151-178.

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

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

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

Van Dolah, R.F., G.H.M. Riekerk, D.C. Bergquist, J. Felber, D.E. Chestnut, A.F. Holland. 2007. Estuarine habitat quality reflects urbanization at large spatial scales in South Carolina's coastal zone. Science of the Total Environment 390: 142-154.