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Preface

The importance of tidal creek ecosystems

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Tidal creeks are widespread and abundant estuarine ecosystems, yet their ecological relevance is undervalued as reflected by the lack of research on these systems relative to larger, better-known estuarine systems (e.g. the Chesapeake Bay, the Albemarle–Pamlico Sound System, Florida Bay, to name a few). These better-known large estuaries contain numerous tidal creeks which, in comparison to the estuary proper, have distinctly diverse hydrological and watershed characteristics that can heavily influence ecosystem function and impact human use of these resources (Sanger et al., 1999a; Lerberg et al., 2000; Mallin et al., 2000). Because tidal creek ecosystems generally have a higher surface-to-volume ratio than larger, river-dominated estuaries, and because they are so abundant and widespread, their collective importance in material transfer and other ecological processes may equal or exceed that of larger estuaries in certain geographic regions (Dame et al., 2000).

Tidal creeks are especially abundant in low-energy systems such as protected areas behind barrier islands along the Atlantic Intracoastal Waterway (ICW), or tributaries to large estuaries or rivers. They are most abundant along the Atlantic Seaboard from New Jersey to Florida, and along the Gulf Coast. As an example, the four southernmost coastal counties in North Carolina (Onslow, Pender, New Hanover and Brunswick) contain at least 73 tidal creeks that are second-order or larger. Each of these creeks receive drainage from first-order and intermittent tributaries, and many more of the latter systems discharge directly into large estuaries and rivers. Tidal creeks are present, but less abundant, in high-energy systems such as the rocky intertidal of the northeast United States and eastern Canada, the open beaches of the California coast and the steep coastlines of the US and Canadian Pacific Northwest.

Tidal creeks generally range in size from first-order to fourth-order streams, and from <1 to >10 km in length. Their depth rarely exceeds 3.0 m at high tide, and some tidal creeks contain broad intertidal sand or mud flats. Tidal creeks can be categorized as follows. High-salinity (polyhaline to marine) tidal creeks are found along the sound side of barrier islands and in Coastal Plain salt marsh estuaries such as South Carolina's North Inlet (Dame et al., 1991). These creeks have strong tidal influence and are characterized by marsh vegetation throughout. A second major category consists of mesohaline to polyhaline tidal creeks draining continental uplands. These creeks drain into larger

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estuaries such as the ICW, Laguna Madre, Chesapeake Bay, Charleston Harbor and the Albemarle–Pamlico Sound system, or the ocean proper (e.g. in some regions of the US Pacific Coast; Kwak and Zedler, 1997; Mallin et al., 1999; Lerberg et al., 2000). These creeks are also strongly tidally influenced, but streamside vegetation ranges from wooded uplands in the headwaters region to salt marsh vegetation in the lower reaches. The third category consists of tidal creeks that are fresh to oligohaline, and drain into tidal rivers such as the ones characterizing the Coastal Plains of Virginia, the Carolinas and Georgia (Odum et al., 1984). For example, at least 19 fresh to oligohaline tidal creeks (second order or larger) drain into North Carolina's Cape Fear River and its two major tributaries. These creeks are often less strongly influenced by the tides, have wooded headwaters areas and the lower reaches may be vegetated by oligohaline marsh or riparian swamp forest.

One critical aspect to this categorization is that the high-salinity systems are often located away from direct anthropogenic influences and are, in some cases, even pristine. In contrast, anthropogenic nutrients, toxins and pathogenic microbes can heavily pollute upland-draining tidal creeks. Finally, tidal canals represent a constructed set of estuaries built primarily for the convenience of boaters, property owners and industries requiring marine access. These are present in various areas along the Atlantic seaboard, and are abundant in south Florida and Louisiana. These canals are often subject to both chemical and physical anthropogenic impacts (Lapointe and Clark, 1992; Maxted et al., 1997).

Tidal creeks are rich areas in terms of aquatic, terrestrial and avian wildlife (Odum et al., 1984; Wiegert and Freeman, 1990), and these creeks can support complex food webs (Kwak and Zedler, 1997; Posey et al., 2002). Upland-draining tidal creeks can serve as compact river continuums, dominated by freshwater in upper regions while becoming euhaline at the creek mouth. Salinity distribution in many of these creeks varies tidally with mesohaline to euhaline conditions occurring at high tide and oligohaline conditions at low tide. In addition, at the same physical location, pollutant parameters may be highly concentrated at low tide and dilute at high tide (Mallin et al., 1999). In addition to the salinity zonation, tidal creeks often create terrestrial ecotones that are utilized by diverse animal communities moving between and among these habitats, as evidenced by clearly visible game trails. These ecotones consist of *Spartina*-dominated salt marshes blending into *Juncus*-dominated fresh and oligohaline marshes, both of which border maritime or inland forests. The tidal creeks and adjacent marshes are often considered to be primary nursery areas for fisheries, providing food and habitat to numerous species of fish and shellfish, including commercially important species (Hettler, 1989; Hoss and Thayer, 1993; Ross, 2003). Higher salinity creeks are very productive in terms of shellfish, and their accessibility makes these creeks popular commercial and recreational shellfishing areas.

The high-salinity salt marsh creeks can receive pollutants from the larger sounds and estuaries. Creeks draining uplands are the recipients of pollutants from the entire watershed that enter the tidal creek through a network of first-order fresh and oligohaline streams, intermittent streams and drainage ditches that often contain stormwater runoff that receives no pre-treatment. Accessibility, shellfishing and the aesthetically pleasing nature of tidal creek systems make their shorelines prime real estate for single and multifamily residential use, marinas and golf courses. Associated clearcutting and other losses of wetland vegetation and adjacent forests reduce the buffering capacity around tidal creeks, increasing the volume and rate of stormwater inflow. The net result of these impacts is that many of these complex and productive ecosystems are anthropogenically degraded to various extents. With increasing human coastal development (Bailey, 1996; Dame et al., 2000; Vernberg and Vernberg, 2001), existing natural tidal creeks are in danger of losing ecological value with increasing impacts (Sanger et al., 1999a; Lerberg et al., 2000; Mallin et al., 2000; Lewitus et al., 2003). Anthropogenic pollutants known to impact these systems include fecal bacteria and other microbes, suspended sediments, nutrients, pesticides and herbicides, heavy metals, petrochemicals and other chemical contaminants (Lapointe and Clark, 1992; Maxted et al., 1997; Mallin et al., 1999; Sanger et al., 1999a,b; DeLorenzo et al., 2001). Effects of these pollutants on these systems include shellfish closures from microbial pathogen exposure, alteration of benthic substrata and loss of submerged macrophyte vegetation, nuisance and toxic algal blooms, hypoxia and anoxia, loss of species through habitat alteration or toxicity, reduced ecosystem function and loss of recreational and commercial fisheries value (Maxted et al., 1997; Lerberg et al., 2000; Mallin et al., 2000; Vernberg and Vernberg, 2001; Lewitus et al., 2003).

The papers within this special issue of JEMBE, Anthropogenic impacts on the ecology of tidal creeks and canals, represent a spectrum of efforts addressing anthropogenic effects from the species to the ecosystem level, and scales of experimental approaches from laboratory bioassays to field-scale bioassays. Some of the papers are not in the traditional experimentation mode, but the researchers instead utilized novel or recent techniques (such as GIS applications and microbial source tracking), and these papers have been included to present a full spectrum of tidal creek study approaches. A broad variety of the aforementioned environmental impacts are considered, and potential solutions are presented including wiser land use planning and the use of enhanced natural ecosystem filtration.

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References

Bailey, W.P., 1996. Population trends in the coastal area, concentrating on South Carolina. In: Vernberg, F.J., Vernberg, W.B., Siewicki, T. (Eds.), Sustainable Development in the Southeastern Coastal Zone. University of South Carolina Press, Columbia, SC, pp. 55–73.

Dame, R.F., Spurrier, J.D., Williams, T.M., Kjerve, B., Zingmark, R.G., Wolaver, T.G., Chrzanowski, T.H., McKellar, H., Vernberg, F.J., 1991. Annual material processing by a salt marsh–estuarine basin in South Carolina. Mar. Ecol. Prog. Ser. 72, 153–166.

Dame, R., Alber, M., Allen, D., Chalmers, A., Gardner, C., Gilman, B., Kjerfve, B., Lewitus, A., Mallin, M., Montague, C., Pinckney, J., Smith, N., 2000. Estuaries of the south Atlantic coast of North America: their geographical signatures. Estuaries 23, 793–819.

DeLorenzo, M.E., Scott, G.I., Ross, P.E., 2001. Toxicity of pesticides to aquatic microorganisms: a review. Environ. Toxicol. Chem. 20, 84–98.

Hettler, W.F., 1989. Nekton use of regularly-flooded saltmarsh cordgrass habitat in North Carolina, USA. Mar. Ecol. Prog. Ser. 56, 111–118.

Hoss, D.E., Thayer, G.W., 1993. The importance of habitat to the early life history of estuarine dependent fishes. Am. Fish. Soc. Symp. 14, 147–158.

Lapointe, B.E., Clark, M.W., 1992. Nutrient inputs from the watershed and coastal eutrophication in the Florida Keys. Estuaries 15, 465–476.

Lerberg, S.B., Holland, A.F., Sanger, D.M., 2000. Responses of tidal creek macrobenthic communities to the effects of watershed development. Estuaries 23, 838–853.

Lewitus, A.J., Schmidt, L.B., Mason, L.J., Kempton, J.W., Wilde, S.B., Wolny, J.L., Williams, B.J., Hayes, K.C., Hymel, S.N., Keppler, C.J., Ringwood, A.H., 2003. Harmful algal blooms in South Carolina residential and golf course ponds. Popul. Environ. 24, 387–413.

Kwak, T.J., Zedler, J.B., 1997. Food web analysis of southern California coastal wetlands using multiple stable isotopes. Oecologia 110, 262–277.

Mallin, M.A., Esham, E.C., Williams, K.E., Nearhoof, J.E., 1999. Tidal stage variability of fecal coliform and chlorophyll *a* concentrations in coastal creeks. Mar. Pollut. Bull. 38, 414–422.

Mallin, M.A., Williams, K.E., Esham, E.C., Lowe, R.P., 2000. Effect of human development on bacteriological water quality in coastal watersheds. Ecol. Appl. 10, 1047–1056.

Maxted, J.R., Weisberg, S.B., Chaillou, J.C., Eskin, R.A., Kutz, F.W., 1997. The ecological condition of dead-end canals of the Delaware and Maryland coastal bays. Estuaries 20, 319–327.

Odum, W.E., Smith III, T.J., Hoover, J.K., McIvor, C.C., 1984. The Ecology of Tidal Freshwater Marshes of the United States East Coast: A Community Profile. U.S. Fish and Wildlife Service. FWS/OBS-83/17. 177 pp.

Posey, M.H., Alphin, T.D., Cahoon, L.B., Lindquist, D.G., Mallin, M.A., Nevers, M.B., 2002. Top-down versus bottom-up limitation in benthic infaunal communities: direct and indirect effects. Estuaries 25, 999–1014.

Ross, S.W., 2003. The relative value of different estuarine nursery areas in North Carolina for transient juvenile marine fishes. Fish. Bull. 101, 384–404.

Sanger, D.M., Holland, A.F., Scott, G.I., 1999a. Tidal creek and salt marsh sediments in South Carolina coastal estuaries: I. Distribution of trace metals. Arch. Environ. Contam. Toxicol. 37, 445–457.

Sanger, D.M., Holland, A.F., Scott, G.I., 1999b. Tidal creek and salt marsh sediments in South Carolina coastal estuaries: I. Distribution of organic contaminants. Arch. Environ. Contam. Toxicol. 37, 458–471.

Vernberg, F.J., Vernberg, W.B., 2001. The Coastal Zone. University of South Carolina Press, Columbia, SC. 191 pp.

Wiegert, R.G., Freeman, B.J., 1990. Tidal salt marshes of the southeast Atlantic Coast: a community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85 (29) (67 pp.).

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