Journal of Coastal Research	SI	57	43-52	Gloucester Point, Virginia	2008

York River Tidal Marshes

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ABSTRACT

PERRY, J.E.* and R.B. ATKINSON, 2009. York River Tidal Marshes. *Journal of Coastal Research,* SI (57), 43-52.

The York River has nine tidal wetland community types that are distributed along gradients of salinity and tidal inundation. These range from the Saltmarsh Cordgrass community dominated by *Spartina alterniflora* to the Tidal Freshwater Mixed community that can have over 50 species in one marsh. These tidal marshes provide a number of important functions and values to the estuarine systems including: high primary productivity, important habitat value, erosion buffering and filtering capacity useful for trapping sediments, pollutants and nutrients. The tidal marsh communities within the four Chesapeake Bay Virginia National Estuarine Research Reserve sites are situated along the York system in polyhaline, mesohaline, oligohaline and freshwater salinity regimes. They are largely pristine vegetation communities and have been documented to have abundant fauna characteristic of their individual community types. Changes in the vegetation communities of each site have been documented over time; however more research is needed on the potential effects of projected sea level rise on these habitats and the roles of watershed sedimentation and nutrient enrichment, vegetation succession, and invasive species on the persistence and value of these tidal marsh areas.

ADDITIONAL INDEX WORDS: *Productivity, ecological function, succession, brackish*

INTRODUCTION TO TIDAL MARSHES OF THE YORK RIVER

The York River has a large number of wetland communities that are distributed along gradients of salinity and tidal inundation (Wass and Wright, 1969, Perry and Atkinson, 1997). The vegetation communities in these wetlands depend on a wetlands location along these gradients (Odum *et al.*, 1984, Odum, 1988, Perry and Atkinson, 1997). In turn, tidal and salinity gradients can vary both spatially and temporally (Odum *et al.*, 1984, Hull and Titus, 1986, Odum, 1988).

The combined stress of inundation and salt water, while limiting the types of biota that can survive in the marshes of the lower portion of the bay, also provide for a diverse number of tidal wetland habitats. In upstream reaches the water column salinity is low to non-existent. Without the stress of salinity, more species of vascular plants are able to survive (Anderson *et al.*, 1968, Wass and Wright, 1969, Odum *et al.*, 1984, Perry and Atkinson, 1997). In these tidal fresh water zones, over 50 species ha^{-1} may be common (Doumlele, 1981, Odum *et al.*, 1984, Odum, 1988, Perry and Atkinson, 1997, Perry and Hershner, 1999). Here tidal inundation can be the principal factor affecting community composition and function. In the lower portion of the river only a few vascular plants are able to tolerate the combined effects of tidal inundation and high salt content of the water. For a comprehensive comparison of tidal salt marshes and freshwater marshes of Chesapeake Bay see Odum (1988).

The tidal wetlands of the Chesapeake Bay perform a number of important ecological functions that are attributed high value by humans. The most important of these functions and values are primary production and detritus availability, wildlife and waterfowl support, shoreline erosion buffering, and water quality control.

Primary productivity in tidal marshes can reach 4 metric ton ha^{-1} y^{-1}, with an average range of 0.4-2.4 metric ton ha^{-1} y^{-1}. This high level of primary productivity results in a high level of detritus production, which is the basis of a major marine food pathway, which includes crabs, other shellfish, and finfish. In addition to providing food, tidal marshes provide spawning and nursery habitat. It has been estimated that 95% of Virginia's annual harvest of fish (commercial and sport) from tidal waters is dependent to some degree on wetlands (Wass and Wright, 1969). Some of the important wetland-dependent fisheries in the Chesapeake Bay include blue crabs, oysters, clams, striped bass, spot, croaker, and menhaden.

The Chesapeake Bay is home to approximately 1 million waterfowl each winter. The ducks and geese benefit both directly and indirectly from the productivity and habitat provided by the Bay's marshes. Marsh-nesting birds include Virginia and clapper rails, mallard and black ducks, willet, marsh wren, seaside sparrow, red-winged blackbird, boat-tailed grackle, and northern harrier (Watts, 1992). Chesapeake Bay marshes are also used by herons and egrets year-round, and by transient shorebirds such as yellowlegs, semi-palmated sandpiper, least sandpiper, dowitcher, dunlin, and sharp-tailed sparrow (Watts, 1992). Muskrats are the most visible marsh-dependent mammals.

Tidal marshes dissipate incoming wave energy, thereby providing a buffer against shoreline erosion. Knutson *et al.*, (1982), studying *Spartina alterniflora* marshes in the Chesapeake Bay, found that over 50% of wave energy was dissipated

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within the first 2.5 meters of the marshes. Rosen (1980) found that marsh margins form the least erodible shorelines.

Marshes in the Chesapeake Bay play a very important role in maintaining and improving water quality by trapping sediment from upland runoff and from the water column, thereby reducing siltation of shellfish beds, submerged aquatic vegetation beds, and navigation channels. Pollutants may also be filtered from runoff and the water column, and taken up by marsh plants.

Over one half of all Virginians live on the coastal plain that makes up a little under a third of the state's landmass (Colgan, 1990, Mason, 1993). This population pressure has resulted in increased impacts to salt marshes. Wetlands Watch, a Virginia NGO, has estimated that Virginia could lose between 50% and 80% of its remaining vegetated tidal wetlands by the year 2107 due to sea level rise (www.wetlandswatch.org, 2007). As sea level rises, homeowners will want to harden their shores to protect against property loss. This hardening may stop any shoreward progression of tidal marshes and more than likely increase tidal marsh losses.

Figure 1. Saltmarsh cordgrass (*Spartina alterniflora*) (Photo courtesy of VIMS CCRM)

DISTRIBUTION AND BIOTA OF YORK RIVER MARSHES

Nine common vegetated marsh types have been described in the tidal freshwater, oligohaline, mesohaline, and polyhaline sections of the York River (VMRC 1980, Perry *et al.*, 2001). These are arranged in the York River landscape along a salinity gradient with the polyhaline marshes at the mouth and tidal freshwater marshes further upstream from the saltwater influence (Wass and Wright, 1969, Odum *et al.*,1984, Perry and Atkinson, 1997).

All of the marshes within the CBNERRVA are high in biomass productivity and are important as wildlife, finfish, and shellfish habitat. A brief description of each community type is presented below. For a more in-depth study of the tidal marshes of the York River see Wass and Wright (1969), Silberhorn (1999), EPA (1983), and Perry and Atkinson (1997).

MARSH TYPES

Saltmarsh Cordgrass (a.k.a. Smooth Cordgrass) Community

The saltmarsh cordgrass community dominates the poly- and mesohaline areas of the York River (Figure 1). The community is comprised of dense, often mono-specific stands of *Spartina alterniflora* (saltmarsh or smooth cordgrass). Physiographical distribution ranges from mean sea level (MSL) to approximately mean high water (MHW). A stout, erect species, *S. alterniflora* often is represented by two forms: a tall form, 1.2-2 m (4-6ft) in height along the waters edge or along levees; and a short form 0.7 m (2ft) or less in height found in poorly drained areas behind levees or at elevations slightly higher than mean high water (Silberhorn, 1999). Other vegetative communities occur landward of the saltmarsh cordgrass communities including the saltmeadow, black needlrush, saltbush, and panne communities.

Natural succession of the saltmarsh cordgrass community for temperate climates analogous to the York River was first described in the 19th century (Mudge, 1862, Shaler, 1885) and is an important aspect of the marsh in respect to our current rise in sea level. These early researchers noted trees were positioned in an upright position at the bottom of saltmarsh peat. Mudge (1862) concluded that the stumps indicated that the area was once located at an elevation above MHW. He further noted *Spartina patens* rootstock, a species normally found at an elevation above mean high water, well below that elevation. He hypothesized, therefore, that saltmarshes "grew" (i.e., accreted) through the gradual accumulation of cordgrass rootstock. Several studies have shown that peat accumulation over time is responsible for the horizontal soil profile found in mid-Atlantic saltmarshes (Blum and Christensen, 2004). Primary succession normally occurs on a protected sand beach or overwash area. As the plant community matures, a solid subterranean root-mat develops. With sea level rises, the root-mat becomes anaerobic and creates reduced chemical conditions in the soil. Low redox conditions make it difficult, if not impossible, for aerobic soil microbes to survive. Without the presence of soil oxygen, biological degradation of the dead root material is considerably slower. The net effect is an increased amount of organic material in the soil and an increase in elevation in response to relative sea level rise (Redfield and Ruben, 1962, Redfield, 1972). Oertel *et al.*, (1989) have shown that a similar process has occurred and is responsible for the saltmarshes of the barrier islands of Virginia. Similar processes of marsh overwash and development are ongoing on a smaller scale within the Chesapeake Bay and its tributaries.

Saltmeadow Community

The saltmeadow community dominates areas of slightly increased elevation located landward of the saltmarsh cordgrass community in meso- to polyhaline waters. It also occurs on the higher portion of natural levees. The dominant vegetation is either *Spartina patens* (saltmeadow hay; Figure 2) or *Distichlis spicata* (salt grass) or a mix of both. Topographically, these "meadows" often remind one of grassland prairies or hay fields. Historically, these marshes have been used as a source of cattle fodder, both grazing and haying, throughout the mid-Atlantic and New England states (Teal and Teal, 1969). Both dominant plants form characteristically dense, low, 0.3-0.7 m (1-2 ft), wiry meadows typically with swirls or cow-licks.

Figure 2. Saltmeadow hay (*Spartina patens*) (Photo courtesy of VIMS CCRM)

Black Needlerush Community

The black needlerush community (Figure 3) is found interspersed among the saltmeadow community, and is common in the high marsh of some meso- and oligohaline areas. *Juncus roemerianus* (black needlerush) nearly always grows in mono-specific stands. The dark green (almost black), leafless stem tapers to a sharp point, giving the plant it's well deserved name. The black needlerush community is normally located behind and/or interspersed within the Salt Marsh community. The boundary is usually distinct (Eleuterius, 1976, Montague *et al*., 1990). Stout (1984) divided black needlerush into three communities based upon elevation and soil salinity influences (modified from Uchytil, 1992): (1) Saline needlerush marsh. Found in eury- to mesohaline waters. Common associates include smooth cordgrass, saltmeadow cordgrass (*S. patens*), giant cordgrass (*S. cynosuroides*), saltgrass *Distichlis spicata*), and glasswort (*Salicornia* spp.). (2) Brackish needlerush marsh. Transitional between Meso- to oligohaline marshes. Associates include smooth cordgrass, giant cordgrass, saltmeadow cordgrass, sea lavender (*Limonium caroliniana*), threesquare, and common arrowhead (*Sagittaria latifolia*). (3) Intermediate needlerush marsh, transitional between brackish and tidal freshwater marsh. Associates include common reed (*Phragmites australis* v. australis, P. a. v. *americanus*) and softstem bulrush (*Scheonoplectus tabernaemontani*).

Figure 3. Black needlerush (*Juncus romerianus*) (Photo courtesy of VIMS CCRM)

Saltbush Community

Landward of the salt meadow and needlerush marshes one encounters the only tidal saltmarsh community dominated by woody vascular plants. The saltbush community is dominated by two shrubs: *Iva frutescens* (salt bush; Figure 4) in the lowest physiographic range, and *Baccharis halimifolia* (groundsel tree; Figure 5) in the higher physiographic range of the marsh. This type of vegetation usually delineates

Figure 4. Saltbush (*Iva frutescens*) (Photo courtesy of VIMS CCRM)

Figure 5. Groundsel Tree (*Baccharis halimifolia*) (Photo courtesy of VIMS CCRM)

Figure 6. Big Cordgrass (*Spartina cynosuroides*) (photo courtesy VIMS CCRM)

the upward boundary of the tidal marsh. The shrubs usually reach heights of 1 to 4 m (3-12.5ft.).

Big Cordgrass Community

The big cordgrass community, dominated by *Spartina cynosuroides*, (big cordgrass; Figure 6) is found slightly above MHW, but is variable in range (Silberhorn, 1999). It usually forms dense, mono-specific stands in low salinity (oligohaline) marshes. This is one of the tallest grass species of our tidal wetlands, usually reaching 2-4 m (6-12 ft) in height. Its stems are stout, leafy, and have a distinct coarse branched flower (seed) head. The leaves have saw-like margins that easily lacerate human skin.

Cattail Community

Although there are several species of cattails in the mid-Atlantic region, there is only one, *Typha angustifolia* (narrow-leaved cattail; Figure 7) that is common in the saline tidal reaches. The community is usually found in isolated stands in brackish marshes, often near the upland margin where there is freshwater seepage. In freshwater areas, *T. latifolia* (broad-leaved cattail) may also be present and is often an indicator of high nutrient loads.

Reed Grass Community

The reed grass community has become quite controversial. The community is dominated by reed grass (*Phragmites australis* ssp. *australis*, *P. a.* ssp. *americanus*; Figure 8), a species considered invasive by many wetlands scientists, regulators, and managers. The community is usually located above MHW and is almost always associated with topographic or other disturbance such as the placement of dredged sediments or other fill material, plant die-back or surface erosion. The species usually cannot tolerate poly- or mesohaline conditions below MHW (Silberhorn, 1999). It is a tall, stiff grass up to 4 m (12 ft) in height with short, wide leaves tapering abruptly to a pointed, purplish plume-like (feathery) flower head that turns brown in seed.

Figure 7. Narrow-leaved Cattail (*Typha angustifolia*)

Salt Panne Community

Salt pannes (Figure 9) are shallow depressions, which often form within the interiors of large saltmarsh cordgrass communities. They are usually the result of wrack accumulation that kills the cordgrass or of "eatouts" caused by muskrats or snow

Figure 8. Reed Grass (*Phragmites australis* ssp. *australis*) (Photo courtesy of VIMS CCRM)

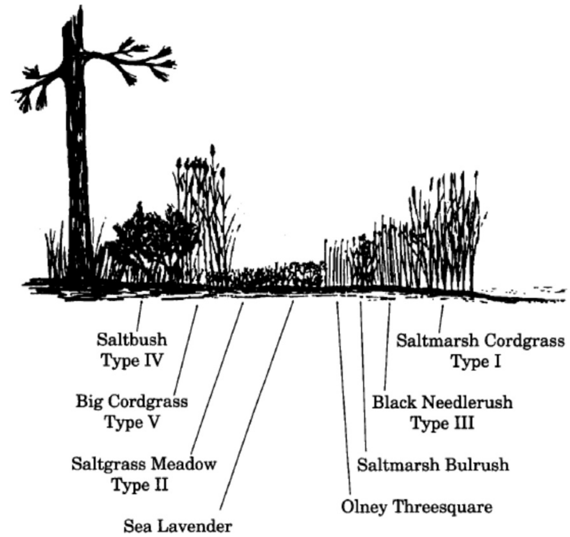

Figure 10. Brackish Water Mixed Community showing distribution of plant species from creek edge to upland. (Reproduced from VMRC 1993)

Figure 9. Salt panne with *Salicornia virginica*

geese. These areas normally become hyper-saline and are sparsely vegetated. They are dominated by several halophytic species of saltworts (*Salicornia virginica*, *S. europea* and *S. bigelovii*). These are succulent plants 1.5-30 cm (6-12 in) tall. By late summer, these plants may turn a dark red, giving those portions of the marsh a striking contrast to the yellow-greens of the surrounding grasses.

Brackish Marsh Community

In the brackish marsh community (Figures 10 and 11) no single species typically covers more than 50% of the marsh and species diversity is much higher than the saltmarsh cordgrass community that occurs in areas of higher salinities (usually 15 to 20 ppt or higher). Typically, associated vegetation includes: saltmarsh cordgrass, saltmeadow hay, saltgrass, black needlerush, saltbushes, threesquare bulrush, big corgrasss and cattails. Small areas within the marsh may be dominated by one or more species as many are distrubted throughout the marsh according to their tolerance for both inundation and salinity. The wetland vegetation is distributed vertically from mean sea level, where saltmarsh corgrass dominates, to the upper limits of tidal inundation, where the saltbushes occur (Figure 10).

Figure 11. Brackish Water Mixed Community showing distribution of plant species from creek edge to upland. (Photo courtesy of VIMS CCRM)

This marsh type is considered a microcosm of all the communities found in saline water and is ranked along with the Saltmarsh Cordgrass community as one of the highest valued marsh areas in Virginia because of its productivity, diversity and value as erosion, water quality control and flood buffering. Because of their location in low to moderate salinity areas many are know spawning and nursery grounds for finfish and crabs. They also are important as a valuable foraging area and habitat for a wide diversity of wildlife species.

Freshwater Mixed Marsh Community

In the freshwater Mixed Marsh Community (Figures 12 and 13) no single species covers more than 50% of the site and in the York River more that 50 species may be found within a

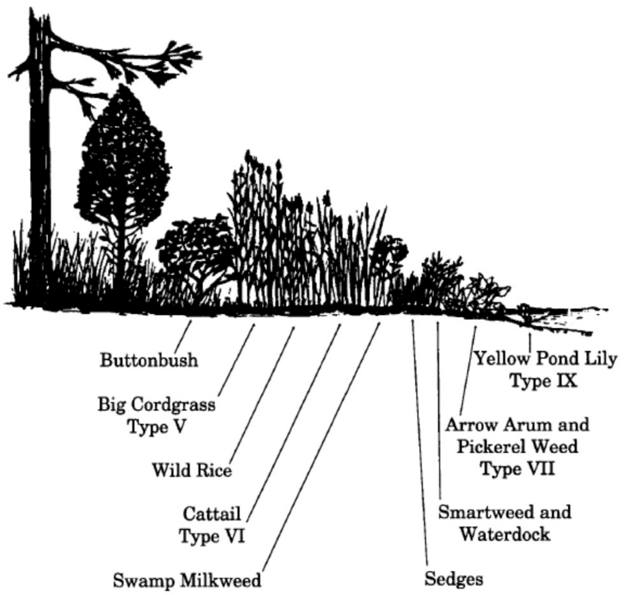

Figure 12. Freshwater Mixed Community showing distribution of plant species from creek edge to upland. (Reproduced from VMRC 1993)

Figure 13. Freshwater Mixed Community (Photo courtesy of VIMS CCRM)

single marsh. There may be both considerable temporal and spatial variability in the abundance of individual species in this marsh community type with principle factors affecting the dominance including: season, elevation and salinity or conductivity of the tidal waters. Figure 10 shows a characteristic distribution of dominant species extending from the creek or river edge to the upland for freshwater marshes in this region. Here the emergent marsh extends from below low water to the upper limits of storm tidal inundation. Yellow pond lily (*Nuphar luteum*) may be found growing below low water, however its leaves and flowering shoots must extend above the usual high tide. Arrow arum (*Peltandra virginica*) and pickerel weed (*Pontederia cordata*) are dominant at low to mid tidal elevations and in the spring and early summer may dominate large areas of the marsh. During the mid to late summer an over story of wild rice (*Zizania aquatica*) and other species may develop as the early species die back. Highest elevation will support big cordgrass, cattails and various small trees and shrubs such as buttonbush.

The freshwater mixed community has one of the highest annual productions of tidal wetlands in this region with annual production exceeding 1800 kg ha-1. These marshes are also highly valuable for wildlife and waterfowl as the plants produce a diversity of abundant seeds, roots and tubers that are readily consumed. Typically, tidal waters are important spawning and nursery grounds for many resident and anadromous fish such as the striped bass, shad and river herring. The marshes are also important as flood and erosion buffers and sediment filters, however much of the aboveground vegetation dies back in the winter creating broad mudflats. Sediments are readily trapped during the growing season however enabling most of these areas to maintain themselves under conditions of rising sea level. Salinity intrusions during years of drought may significantly change the community structure within one year's time (Davies, 2004) as more salt resistant species dominate. A broad diversity of species helps to maintain this flexibility.

CBNERRVA TIDAL WETLANDS

Goodwin Island

The wetland types within the Goodwin Island complex (see Hobbs, this Issue, Figure 3) include smooth cordgrass, black needlerush, salt-meadow hay, and tall reed marshes. The smooth cordgrass marshes make up a predominant portion of the Goodwin Island marshes. They are dominated by smooth cordgrass (*Spartina alterniflora*) with few other species present. Several small salt pannes, less than 200 m^2 and dominated by scattered patches of saltgrass (*Distichlis spicata*) and glasswort (*Salicornia virginica* and *S. bigelovii*), exist scattered within the northern smooth cordgrass marsh communities. A 1-2 m wide berm, approximately 0.5 m height, is found on the north, south, and west border of the islands. The berms are dominated by salt bushes (*Iva frutescens*) and salt meadow hay (*S. patens*) (Laird, 2001). No berm is found on the east side, having been eroded by wave activity (Perry, personal observation). Here, smooth cordgrass dominates to the edge of the marsh.

A large salt-meadow hay community exists on the west side of the islands, inland of the smooth cordgrass community. The community is dominated by a mix of salt meadow hay and saltgrass. Other species present include: marsh aster (*Aster tenuifolius*), *Fimbrisstylis autumnalis* (no common name), smooth cordgrass, and water parsnip (*Sium suave*) (Laird, 2001). Fires are a common disturbance in this community, as well as the tall reed community (see below) and maritime forest found on the largest island.

A large (approx. 13 ha) tall reed type community is located on the south-east side of the largest island, landward of the smooth cordgrass marsh. Dominated by tall reed (*Phragmites australis* ssp. *australis*), few other species were present (Laird, 2001). Small patches of tall reed also exist on the east side of the largest island; however, they are constantly eroding away (Perry, personal observations). Reserve managers are actively working to eradicate this invasive form of the tall reed (Reay, personal communications).

Several saline needlerush communities are found scattered throughout the salt marsh community on the southeast side of the largest island. These were usually monotypic and consisted solely of the black needlerush (*Juncus roemerianus*).

Overall, the dominant plant of Goodwin Island marshes is the saltgrass, followed closely by smooth cordgrass. Marsh aster, sea ox-eye (*Borrichia frutescens*), sea lavender (*Limonium carolinianum*), glasswort (*Salicornia virginica*) and (*Suaeda linearis*), all obligate halophytes, are common (Perry and Atkinson, 1997, Laird, 2001). Perry and Atkinson (1997) and Laird (2001) identified a total of eleven vascular plant species in the Goodwin Island marshes. Vascular plant diversity is low due to the stress of salt and inundation.

Catlett Islands

Catlett Islands (see Hobbs, this Issue, Figure 5) are comprised of a series of Holocene sand ridges and valleys. The ridges are covered with maritime forest dominated by *Juniperous virginiana* (eastern red cedar) and *Pinus taeda* (loblolly pine). The valleys are dominated by salt marsh communities; however several large saltmeadow communities existed in the high marsh zone. Numerous small monotypic stands of saline black needlerush are dispersed in the upper end of the salt marsh community. *Iva frutescens* (salt bushes) forms a thin ecozone (approx. 2 m, Laird 2001) between the tidal marshes and maritime forest. Erosion is common on the south and southeast side of the islands and, therefore, the saltmeadow communities may dominate to the waters edge.

Spartina alterniflora (salt marsh cordgrass) is the most common species in the tidal marshes with co-dominants *Distichlis spicata* (saltgrass), *Spartina patens* (saltmeadow hay), and *Juncus roemerianus* (black needlerush) (Perry and Atkinson, 1997). The Catlett Island marsh communities are very similar in distribution and composition to those of Goodwin Islands. Perry and Atkinson (1997) found only six species along a series of five wetland vegetation transects. Missing were the halophytes found in the more saline tidal marshes (e.g. *Borrichia frutescens*) (Perry and Atkinson, 1997, Laird 2001).

Taskinas Creek

Taskinas Creek (see Hobbs, this Issue, Figure 6) is comprised of a large watershed with embayment marshes. It receives a large freshwater input from runoff in its headwaters creating a sub-estuary system. Because of its topography, it contains both high and low marshes. It has a 1 m tidal range and a salinity range of 15-20 ppt at the mouth (reference CB-NERR-VA data) to <0.05 ppt at the headwater. The beaver (*Castor canadensis*) plays an important role in the headwater of this ecosystem. They have built long dams across the headwaters that are several decimeters high. New growth of swamp forest is found upstream of the dams (see Reay, this issue). Downstream of the dams are found a large array of wetland types from tidal freshwater to brackish to smooth cordgrass type communities. Berms and high organic content of soil characteristic of salt marsh communities are located near the mouth and decreases as one moves upstream and nears the tidal freshwater marshes (freshwater mixed community).

Spartina alterniflora dominate the marshes at the junction of the York River and Taskinas Creek. Originally, a large high marsh zone of *Iva frutescens* (saltbush) inhabited the north end of the marsh at the junction where it was presumed that the *S. alterniflora* had eroded away earlier (Perry and Atkinson, 1997). On a current data-gathering trip (Perry, unpublished data 2006), we noted that most of the *I. frutescens* has now eroded away and that that remains has died back, apparently from an increase in inundation. The remaining highmarsh, which appears to be rebuilding by sand washing onto the marsh during storms, has become dominated with *S. cynosuroides* (tall cordgrass). Freshwater species such as *Juncus geradii* (military rush) and *Schoenoplectus pungens* were first found in the high end of this marsh.

Moving upstream approximately 1 km, *S. cynosuroides* becomes more dominant on the edges and the points (tips) of the marshes while the saltmeadow communities became more common in the interior, indicating a possible increase in marsh elevation (Laird, 2001). The saltmeadow community was dominated by *S. patens* and *D. spicata* (Perry and Atkinson, 1997, Laird, 2001). *Schoenoplectus robustus* (saltmarsh rush) dominated some small areas (less than 100 m^{-2}), scattered throughout the mid-marsh and marsh edges. *Schoenoplectus pungens*, and *Typha angustifolia* are commonly scattered to along the landward margin of the marshes. Perry and Atkinson (1997) note that ten species occurred in the mesohaline marshes, however, they noted that there were fewer obligate halophytes.

Taskinas Creek has moderate diversity overall due to the diversity of habitats. Diversity is low in marshes located near mouth (characteristic salt marsh communities) and jumps in the freshwater mixed community located approximately 2 km upstream.

Sweet Hall Marsh

Sweet Hall marsh (see Hobbs, this Issue, Figure 8) is a 440 ha. point marsh with a moderate forested watershed located on its north boundary. The wetland is dominated by low tidal marshes with a 1 m tide range. Salinity varies from <0.05 ppt to >15 ppt and is responsive to freshwater flows (CBNERR-VA data). Moderate freshwater input from runoff enters through the north forested area and from upstream. Upstream channel causes diversion of freshwater ebb-flows to use a southwest rout around the marsh. Flood-flows, on the other hand, travel through the major cross-marsh channel (see Hobbs, this issue, Figure 8). Wrack lines form berms on the rive edge up to 5 m wide. The berms are dominated by either a mix or low diversity stand of *S. cynosuroides*, *P. australis* ssp. *americanus* (tall reed grass), *Peltandra virginica* (arrow arum) and *Carex hyalinolepis*. More salt tolerant species are found on the downstream edge (east edge) than the upstream edge (west). Muskrat activity is common and appears to play a role in hydrology and composition of vegetation community (Doumlele, 1981, Perry and Hershner, 1999).

Wetland types include large areas of freshwater mixed communities, with a thin band of *Peltandra virginica* (arrow arum) along the lower elevations of the waterward fringe. A small Spatterdock community (dominated by *Nuphar luteum* (spatter dock)) is found midway down the upstream (west) side of the marsh. Fifty-six species were encountered by Perry and Hershner (1999) along a series of seven transects dissecting the marsh. Salt tolerant species (facultative halophytes) were poorly represented, but fresh water species were common. *Peltandra virginica* (arrow arum) is the dominant species in the mixed marsh areas, particularly in the first half of the growing season (Doumlele, 1981,Perry and Atkinson, 1997, Perry and Hershner, 1999, Davies, 2004). Co-dominants include: *Carex stricta*, *Leersia oryzoides* (rice cut-grass), *Polygonum punctatum* (spotted knotweed), and *P. arifolium* (tear-thumb). Late in the growing season, grasses such as *Echinochloa walteri* (Walter's millet), *Leersia oryzoides*, and *Zizania aquatica* (northern wild rice), and composites such as *Bidens laevis*, *B. cernua* (marsh beggar ticks), and *Pluchea odorata* (marsh fleabane) will become prominent, each dominating large, but highly diverse regions of the marsh (Doumlele, 1981, Perry and Hershner, 1999, Davies, 2004). Plant diversity is higher than that of the salt marshes and brackish marshes of the York River (Doumlele, 1981, Perry and Atkinson, 1997). While few obligate or facultative halophytes are present, their numbers have been increasing over past several decades (Perry and Hershner, 1999, Davies, 2004).

TIDAL MARSH FAUNA

The dominant fish species from Goodwin Island, based on biomass and total number of fish caught, was *Fundulus heteroclitus* (mummichogs) (Ayers, 1995, Cicchetti, 1998). Ayers (1995) reported that biomass peaked in Goodwin Islands in June, with a second peak in late September. Cicchetti (1998) found that *F. heteroclitus* used seagrass beds, unvegetated areas, and portions of the marsh as a low tide refuge. In all, there were 32 species of nekton captured between June and October 1995, with a mean overall abundance of 28.6 individuals per m^2 and a mean biomass of 3.89 g/m^2 (dry weight). Based only on biomass, the most dominant species was the blue crab, *Callinectes sapidus* (Cicchetti, 1998). Certain fish from the sciaenid family (e.g. white croaker, spot croaker, and weakfish) use marsh habitats in a transient or opportunistic manner, as do silversides (*Menidia menidia*). As well, the marsh surface is apparently used as a nighttime refuge by silversides. Cicchetti and Diaz (2000) found that predation on invertebrates was highest in marsh edge areas and a large portion was consumed by transient species. The major path for export of material from the marsh interior habitats into shallow water habitats was by blue crab predation on resident mud fiddler *Uca* and *Sesarma* crabs (Cicchetti, 1998, Cicchetti and Diaz, 2000).

Few studies have addressed fauna of marshes and adjacent tidal streams in freshwater habitats (see Brown and Erdle, this Issue). Tidal freshwater marshes have been reported to be more diverse than salt marshes for certain fish taxa and for earlier life stages, as well as for other vertebrate groups (Odum *et al.*, 1984, Odum, 1988). Only non-insect invertebrates were reported to be less diverse in tidal freshwater marshes than in salt marshes (Odum, 1988). In a review of the literature, Brinson *et al.*, (1981) found insect abundance and diversity was high for salt and freshwater systems, which was taken as evidence that low diversity vegetation (i.e. salt marshes) can still support diverse consumer assemblages. Muskrat (*Ondatra zibethicus*) are a commonly occurring mammal in many tidal fresh and brackish marshes (sensu Brinson *et al.*, 1981, Odum, 1984). Connors *et al.*, (2000) detected significant nitrogen cycle effects due to muskrat activities in tidal freshwater marshes, but concluded that their effect on vegetation structure was limited. *Aeschynomene virginica*, a vascular plant with the federally status of threatened and Commonwealth of Virginia status of endangered, has been identified in several muskrat eatout areas in the tidal freshwater marshes of the Mattaponi, Pamunkey, and Rappahannock rivers. Black rat snakes (*Elaphe obsoleta*), brown water snakes (*Nerodia taxispilota*), and diamondback terrapins (*Malaclemys terrapin*) have all been observed in all four CBNERRVA tidal marshes. Virginia rail have been seen and heard in Sweet Hall and Goodwin Island marshes (several nest were encountered at both sites) (Perry, personal observations).

RESEARCH AND MONITORING NEEDS

Changes in vegetation communities have been documented in Goodwin Island (Cicchetti, 1998, Cicchetti and Diaz, 2000, Laird, 2001) and Catlett Islands (Perry and Atkinson, 1997, Laird, 2001). On Goodwin Island these changes include loss due to eroding marsh faces (Cicchetti, 1998, Cicchetti and Diaz, 2000, Laird, 2001) and the progression of an aggressive wetland invasive plant; *Phragmites australis*). Understanding the rate of erosion, and rate of spread of the *P. australis*, will help understand how these changes may alter the functions served by these marshes. The role of sea level rise and the ability of accretion in the salt marshes to keep up with the rise is poorly understood on all the York River marshes. More information on accretion rates, sediment composition, changes in above and below ground biomass, is needed.

The population decline of the diamondback (*Malaclemys terrapin*) terrapin, such as found in the marshes of the Goodwin Islands, Catlett Islands, Taskinas Creek and Sweet Hall Marsh reserve sites (Chambers, personal communications), is of national concern. Diamondback terrapin populations are threatened by juvenile and adult mortality in crabpots, loss of nesting habitat, and nest destruction by mammalian predators (Ruzicka, 2006). Raccoons (*Procyon lotor*) on Goodwin Island are known to play a major role in the decline (Ruzicka, 2006, Chambers, personal communications). It is not known, however, if the interaction is through natural trophic interactions (predator/prey relationship), or if there is an anthropogenic increase in raccoon populations (aka subsidization, sensu Klemens, 2000), that, therefore, may lead to an increase in predation on the terrapin. The brown water -snake (*Nerodia taxispilota*), has been seen on all four CBNEERVA sites (Perry, personal observations). Little is known of its habitat needs, population status, or the role it plays in the tidal marsh ecosystem.

As sea level rates increase, salinity and inundation period are also expected to increase. Data are needed to better understand the impact that these changes may bring to the tidal marshes in the York River. Several studies have documented changes in the vegetation communities of Sweet Hall Marsh (Perry and Hershner, 1999, Davies, 2004). These changes have been attributed to relative sea level rise since salt-tolerant perennial species, e.g. *Spartina alternifolia* and *S. cynosuroides*, have become more prominent (Perry and Hershner, 1999, Davies, 2004). Perry and Hershner (1999) predicted that salt – tolerant perennials will play a more important role in the future. Davis (2004) found that yearly changes in vegetation composition was more complex than believed and that both fresh and salt water perennial species had the ability to lay dormant through adverse environmental conditions. Research is needed to better understand the role of both annual and perennial plant species in vegetation succession brought on by sea level rise, and what any change in vegetation composition may mean to loss of, or changes in, habitat values of the marsh. Data on the potential changes in tidal marsh nutrient processes due to increased salinity in the water column and soil pore spaces (as a function of increased rates of sea level rise) is poorly understood. Both above and below ground carbon storage may be affected (Blum and Christian, 2004), altering nitrogen and carbon storage. However, these data are lacking.

Little is known about how an increase in nutrient input from agriculture, industry, and non-point sources may alter the turbidity of the water column and change the sediment content available to the York River marshes. The former effect may decrease the amount of photoactive light available to aquatic and marsh plants, as well as deliver toxic pollutants into the marsh. The latter may alter the available sediments needed by the marsh to keep up with increases in sea level rise rates.

ACKNOWLEDGEMENTS

This is contribution No. 2878 from the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary.

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