Hydrologic and geomorphological processes of Atlantic Coast & Chesapeake Bay grid-ditched marshes
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There are four main objectives of this study: (1) assess the hydrological, nutrient, and ecological conditions of pre/post plugging of ditched marshes compared to a natural unaltered referenced site nearby; (2) determine whether these ditched sites are degraded relative to unditched reference marshes, (3) model the hydrology at these sites, and (4) determine whether the condition of the ditched sites may be improved with ditch remediation practices. The ditched and unditched sites will be compared both using field-collected data and modeling results. The determination of the success of restoration techniques will be made by putting the comparative ecological data in their hydrological context and by directly modeling predicted effects of remediation practices. Particular comparisons to be made between ditched restored, ditched control, and unditched sites include: (1) Water table and quality dynamics across the marsh both spatially (laterally and horizontally) and temporally (across seasons and lunar and wind-driven tidal cycles); (2) Differences in hydrologic function between ditches and natural tidal creeks; (3) Vegetative community and plant productivity differences between sites within the context of water level, salinity, and sulfide toxicity controls; (4) Sediment outflow dynamics; (4) Habitat for pestiferous mosquitoes; and (5) Dependence of these comparisons on geomorphic condition differences between sites.

Methods, Procedures

The project will be conducted in the Maryland portion of the Delmarva Peninsula. Two marshes, at the Deal Island and EA Vaughn Wildlife Management Areas, will both have a ditched site, ditched control site, and a nearby natural unditched reference site. The Deal Island sites are located along the western shore of the Delmarva; the EA Vaughn site is located along the eastern shore, on the mainland side of a coastal bay (Chincoteague). The study sites have salinities ranging from mesohaline to polyhaline (approximately 10 to 20 ppt). They are dominated by clonal perennial plant communities with Spartina alterniflora (smooth cordgrass), Juncus roemerianus (black needelrush), and Spartina patens (marsh hay cordgrass) the most common plants in the marsh. Additional plants species, Schoenoplectus americanus (Olney’s threesquare) and the invasive Phragmites australis (common reed) are also found in the high marsh at all sites. The MD-DNR has agreed to provide field elevation surveys of these sites using a combination of real time kinematic GPS and laser-based survey to provide coordinate and elevation values benchmarked to NAVD88 across our data collection locations. We will conduct field surveys, analyses, and comparisons to assess the hydrological and ecological conditions of each of the sites. We will be sampling hydrological, vegetation, soil, and mosquito variables. The hydrological components to be measured will be water table fluctuations, water quality (salinity, nitrogen, phosphorus, suspended sediments), porewater (salinity, sulfides), and surfacewater interactions. The data collected using this protocol will allow for the assessment of the health of ditched marshes and baseline data that will be used to predict ecosystem responses to restoration practices consisting of ditch plugging.

Water Table Analyses

Water table fluctuations will be monitored with screened wells equipped with data loggers recording every 15 minutes. A total of 68 wells will be installed in the study, with an estimated 14 wells at each of the two future plugged ditched sites, 11 wells at each control ditched sites, and 9 wells at the unditched reference sites. At each site, they will be installed along two main transects (50 meters and approximately 200 meters from the tidal creek or main inlet point), one well at the tidal creek or primary inlet point, and a small transect of two wells approximately 10 meters into the bordering forested uplands. These upland wells are targeted at locations that have shown high mosquito densities.
(Leisnham and Sandoval-Mohapatara 2011) and should represent the potential extent of the effects of marsh hydrologic alteration. Wells will be installed at a depth of 2.2 meters. At the ditched sites, transects will consist of five wells per the two main transects, running laterally from a dominant ditch with the first well located in the dominant ditch and additional wells on each side at the midpoint between ditches and in the adjacent ditches. By “dominant” we mean a ditch that is controlling the hydrology at a site as determined through field inspection of size, flow rate, and drainage area. Three wells for each of the two transects will be installed within the marsh platform at similar locations in the unditched reference sites. Data logging will be conducted throughout the project period of minimal of three years. Vertical and horizontal water table flow paths and interactions tidally, seasonally, and between restored ditch versus control ditch sites and unditched versus ditched marsh will be determined through well data logger data.

Water Quality Sampling

Water quality parameters will be sampled in the main tidal channel, ditches, and surfacewater (ponding) and will include salinity, dissolved oxygen, temperature, pH, suspended sediment, ammonium, nitrate, and phosphate. Two methods will be used for measuring salinity: salinity loggers and YSI handheld probes. Dissolved oxygen, salinity, temperature, and pH will be measured in the field using YSI handheld multiprobes. Water quality samples will be collected for nutrient and suspended sediment analyses. All data will be collected at each well location at least once per month for the three years, with an estimated 16 collection events per year. In addition to water table levels, soil water salinity is a critical factor controlling the distribution and abundance of plant species in marshes (Niering & Warren 1980). Salinity loggers will be deployed along each well at one well transect per site to generate a continuous record of lateral salinity, providing information on freshwater inputs (infiltration from precipitation, surface, and groundwater) and connectivity. These data will be extended throughout the study area using manual handheld multiprobe readings conducted at all well locations during eight of the site visits. We will sample vertically using permanently installed nested piezometers at intervals of 10 cm from 0-50 cm. Piezometers will be used because salinity is critical in the soil layer with the most active roots and rhizomes, which is typically within the upper 30 cm. The water table wells are integrating soil water from the surface to a greater depth (2-3 meters). Also, water collected within water table wells tends to stratify over-time, with denser high salinity water near the bottom of the well and fresher water near the surface of the well. We will also collect readings on water table, pH, temperature, and dissolved oxygen within these piezometers during these data collection events, allowing us to measure stratification of these variables. Porewater sulfides samples will be collected concurrently with salinity readings. We will insert a 5 mm-diameter Teflon well (sippers) into the soil to the specified depth and withdraw about 120 ml of water. The water collected will be placed in an antioxidant buffer of equal volume. A 5 mL subsample of each (buffer and sample) will be used. The sample container will be capped, recorded, and returned to the laboratory for analysis within 24 hours. A fresh bottle of antioxidant will be opened at each sampling site. Sulfide laboratory analysis consists of measuring the concentration using a sulfide-specific electrode calibrated by standards.

Hydrological Modeling

Application of two different models will be applied to the study sites and calibrated using field-collected data. First ArcGIS will be used to interpolate and create visualizations of conditions across the marsh. The two models to be used were specifically designed to stimulate wetland hydrology: the Physically-based, Integrated model for Hydro-Ecological Assessments of Ditch networks (PINHEAD) model (Gasca-Tucker and Acreman 2000) and the Drain Interaction with Channel Hydrology (DITCH) model (Armstrong 2000). PINHEAD was developed to stimulate water level fluctuations in ditch
systems. The model treats the ditches as a reservoir and simulates storage changes caused by rainfall, runoff, evaporation, and interaction with shallow water tables. DITCH was developed to investigate the influence of ditch water levels on the water table.

Vegetation Sampling

Vegetation monitoring will be conducted in August (late summer) pre-post plugging and at all three sites. Plant communities will be described at two spatial scales: site and plot. At the site scale, broad plant communities will be delineated based on aerial photos and ground observations. The boundaries between plant communities will be marked and then surveyed using survey-grade GPS and transferred to the base map prepared for each site. Large areas lacking vegetation (e.g., pools, mud flats) will also be delineated and mapped as part of the base maps. For the plot scale, marked sampling plots will be set up along the previously mentioned transects containing the water table wells. In addition a new transect will be constructed between the two low marsh transects where transition could be expected with ditch plugging restoration. Vegetation monitoring plots will be established at a subset of the 15-20 sampling plots set up along the three transects per site (3-5 plots per transect). At each vegetation monitoring location, non-destructive vegetation sampling will be conducted in a marked 10x10-m quadrat following the methods Peet et al. (1998). This method involves assigning one of 10 cover classes for each species in the 10x10 m quadrats and is well-suited to describing the patchy plant communities often found in coastal marshes (Sharpe and Baldwin 2009).

In addition to cover, peak aboveground plant biomass (an index of aboveground net primary production) will be harvested in two 1-m2 quadrats near each well, sorted by species, dried to a constant mass at 70°C, and weighed to 0.1 g. To assess plant vigor, the height of the three tallest plants of each species will be measured using 10-cm height classes in each 1-m2 biomass quadrat prior to harvest. Relative belowground production will be assessed using root ingrowth cores (one in each biomass quadrat). This will involve placing 5-cm diameter by 30-cm long cylinders of milled peat in mesh bags into cored holes in the marsh substrate at the beginning of the growing season and excavating them during the time of aboveground biomass harvest. Roots and rhizomes will be separated by rinsing exhumed cores on a 1-mm sieve, dried, and weighed.

Mosquito Sampling

Mosquito production will be evaluated by sampling mosquito larvae using the dip-count method and a standard 400-mL dipper. Sampling trips will be conducted 4 to 5 days after high tide events or major rainfall events from May-August, when marsh mosquito hatching is expected to have occurred and mosquitoes are most active. Three sampling procedures will be employed to monitor larvae: 1) random sampling at stations along transects used for marsh vegetation sampling, 2) random sampling at stations in ponds and ditches, and 3) targeted sampling of habitats producing dense larval populations. Random sampling: At each marsh vegetation sampling station and at 5 randomly chosen ditch and pond sampling stations, three dips will be taken. At marsh stations, the nearest standing water within a 3-m radius will be located and sampled. All larvae from each dip will be counted. Dipping within marshes often results in dips of varying volume. To standardize the larval counts as an index of density (number per dipper), the amount of water present in the dipper was estimated using a scale from 0 to 5 (0, empty; 1 one-fourth full; 2, half full, 3, three-fourths full; and 4, full). Density of larvae per dipper will then be calculated using the following volumes on a 0-5 scale: 0, 0 ml; 1, 100 ml; 2, 200 ml; 3, 300 ml; 4, 400 ml. If no water is present at station then the station was recorded as “dry.” Mosquito data will analyzed
using three different parameters: proportion of sampling stations that were wet (marsh stations only; a surrogate for potential mosquito production areas), proportion of sampling stations with mosquito larvae present (a proxy for potential mosquito production), and density of mosquito larvae (standardized by the amount of water in the dipper). Up to 10 randomly selected larvae from each sample station will be brought back to the laboratory for identification. Because salt marsh mosquitoes vary considerably in time and space, we do not expect to collect larvae on most sample occasions. Thus, following published procedures (James-Pirri et al. 2009), data for all dates within each year will be averaged for each sampling station. Targeted sampling: Up to 20 habitats in each future plugged site, control site, and reference site that were identified as high mosquito production locations will be repeatedly sampled. Three dips will be taken and up to 10 randomly selected larvae from each station will be brought back to the laboratory for identification.

Ditched site at EA Vaughan showing existing ditches, well locations, and one proposed plugging location (in addition to other ditches in area).

Ditched site at Deal Island showing existing ditches, well locations, and one proposed plugging location.
References


