## Friends of Herring River

# Effects of Diking and Tidal Restoration on Natural Chemical Cycling

Salt marshes and all wetlands amass large stores of plant nutrients like carbon, nitrogen and phosphorus. This is because wetlands produce organic matter so rapidly that oxygen is depleted in the sediment; this slows decomposition so that plant remains, and the nutrients they contain, accumulate. Globally, the storage of carbon in wetland peat helps to limit the buildup of carbon dioxide, and "greenhouse" heating, in the Earth's atmosphere. Salt marsh sediments are also rich in sulfur minerals, because the marsh's anaerobic (oxygen free) peat contains microbes that can use sulfate, abundant in seawater, in place of oxygen to break down organic matter.

The cycling of all of these elements is highly dependent on the degree of soil waterlogging and, thus, oxygen content. It follows that any major changes in wetland flooding will greatly affect their natural cycling. In Herring River marshes, 100 years of diking and drainage have had profound effects on the marsh's flooding frequency, generally lowering water levels and allowing oxygen-rich air to enter peat that would normally be saturated with water and devoid of oxygen.

This fundamental change in peat aeration causes both physical and chemical changes. Salt marsh peat is actually mostly composed of "empty" spaces, pores normally filled with water. When artificial drainage removes this water, the marsh surface sinks. Subsidence of the marsh surface leaves it more vulnerable to drowning in the face of ongoing sea-level rise. Peat aeration also accelerates decomposition, causing more marsh shrinkage and releasing the oxidized carbon ($CO_2$) into the atmosphere to add to global warming.

Drainage, peat aeration and organic matter loss can also compromise the marsh's ability to remove nitrogen, a potential pollutant of coastal waters leading to eutrophication, oxygen depletions and fish kills. Under water-saturated and thus anaerobic conditions, there are bacteria in the peat that use nitrate instead of oxygen to break down organic matter; the process converts potentially polluting nitrate to non-polluting nitrogen gas, which leaves the system. With tidal restriction and consequent peat drainage, soil conditions no longer favor this pathway of nitrogen removal.

Drainage produces other conditions that compromise the wetland's nitrogen-removal potential. Aeration causes the abundant sulfur minerals in peat to oxidize and form sulfuric acid, further harming the bacterial communities responsible for nitrogen removal. This acidification has had much more conspicuous effects in Herring River over the years, causing major fish kills and decimating a once diverse and abundant estuarine fauna.

Fortunately, basic chemical principles and Herring River-specific scientific experiments tell us that these disturbances to natural chemical cycling can be reversed by the restoration of tidal flow. The acidity problem should disappear just a few months after tidewaters again re-saturate the marsh peat. Recovery of the marsh's normal pH plus restored organic production and storage should re-invigorate nitrogen removal and help protect receiving waters from nitrogen pollution. Unfortunately, the net accumulation of organic matter and rebound of the marsh surface, however, will be a much slower process, probably taking decades to reach the height of the undiked salt marshes of Wellfleet Harbor.