9 Regional Examples of Tidal Restoration Projects

In recent years the efforts to restore degraded wetlands have been receiving increasing attention. In Massachusetts, for example, the CZM Wetlands Restoration Program has been working towards completing 100 coastal wetland restoration projects totaling nearly 600 acres; the significance of the Herring River project can readily be seen by understanding that the 1100 acres of potential salt marsh restoration is nearly twice the amount of all these other projects combined. Gaining an understanding of other coastal habitat restoration efforts with similar goals has been a critical component of restoration planning for the Herring River project. Lessons learned from the planning and implementation of these projects is invaluable, although each situation has unique features. Descriptions of tidal restoration projects being performed in the region are provided below.

9.1 Hatches Harbor, Provincetown

A 1-kilmeter-long dike constructed in 1930 for mosquito control essentially bisected the 400-acre floodplain completely blocking tidal exchange and reducing salinity in the landward half of the wetland. As a result, native salt marsh grasses were replaced by many species of salt-sensitive plants, including 20-25 acres of the somewhat salt-tolerant *Phragmites* by the 1990s; relict *Spartina* cover in the diked marsh amounted to only about 12 acres at lowest elevations nearest the tidal creeks. The Provincetown Airport was constructed within the flood plain in the 1940s, about 20 years before Park establishment, using the pre-existing dike as protection against tidal flooding.

The need for dike repair in 1986 prompted interagency discussions about the actual flood-protection needs of the airport and the possibility of tidal restoration. Principal concerns were for tidal flooding of the airport instrument landing system and increased nuisance mosquito production. Federal Aviation Administration engineers determined critical flooding elevations for airport structures, while NPS scientists and cooperators developed a numerical hydrodynamic model of the estuarine system (Roman et al. 1995). The model showed that a wide, low culvert cross-section (8.5 meters wide x 1 meter high) should provide sufficient seawater flooding to restore 60-90 acres of salt marsh and, at the same time, dampen storm tides that may otherwise affect the airport's instrument landing system. This culvert configuration and a general restoration plan were finally approved by a planning and regulatory team representing 10 local, state and federal agencies in 1997. Pre-restoration monitoring began in summer 1997, with the new culverts installed in the winter of 1998-1999.

Despite model predictions, the new culverts were not fully opened after construction. Opening has been done in small increments to build confidence among cooperators, especially airport officials, in the reliability of the model, and because of concerns for extensive plant death due to waterlogging should the marsh fail to drain during each low tide. Experience since 1999 has allayed most concerns.

With all culverts fully open since 2005, monitoring of the marsh has shown higher high tides and lower low tides, steadily increasing the mean tidal range. Monitoring is a multi-decade process, but increasing salinity has already lowered *Phragmites* biomass and allowed salt-marsh grasses and forbs to expand rapidly across the flood plain (Portnoy et al. 2003). At the same time, high-tide heights have been controlled to levels that do not affect airport operations, and monitoring by NPS and the Cape Cod Mosquito Control Project has shown no measurable increase in nuisance mosquitoes or change in their species composition (Portnoy et al. 2004).

9.2 East Harbor, Truro and Provincetown

Before diking in 1868 East Harbor (currently mapped as "Pilgrim Lake") comprised a 350-acre tidal lagoon and 400-acre salt marsh receiving semi-diurnal tidal exchange from Cape Cod Bay through a 300-m wide inlet. Presently, tidal exchange is limited through a 1.2-meter diameter culvert. Modern salinity has ranged 3-4 ppt in the harbor proper and < 2 ppt in surrounding wetlands. *Typha angustifolia* and *Phragmites australis* dominate the lowest-elevation wetlands probably first vegetated with *Spartina alterniflora*, whereas diverse wetland shrubs occupy slightly higher elevations replacing the original high marsh halophytes (e.g. *S. patens, Juncus gerardii*). The lagoon is shallow (< 2 m), highly eutrophic and therefore subject to chronic hypoxia and summertime fish kills.

Since December 2001, NPS and the Town of Truro have cabled open clapper valves in the only remaining connection between East Harbor and Cape Cod Bay, a 4-ft diameter culvert, to see if increased tidal exchange can dilute the organic load and improve aeration of East Harbor. Shortly thereafter, the NPS funded a detailed hydrodynamic assessment of tidal restoration alternatives.

Although eutrophication and summertime oxygen stress has continued, the lagoon has shown a dramatic recovery in salinity, from 4 to 20-25 parts per thousand (about two-thirds that of seawater), and estuarine biota, including extensive widgeon grass beds, finfish, crustaceans, bivalves and other benthic animals, and wintering waterfowl.

NPS-funded hydrodynamic modeling (Spaulding & Grilli 2005) has shown that substantial increases in tidal range and flushing, and open-water and salt-marsh habitat, can be accomplished by increasing the width of the surface-water connection between the East Harbor lagoon and Cape Cod Bay to the extent possible given current land use. More complete tidal restoration awaits funding for a US Army Corps of Engineers Comprehensive Feasibility Study; this work was begun in 2006, interrupted due to insufficient funding in 2007, but may be funded again in federal fiscal year 2008.

9.3 Bridge Creek, Barnstable

The restoration project of Bridge Creek in Barnstable restored the tidal flow of approximately 40 acres of coastal wetlands in Barnstable. The creek's tidal flow had been altered by two undersized culverts, one along Route 6A and another along the adjacent Old

Colony railroad line. These inadequate culverts cut off most of the tidal flows to the upstream marsh and degraded the upstream aquatic ecosystem over time. While deemed a priority site for restoration by the Army Corps of Engineers in 1996, the project was seen as impractical as it would disrupt railway services and be a very costly endeavor (Massachusetts Office of Coastal Zone Management 2007).

Fortunately for the Bridge Creek ecosystem, a four-month closure was scheduled for the railroad line in early 2003 to complete repair work on the Cape Cod Canal railroad bridge. This closure opened up a narrow window of time to complete the first phase of the project, which was replacing the culvert underneath the railway. This phase of the project was completed in April of 2003. The project then entered its second phase, which replaced the inadequate culvert under Route 6A. This was completed in May of 2005.

Overall, the project faced many obstacles and cost $1.267 million, but was made possible through collaboration with over 38 groups and 84 individual partners (Massachusetts Office of Coastal Zone Management 2007). It required work on private residential property and the alteration of a deed restriction for access and construction of the culverts. The project was well worth the efforts, however, as it renewed the creek's full tidal range for the first time in over 100 years. This has restored the hydrology and water chemistry in the marsh, which is now recovering and fish and wildlife are returning to the area (Massachusetts Office of Coastal Zone Management 2007).

9.4 Damde Meddowes, Hingham

Damde Meddowes is located at The Trustees of Reservations World's End property in Hingham and originally was a 14-acre saltmarsh that extended east-west from Hingham Harbor to the Weir River. However, in the 1600s, settlers constructed two dams in the marsh, one near the harbor's cove and another near Weir River. In the 1880s, a second dike was constructed near the harbor end to improve access to the World's End Reservation (National Estuaries Restoration Inventory 2006). These dikes, which acted as carriage crossings as well as barriers to the marsh, had undersized culverts and even when tidegates were installed, fresh water could drain from the wetlands, but tides were prohibited from entering (National Estuaries Restoration Inventory 2006). This situation has converted the marsh into stagnant, brackish water inhabited with invasive species (Gulf of Maine Council on the Marine Environment 2005). To restore the marsh, both culverts were replaced in 2003 with four foot by eight foot concrete box culverts. The site did not initially respond as predicted by modeling output and design objectives. While high tides reach further upgradient, the impoundment was not draining adequately at low tide. Saltmarsh vegetation is also not recolonizing inter-tidal zones as quickly as expected. Intervention has been taken to establish more efficient drainage channels, but the results remain inconclusive to date.

9.5 Sagamore Marsh, Sandwich and Bourne

Before the Cape Cod Canal was deepened and widened in the mid 1930s, the Scusset River

flowed freely into Cape Cod Bay and provided tidal flushing to Sagamore Marsh (Coastal America 2006). When the Canal was reconstructed, however, a 48-inch diameter culvert was installed and provided the only pathway for run-off from the marsh to reach the bay (US Army Corps of Engineers 2007). This culvert was inadequate to allow tidal flow to and from the marsh. Consequently, the marsh became degraded and dominated by *Phragmites*. Without intervention, the marsh would continue to degrade, become a fire hazard, and be ideal for mosquitoes to breed (Coastal America 2006).

Due to the poor ecological value of the marsh, the Army Corps of Engineers undertook restoration of the marsh under its Ecosystem Restoration Program. In a $2 million project, where the federal government paid 75%, the Army Corps replaced the undersized culvert with two six feet wide and six feet high box culverts (US Army Corps of Engineers 2007). They also installed an electric-sluice gate to regulate water levels. The project was scaled back from restoring a proposed 175 acres to restoring 50 acres in order to protect low-laying cottages along Scusset Beach. The highest tides were also limited to four feet due to the state-listed rare wildlife species *Hemidactylium scutatum*, four toed salamander.