FY23 Coastal Resilience Grant Case Study

Municipality/Organization: Town of Plymouth
Project Title: Plymouth Long Beach Mixed-Sediment Nourishment – Construction
Grant Award: $2,000,000
Match: $1,052,744

Community/organization overview:
The Town of Plymouth is a coastal community located on the South Shore of Massachusetts. As "America's Hometown", Plymouth has an abundance of historic and cultural resources, concentrated in the downtown waterfront area, which serves as the Town's economic center. Much of Plymouth's vibrant – and economically critical – tourism industry is centered in and around Plymouth Harbor, making it highly vulnerable to climate change. The Harbor is central to the region's recreational and commercial boating economies, encompassing whale watching, fishing charters, and a fishing fleet with among the highest lobster landings in the state. Long Beach, an approximately 2.8-mile-long barrier beach, provides storm protection for all of these harbor-related industries and amenities, including approximately 700 moorings for recreational boats, a commercial marina, community yacht club, Town Pier, State Pier, and State Boat Ramp. Historic resources such as Plymouth Rock and the Mayflower II are also located within the harbor area. The adjacent coastline, approximately 4.5 mile long, consists of both residential and commercial development.

In addition to the storm protection benefits it provides, Long Beach is a popular recreational area and an important breeding and migratory staging area for several species of coastal waterbirds protected by state and/or federal law. Although approximately 90% of the beach is owned by the Town, there are 20 privately owned properties, including 16 residential dwellings. A gravel access road runs approximately two miles along the length of the beach and serves as the only access point to the mainland.

Long Beach has a long history of shoreline management dating back to the early 1800's. The most significant effort is a stone dike running the length of the beach that was built by the Army Corps of Engineers in the early 1900's. In the 1970's, the Army Corps rebuilt the southernmost 5,000 feet of the stone dike, adding scour and splash aprons. The northernmost part of the beach is protected from the east and northeast by an offshore bank ("Brown's Bank") and by Duxbury Beach, Gurnet, and Saquish, leaving the stone dike in this area covered by an extensive dune system over most of its length. The project area is an approximately 2,000ft long portion of the beach, located between the naturally and artificially protected sections, where the stone dike has deteriorated, and offshore storm protection is limited.

Description of climate impact(s):
Most of the protected northern portions of the beach are stable or even accreting. Other areas, including the project area, do not have this protection, and therefore receive the full force of coastal storms. Severe storms, particularly over the last decade, have caused an increasing level of erosion on

the southern part of Long Beach. Impacts from coastal storms have included failure of portions of the Plymouth Beach seawall; scouring the front of the stone dike that runs the length of the beach; significant erosion of overwash areas adjacent to the stone dike; and significant erosion resulting in lowering of beach elevation and shoreline retreat where the stone dike has deteriorated.

The shoreline change rate for the project area between 1951 and 2001 was a loss of 2 feet of shoreline per year[1]. More recently, the project area was impacted by the 2013 and 2015 blizzards, but the area experienced the most significant erosion during the March 2018 series of nor'easters. During these storms, the elevation of the project area was lowered 8-10 feet in some areas, and the gravel access road, known as Ryder Way, washed out completely in the southern portion of the project area. Even at mean high tides, the road was flooded with water for several hours before and after high tide. In addition, two private homes in the area sustained damage, exposing the associated septic systems. The road was repaired with beach-compatible mixed sediment material, however, it continued to need minor repairs throughout the year during spring high tides and minor storm events, and more significant repairs annually following the winter storm season so that vehicles could safely pass through the area.

Piping plover and least tern nesting habitat is located within and adjacent to the project area. In recent years, as many as 4 pairs of piping plovers per season have nested in or near the project area and a small colony of least terns uses this area each season. Erosion significantly narrowed and lowered the available nesting habitat making it more vulnerable to flooding and nest loss.

Continued erosion in the project area would result in degradation of natural resources including piping plover and least tern nesting habitat, vegetated and dune areas and saltmarsh along the harborside; repetitive and costly road maintenance and repairs needed to maintain safe vehicle access; and compromise the barrier beach's ability to provide storm damage protection and flood control for the harbor and downtown waterfront areas.

The erosion and storm damage occurring is even more concerning in light of climate change and sea level rise. Sea level rise and increased erosion rates will lead to increased susceptibility of barrier beaches to erosion, overwash and breaching, putting the developed shorelines behind the barrier beaches at risk. Barrier beaches are particularly vulnerable because they are generally low-lying areas within a few feet of current sea levels.

Even the most conservative sea level rise projections will result in increased coastal erosion and storm damage. The documented trend of more frequent and higher intensity storm events will compound the problems of sea level rise in the future. Maintaining Long Beach as a functioning barrier beach that can continue to provide flood control and storm surge protection is important to long term protection of the harbor and adjacent coastline.

[1]Massachusetts Office of Coastal Zone Management - South Shore Coastal Hazards Characterization Atlas. https://www.mass.gov/service-details/south-shore-coastal-hazards-characterization-atlas

Climate change projection(s):
For the nourishment design for Long Beach, a specific sea level rise scenario was not utilized but was examined and accounted for as the littoral response at varying still water elevations and wave conditions was analyzed. Mixed sediment beaches, or in this case nourishment, naturally offer a flexible landform that can continuously adapt and adjust to changes in sea level and wave climate. Therefore, the nourishment will naturally adapt to low and intermediate sea level rise projections. If at some point in the future, a rapid intensification of sea level rise occurs, the nourishment can be quickly adapted to the changing conditions by adding additional sediment to increase the elevation of the nourishment crest to allow for natural response to higher water levels and increases in wave energy at higher elevations along the barrier beach.

Project goals:
The goal of the project was to increase the resilience of Long Beach with a nature-based solution, specifically, to construct the designed and permitted mixed-sediment dune nourishment project and increase the resiliency of an area vulnerable to coastal storm damage and sea-level rise, enhance barrier beach function, including providing storm damage protection and flood control, and protect the infrastructure on Long Beach.

Approach and result:
The Town used a nature-based approach to increase the resilience and function of an area of Long Beach that is vulnerable to coastal storms and sea-level rise. This project used a similar concept as a mixed-sediment nourishment project completed at Long Beach in 2016. That project, also funded through a Massachusetts Office of Coastal Zone Management grant program, nourished eroded overwash areas that had been scoured out by storm-driven waves overtopping the stone dike. The 2016 mixed-sediment nourishment project performed well, particularly in areas where a sufficient volume of nourishment material was added to bring the area up to a 12ft elevation. The successes of that project provided the conceptual starting point for this project.

The design and permitting phase, which was funded through the FY21 CZM Coastal Resilience Grant Program, began by surveying existing conditions as well as conducting a shellfish survey and sediment sampling. The project team met with reviewers from different permitting agencies several times during the analysis and project design phase to identify specific design elements required in the presence of endangered species, wetland habitats and other resources. The engineers analyzed the existing sediment for compatibility of mixed sediment nourishment material including sand, gravel and cobble. Coastal modeling was performed to identify a nourishment design that would have some longevity and would accomplish the goals of enhancing resiliency and protecting infrastructure. The modeling performed looked at several different scenarios, including varying elevations with dune only or dune and beach nourishment. Through the alternatives analysis, dune nourishment at a 12-foot elevation was identified as the alternative that would have the greatest longevity and would accomplish the project goals.

Prior to preparing permit applications, the project team met with the permitting agencies to receive feedback on project design, permitting process and to identify additional information required with application submittals. After permit applications were submitted, the team continued to reach out during the permitting process and provided additional information as needed to facilitate project review.

During construction phase of the project, which was funded through the FY23 Coastal Resilience Grant Program, sand, gravel and cobble were delivered to a staging area in the parking lot at the beach entrance, where it was mixed to the meet the grain size gradation required for the project. The mixed nourishment material was sampled and analyzed for grain size distribution prior to placement of material and periodically throughout the construction phase. The material was hauled out approximately 1 mile along the gravel access road to the project area using articulated dump trucks appropriate for off-road use. Material was spread and graded with a bulldozer to meet the designed slopes. In total, approximately 35,030 cubic yards of mixed nourishment material was placed over the approximately 2,000 linear foot long project area. American beachgrass (*Ammophila breviligulata*) was planted at 36" on center in an approximately 16,800 square foot area to stabilize the newly created dune crest as well as in areas where existing beachgrass was impacted withing the nourishment footprint. Northern bayberry (*Morella pensylvanica*) and beach plum (*Prunus maritima*) were planted to replace existing woody shrubs impacted by the project.

A survey was conducted following the completion of the nourishment project and an as-built plan was produced that includes the nourishment footprint and slopes over several transects.

More information about this project and others completed at Plymouth Long Beach is available on the Town of Plymouth website at https://www.plymouth-ma.gov/496/Plymouth-Long-Beach-Projects.

Permits:
Permits required to construct the project included an Order of Conditions, Massachusetts Environmental Policy Act review, Massachusetts Endangered Species Act review, Chapter 91 Waterways Permit, and US Army Corps of Engineers Section 404 and Section 408 approvals.

Lessons learned:
The Town reached out to the owners of the private properties adjacent to the project area as well as the homeowners' association during the design and permitting process to build project support. Communication during the construction phase allowed concerns to be addressed and issued rectified quickly.

To avoid project delays, plan for additional time during the permitting process to ensure any issues can be resolved. Pre-application meetings with regulatory agencies and communication throughout the permitting process allowed the project to proceed more smoothly.

Sampling the mixed-sediment nourishment material for grain size analysis prior to and periodically throughout the project ensured the nourishment material was consistent and met the permitted specifications.

Piping plovers and least terns will nest in the mixed-sediment nourishment material. Two pairs of piping plovers and a small sub-colony of least terns used the newly expanded habitat area in the first season following nourishment. The plovers preferentially nested in the nourishment material rather than native sediment in adjacent areas. Nests in the project area suffered significantly less overwash and flooding during spring tides and storms than other areas of the beach.

Partners and other support:
The Massachusetts Office of Coastal Zone Management provided grant funding and technical assistance for the project.

Foth Infrastructure and Environment, LLC provided construction oversight and Dig It Construction, LLC constructed the nourishment project.

A portion of the nourishment footprint was located on two adjacent private properties. The private property owners gave permission for the project to occur on their property and participated in the permitting process, provided feedback and supported the project.

Feedback and letters of support were provided by the Plymouth Long Beach Homeowners' Association, an association of private property owners and lessees on Long Beach; the Natural Resources and Coastal Beaches Committee, an appointed Town committee that represents residents' interests in managing the Town's natural resources; the Plymouth Harbor Committee, an appointed Town committee that reviews and makes recommendations on issues relating to the waterfront and Plymouth Harbor; and the Plymouth Area Chamber of Commerce.

Next steps:
Next steps include initiating a monitoring plan to measure and document changes in the shoreline and nourishment position. Monitoring of the nourishment material will be completed annually, following nourishment. The elevation will be measured along a series of cross-section transects along the length of the project area, as well as outside the project area to monitor adjacent shorelines. The change in dune position and elevation will be recorded and plotted to identify changes in the fill volume and determine if there is a net loss of material. Monitoring reports will be prepared after completion of this project and then continued with each re-nourishment cycle (if applicable), so that the performance of the nourishment can be evaluated, relative to design predictions and re-nourishment triggers.

The monitoring data will provide a comprehensive assessment of the nourishment performance and allow for the use of objective parameters to gauge beach conditions and trigger future nourishment cycles. Once the volume of the nourishment area is reduced to 30% of the initial volume, the Town will reexamine potential measures to maintain the coastal resiliency and protection of Long Beach.