Project Name: Beach Stabilization and Dune Restoration in Progreso, Yucatan, Mexico

Project Location: Municipality of Progreso, Yucatan, Mexico

Award Category: Mitigation or Adaptation to Climate Change

Team Members:

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Demonstration project site to enhance the stabilization of a renourished beach using eco-friendly solutions. Windblown sand was used to build small dunes behind the sand fences. The footprint of trenches that were dug for the first application of the PPB technology are visible in the lower part of the beach (berm).

Summary

Project Description: The sandy beaches of Progreso (Yucatan, Mexico) have been experiencing severe erosion and shoreline retreat for decades. As a result, local governments have developed various beach renourishment projects for erosion control. The last renourishment project occurred in March 2015. It had limited success following severe storm-related erosion events. Consequently, a governmental agency (Secretariat of Urban Development and the Environment, SEDUMA) promoted a number of pilot projects to evaluate sustainable alternatives for beach erosion control and shoreline stabilization. From June 2016 to January 2017, an innovative pilot project was implemented in an 85 m-long beach section of Progreso (Section T100-T400 in Figure 1) and monitored until June 2017. The project consisted of the application of a novel Protein Polysaccharide Biopolymer (PPB) technology (SandFirst) to stabilize the beach through sand cohesion enhancement, and the restoration of a dune. SandFirst is a non-toxic PPB that enhances sand cohesion without changing the sand color or texture. The dune restoration aspect of the project consisted of placing 100 m^3 of windblown sand that was reclaimed to form a small dune. The dune was subsequently vegetated with two native plant species: *Sesuvium portulacastrum* and *Sporobolus virginicus*. In addition, dune stabilization was reinforced by applying a solution of SandFirst PPB and constructing a wooden sand fence (Figure 2). The SandFirst biopolymer applications on the beach were conducted using low concentration solutions applied weekly or biweekly using two methods (Figure 3):

1) Application in ditches: ditches approximately 40 cm wide and 50 cm deep were excavated at low tide along the beach on a strip that was two meters wide from the high tide line seaward. Subsequently, the SandFirst biopolymer solution was placed in the trench and the trench was filled with the excavated sand.
2) Irrigation: a SandFirst solution was applied throughout the length of the dry beach using a sprayer system designed for this application. This method was used to ensure that all the sand in the dry beach and intertidal area was treated.

Goal: The main goal of the project was to stabilize the renourished beach using innovative and sustainable alternatives; i.e. a *"working with nature"* approach.

Objectives: To assess the performance of the SandFirst biopolymer treatment and dune restoration in controlling beach erosion. To this end, beach profiles were measured for 12 months in the SandFirst-treated beach section and compared with control beach profiles east and west of the treated beach. Success metrics included the evolution of the shoreline and sediment volume variations in the berm and foreshore. Other metrics included changes in dune vegetation cover and variations in dune toe elevation.

Accomplishments: The application of SandFirst to the dune stabilized the dune until the establishment of vegetation. After five months, vegetation cover was established on approximately 70% of the dune area (Figure 4) and the sand fences increased the elevation of the dune toe by 12 cm. The SandFirst biopolymer treatment also stabilized the beach. Beach width increased in the SF-treated section (Figure 5). On the other hand, the control sections displayed continued erosion. Moreover, the sand erosion/accretion rate in the treated section was +0.06 m^3/m, whereas in the non-treated section the rate was -4.04 m^3/m, which is consistent with reported erosion data in neighboring coastal areas. Our findings suggest that the PPB treatment may be a suitable method for increasing beach resilience and may be used to complement beach renourishment projects. Other potential positive attributes of the PPB technology include sand dune restoration and a decrease in aeolian sediment transport.

Figure 1. Location of the study area. T100-T400 represent the profiles measured in the Treatment zone and profiles O100-O200 and E100-E200 correspond to the West and East Control zones, respectively.

Figure 2. Dune restoration using reclaimed windblown sand, native plant species placement, sand fence installation and application of the PPB SandFirst technology for dune stabilization.

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Dr. Dahmani is a current WEDA member and the lead for the PPB technology. Mr. Pinzón is the project manager. Dr. Ocaña is the technical lead. Mr. Ceballos and Ms. Pinzón are the field leads. Mr. Mariño is the scientific advisor. MARCOST de México SA de CV is the project owner and nominating entity.

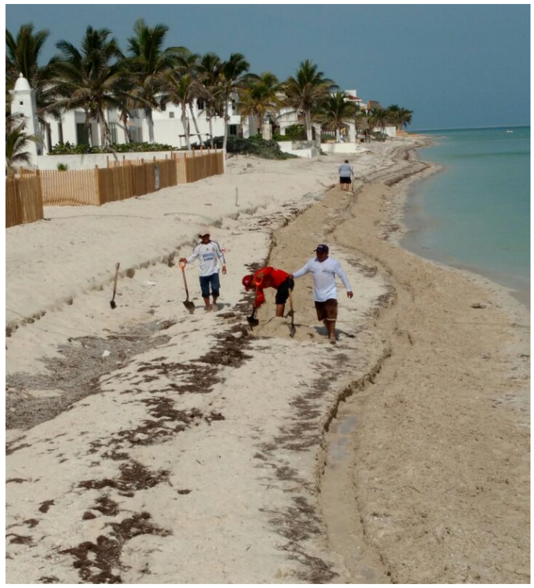

Figure 3. Applying the PPB technology in ditches excavated in the lower part of the beach (berm).

Figure 4. Evolution of the vegetation cover: Planting (left), two months later (middle), and five months later (right).

Figure 5. The beach site before project initiation (left) and a year later, after completion of the project (right).

Exemplifying the WODA Statement on Climate Change: The "Beach Stabilization and Dune Restoration in Progreso, Yucatan, Mexico" project exemplifies and implements the three commitments of the WODA Statement on Mitigating and Adapting to Climate Change in various ways. The project increases energy efficiency by optimizing renourishment projects. Since 2002 in the coast of Yucatan, nourishment projects occurred every two to three years because of excessive sand losses. The use of soft technologies such as the PPB technology and dune restoration optimizes sand renourishment projects by increasing sand retention. Although carbon sequestration could not be quantified in this project, the project created a carbon sink through the restoration of the beach dune by reclaiming windblown sand and planting native species. The project enhanced beach resilience by increasing sand cohesion using the PPB technology. This was demonstrated by the increase in beach width and the positive net sediment balance (+0.06 m^3/m) as compared to the untreated control beach sections where the shoreline receded and the sediment budget was significantly negative (-4.04 m^3/m). Moreover, the restored dune prevented an inundation during an extreme storm event that occurred on May 4th, 2017 (cold front storm number 45) (Figure 6).

Figure 6. A severe storm affected the Yucatan coast on May 4th, 2017. The dune demonstrated its importance by preventing an inundation of the premises.

Environmental Benefits: This project enhanced beach resilience, thus reducing the risk of erosion. In addition, restoration of the dune created new habitat (275 m^2) that acted as a carbon sink and provided protection to some invertebrate species. Unfortunately, carbon sequestration could not be quantified as there is no existing methodology on carbon sequestration in coastal dunes in the literature. The PPB treatment and sand dune and fence design/location did not impede the nesting of sea turtles as three successful nestings and hatchings were observed on the beach during the project. Environmental benefits were also gained by increasing the longevity of the renourishment project.

Innovation: The PPB treatment is an innovative technology that can enhance renourished beach sand retention and minimize beach erosion. It can improve the effectiveness and eco-friendliness of other soft beach erosion mitigation technologies such as beach renourishment. In addition, this technology may be used to reduce the sediment plume that is frequently associated with beach renourishment projects, thus reducing the risk of negative impacts on important nearshore habitats such as seagrass beds and coral reefs.

Economic Benefits: Data provided by SEDUMA indicates that renourishment projects have an average cost of 450,000 USD per kilometer of beach, and these projects are implemented on average every five years. Thus, significant savings may be achieved by using the PPB treatment and extending the life of a beach renourishment project.

Transferability: The PPB technology and dune restoration method can be used in any sandy shoreline that requires stabilization or beach renourishment.

Outreach and Education: During project implementation, project activities and procedures were presented to the Colegio Santa Teresa de Jesús, owners of the property located behind the treated beach. Local meetings were also conducted to inform and educate beach front property owners and beach users about this eco-friendly beach stabilization and dune restoration approach. Project results were presented during the Symposium ECO´17 held in Playa del Carmen (Quintana Roo, Mexico) in November 2017, and recently (March 6th, 2018) to the Beach Management Committee of the State of Yucatan (Figure 7). A detailed manuscript of the project has been submitted for publication in the Dredging Summit & Expo '18 Proceedings of WEDA along with a manuscript on the PPB technology development work conducted by Dr. Dahmani at SAMARCEL and the University of Connecticut in the USA.

Figure 7. Dr. Frank A. Ocaña, technical lead of the project, presenting results to the Beach Management Committee from the State of Yucatan.