**Padre Island Water Resources**

*Monitoring Historic Shoreline Change and Suspended Sediment Patterns Along Padre Island National Seashore*

**Project Team**

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**Project Overview**

***Project Synopsis:***

For decades, the Padre Island National Seashore has faced shoreline erosion, which has been combated with occasional dredging projects. The long-term efficacy of these projects was evaluated to inform the National Park Service's decisions in their upcoming beach management plan. The team generated a time series of shoreline changes using high resolution imagery from 2010–2021 in conjunction with coastal topography datasets to evaluate sediment volume changes over the past decade. Finally, the team analyzed and mapped the nearshore suspended sediment profile to provide insight on sediment distribution following beneficial use placements.

***Abstract:***

Land loss along Padre Island National Seashore threatens the safety of the recreational beach for the general public and endangers wildlife habitats and nesting sites. Historically, the Army Corps of Engineers has conducted dredging efforts to thwart erosion. Quantifying spatial and temporal variations of shoreline change is vital to understanding the interaction of land loss and historical dredging efforts. NASA DEVELOP collaborated with the National Park Service to use remote sensing to investigate the impact of dredging on Padre Island National Seashore’s shoreline. The team utilized high-resolution imagery from Maxar and Planet to create a time series of shoreline changes between 2011 and 2020, conduct shoreline extraction, and quantify shoreline changes. Additionally, the team monitored turbidity and sediment dynamics using Landsat 8 Operational Land Imager (OLI), Landsat 4 Thematic Mapper (TM), Landsat 5 TM, and Sentinel-2 MultiSpectral Instrument (MSI). Shoreline change results demonstrated an average change between 4.5 to 32 meters annually. Meanwhile, the dredging area directly north of the seashore’s Port Mansfield Channel experienced an areal gain of 152,000 m² between 2010 and 2021. The team also observed that turbidity values increased in areas close to the channel where dredging occurred, especially in the 2018 and 2021 dredging years. Dredging years corresponded with less shoreline change than years without dredging. These results will be used to better inform future partner-designed shoreline management projects in the face of continued erosion and sea level rise.

***Key Terms:*** remote sensing, coastal erosion, turbidity, barrier island, Landsat, Maxar, Planet

***National Application Area Addressed:*** Water Resources

***Study Location:*** Padre Island National Seashore, TX

***Study Period:*** 2005, January 2010 to January 2022

***Community Concerns:***

* Erosion of Padre Island National Seashore narrows the width of the beach and causes pinch points and flooding; this is a safety threat to visitors of the recreational beach.
* The biodiversity of local wildlife, specifically sea turtles, are threatened by the loss of habitat and nesting domain.
* Storms, such as Hurricane Hanna of 2020, increase erosion of the beach on Padre Island and further implicate a need for dredging efforts.

***Project Objectives:***

* Produce a series of high-resolution maps to compare shoreline change throughout time
* Understand the effects of dredging on shoreline change along Padre Island National Seashore
* Provide partner organizations insight into dredging frequency and potential future locations

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service, Padre Island National Seashore** | Shelley Todd, Chief of Resource Management; Kelly Nesvacil, Science and Resources Management; Dr. Donna Shaver, Chief of Division of Sea Turtle Science and Recovery. | End User | No |
| **National Park Service, Natural Resources Division** | Don Weeks, Physical Resources Program Manager | End User | No |

***Decision-Making Practices & Policies:***

Padre Island National Seashore has been experiencing shoreline erosion problems dating back to 1962 as a result of the construction of multiple jetties. The National Park Service and Padre Island National Seashore are federally obligated to protect and preserve this land, and beach management includes monitoring by the National Park Service and occasional dredging provided by the Army Corp of Engineers. Historically, beach nourishment events have been aimed at slowing erosion by transporting large amounts of sediment to areas which have the highest erosion rates. However, the local erosion problem still has not been successfully contained. As a result of the temporal and financial limitations of in-person sediment tracing, partners are not able to precisely confirm the areas that are experiencing the most severe erosion and take actions accordingly.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | The team utilized this data to generate turbidity maps and extract turbidity values at points along the beach. |
| **Landsat 5 TM** | Surface reflectance | The team utilized this data to generate turbidity maps and extract turbidity values at points along the beach. |
| **Sentinel-2 MSI** | Surface reflectance | The team utilized this data to generate turbidity maps and extract turbidity values at points along the beach. |
| **WorldView-2** | Surface reflectance | The team utilized this data to generate annual shoreline shapefiles for the shoreline change analysis. |
| **GeoEye** | Surface reflectance | The team utilized this data to generate annual shoreline shapefiles for the shoreline change analysis. |
| **PlanetScope** | Surface reflectance | The team utilized this data to generate annual shoreline shapefiles for the shoreline change analysis. |

***Ancillary Datasets:***

* United States Department of Agriculture National Agriculture Imagery Program (NAIP) Imagery – Aerial imagery utilized for georectification of the high-resolution data.
* United States Army Corps of Engineers National Coastal Mapping Program (USACE NCMP) Topobathy Lidar – USACE NCMP topobathy Lidar data used to understand sediment volume changes over time. [2016 USACE NCMP topobathy Lidar DEM: Gulf Coast (AL, FL, MS, TX)]
* United States Geologic Survey American Recovery and Reinvestment Act (USGS ARRA) Lidar – USGS Lidar data used to understand sediment volume changes over time. [2011 ARRA Lidar: Willacy County (TX)]

***Software & Scripting:***

* Esri ArcGIS Pro 2.8.3 – Data visualization and geospatial analysis
* Esri ArcGIS Online – StoryMap creation
* Python 3.10.1 – Data analysis
* Atmospheric Correction for OLI Lite (ACOLITE) 20210114.0- Atmospherically correct and process Landsat 5 TM, Landsat 8 OLI, and Sentinel-2 MSI imagery for turbidity
* SeaWiFs Data Analysis System (SeaDAS) 7.5.3 – Turbidity data visualization
* R 4.1.2 – Turbidity time series analysis and graphing
* RStudio 1.4.1717 – Turbidity time series analysis and graphing
* QGIS 3.10.8 – Data visualization and geospatial analysis
* ENVI 5.5.2 – Data visualization and geospatial analysis
* Orfeo Toolbox 7.0.0 – Random Forest classification

***End Product(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **High Resolution Shoreline Change Time Series** | WorldView-2  GeoEye  PlanetScope | Shoreline change quantification will help partners understand which areas of the island require more dredging. | N/A |
| **Sediment Turbidity Graphs** | Landsat 8 OLI  Landsat 5 TM  Sentinel-2 MSI | Padre Island National Seashore currently does not have any *in situ* turbidity measurement instruments. Turbidity derived from satellite imagery will give information on the interaction between the water column near shore and shoreline change. | N/A |
| **ArcGIS Online Story Map** | Maxar  Planet  Landsat 8 OLI  Landsat 5 TM  Sentinel-2 MSI | The Padre Island National Seashore is interested in scientific communication and increasing public awareness for the state of the seashore. The story map will help them to communicate changes in the shoreline and nearshore environment to the general public in a user-friendly and accessible manner online. | N/A |

***Product Benefit to End User:***

The development of a shoreline change time series utilizing Earth observations will aid the National Park Service in their endeavors to protect the shoreline from continued erosion. This evaluation will assist the National Park Service in ascertaining the frequency and location of beneficial use material, material from dredging, and determine placement practices for the near future. The suspended sediment time series product will provide partners insight into the effectiveness of their more recent dredging and beneficial use material placement events from the past decade. The National Park Service will use the end products generated in their evaluation of potential beneficial use placements soon, which will shape the local ecology and shoreline of the region.

**References**

Dogliotti, A. I., Ruddick, K. G., Nechad, B., Doxaran, D., & Knaeps, E. (2015). A single algorithm to retrieve turbidity from remotely-sensed data in all coastal and estuarine waters. *Remote Sensing of Environment*, *156*, 157–168. <https://doi.org/10.1016/j.rse.2014.09.020>

Psuty, N. P. (2010). *Coastal geomorphology of the ocean shoreline, Gateway National Recreation Area: natural evolution*  *and cultural modifications, a synthesis*. US Department of the Interior, National Park Service, Natural Resource Program Center. https://irma.nps.gov/DataStore/DownloadFile/151118