**Cape Hatteras Ecological Conservation**

*Delineating Shoreline and Mapping Change along the Cape Hatteras National Seashore for Coastline Management and Transportation Corridor Adaptation Strategies*

**Project Team**

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**Project Overview**

***Project Synopsis:***

This project partnered with the National Park Service at Cape Hatteras National Seashore in North Carolina to explore the use of optical data to delineate shorelines and map coastline change over the past ~10 years. Using Earth observing data from multiple NASA sources, this project supports decision-making relating to prioritization of investments in mitigation and strategic planning for transportation corridor adaptations including potential relocation of infrastructure and placement of beach nourishment efforts.

***Abstract:***

The National Park Service at Cape Hatteras National Seashore works to protect North Carolina’s Outer Banks where frequent storms bring heavy winds and flooding, leading to overwash events on the main highway, North Carolina Highway 12. Shorelines are susceptible to erosion directly affecting transportation and housing infrastructures. Storm events can disrupt transportation on NC-12 and ferry service from Ocracoke Island to Hatteras Island, leaving inhabitants stranded on Ocracoke Island for indefinite amounts of time. The National Park Service’s current decision-making practices involve mitigating infrastructure damage by enlisting the help of North Carolina’s Department of Transportation and finding ways to relocate this infrastructure, as well as dredging and sediment placement that support beach nourishment efforts. Our NASA DEVELOP team partnered with the National Park Service to explore the use of electro-optical data to delineate shoreline and map coastline change from 2014 to 2024. We used Earth observations collected by Landsat 8 Operational Land Imager, Landsat 9 Operational Land Imager-2, and Sentinel-2 MultiSpectral instrument to support decision-making related to prioritizing strategic planning for transportation corridor adaptations including potential relocation of infrastructure, and beach nourishment efforts. We derived coastline maps by consolidating single date images from each year to derive seasonal composite images for assessing winter and summer coastline seasonal oscillation patterns. The results highlight shoreline loss over the ~10-year study period, and the difference in shoreline inundation in the winter and summer seasons. These observations create a better understanding of storm damage mitigation efforts and help the National Park Service to plan for infrastructure updates.

***Key Terms:*** remote sensing, Landsat, Sentinel, barrier island, NC-12, Hurricane Dorian

***Application Area:*** Ecological Conservation

***Study Location:*** Cape Hatteras National Seashore, NC

***Study Period:*** April 2014 to February 2024

***Community Concerns:***

* Frequent storms that erode the susceptible oceanfront and damage transportation infrastructure due to flooding and shoreline loss have created a constant state of recovery.
* Methods to minimize damage to existing transportation infrastructure and to construct new infrastructure are constantly being implemented and reevaluated. However, road closures due to overwash are common, which poses a threat to residents and visitors alike.
* NC-12, which connects the barrier islands, runs through areas that are extremely vulnerable to erosion.
* The extent of this shoreline loss has not been extensively quantified seasonally or in relation to specific storm events.

***Project Objectives:***

* Develop an efficient method for analyzing shoreline change within the study area
* Identify the regions and infrastructure vulnerable to coastal erosion
* Aid the National Park Service shoreline conservation efforts through the creation of shoreline change and infrastructure maps

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **National Park Service, Cape Hatteras National Seashore** | Michael Flynn, Physical Scientist | End User | Federal Government |

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

Past research by the National Park Service focused on coastal resilience, vulnerability, and management using the Digital Shoreline Analysis System, developed by the United States Geological Survey. The National Park Service primarily used aerial and field survey data, supplemented by limited high-resolution satellite imagery in this research to calculate shoreline change rates. The National Park Service used these data sources to support transportation infrastructure management recommendations and communication with the Department of Transportation. However, these methods of data collection have limitations. The National Park Service currently only records data during the spring and autumn, despite the annual sea level extremities occurring during the summer and winter.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | Moderate-resolution maps (30m) showing historic shoreline change were used to better understand shoreline dynamics. These data were combined with Landsat 9 OLI-2 to increase the temporal coverage for the study area. |
| **Landsat 9 OLI-2** | Surface reflectance | Moderate-resolution maps (30m) showing historic shoreline change were used to better understand shoreline dynamics. These data were combined with Landsat 8 OLI to increase the temporal coverage for the study area. |
| **Sentinel-2 MSI** | Surface reflectance | Sentinel-2 MSI data was used for a higher resolution comparison to Landsat results. |

***Software & Coding Languages:***

* Esri ArcGIS Pro 3.2.1 – Data processing & manipulation, water classifications, change analyses, map making
* Google Earth Engine – Data processing & manipulation, water indices, annual coastline averages

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** |
| **Shoreline Change Time Series Maps** | Landsat 9 OLI-2  Landsat 8 OLI  Sentinel-2 MSI | The shoreline change time series maps will inform decision making related to shoreline loss and transportation infrastructure. |
| **Hurricane Dorian Case Study** | Landsat 8 OLI  Sentinel-2 MSI | The National Park Service can use the case study to understand the impact of major storm events on the shoreline. |

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

With the Outer Banks’s barrier islands being susceptible to storm events causing flooding and overwash, plans to combat shoreline change and update infrastructure are very important to the National Park Service and the people who live on the barrier islands. The final products will deliver data on shoreline change and seasonal oscillation patterns that will assist researchers at the National Park Service in future planning and decision-making efforts. The National Park Service can use the time series maps and the Hurricane Dorian case study in their efforts to oversee the preservation of the seashore and to monitor coastal hazards. This, in turn, will allow the National Park Service to upgrade infrastructure where they deem necessary to benefit local communities.

***Project Continuation Plan:***

The project was handed off to our partners, virtually, in the 10th week of the term. We handed off our end products, which included maps, figures, and tables representing shoreline change and seasonal oscillation averages throughout the ~10-year study period of each of the study areas. We also handed off an ArcGIS Pro and Google Earth Engine tutorial to acquire, process, and analyze data, which included open-source code. In future terms, teams will have access to the same material as the partners and specific code used in GEE. Future DEVELOP projects could expand upon our research by applying the same methods to the sound side of the island, using additional optical datasets or SAR datasets, and focusing on additional infrastructure such as park housing.

**References**

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National Park Service (2016). *State of the Park Report for Cape Hatteras National Seashore.* (Publication No. 33). [https://irma.nps.gov/DataStore/Reference/Profile/2240572](https://irma.nps.gov/DataStore/Reference/Profile/2240572%20%20)