**St. Joseph Peninsula Disasters**

*Using NASA Earth Observations to Investigate Land Cover, Shoreline Change, and Sediment Transport in St. Joseph Peninsula after Hurricane Michael*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

St. Joseph Peninsula extends twenty miles from Cape San Blas, Florida into the Gulf of Mexico, and visitors travel far and wide to experience its beautiful beaches and wildlife. After Hurricane Michael in 2018, access to the area was largely restricted, and the community continues to recover from the Category 5 storm. In partnership with the Florida Department of Environmental Protection, this project utilized NASA Earth observations to evaluate the current state of St. Joseph Peninsula. The project assessed land cover, shoreline change, and sediment transport pre- and post-Hurricane Michael. It also provided a climatology timeseries to prepare for future severe storm events.

***Abstract:***

T.H. Stone Memorial St. Joseph Peninsula State Park experienced significant damages from Hurricane Michael in 2018, the first Category 5 hurricane to hit the contiguous United States since 1992. These damages included a 300-meter-wide and 10-meter-deep breach in the peninsula, habitat disruption, and a forced closure of over half of the total park area. These damages, coupled with restricted visitor access, resulted in a significant loss of revenue for the park. NASA DEVELOP partnered with the Florida Department of Environmental Protection (DEP) to determine the overall impact of Hurricane Michael on land cover and shoreline change by using NASA Earth observations including Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and the European Space Agency’s Sentinel-2 Multispectral Instrument (MSI) to analyze sediment transport and climatology to further understand the lasting impacts of hurricanes on the ecosystems of the park. The DEVELOP team’s analyses showed that chlorophyll-a concentrations, sea surface temperature, and precipitation are increasing over time. The sediment transport analysis showed dynamic movement across the peninsula, with the greatest erosion occurring within the bay and along the length of the peninsula. These results are supported by evidence of declining seagrass abundances and seasonal turbidity patterns within those areas. Providing these analyses for the partner allows for a greater understanding of how best to proceed with restoration efforts, which may include rebuilding camping services, expanding fishing recreation, and conserving habitats for endangered species.

***Key Terms:***

coastline restoration, remote sensing, NDVI, climatology, timeseries, Landsat 7 ETM+, Landsat 8 OLI, disaster mitigation

***National Application Area Addressed:*** Disasters

***Study Location:*** Cape San Blas, FL

***Study Period:*** January 1990 – October 2021

***Community Concerns:***

* Tourism and revenue were severely impacted by hurricane damage that resulted in partial park closure restricting public access to park land.
* St. Joseph Peninsula provides vital habitat for wildlife, including endangered species, but major changes to land cover have created tension between tourists and vulnerable wildlife.
* Rising sea levels and increasing storm severity threaten the integrity of the park and the safety of surrounding communities.

***Project Objectives:***

* Investigate land cover and shoreline change pre-and post-Hurricane Michael using data from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Sentinel-2 Multispectral Instrument (MSI), Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and NOAA-19
* Generate timeseries analyses of sediment transport and climatology using Google Earth Engine and the DEVELOP Optical Reef and Coastal Area Assessment (ORCAA) tool to help the partner visualize changes to the landscape resulting from extreme weather
* Illustrate how to use these analyses for prediction and modeling by creating documentation for the project partner
* Communicate data through an interactive and publicly accessible ArcGIS StoryMap to accompany partner restoration plans

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Florida Department of Environmental Protection** | Christopher Whittle, Environmental Specialist; Mark Wimberly, Park Service Specialist; Jonathan Dillard, Assistant Park Manager | End User | Yes |

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

The Florida Department of Environmental Protection (DEP) is chiefly concerned with the protection and enhancement of local ecosystems. They have created restoration plans based primarily on balancing community concerns with environmental concerns derived from *in situ* data. These include dredging sand to rebuild the park's sand-based areas, rebuilding campsites, repairing land around the breach site, and reopening the tip of the peninsula to the general public for recreation. Despite a familiarity with remote sensing, they have not previously used NASA Earth observations as a tool for decision-making.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 7 ETM+** | land cover, Normalized Difference Vegetation Index (NDVI), aquatic reflectance, sediment, chlorophyll-a | Land cover and NDVI datasets were used to investigate land cover and shoreline change in the study area. Aquatic reflectance and sediment data were used to investigate sediment transport along the cape. Chlorophyll-a datasets were used to investigate algae abundance and coverage over time. |
| **Landsat 8 OLI** | land cover, NDVI, Normalized Difference Aquatic Vegetation Index (NDAVI), aquatic reflectance, sediment, chlorophyll-a | Land cover, NDVI, NDVI, and NDVAAI datasets were used to investigate land cover and shoreline change in the study area. Aquatic reflectance and sediment data were used to investigate sediment transport along the cape. Chlorophyll-a datasets were used to investigate algae abundance and coverage over time. |
| **Landsat 5 TM** | NDAVI,  chlorophyll-a | NDAVI datasets were used to investigate seagrass concentrations pre- and post-Hurricane Opal in 1995. Chlorophyll-a datasets were used to investigate algae abundance and coverage over time. |
| **Sentinel-2 MSI** | land cover, NDVI, aquatic reflectance, sediment | Land cover and NDVI datasets were used to investigate land cover and shoreline change in the study area. Aquatic reflectance and sediment data were used to investigate sediment transport along the cape. |
| **Aqua MODIS** | ocean color, sediment | Ocean color and sediment were used to investigate sediment transport along the cape. |
| **NOAA-19** | precipitation, sea surface temperature (SST) | Precipitation and SST were used to investigate climatology data over time. |

***Ancillary Datasets:***

* Florida DEP *in situ* Historical Land Cover Types – Analysis of land cover change
* Florida DEP Shoreline Shapefiles – Analysis of shoreline change
* Florida Fish and Wildlife Conservation Commission Bathymetry Contours Southeast United States – Masking of water shallower than 1.8 meters
* Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS) Precipitation – Climatology timeseries
* NOAA Climate Data Record (CDR) Optimum Interpolation Sea Surface Temperature (OISST) version 2 – Climatology timeseries

***Software & Scripting:***

* Optical Reef and Coastal Area Assessment (ORCAA) tool – Analysis of Normalized Difference Turbidity Index (NDTI)
* Coastal Remote Ecological Observations in Louisiana (CREOL) tool – Analysis of Suspended Aquatic Vegetation (SAV) and chlorophyll-a
* Google Earth Engine (GEE) – Calculation of indices
* Esri ArcGIS Pro 2.7.26828 – Raster manipulation and map generation
* Python 3.7 – Statistical analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Land Cover and Shoreline Change Analysis** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | This product allows the partner to visualize land cover and shoreline change before and after Hurricane Michael. It can aid the decision-making process of future restoration efforts for both recreational areas and endangered species. | N/A |
| **Sediment Transport Timeseries Analysis** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI  Sentinel-2 MSI | The Sediment Transport Timeseries Analysis enables the partner to analyze the movement of sediment throughout the park in the years since Hurricane Michael and better understand the restorative needs of the park’s shoreline. | II |
| **Climatology Timeseries** | Landsat 5 TM  Aqua MODIS  NOAA-19 | The partner organization will use this product to project future sediment and land cover change in the park as it relates to increased climatic activity. This helps with mitigation efforts and future disaster relief. | N/A |
| **Written Methodology Tutorial** | N/A | This product outlines the methodology and processes used to complete analyses within the project. It allows the partner to replicate any desired research. | N/A |

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

This project will help the Florida DEP better understand the land cover and shoreline change of the St. Joseph Peninsula that has occurred over the past several decades, as well as climate impacts and the effects of sediment transport. The analyses provided will directly inform current and future restoration projects by allowing the partner to estimate how the peninsula may continue to change in the future. This information will aid in their efforts to make better-informed decisions regarding park expansion, wildlife protection, and disaster mitigation.

**References**

Absalonsen, L., & Dean, R. G. (2011). Characteristics of the shoreline change along Florida sandy beaches with an example for Palm Beach County. *Journal of Coastal Research, 275*, 16–26. https://doi.org/10.2112/jcoastres-d-10-00192.1

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