**Jobos Bay Water Resources**

*Using Earth Observations to Analyze Shoreline Changes and Understand the Effects of Sea Level Rise in Southern Puerto Rico*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

This project aimed to understand the effect of sea level rise (SLR) on Puerto Rico’s southern shoreline in order to inform the Jobos Bay National Estuarine Research Reserve (JBNERR) in coastal protection efforts. The team used NASA Earth observations to create a historical shoreline change map and time series analysis, land use land cover change (LULC) maps, a mangrove habitat extent map, and water quality time series analyses and visualization maps. These products will build upon current knowledge at JBNERR, allowing the partners to continue public outreach and coastal resiliency and management practices in the face of climate change.

***Abstract:***

 Jobos Bay is located on the southern coast of Puerto Rico, which is known for intense hurricane seasons and increased seasonal storm surge. Scientists at Jobos Bay National Estuarine Research Reserve (JBNERR) are concerned that sea level rise will exacerbate coastal damage from these weather events. Using NASA Earth observations, our team analyzed coastal change, land use land cover change (LULC), mangrove forest extent, and water quality of Jobos Bay. Using Google Earth Engine, we evaluated coastal change and mangrove forest habitat within the study region by classifying NASA Earth observation imagery. We created historic LULC composite images to observe how land use changes over time and improve understanding of urbanization in the watershed. Leveraging previous water quality studies, our team compared water quality datasets generated by the Optical Reef and Coastal Area Assessment (ORCAA) tool to in situ sensors provided by JBNERR partners to understand the overall quality of water in the study area with respect to turbidity, chlorophyll-a, sea surface temperature, and colored dissolved organic matter (CDOM) concentrations. We discovered that 17% of the reserve has shifted from land to water since 1997 and lost 4.85 square kilometers of mangrove habitat over the past decade. Results from this study will inform the scientists of JBNERR and community members of the regional impacts of sea level rise. Being the first comprehensive study done in the estuary in nearly a decade, this serves as a baseline for future conservation efforts and research in the estuary.

***Key Terms:***

remote sensing, mangroves, water quality, Landsat, SDGS, GEE, shoreline, NASA

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

***Study Location:*** Guayama & Salinas, Puerto Rico

***Study Period:*** January 1997 – July 2021

***Community Concerns:***

* Little is known about the effects of SLR and recent tropical cyclone activity on coastal habitats and shoreline within Jobos Bay, limiting decision-making capacity for policymakers.
* Scientists and local communities fear that anthropogenic growth near the watershed may impact estuarine water quality.
* Mangrove forests are protected habitats that are in decline in some areas; JBNERR members aim to better understand mangrove loss drivers.
* Geologically, Puerto Rico has semi-permeable karst aquifers that provide drinking water to local communities that could potentially be contaminated by salt-water intrusion as sea level rises.

***Project Objectives:***

* Observe mean sea-level change of Jobos Bay over time
* Provide updated land use land cover composite imagery to JBNERR
* Highlight local mangrove forest extent and its changes over time
* Evaluate turbidity, chlorophyll-a, sea surface temperature, and CDOM levels in the Jobos Bay watershed over time

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Jobos Bay National Estuarine Research Reserve (JBNERR)** | Milton Muñoz Hincapié, Stewardship Coordinator;Angel Dieppa, Research and Monitoring Coordinator;Aitza E. Pabón Valentín, Director | End User | Yes |

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

The JBNERR is managed by the Puerto Rico Department of Natural and Environmental Resources and the NOAA Office of Coastal Management. JBNERR and other coastal sites in the National Estuarine Research Reserve System follow the protocols of NOAA’s System-Wide Monitoring Program. The researchers at the Reserve create initiatives to protect the estuary from anthropogenic stressors and climate change impacts, conduct research to enhance coastal conservation and management practices, and educate local communities. They currently use drone imagery and *in situ* field collections to inform their decision-making. *In situ* measurements include water quality parameters (e.g., salinity, turbidity, and dissolved oxygen) collected using automatic sondes and a weather station for meteorological data.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI**  | Land Cover  | Land cover data was used in the creation of mangrove extent mapping and a time series analysis of shoreline changes in southern Puerto Rico.  |
| **Landsat 7 ETM+** | Land Cover | Land cover data was used in the creation of mangrove extent mapping and a time series analysis of shoreline changes in southern Puerto Rico.  |
| **Landsat 5 TM** | Land Cover | Land cover data was used in the creation of a time series analysis of shoreline changes in southern Puerto Rico. |
| **Sentinel-2 MSI** | Chlorophyll-a, Turbidity,Sea Surface Temperature,CDOM, Land Cover | Water quality data was used for a higher resolution comparison to Landsat results and to identify chlorophyll-a concentration and turbidity in relation to recent tropical storms. Land cover data was used in LULC classification.  |

***Ancillary Datasets:***

* JBNERR Jobos Bay Shapefile – Shapefiles delineating various classified areas of the bay, including mangrove forests, were used with satellite imagery to identify the change in density.
* JBNERR *in situ* Data – Water quality data measured at four water stations were compared to remote sensing data to assess the accuracy of using remote sensing to measure turbidity, sea surface temperature, and chlorophyll-a.
* NOAA Coastal Change Analysis Program (C-CAP) – Used as a source for wetland data for the LULC analysis.
* Esri 2020 Land Cover – Used as comparison to our 2020 LULC classification for validation.
* U.S. Army Corps of Engineers 2018 topobathy Light Detection and Ranging (LiDAR) dataset - Used in water quality parameter mapping

***Software & Scripting:***

* Esri ArcGIS Pro 2.8 – data processing & manipulation, land cover classifications, change analyses, map making.
* Google Earth Engine API – data processing & manipulation, water indices, annual coastline averages.
* Jupyter Notebook 6.3.0 - data manipulation and water quality parameter time-series analyses
* RStudio 1.4.1717 - linear regressions & statistical analyses for water parameters

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Water Quality Time Series Analysis and Visualization Maps** | Sentinel-2 MSI | The JBNERR can use the time series analyses and visualizations to understand how various water parameters fluctuate through seasons and surrounding natural disasters. | N/A |
| **Historical Shoreline Change Map and Time Series Analysis** | Landsat 8 OLI, Landsat 7 ETM+,Landsat 5 TM | The JBNERR can use the shoreline change map and time series analysis to understand the effects of past shoreline monitoring efforts, as well as improve current coastal management practices. | N/A |
| **Historic Land Use Land Cover Changes Maps**  | Sentinel-2 MSI | The JBNERR can use the land cover change map to monitor the spatiotemporal trends for the Jobos Bay watershed and build upon their existing data to create an up-to-date land use and land cover change analysis. | N/A |
| **Mangrove Habitat Extent Map** | Landsat 8 OLI, Landsat 7 ETM+ | The JBNERR can use the mangrove habitat extent map to observe how mangrove habitat is changing over time and identify areas of loss to better focus conservation efforts. | N/A |

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

This project will help the JBNERR improve their coastal resiliency and management practices by providing a historical perspective for multiple environmental parameters that are related to changes in sea level and land cover. The historical shoreline change map and time series analysis will support the JBNERR’s coastal monitoring efforts by detailing the ways that SLR has caused the soil, water parameters, and coastline of Jobos Bay to change over time. Furthermore, the historic land use land cover changes maps will give the JBNERR a snapshot of the spatiotemporal trends of Jobos Bay in the past decade, which they can then add to their archive of land use land cover analyses from previous decades. The mangrove habitat extent map can give the JBNERR insight as to how the mangrove habitats within the bay have been affected by tropical storms and anthropogenic factors over the past decade. In addition to this, the water quality time series analyses and visualizations will allow the JBNERR to easily visualize the fluctuations in various water parameters within the bay, and how they vary between seasons and tropical storm events. With these products, the JBNERR will update their public outreach curriculum and coastal resiliency and management practices.

***Project Continuation Plan:***

Future terms will explore the use of NOAA’s Sea Level Affecting Marshes Model (SLAMM) to further model SLR on the southern coast of Puerto Rico.

**References**

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. <https://doi.org/10.1016/j.rse.2017.06.031>

Jobos Bay NERR, & Puerto Rico Department of Natural and Environmental Resources. (2017). *Jobos Bay National Estuarine Research Reserve Management Plan 2017 - 2022*. Retrieved from <https://www.drna.pr.gov/jbnerr/pm-jbnerr/jobos-bay-national-estuarine-research-reserve-management-plan-2017-2022/>

Whitall, D. R., Costa, B. M., Bauer, L. J., Dieppa, A., & Hile, S. D. (2011). A Baseline Assessment of the Ecological Resources of Jobos Bay, Puerto Rico. *NOAA Technical Memorandum NOS NCCOS 133*, 188. Retrieved from https://repository.library.noaa.gov/view/noaa/669