**Florida Transportation and Infrastructure**

*Monitoring Water Quality Along Southern Florida Seaports to Assess Impact on Coral Reef Tracts from Harbor Deepening Projects*

**Project Team**

***Project Team:***

Benjamin Rocha (Project Lead)

Alexis Smith

Estenia Ortiz

Melanie Leung

Michael Enz

***Advisors & Mentors:***

Dr. Juan Torres-Pérez (NASA Ames Research Center)

***Team POC:*** Benjamin Rocha, brocha203@gmail.com

***Software Release POC:*** Melanie Leung, leungmelanie.s@gmail.com

***Partner POC:*** Dr. Xaymara Serrano Vicente, xaymara.M.SerranoVicente@usace.army.mil

Jocelyn Karazsia, jocelyn.karazsia@noaa.gov jocelyn.karazsia@noaa.gov

**Project Overview**

***Project Synopsis:*** In early 2022, the U.S. Army Corps of Engineers (USACE) will begin a harbor deepening project on the Port Everglades seaport in southern Florida. To better understand the impacts of this dredging project on coral reefs and water quality, the DEVELOP Florida Transportation & Infrastructure team, in collaboration with the USACE, and National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Services (NMFS), created a Google Earth Engine (GEE) tool that outputs a 20-year time series analysis of water quality changes. This tool will help to understand the seaport’s historical conditions and better inform future decisions for the dredging project.

***Abstract:***   The U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) will be supervising a harbor deepening project in Port Everglades, Florida. The project raises concerns about potential impacts on the nearby Florida reef tract through increased turbidity and sediment from the dredging. To better understand these potential impacts, the NASA DEVELOP team created an interactive Google Earth Engine tool to help establish a historical baseline of water quality parameters and assist monitoring these parameters more frequently than traditional sampling. This Seaport & Harbor Area Resource Quality (SHARQ) tool incorporates remotely sensed data from Sentinel-2 Multispectral Instrument, Landsat 5 Thematic Mapper, Landsat 7 Enhanced Thematic Mapper+, Landsat 8 Operational Land Imager, and Aqua Moderate Resolution Imaging Spectroradiometer. It allows users to view true color images and calculate water quality parameters, like turbidity and chlorophyll-a, for any given study area and time period from 1984 onward. The SHARQ tool also generate time series charts, allowing users to interpret changes in water quality over a given time range. The accuracy of the remotely sensed water quality parameter algorithms was determined using in situ data to calculate percent difference and root mean square error values (RMSE), which ranged from 0.32 to 0.58 error between sites. Using the SHARQ tool’s time series analysis feature, a baseline average turbidity metric of ~6.8 FNUs provides a historical baseline average for turbidity between September 2000 and 2020 and can assist in future decision-making for determining thresholds for turbidity.

***Key Terms:*** Coral Reefs, Turbidity, Chlorophyll-a, Water Quality, Remote Sensing, Landsat 8 OLI, Aqua MODIS, Sentinel-2, Florida

***National Application Areas Addressed:*** Transportation & Infrastructure, Water Resources

***Study Location:*** Port Everglades Seaport, FL

***Study Period:*** September 2000 – September 2020

***Community Concerns:***

* The dredging of Port Everglades would add a boost to the regional economy by increasing commercial fishing and increasing passenger capacity at the seaport. However, this project may come at the cost of the Florida Reef Tract, which provides its own set of economic benefits and ecosystem services.
* The reef provides recreational and commercial services which stimulate the local economy. The reef also provides environmental protection, which, if lost, could result in economic cost associated with damage from lack of protection.
* More frequent and thorough water quality monitoring is needed to establish a historical baseline of seasonal and annual water quality trends and to ensure that the dredging project does as little harm to the Florida Reef Tract as possible.

***Project Objectives:***

* Monitor and model water quality conditions over time
* Visualize seasonal and yearly patterns of water quality using a time series analysis along the Southeast portion of Florida’s seaports over the last 20 years
* Cross-validate remotely sensed turbidity measurements with *in situ* data to assess validity of utilizing NASA Earth observations for water quality monitoring

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **U.S. Army Corps of Engineers,**  **Jacksonville District** | Dr. Xaymara Serrano Vicente, Coral Biologist | End User | No |
| **NOAA Marine Fisheries Service, Habitat Conservation Division** | Jocelyn Karazsia, Fish Biologist | End User | No |

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

The USACE has standard requirements in its project specifications to minimize and avoid impacts to protected species during the construction, operation, and maintenance of its projects. Working with state and federal regulatory and permitting programs, the NOAA NMFS attempts to minimize the loss of coastal waters and wetlands while successfully enhancing and restoring fishery habitats and accommodating sustainable development. Currently, the partners are mostly using field-collected measurements to assess and monitor the study area. Such data, also known as *in situ* data, can be costly and time consuming, making the use of NASA satellite imagery helpful in supporting coastal water quality research.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | turbidity, chlorophyll-a, Normalized Difference Turbidity Index (NDTI), colored dissolved organic matter (CDOM), Kd(490),  remote sensing  reflectance | This data was used to analyze changes in water  quality parameters from 2000 to 2012 to determine  annual trends. |
| **Landsat 7 ETM+** | turbidity, chlorophyll-a, NDTI, Kd(490),  remote sensing  reflectance | This data was used to analyze changes in water quality parameters from January 2012 to April 2013 to determine annual trends. |
| **Landsat 8 OLI** | turbidity, chlorophyll-a, NDTI, Kd(490),  remote sensing  reflectance | This data was used to analyze changes in water quality parameters over the last 8 years to determine annual trends. |
| **Sentinel-2 MSI** | turbidity, chlorophyll-a, Normalized Difference Chlorophyll Index (NDCI), NDTI, CDOM,  remote sensing  reflectance | This data was used to analyze changes in water  quality parameters over the last 6 years to  determine annual trends. |
| **Aqua-Terra MODIS** | Sea surface temperature | This data was used to analyze changes in water  quality parameters over the last 19 years to  determine annual trends and observe water quality  changes from previous dredging projects. |

***Ancillary Datasets:***

* NOAA National Marine Fisheries Service, Habitat Conservation Division: *In situ* measurements – Diver-based observations and measurements of sea temperature and turbidity were used to validate remotely-sensed data.

***Software & Scripting:***

* ESRI ArcGIS Pro 2.8.0 – Used to create maps and the study area shapefile.
* Google Earth Engine – Used to develop a graphic user interface dashboard that extracts water quality parameters (turbidity, chlorophyll-a, diffuse attenuation coefficient (Kd(490)), CDOM, NDTI, NDCI) from Landsat 8 OLI, Landsat 5 TM, Landsat 7 ETM+, Sentinel-2 MSI, and Aqua MODIS imagery.
* Microsoft Excel Version 2017 – Used to run statistical analyses and generate graphics for the cross-validation of satellite imagery and in situ data.

***End Products***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Google Earth Engine Seaport & Harbor Area Resource Quality (SHARQ) Tool** | Aqua MODIS  Sentinel-2 MSI  Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | This tool creates charts and maps of water quality conditions, allowing partners to monitor changes in water quality throughout the Southeast portion of Florida’s seaports over the last 20 years. | III |
| **SHARQ Tool Tutorial** | Aqua MODIS  Sentinel-2 MSI  Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | This tutorial will inform our partners on how to use and customize the SHARQ Tool. | N/A |

***Product Benefit to End User:*** The end results of this project will provide the partners with an interactive tool able that provides insight into historical water quality trends of the Port Everglades area over the past 20 years. This will help end users understand water quality trends in the surrounding Florida Reef Tract, as well as the role that dredging projects have played into this. End products can be incorporated into their water quality monitoring efforts, and later used to better inform their decision-making processes surrounding dredging practices.

**References**

Erftemeijer, P. L. A., Riegl, B., Hoeksema, B. W., & Todd, P. A. (2012). Environmental impacts of dredging and other sediment disturbances on corals: A review. *Marine Pollution Bulletin*, *64*(9), 1737–1765. <https://doi.org/10.1016/j.marpolbul.2012.05.008>

Fisher, R., Jones, R., Ridd, P., Stark, C. (2015). Temporal Patterns in Seawater Quality from Dredging in Tropical Environments. PLoS ONE 10(10): e0137112. https://doi:10.1371/journal.pone.0137112