**Keweenaw Bay Water Resources**

*Utilizing NASA Earth Observations to Enhance Shoreline Management and Support Future Erosion Mitigation Interventions in Michigan*

**Project Team**

***Project Team:***

Khaim Syed-Raza (Project Lead)

Nora Whitelaw-McDonald

Lisa Siewert

Sofia Vakhutinsky

***Advisors & Mentors:***

Dr. Kenton Ross (NASA Langley Research Center) Kenton.W.Ross@nasa.gov

Lauren Childs-Gleason (NASA Langley Research Center) Lauren.M.Childs@nasa.gov

***Fellow:***

Olivia Landry (NASA Langley Research Center) olivia.landry@ssaihq.com

***Team Contact:*** Khaim Syed-Raza

***Partner Contact:*** Evelyn Ravindran, eravindran@kbic-nsn.gov

Abby Hall, hall.abby@epa.gov

**Project Overview**

***Project Synopsis:***

In collaboration with the Keweenaw Bay Indian Community (KBIC) and the Environmental Protection Agency (EPA), this project developed an analysis of sediment redistribution affecting the Keweenaw Bay to help inform decisions regarding stamp sand erosion, shoreline armoring, and coastal highway relocation. The DEVELOP team examined the turbidity of the bay during three periods of time—the snowmelt season (~mid-March through early May), the rain-dominated season (~mid-June through July), and the drier season (~late August through early October). The analyses and products created will support the end user’s decision making to mitigate coastal erosion and shoreline management along the Keweenaw Bay.

***Abstract:***

The Keweenaw Bay Indian Community (KBIC) has shoreline along the south of Lake Superior that is contaminated with stamp sands from legacy mining. The stamp sands have been capped with sandy-loam soils and restored native species, but erosion and flooding threaten to re-deposit these stamp sands onto wetlands and into the bay. Erosion and flooding also threaten loss of beaches and shoreline, infrastructure, wetland restoration projects, and impacts to coastal highways, which has driven shoreline armoring. However, while shoreline armoring can be effective in protecting the intended areas, it can also exacerbate erosion in nearby unarmored areas, so its net impact on the shoreline is yet to be quantified. The DEVELOP team partnered with KBIC and the Environmental Protection Agency (EPA) to utilize imagery from Landsat 8 Operational Land Imager (OLI) and Sentinel- 2 Multispectral Imager (MSI) in order to analyze turbidity proxies. The results from these analyses showed seasonal variation in turbidity was greatest during the season dominated by rain, but spatial variability across our study period was unclear. These results will be used to better inform future shoreline management efforts and support resilience in the face of more coastal erosion.

***Key Terms:***

Landsat, Sentinel, coastal erosion, turbidity, stamp sands, GEE, NDTI

***Study Location:*** Keweenaw Bay, Lake Superior, Michigan

***Study Period:*** 2013 – 2022 (May – October)

***Community Concerns:***

* KBIC has shoreline property in southern Lake Superior that is contaminated with stamp sands from legacy mining. The stamp sands have been capped with sandy-loam soils and restored native species, but coastal erosion and flooding threaten to re-deposit the stamp sands onto the wetlands which provide critical habitat for wildlife and fish and serve as a traditional food source and drinking water for the community.
* Coastal erosion has threatened a major roadway positioned along the bay, which has driven shoreline armoring projects. However, the effects of the armoring are exacerbating the erosion of unarmored shoreline, which includes public beaches and community coastal infrastructure.

***Project Objectives:***

* Create a seasonal turbidity analysis
* Understand sediment redistribution patterns in the bay during snowmelt, rainy, and dry seasons
* Provide insight to our partners on coastal sediment dynamics

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Keweenaw Bay Indian Community, Natural Resources Department** | Dione Price, Environmental Specialist & Environmental Health Section Lead; Evelyn Ravindran, Director of Natural Resources Department | End User |
| **Environmental Protection Agency, Office of Community Revitalization** | Abby Hall, Senior Advisor of Local & Regional Planning; Sarah Gruza, Brownfields Project Manager; Jennifer Manville, Region 5 Tribal Liaison | Collaborator |

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

KBIC and the EPA have partnered in an initiative to study and mitigate coastline change. They are between Phase I and II of this study, Phase I having been funded by the EPA in 2019 and Phase II awaiting approval. In Phase I, their team assessed the coastal geomorphology, erosion, and accretion of stamp sands deposits within select regions of western Keweenaw Bay using a combination of Maxar high-resolution imagery, aerial photography, historical cartographical documents, and both airborne and bathymetric LiDAR. A major concern of the partners is protecting coastal infrastructure, public beaches, and determining whether a major road currently abutting the bay should be relocated. Relocating the road could result in the removal of coastal armoring put in place to protect the road from coastal erosion and flooding.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Used** |
| **Landsat 8 OLI** | Turbidity | These data were used as part of a 2013-2022 historical analysis to discern nearshore turbidity. |
| **Sentinel-2 MSI** | Turbidity | These data were used as part of a 2013-2022 historical analysis to discern nearshore turbidity. |

***Ancillary Datasets:***

* NOAA NCEI Past Weather data from the Baraga-7 Station – used to determine beginning and end of rain-dominated and drier seasons

***Software & Scripting:***

* Google Earth Engine (GEE) – image masking and calculation of NDTI
* Esri ArcGIS Pro 3.0.2 – Raster manipulation and map generation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Seasonal Turbidity Proxy Time Series** | Landsat 8 OLI  Sentinel-2 MSI | The time series of seaonally-averaged turbidity proxy data in Keweenaw Bay (2013-2022) provided partners with insights regarding seasonal controls on sediment inputs from the shoreline. | N/A |

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

The project results supported the Keweenaw Bay Indian Community by analyzing a turbidity proxy during seasons when the bay is ice-free, which provided insight into what plays a greater role in coastal erosion: snowmelt or precipitation events. Understanding how the coastline erodes supports informed decision-making of shoreline management by narrowing down the most effective erosion mitigation methods, which continue to be explored by the partners to mitigate the redistribution of stamp sands into the bay.

**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>