**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**California – Ames**

**Lake Michigan Water Resources II**

*Analyzing Cladophora Habitat Suitability on Wisconsin’s Western Shores using Landsat and MODIS and Validating a Cladophora Detection and Monitoring Tool with In Situ Data*

**Project Overview**

***Project Synopsis*:** Building on the work completed during the summer 2018 term, this project will expand the study area to the entire western shore of Lake Michigan. Leveraging NASA’s Landsat and MODIS data along with ESA’s Sentinel-2, this project will apply previously developed methods for identifying suitable growing locations for *Cladophora.* These data, coupled with surface wind data from NOAAPORT, will provide insight into locations where *Cladophora* may wash ashore. Validation of the *Cladophora* Wash-Up Predictive Map will be completed by utilizing *in situ* data points of *Cladophora* signtings gathered by Groundwork Milwaukee’s (GWMKE) GIS team. These methods will be used to create the *Cladophora* Detection and Monitoring Tool (CDMT) that will incorporate Earth observations and *in situ* data, allowing for more accurate predictions of future algae wash-up. Ultimately, this study will provide our partners with unique capabilities when competing for the *Cladophora* cleanup contract, which the City of Milwaukee competes on a yearly basis.

***Community Concern:*** There has been a recent resurgence of macroalgae, predominantly *Cladophora*, along the coastline of Lake Michigan and other Great Lakes. *Cladophora* occurs naturally along these coastlines and is not toxic to humans, but when it washes ashore and decays it can lead to unsightly and foul-smelling beaches. An abundance of *Cladophora* can also promote bacteria growth that may be harmful to humans if ingested. *Cladophora* deters visitors to public beaches, decreases property value and reduces the quality of community drinking water. The remediation of *Cladophora* will positively affect wildlife, socioeconomic resources, and local communities.

***Source of Project Idea:*** This project was requested by Groundwork Milwaukee as part of a greater partnership cultivation effort between NASA DEVELOP and Groundwork USA.

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

***Study Location:*** Lake Michigan, WI

***Study Period:***  1985 – 2018 (May – September)

***Advisor:*** Dr. Juan Torres-Pérez (Bay Area Environmental Research Institute)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Groundwork USA, Groundwork Milwaukee** | Deneine Christa Powell, Executive Director  Lawrence Hoffman, GIS Program Manager | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The broad goal of Groundwork Milwaukee’s Urban Waters *Cladophora* Removal Project is to remove *Cladophora* and non-hazardous waste from three of Milwaukee’s beaches and to keep it out of landfills by composting and recycling harvested debris. Currently, GWMKE must visit each beach and visually inspect if *Cladophora* has washed ashore. The Green Team, a Conservation and Green Infrastructure Workforce Development Training Program at GWMKE, is actively involved in the remediation of *Cladophora*. This process is labor intensive as Milwaukee’s beaches are often below steep bluffs. Removing the algae involves racking from the beaches and hauling it out in truck beds.GWMKE exposes young men and women from Milwaukee’s central city to various ways of learning about and improving the quality of Milwaukee’s water resources, while earning wages and preparing them for careers in “green” jobs.

***End User’s Capacity to Use NASA Earth Observations:***

*Groundwork USA, Groundwork Milwaukee* – Groundwork Milwaukee has not had the opportunity to use NASA’s Earth observations, but they do have access to ArcMap and Collector. They do not apply these technologies to track locations of *Cladophora* cleanup. This DEVELOP project will teach GWMKE how to leverage currently available geospatial programs and data with Earth observing data.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Over the course of this project, the Lake Michigan Water Resources II team will engage with GWMKE Green Team and Groundwork GIS teams to continue to build a database of *in situ* data of *Cladophora* presence on city beaches using Collector for ArcMap. GWMKE and the DEVELOP team will also explore using Instagram to collect citizen science data through a social media campaign designed to engage the greater Milwaukee beach communities. This campaign will be executed by GWMKE on their social media platforms. The DEVELOP team will provide scientific content. These data will be ingested into the CDMT as another *in situ* data sources. There will be bi-weekly teleconference meetings throughout the term. The team will create a meeting agenda prior to the calls. The Project Lead will serve as the POC and will lead the calls.

***Transition Plan*:** A formal end-user handoff will take place at the end of the project term. The team will facilitate a webinar training that will teach GWMKEs GIS and Green Teams how to use the CDMT tool. The team will also give a formal presentation explaining the lifecycle of this project and its results. This will be done through a WebEx teleconference. All end products, deliverables, and result maps will be sent through NASA’s Large File Transfer (LFT) system. This project will not require software release. A video tutorial will be made by the team to explain how Collector data can be digested into the CDMT tool. This will accompany a read me file in a tool handoff package.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 7 TM** | Remote Sensing and Surface Reflectance | The team will use the SAV to look at optical water depth, NDVI, and the Floating Algae Index (FAI) to identify locations of *Cladophora*. |
| **Landsat 8 OLI** | Remote Sensing and Surface Reflectance | The team will use the SAV to look at optical water depth, NDVI, and the FAI to identify locations of *Cladophora*. |
| **Sentinel-2 MSI** | Remote Sensing and Surface Reflectance | The team will use the SAV to look at optical water depth, NDVI, and the FAI to identify locations of *Cladophora*. |
| **Aqua MODIS** | Surface water temperature, Colored  Dissolved Organic  Matter (CDOM) | Surface water temperature and CDOM will be produced during the *Cladophora* growing season and used for habitat suitability analysis. |

***Ancillary Datasets:***

Great Lakes WATER Institute & Wisconsin Coastal Imagery Database – Use as validation for processed imagery

Great Lakes Data Rescue Project Lake Michigan Bathymetry – Use in the habitat suitability analysis

NOAA National Centers for Environmental Information & Bathymetry of Lake Michigan – Create a present likelihood raster based on the depth and surface type of the lake bed

NOAAPORT & Realtime Great Lakes Weather Data and Marine Observations – Gather recent *in situ* observations of wind speed, wind direction, water temperature to input into tool

NOAA NCEP Global Forecast System – 384-hour predicted atmosphere data to aid in developing a tracking predictor for the GEE tool

***Software & Scripting:***

Satellite-Derived Great Lakes Submerged Aquatic Vegetation Classification Map – Michigan Tech created this web map that produces layers that classifies bottom type and Great Lakes SAV layers for Lake Michigan

ACOLITE – Atmospheric correction using rhos\_\* to convert images to surface reflectance. Water quality analysis will include; chl\_oc3 (Chlorophyll a in Landsat), chl\_re\_moses3b (Chlorophyll a Sentinel-2)

Collector for ArcGIS – Create a robust dataset of *in situ Cladophora* locations

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| ***Cladophora* Predictive Wash-Up Map Validation** | The validation of this map will ensure that the methods used in the CDMT can be relied upon for future use. | This product was derived from bathymetry, substrate, water temperature (Aqua MODIS), turbidity (Landsat 8 and Sentinel-2), and number of near shore structures. Validation will be done using *in situ* data collected by our project partners using the Arc Collector tool created in the first term. | N/A |
| ***Cladophora* Detection and Monitoring Tool (CDMT)** | This product will allow our partners to continually produce predictive wash-up maps, so they can monitor their beaches over time. GWMKE will build a robust database of known *Cladophora* sites that can be used to validate future raster’s. Ultimately, these raster’s will inform partners on location of *Cladophora* on shores that should be prioritized for cleanup. | This product will use model builder inside ArcMap to create a tool that streamlines the methods developed for the Predictive Wash-Up Map. It will include a sub-model that will easily ingest the Arc Collector data points for future validations. | I |
| ***Cladophora* Detection and Monitoring Tool Tutorial** | This easy to follow video tutorial will explain how the CDMT model used and how to use Collector for ArcGIS to gather *in situ* points for continued monitoring of *Cladophora*. | N/A | I |
| **Lake Michigan’s Western Shore *Cladophora* Habitat Suitability** | Investigating different factors that influence the displacement of *Cladophora* will aid in identifying suitable habitats for this algae. These data will be used to adjust the CDMT as needed to provide the highest accuracy for long term *Cladophora* detection and help our partners better understand where to target their resources for cleanup and mitigation. | Landsat imagery will be atmospherically corrected using ACOLITE and calculate water turbidity using the built-in water turbidity function. The Submerged Aquatic Vegetation Mapping Algorithm (SAVMA) equation as derived from Shuchman et al. (2013) and Brooks et al. (2015) will be used to calculate the density of submerged aquatic vegetation using. These factors will be standardized (so that all values fall in between 0 and 1) to ensure that larger values do not influence the results of the multi-criteria evaluationwhen identifing *Cladophora* habitat suitability for. | N/A |
| ***Cladophora* on Lake Michigan’s Western Shore’s Story Map** | This story map will walk a viewer through the purpose of the second stage of this project, community benefits of this partnership, as well as the use of Earth observations for answering environmental questions. It will aid in teaching community members how to get involved in monitoring *Cladophora*. This will be hosted by GWMKE. | N/A | N/A |

***End-User Benefit*:** Groundwork Milwaukee competes for the *Cladophora* cleanup contract that the City of Milwaukee provides each year. The products and assessment produced by this project will provide our partner with an enhanced toolset designed to aid in the remediation of *Cladophora*. This toolset will make GWMKE more competitive when applying for the city’s *Cladophora* Cleanup funding. This project will save our partner, and in turn the City of Milwaukee, both time and money when planning for weather events and summer algal blooms that could require an increased effort to keep Milwaukee’s public beaches clear of the nuisance algae. With advanced planning, our partners can allocate resources and personnel to the most affected sites, reducing time spent going to and from beaches when verifying the presence *Cladophora*.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Summer to 2018 Fall

***Multi-Term Objectives:***

* **Term 1:** 2018 Summer (ARC) – Lake Michigan Water Resources I
  + This term developed methods for a *Cladophora* Predictive Wash-Up Map and *Cladophora* Habitat Suitability Map. It also built a geodatabase that uses Collector for ArcGIS that GWMKE’s GIS team uses to gather *in situ* data points of *Cladophora* presence on Milwaukee beaches. These products set the second term up to determine the best method to expand the *Cladophora* Habitat Suitability Map to the entire western shore of Lake Michigan and allowed for the development of the CDMT that provided our partners with a way to replicate this projects results. This in turn provided them with a way to plan in advance for resource allocation saving them both time and money.
* **Term 2 (Proposed Term):** 2018 Fall (ARC) – Lake Michigan Water Resources II
  + This term will expand the study area to the entire western shore of Lake Michigan and produce a *Cladophora* Habitat Suitability Map that will be coupled with surface wind data from NOAAPORT will provide insight into where *Cladophora* may wash ashore. Validation of the *Cladophora* Wash-Up Predictive Map will be completed by utilizing *in situ* data points of *Cladophora* sittings gathered by Groundwork Milwaukee’s (GWMKE) GIS team. This product’s method will be made into a *Cladophora* Detection and Monitoring Tool (CDMT) that will incorporate Earth observations and future *in situ* data allowing for more accurate predictions of future algae wash-up.

***Related DEVELOP Work:***

2016 Summer (ARC) – Caribbean Oceans: Utilizing NASA Earth Observations to Detect, Monitor, and Respond to Unprecedented Levels of Sargassum in the Caribbean Sea

2014 Spring (SSC) – Texas Oceans SSC: Enhancing Remote Sensing Capabilities of the Sargassum Early Advisory System (SEAS) Through the Use of NASA EOS and Open Source GIS

**Notes & References:**

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