**Lake Michigan Water Resources**

*Utilizing NASA Earth Observations and Community Science to Detect and Map the Displacement of Cladophora along the Milwaukee County Shoreline*

**VPS Title:** From Lake Floor to Beach Shore

**Project Team**

***Project Team*:**

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**Project Overview**

***Project Synopsis*:**

Each year, organizations in Milwaukee, WI, seek to earn the city’s contract to remove *Cladophora*, a green macroalgae, from beaches along the shorelines of Milwaukee County. When *Cladophora* decays, it creates an unattractive, foul-smelling environment and promotes the growth of toxic bacteria, steering people away from enjoying beaches surrounding Lake Michigan. The team partnered with Groundwork Milwaukee (GWMKE), a local nonprofit organization, to create a series of end products using remotely sensed imagery and community science that identify the habitat and predict the movement and deposition of *Cladophora*.

***Abstract*:**

Although *Cladophora* is naturally occurring and nontoxic, the accumulation and decay of this green macroalgae creates salient socioeconomic issues for communities situated along the shoreline of Lake Michigan. When *Cladophora* washes ashore and decays, it creates unaesthetic and unpleasant smelling beaches, potentially endangering public health and threatening the local tourism economy. Furthermore, decaying *Cladophora* promotes the growth of toxic bacteria, which can impact organisms that come into contact with it. In collaboration with Groundwork Milwaukee, the 2018 NASA DEVELOP Lake Michigan Water Resources team created *Cladophora* Habitat Suitability and Washup Predictive Maps to identify areas where the algaegrows and predict where it will most likely come ashore. These maps were created using Landsat 8 Operational Land Imager (OLI) and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) imagery of Lake Michigan near Milwaukee, WI, from June to September for the years 2016 and 2017. The results of this project will be validated during the fall 2018 DEVELOP term using *in situ* data of *Cladophora* sightings collected by Groundwork Milwaukee using an ArcGIS Collector App. To encourage community involvement, the team developed a project story map and provided Groundwork Milwaukee with content for their community science social media campaign that highlights the significance of this project while informing members of the general public about how they can contribute to cleanup efforts. These products will allow local organizations such as Groundwork Milwaukee to identify, monitor, and predict the movement of *Cladophora* and allocate cleanup resources more efficiently along the shores of Lake Michigan.

**Keywords:**

*Cladophora,* Aqua MODIS, Landsat, Groundwork Milwaukee, community science, submerged aquatic vegetation, floating algae index, habitat suitability map

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

***Study Location:*** Milwaukee County, WI

***Study Period:*** 2016 – 2017 (June – September)

***Community Concern:***

* *Cladophora* is a green macroalgae found in Lake Michigan that grows on hard surfaces at the bottom of the lake and washes on shore in mid-August due to wave action and sloughing.
* A recent surge in *Cladophora* caused large accumulations of algal mats to wash up on Lake Michigan’s western shores, creating nuisances and socioeconomic challenges to nearby communities.
* *Cladophora* releases a pungent smell that deters people from visiting the beach and can promote bacterial growth, which is toxic to humans and wildlife if ingested. It is unsightly, decreases property values, reduces the quality of drinking water, and clogs water intakes.
* Groundwork Milwaukee is a non-profit organization that seeks to remediate *Cladophora* and remove algal mats from beaches when they wash onto the shore, which is a time-consuming and challenging process.
* An effective monitoring tool would allow Groundwork Milwaukee to find *Cladophora* earlier, prevent large algal accumulations, minimize odor, conserve cleanup resources, and increase planning efficiency.

***Project Objectives:***

* Create *Cladophora* Habitat Suitability and Washup Predictive Maps to identify factors influencing growth, displacement, and deposition
* Utilize Collector for ArcGIS to gather *in situ* data of *Cladophora* washup locations using a mobile phone application
* Produce social media campaign content and a project story map to inform the public about how they can help address issues regarding *Cladophora* nuisance in their own communities

**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 |

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

Remediating *Cladophora* is difficult due to challenges in identifying and removing the algae, requiring excessive time and resources. Current cleanup efforts involve disposing *Cladophora* into large garbage bins, which are then transported to the local landfill. GWMKE seeks to earn a contract with the City of Milwaukee to hire youth who can assist with the cleanup and compost the algae instead of transporting it to the landfill. GWMKE wishes to acquire a tool or model that will improve their remediation process and help them acquire a contract from the city in order to dispose of algae in a sustainable manner.

***Project Benefit to End User***:

The results of this project can provide GWMKE with resources that will help them acquire Milwaukee’s yearly cleanup contract. *Cladophora* Habitat Suitability and Washup Predictive maps will improve planning efficiency and minimize time spent searching for algal washup by locating areas where algae will most likely deposit on shore. Additionally, the ArcGIS Collector Monitoring Tool, *A Stinky Situation* Project Story Map, and Social Media Community Science Campaign content end products build a geodatabase of *in situ* data collected by GWMKE members and the general public that can be used to validate *Cladophora* models while also introducing members of GWMKE, and the larger Milwaukee community, to the capabilities of NASA Earth Science.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Submerged Aquatic Vegetation, Turbidity, Floating Algal Index (FAI) | SAV, Water Turbidity, PC, and FAI were calculated from Landsat imagery for use in the *Cladophora* Habitat Suitability Map. |
| **Aqua MODIS** | Sea Surface Temperature (SST) | SST data products were incorporated into the *Cladophora* Habitat Suitability Map. |

***Ancillary Datasets:***

United States Army Corps of Engineers and Great Lakes Aquatic Habitat Framework Datasets – substrate data for Lake Michigan to use in habitat suitability and washup predictive analysis

NOAA National Centers for Environmental Information (NCEI) Great Lakes Bathymetry – Lake Michigan Bathymetry to use in habitat suitability and washup predictive analysis

University of Michigan, Michigan Tech, Cooperative Institute for Limnology and Ecosystems Research, Great Lakes Environmental Research Laboratory, and NOAA Datasets on Invasive Mussels and the Productivity of Lake Michigan – mussel distribution data to use as a proxy for phosphorus levels in habitat suitability analysis

Michigan Tech Research Institute – Satellite-derived Great Lakes Submerged Aquatic Vegetation Classification Map for aid in classification processes

Great Lakes Observing System – Great Lakes Coastal Forecasting System surface water current data

US Census Bureau – US population per county subdivision, TIGER/LINE ® county and shoreline shapefiles

NOAA Continually Updated Shoreline Product – Lake Michigan shoreline shapefile

***Software & Scripting:***

ACOLITE – Atmospheric correction, turbidity, and FAI processing

Esri ArcGIS for Desktop 10.6 – Compile data to perform geospatial analysis in the study area

QGIS – Compile data to perform geospatial analysis in the study area

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

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| ***Cladophora* Habitat Suitability Map** | Landsat 8 OLI,  Aqua MODIS | This map provides insight on where *Cladophora* grows near the shore and can be used to predict where it might come ashore. | N/A |
| ***Cladophora* Washup Predictive Map** | Landsat 8 OLI | This predictive map highlights potential locations along the shores of Lake Michigan where *Cladophora* could wash up. Once validated, GWMKE could use this map in conjunction with the *Cladophora* Habitat Suitability Map to monitor the areas with significant amounts of *Cladophora*. | N/A |
| **ArcGIS Collector *Cladophora* Monitoring Tool** | N/A | This on-the-ground monitoring tool is used to create algae washup point locations and provide detailed descriptions of the conditions, time, weather, and other factors that cause displacement of *Cladophora*. The geospatial and qualitative data points that are stored on an ArcGIS project can later be used for spatial analysis. The data collected will provide validation points to ground truth the *Cladophora* Habitat Suitability and Washup Predictive Maps. | N/A |
| ***A Stinky Situation***  **(Project Story Map)** | Landsat 8 OLI,  Aqua MODIS | The story map guides viewers through the significance of project results. This end product highlights how NASA Earth observations are used to help address environmental challenges facing local communities while also informing them how to be involved in GWMKE’s *Cladophora* cleanup initiatives in Milwaukee County. | N/A |
| **#StinkyClad**  **(Social Media Community Science Campaign Content)** | N/A | This end product provides GWMKE with social media campaign content that emphasizes GWMKE’s work in Milwaukee County and highlights how the growth of *Cladophora* affects the local community. The goal of the campaign is to encourage community members to post pictures on social media of *Cladophora* washup, which adds to the ArcGIS Collector geodatabase of washup locations, creating more ground truth points for future analysis. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team disseminated end products and project deliverables to partners at the end of the term. The ArcGIS Collector *Cladophora* Monitoring Tool and Project Story Map were created using GWMKE’s ArcGIS Online account and are thus readily accessible to partners. Social Media Campaign Content was written in a shared Google Document and is also readily accessible. Project results will be presented to any attending partners at the end-of-term event and to those unable to attend in person through a WebEx teleconference. All project deliverables and end products will be sent as a handoff package via NASA’s Large File Transfer to GWMKE.

*Project Continuation Plan*:

The continuation project team will strive to expand the study area beyond Milwaukee County to find other areas of *Cladophora* growth and more robustly incorporate surface water currents in future washup location predictive analyses. The use of community science will also be incorporated by launching a social media campaign on Twitter and Instagram, where images can be georeferenced and used to identify beaches with algae accumulations. By having *in situ* data from both the ArcGIS Collector *Cladophora* Monitoring Tool and the community science campaign, the fall 2018 team will ultimately be able to calibrate and modify the maps and models built during this term.

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**Handoff Package:**

* Project Summary
* Technical Paper
* Project Video
* Poster
* Presentation
* Shapefiles
* *Cladophora* Habitat Suitability Map
* *Cladophora* Washup Predictive Map
* ArcGIS Collector *Cladophora* Monitoring Tool
* *A Stinky Situation* Project Story Map
* #StinkyClad Social Media Campaign Content

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