**NASA DEVELOP National Program**

**2018 Summer Project Proposal**

**California – Ames**

**Lake Michigan Water Resources**

*Tracking Cladophora on Wisconsin’s Western Shores over Time using the Landsat Historical Archive and Cloud-Based Processing*

**Project Overview**

***Project Synopsis*:** This project will design an ArcMap model that will ingest *in situ Cladophora* data collected from our project partners at Groundwork Milwaukee (GWMKE). These data, along with satellite observations, will be used to identify and monitor *Cladophora* in Lake Michigan. Satellite-derived Normalized Difference Vegetation Index (NDVI) and Floating Algae Index (FAI) from Landsat 8 OLI and Sentinel-2 MSI, Surface Water Temperature (SWT) from Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS), and bathometric lidar from NOAAs Great Lakes Data Rescue Project, data will be used to design a *Cladorpha* Detection and Monitoring Model and aid in the analysis of a habitat suitability for *Cladohpora* on Wisconsin’s western shores. These products will provide useful information on a continuing basis to aid our partners in their remediation of *Cladophora* on their city beaches.

***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. This project is one of multiple Groundwork projects planned for 2018. These projects will improve Groundwork’s overall awareness of NASA Earth observations and enhance exposure to geospatial technology for the youth it engages.

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

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

***Study Period:***  2015 – 2017 (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. The Green Team, a Conservation and Green Infrastructure Workforce Development Training Program at Groundwork Milwaukee, is actively involved in the remediation of *Cladophora*. Groundwork Milwaukee 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 DEVELOP team will engage with the GWMKE Green Team, Urban Water, and Groundwork GIS teams to implement a Collector for ArcMap database that stores *in situ* data of *Cladophora* presence on city beaches. The teams will collect data over the summer 2018 term that will be used for model validation in a future term project. GWMKE and the DEVELOP team will also explore using Instagram to collect citizen science data as another *in situ* data sources, effectively involving the greater Milwaukee beach communities. There will be bi-weekly telecon 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 research term in the form of a WebEx teleconference. All deliverables and result maps will be sent via NASA’s Large File Transfer (LFT). This project will require software release. A video tutorial will be made by the team, and it will accompany a read me file and well a commented code in a tool handoff package (THP). The THP will be delivered by the Center Lead once the code has been approved for release.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Remote Sensing and Surface Reflectance | The team derive water quality parameters, optical water depth, NDVI, and the FAI to identify potential locations of *Cladophora.* |
| **Landsat 7 TM** | Remote Sensing and Surface Reflectance | The team derive water quality parameters, optical water depth, NDVI, and the FAI to identify potential locations of *Cladophora.* |
| **Sentinel-2 MSI** | Remote Sensing and Surface Reflectance | The team derive water quality parameters, optical water depth, NDVI, and the FAI to identify potential locations of *Cladophora.* |
| **Aqua MODIS** | Surface water temperature, Colored  Dissolved Organic  Matter (CDOM) | Assess surface water temperature during *Cladorpha* growth season for habitat suitability analysis. |
| **Terra MODIS** | Irradiance/ Reflectance | Surface reflectance for FAI to identify locations of *Cladophora*. |

***Ancillary Datasets:***

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

Great Lakes Data Rescue Project – Download Lake Michigan Bathymetry to 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 Detection and Monitoring Tool** | This model will allow for continued monitoring of *Cladophora*. Presence time accumulation raster’s will inform partners on location of *Cladophora* that have been on shore longer and should be prioritized for cleanup. | The team will build a model inside ArcMap that conducts regression tree analysis on rasters derived from Landsat 8 OLI, Sentinel-2 MSI, and Aqua and Terra MODIS and to produce a Cladophora Presence raster. Multiple dates will be layered to produce presence time accumulation raster’s for locations of *Cladophora* mats. | I |
| **Cladophora Habitat Suitability Map** | Identifying suitable habitats for *Cladophora* will help train the above model and help our partners better understand where to target their resources for cleanup and mitigation. | Using the Landsat archive, Sentinel-2 MSI, Aqua and Terra MODIS, and bottom type classifications of Lake Michigan these data will be used in a classification tree to identify habitat suitability for *Cladophora* and investigate different factors that influence the displacement of this algae. | N/A |
| **Lake Michigan Water Resources Story Map** | This story map will walk a viewer through the purpose of the project, initial results, and community benefits of this partnership as well as the use of Earth observations for answering environmental questions. It will also teach community member on how to get involved in monitoring *Cladophora*. This will be hosted by GWMKE. | N/A | N/A |

***End-User Benefit*:** Groundwork Milwaukee, is actively involved in the remediation of *Cladophora*; with this project, Groundwork Milwaukee will be able to better assess when and where the *Cladophora* will wash up on the city’s beaches. This project will save our partners both time and money when planning for weather events and summer algae 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(Proposed Term):** 2018 Summer (ARC) – Lake Michigan Water Resources
  + This term will build a *Cladophora* Detection and Monitoring model that would ingest Collector for ArcGIS data points gathered by GWMKE’s youth programs during the summer 2018. It will also produce a habitat suitability analysis identifying locations for *Cladophora* growth. The detection of *Cladophora* will allow the second term up to determine the best method to track *Cladophora* and where it is moving. This tool will aid in the advanced planning of resource allocation by our partners, saving them both time and money.
* **Term 2:** 2018 Fall (ARC) – Lake Michigan Water Resources II
  + The second term will produce a historical time series identifying *Cladophora* growth in the past. The summer 2018 *in situ* data will be used to validate this hind cast model and assess if the location for good habitat suitability tracks over time, then adjusting the model as needed to provide the highest accuracy for long term *Cladophora* detection. These tools will allow our partners to be more competitive when applying for the city’s *Cladophora* cleanup bid as well as provide them a validated tool that can be used for long term monitoring.

***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:**

***References:***

Auer, M. T., Tomlinson, L. M., Higgins, S. N., Malkin, S. Y., Howell, E. T., & Bootsma, H. A. (2010). Great

Lakes *Cladophora* in the 21st century: same algae—different ecosystem. *Journal of Great Lakes Research, 36*(2), 248-255. doi:10.1016/j.jglr.2010.03.001

Botha, E. J., Brando, V. E., Anstee, J. M., Dekker, A. G., & Sagar, S. (2013). Increased spectral resolution

enhances coral detection under varying water conditions. *Remote Sensing of Environment, 131*, 247-261. doi:10.1016/j.rse.2012.12.021

Brooks, C., Grimm, A., Shuchman, R., Sayers, M., & Jessee, N. (2015). A satellite-based multi-temporal

assessment of the extent of nuisance *Cladophora* and related submerged aquatic vegetation for the Laurentian Great Lakes. *Remote Sensing of Environment, 157*, 58-71. doi:10.1016/j.rse.2014.04.032

Dörnhöfer, K., & Oppelt, N. (2016). Remote sensing for lake research and monitoring – Recent advances.

*Ecological Indicators, 64*, 105-122. doi:10.1016/j.ecolind.2015.12.009

Garrison, P. J., Greb, S. R., & LaLiberte, G. (2008). *Western Lake Michigan nearshore survey of water chemistry and Cladophora distribution, 2004-2007*. Retrieved April 12, 2018, from <https://dnr.wi.gov/files/PDF/pubs/ss/SS1038.pdf>

Greb, S., Garrison, P., & Pfeiffer, S. (2004). *Cladophora and water quality of Lake Michigan:*

*A systematic survey of Wisconsin*. Retrieved from <http://dnr.wi.gov/topic/greatlakes/documents/DNR_ResearchSummary2004.pdf>

Kutser, T., Vahtmäe, E., & Martin, G. (2006). Assessing suitability of multispectral satellites for mapping

benthic macroalgal cover in turbid coastal waters by means of model simulations. *Estuarine, Coastal and Shelf Science, 67*(3), 521-529. doi:10.1016/j.ecss.2005.12.004

Shuchman, R.A., Sayers, M.J. & Brooks, C.N. (2013). Mapping and monitoring the extent of submerged

aquatic vegetation in the Laurentian Great Lakes with multi-scale satellite remote sensing. *Journal of Great Lakes Research, 39*, 78-89. https://doi.org/10.1016/j.jglr.2013.05.006

Wan, W., Li, H., Xie, H., Hong, Y., Long, D., Zhao, L., . . . Yang, W. (2017). A comprehensive data set of

lake surface water temperature over the Tibetan Plateau derived from MODIS LST products 2001–2015. *Scientific Data, 4*, 170095. doi:10.1038/sdata.2017.95