**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Alabama – Marshall**

**Puget Sound Water Resources**

*Evaluating Methods for Identification and Monitoring of Factors in the Puget Sound that Indicate Eutrophication and Hypoxia*

**Project Overview**

***Project Synopsis*:** Eutrophication and subsequent lowered dissolved oxygen levels have increased in the Puget Sound, negatively impacting water quality and wildlife. The Pacific States Marine Fisheries Commission (PSMFC) Habitat Program partners with communities and organizations to maintain water quality and preserve watersheds and estuaries on the West Coast. DEVELOP will partner with the Habitat Program to map harmful algal blooms and create a tool that identifies probable areas of eutrophication using data from Aqua and Terra MODIS, Sentinel-2, and Landsat 8 OLI. The team will validate the tool with boat and buoy sample sites that collect chlorophyll concentration, dissolved oxygen content, turbidity, and salinity data from the Northwest Association of Networked Ocean Observing Systems (NANOOS). The Eutrophication Identification Tool, Harmful Algal Bloom (HAB) Hotspots Map, and Seasonal Water Quality Time Series Analysis will be used to fill geographic and temporal gaps in data available to the PSMFC Habitat Program and will further inform local decision-making practices and management.

***Community Concern:*** According to the Environmental Protection Agency, dissolved oxygen (DO) levels have been declining in the Puget Sound since 2000. Decreases in DO levels are due to eutrophication, the introduction of an excess of a limiting nutrient that encourages a spike in algal growth that can result in hypoxic, or even anoxic, waters. Hypoxia directly reduces populations of sessile organisms, such as geoduck clams, that are an important economic commodity for rural counties in Washington State. Eutrophication and hypoxia also increase the potential for fish kill events in the Puget Sound and have indirect negative impacts on mobile species, such as reduced feeding and growth rates, as well as enhanced vulnerability to predators. In addition, some algal blooms produce toxins that negatively impact the health of people living nearby.

***Source of Project Idea:*** This project developed from discussions between DEVELOP advisors and Alabama – Marshall node leadership. Stephen Phillips, Senior Program Manager of Aquatic Invasive Species Program at the Pacific States Marine Fisheries Commission, communicated that this project and its end-products would complement the activities of their Habitat Program.

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

***Study Location:*** WA

***Study Period:*** June2002 – September 2016

***Advisors:*** Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), Dr. Robert Griffin (University of

Alabama in Huntsville), Leigh Sinclair (University of Alabama in Huntsville/Information Technology and

Systems Center), Maggi Klug (University of Alabama in Huntsville)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Pacific States Marine Fisheries Commission, Habitat Program** | Fran Recht, Habitat Program Manager | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:*** The PSMFC aims to protect and manage fisheries in over five states, including Washington’s Puget Sound. The PSMFC’s Habitat Program conserves and restores watersheds and estuaries. The Habitat Program has a non-voting seat on the Pacific Fishery Management Council as well as on the Habitat Committee, advising the Council on protection of essential fish habitats. Monitoring eutrophication and hypoxia is essential considering their effect on fish habitat. The Habitat Program also provides water quality management advice to communities and organizations. Currently, eutrophication and hypoxia are monitored in the Puget Sound using seaplanes, ferries, and moored instruments.

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

*Pacific States Marine Fisheries Commission, Habitat* *Program* – PSMFC produces the fish health and habitat databases StreamNet and CalFish which are disseminated through the Habitat Program’s website. These datasets demonstrate the ability of the Habitat Program to utilize GIS data; however, the predominance of *in situ* observations as data sources demonstrates that there is room for growth in terms of incorporating point data coupled with NASA Earth observations into the organization’s decision-making practices.

***Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Pacific States Marine Fisheries Commission, Habitat* *Program* –The Habitat Program supports fish habitat conservation and restoration, including recycling of marine debris. The Habitat Program works with fishermen and communities, serves as the grant coordinator for the Oregon Watershed Enhancement Board, and serves on the boards of the Oregon Central Coast Estuarine Collaborative, MidCoast Watersheds Council, and the Salmon Drift Creek Watersheds Council. The products created by the Puget Sound Water Resources team will be used by the Habitat Program to benefit their goals in partnership with these organizations and communities.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The project lead will be the main POC for communication with the project partners. Teleconferences will be held with the project partner every one to two weeks throughout the term.

***Transition Plan*:** Eutrophication Identification Tool, HAB Hotspots Map, Water Quality Time Series Analysis, tutorials, and deliverables will be shared with the end user via Google Drive folder at the end of the term. A conference call will be held to present findings from the project and field questions about products and a virtual workshop will be conducted to demonstrate use of the tool.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | Spectral signatures from Landsat 8 OLI will be used to identify turbidity, an indicator of water quality. |
| **Aqua MODIS** | Chlorophyll-a concentration, surface reflectance | Spectral signatures from Aqua MODIS will be used to identify factors indicative of eutrophication: Colored Dissolved Organic Matter and turbidity. Additionally, the MODIS chlorophyll-a product will be used to assess chlorophyll-a concentration. |
| **Terra MODIS** | Chlorophyll-a concentration, surface reflectance | Spectral signatures from Terra MODIS will be used to identify factors indicative of eutrophication: Colored Dissolved Organic Matter and turbidity. Additionally, the MODIS chlorophyll-a product will be used to assess chlorophyll-a concentration. |
| **Sentinel-2 MSI** | Surface reflectance | Spectral signatures from Sentinel-2 will be used to identify chlorophyll-a concentrations and colored dissolved organic matter. |

***Ancillary Datasets:***

Northwest Association of Networked Ocean Observing Systems (NANOOS) *in situ* Salish Cruise and Buoy Chlorophyll Concentration, Turbidity and Dissolved Oxygen Data – Used to validate the eutrophication identification tool

***Software & Scripting:***

Esri ArcGIS 10.4 – Process Landsat 8 and Aqua MODIS imagery, create tool, produce map

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Eutrophication Identification ArcMap Model Builder Tool** | This tool will be used to identify suitability for harmful algal bloom (HAB) events. The partner will use the tool to pinpoint areas that may need more resources during conservation and water quality efforts. This tool complements the geographic and temporal limitations of *in situ* data collection. | Aqua MODIS and Landsat 8 OLI will be processed to detect chlorophyll-a concentrations, turbidity levels, and dissolved oxygen counts and then analyzed in ArcMap 10.4 to determine habitat suitability for eutrophication events. This tool will be created via Model Builder. Results will be validated by boat and buoy data from the region. | N/A |
| **HAB Hotspots Map** | The partner will use the HAB Hotspots Map to identify areas that historically have had more HAB events, and thus may require special monitoring and care because of their location or other variables. | The map will display areas within the Puget Sound that have historically had a greater number of HAB events identified using the Eutrophication Identification Tool on past EO data and validated with *in situ* data. | N/A |
| **Water Quality Time Series Analysis** | This analysis will give the partner more information about where eutrophication events tend to occur by showing how eutrophication suitability parameters change geographically and seasonally within the Puget Sound. | This time series will be created from data from Aqua and Terra MODIS and Landsat 8, processed to show how eutrophication indicators change throughout the study period. It will be validated with *in situ* boat and buoy data. | N/A |

***End-User Benefit*:** The team will create a tool using the Model Builder in ArcMap that overlays chlorophyll-a concentrations, turbidity, and dissolved oxygen levels to display suitability for eutrophication (i.e. probability of a hypoxic event). Incorporating satellite data into the PSMFC’s repertoire will enhance their sample site monitoring practices and provide more robust material for outreach programs, thus increasing the efforts towards improving water quality.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Spring

***Related DEVELOP Work:***

Summer 2015 (PHB) – Virginia Water Resources: Monitoring Harmful Algal Blooms through NASA Earth Observations in the James River for Improved Water Management

Summer 2015 (ARC) – Mexico Water Resources: Utilizing NASA Earth Observations to Detect Factors Contributing to Hypoxic Events in the Southern Gulf of Mexico

Spring 2017 (ARC) – Lake Erie Water Resources: Utilizing Satellite Multispectral and Airborne Hyperspectral Imagery to Identify Annual and Seasonal Trends of Harmful Algal Blooms and Resulting Water Quality in Lake Erie’s Western Basin

Spring 2017 (LaRC) – Chesapeake Bay Water Resources: Assessing Water Clarity to Identifiy Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

Summer 2017 (LaRC) – Chesapeake Bay Water Resources II: Assessing and Assisting Monitoring Efforts of Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

Summer 2017 (LaRC) – Miami Beach Water Resources: Assessing the Feasibility of Using NASA Earth Observations to Monitor Trends in Runoff and Storm Water Discharge of the Biscayne Bay

**Notes & References:**

***References:***

Department of Ecology: State of Washington (n.d.). Marine water quality monitoring. Retrieved November 27, 2017 from http://www.ecy.wa.gov/programs/eap/mar\_wat/index.html

Environmental Protection Agency (2017). Marine water quality*. Salish Sea Report.* Retrieved September 18, 2017 from www.epa.gov/salish-sea/marine-water-quality Last Updated May 15, 2017

Toming, K., Kutser, T., Laas, A., Sepp, M., Paavel, B., and Noges, T. (2016). First experiences in mapping lake water quality parameters with Sentinel-2 MSI imagery. *Remote Sensing*, 8(8). Retrieved 27, 2017 from http://www.mdpi.com/2072-4292/8/8/640