**NASA DEVELOP National Program**

**Alabama – Marshall**

*Project Summary – Spring 2018*

**Puget Sound Water Resources**

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

**VPS Title:** Oxygenless in Seattle: Identifying and Monitoring Eutrophication in the Puget Sound

**Project Team**

***Project Team*:**

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**Project Overview**

***Project Synopsis*:** Eutrophication and harmful algal blooms (HAB), which have become more prevalent in the Puget Sound since 2000, have led to negative impacts on water quality and wildlife. NASA DEVELOP at Alabama – Marshall partnered with the Pacific States Marine Fisheries Commission (PSMFC) Habitat Program to identify the most accurate methods for monitoring water quality in the Puget Sound. The products developed during this project will help the PSMFC Habitat Program determine areas at a higher risk of HAB events and further inform local decision-making practices and management of water resources.

***Abstract*:**

Dissolved oxygen levels have been declining in the Puget Sound since 2000 due to eutrophication, resulting in harmful algal bloom (HAB) events, which negatively impact water quality and wildlife in the area. Therefore, analyzing and identifying eutrophication and hypoxic events is integral to water quality control and watershed management. The Puget Sound Water Resources team partnered with the Pacific States Marine Fisheries Commission (PSMFC) Habitat Program to test methods for monitoring water quality using remote sensing. The team tested multiple algorithms utilizing Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) data to detect turbidity and chlorophyll concentrations. Results will assist the PSMFC Habitat Program to fill geographic and temporal data gaps and to enhance local decision-making practices and management of water resources.

**Keywords:**

Sentinel-2 MSI, Landsat 8 OLI, dissolved oxygen, turbidity, harmful algal bloom

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

***Study Location:*** Puget Sound, WA

***Study Period:*** 2013 – 2017 (May – October)

***Community Concern:***

* Hypoxia and eutrophication have become more prevalent in the Puget Sound since 2000.
* Due to lower oxygen levels, HABs are impacting populations of sessile organisms, such as geoduck clams, which are important to the local economy.
* HABs increase potential for fish kill events, which indirectly impact other species in the area by posing a health risk if consumed.
* Domoic acid levels, produced by the algae strain *pseudo-nitzchia*, have been increasing during HAB events and are hazardous to human health.

***Project Objectives:***

* Provide the PSMFC with a resource to bridge spatial gaps in *in situ* data by assessing the suitability of 9 algorithms utilizing Sentinel-2 MSI and Landsat 8 OLI data processed through ACOLITE to most accurate algorithms to identify indicators of HAB events within the Puget Sound
* Aid project partners in enhance water quality management by identifying areas that are historically prone to development of HABs

**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 |

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

The PSMFC aims to protect and manage fisheries in over five Pacific states through their Habitat Program, which focuses on the conservation and restoration of watersheds and estuaries. The Habitat Program has a non-voting seat on the Pacific Fishery Management Council, as well as on the Habitat Committee. They advise the Council on protection of essential fish habitats, where monitoring eutrophication and hypoxia is essential. The Habitat Program also provides water quality management advice to communities and organizations. Currently, seaplanes, ferries, and moored instruments are used to monitor eutrophication and hypoxia in the Puget Sound.

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

The PSMFC Habitat Program will use the results of this project to monitor factors indicative of eutrophication, specifically chlorophyll-a concentrations, turbidity, and sea surface temperature. Incorporating the most statistically accurate algorithms and sensors for each parameter within the Puget Sound region will allow the PSMFC to monitor these water quality indicators with greater spatial and temporal resolution and to pinpoint areas that may need further attention. This will provide PSMFC with more robust material for outreach programs and enhance their efforts towards improving water quality.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI spectral signatures were processed to identify turbidity and chlorophyll-a concentrations. |
| **Sentinel-2 MSI** | Surface reflectance | Spectral signatures from Sentinel-2 MSI were used to identify turbidity and chlorophyll-a concentrations. |

***Ancillary Datasets:***

State of Washington Department of Ecology Marine Water Monitoring *in situ* buoy Chlorophyll-a Concentration, and Water Temperature data – Determine accuracy of algorithms and validate final maps

King County Mooring *in situ* buoy Chlorophyll-a Concentration, Turbidity, and Water Temperature data – Determine accuracy of algorithms and validate final maps

National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center *in situ* buoy

Chlorophyll-a Concentration, and Water Temperature data – Determine accuracy of algorithms and validate final maps

***Software & Scripting:***

ACOLITE – Process Landsat 8 OLI and Sentinel-2 MSI imagery to determine chlorophyll-a concentrations and turbidity

Esri ArcGIS 10.4 – Process Landsat 8 OLI, Aqua MODIS, and Sentinel-2 MSI imagery, create Model Builder Tool, produce maps

Rstudio – Conduct statistical analysis to compare *in situ* and remotely sensed data

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Chlorophyll & Turbidity Time Series Analysis** | Landsat 8 OLI | The analysis will give the partner information identifying where HAB events tend to occur using algorithms within ACOLITE that show how HAB suitability parameters change geographically within the Puget Sound. | N/A |
| **ACOLITE Tutorial** | Landsat 8 OLI  Sentinel-2 MSI | The tutorial will explain the methods used within ACOLITE. This will allow the project partner to recreate project work and change settings within ACOLITE for better accuracy in the future. | N/A |
| **Buoy Interpolation & ACOLITE Analysis Maps** | Landsat 8 OLI  Sentinel-2 MSI | The analysis will provide the partner with an assessment of the utility of algorithms processed through ACOLITE along with additional GIS techniques for filling in spatial gaps in *in situ* data. | N/A |

**Project Handoff Package**

**Transition Plan:**

HAB Factors Identification Tool, HAB Hotspots Map, HAB 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.

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**Partner POC**: Fran Recht, franrecht@gmail.com

**Handoff Package:**

* Chlorophyll & Turbidity Time Series Analysis
* ACOLITE Tutorial
* Buoy Interpolation & ACOLITE Analysis Maps

**References:**

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