**Puget Sound Water Resources**

*Using Earth Observations to Map Bull Kelp in the Puget Sound, Washington to Support Conservation and Restoration*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

The Puget Sound Water Resources project team evaluated the feasibility of using remote sensing methods to detect and map nearshore kelp beds throughout the Central Puget Sound of Washington. Project partners at the Port of Seattle and Washington State Department of Natural Resources will use these results to enhance their understanding of remote sensing as a kelp monitoring tool. The partners are interested in broadening their kelp monitoring methods as kelp beds provide critical ecosystem services and habitat, improve nearshore water circulation patterns, and hold tremendous cultural significance to the Coast Salish peoples who have inhabited the region since time immemorial.

***Abstract:***

Bull kelp (*Nereocystis luetkeana*) is a critical component of nearshore ecosystems in the Puget Sound region of the Salish Sea. The Port of Seattle and Washington State Department of Natural Resources (DNR) have identified possible reductions in bull kelp extent and presence throughout the Central Puget Sound near Seattle, Washington. Bull kelp losses threaten critical ecological services and marine habitat, as well as important cultural resources for the Coast Salish peoples. The Port of Seattle and Washington DNR partnered with NASA DEVELOP to examine the current extent of the near-shore urban kelp beds as well as develop a time series highlighting changes in kelp presence and extent over the last 10 years. The NASA DEVELOP team utilized the Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI) to assess the feasibility of remote sensing as a kelp canopy monitoring tool. The results show that satellite-based remote sensing may be an effective tool for mapping and monitoring kelp. However, there are a variety of challenges that need to be addressed in this approach before it can be an effective means for identifying nearshore urban kelp beds.

***Key Terms:***

Bull kelp, remote sensing, conservation, Landsat 8 OLI, Sentinel-2 MSI, macroalgae

***National Application Areas Addressed:*** Water Resources

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

***Study Period:*** June 2016 to September 2021

***Community Concerns:***

* Bull kelp provides crucial habitat and nutrients to many species in the Puget Sound ecosystem, including endangered, threatened, and economically significant marine animals. Reduced abundance of bull kelp diminishes its ability to provide these ecosystem services within Puget Sound.
* Bull kelp has cultural and historical significance among communities in the region and contributes to traditional knowledge and spiritual aspects of the Coast Salish people.
* Long-term data indicate declines of bull kelp extent in Puget Sound; however, significant research gaps exist in understanding the driving forces. Because the drivers of kelp decline vary regionally, it is crucial to improve local understanding of the trends and stressors impacting kelp in Puget Sound in order to develop appropriate management responses.

***Project Objectives:***

* Evaluate the capability of Landsat 8 OLI and Sentinel-2 MSI data for mapping and monitoring bull kelp extent in Puget Sound
* Produce map of 2021 bull kelp extent
* Analyze changes in bull kelp extent over time by creating time series maps from 2016 to 2021

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Port of Seattle** | Kathleen Hurley, Senior Environmental Program Manager, Maritime Environment & Sustainability; Jon Sloan, Interim Director, Maritime Environment & Sustainability | End User |
| **Washington State Department of Natural Resources** | Cinde Donoghue, Program Manager, Aquatic Assessment and Monitoring Team | End User |

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

The Washington State Department of Natural Resources (WADNR) and the Port of Seattle, in partnership with several other stakeholders, are prioritizing the recovery and conservation of bull kelp in the Puget Sound region. Bull kelp has ecological and cultural importance in the region, and has experienced declines in the past decades due to anthropogenic and environmental impacts. In pursuit of creating a thorough conservation and recovery plan, many studies have used field observations carried out on the water or unmanned aerial vehicle imagery to better understand the extent and trends of bull kelp around the Puget Sound. These methods are time-intensive and costly. Partners want to know where bull kelp still exists, to improve their existing kelp protection, restoration, and mitigation efforts.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 Operational Land Imager (OLI)** | Normalized Difference Vegetation Index (NDVI) | This dataset provides spectral indices used for mapping current as well as past bull kelp extent within the study area. |
| **Sentinel-2 Multispectral Instrument (MSI)** | Normalized Difference Vegetation Index (NDVI), Normalized Difference Red-Edge Blue (NDREB) | This dataset provides spectral indices used for mapping current as well as past bull kelp extent within the study area. |

***Ancillary Datasets:***

* National Oceanic and Atmospheric Administration Tides and Currents – Tide and current information used to select imagery that shows kelp extent at low and mid tide, the optimal canopy visibility conditions
* Kelp Occurrence Locations – Partner-provided linear extents of known bull kelp forests obtained from boat surveys
* Finlayson D.P. Combined bathymetry and topography of the Puget Lowland, Washington State. University of Washington, (2005) (http://www.ocean.washington.edu/data/pugetsound/) – Depth raster data used to define the study area for mapping kelp growing at depths of approximately 12 to 40 feet
* Northwest Straits Commission Annual Kelp Surveys – Locations of known bull kelp forests obtained from kayak surveys for [model calibration and validation]

***Software & Scripting:***

* Google Earth Engine – Imagery acquisition, initial large-scale analysis, and image exploration
* R 4.1.3 – Statistical analysis and data visualization
* Esri ArcGIS Pro 3.0.0– Visualization and cartography as well as other analysis and end product generation for partner handoff

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Kelp Mapping Feasibility Assessment** | Landsat 8 OLISentinel-2 MSI | Partners will gain understanding of the utility of satellite Earth observations for mapping nearshore bull kelp beds in the Puget Sound | N/A |

***Product Benefit to End User:***

The project investigates the feasibility of remote sensing as a kelp forest management tool for the project partners. The end product will improve partners’ understanding of how to monitor changes in urban kelp extent in the Puget Sound in response to anthropogenic or environmental stressors. Remote sensing has not been used in this capacity in Puget Sound before, so these products represent an initial exploration of a new kelp management tool for the project partners.

**References**

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