**South Slough Water Resources**

*Monitoring Changes in Water Quality to Identify Stressors in Eelgrass Extent Throughout the Coos Estuary*

**Project Team**

***Project Team:***

Maya Hall (Project Lead)

Gabriel Halaweh

Sean McCollum

Zoë Siman-Tov

***Advisors & Mentors:***

Dr. Juan Torres-Pérez (NASA Ames Research Center)

Dr. Liane Guild (NASA Ames Research Center)

Britnay Beaudry (Bay Area Environmental Research Insitute, NASA Ames Research Center)

***Fellow:***

Lisa Tanh (California – Ames)

***Team Contact:*** Maya Hall, mayaLhall@gmail.com

***Partner Contact:*** Alicia Helms, alicia.r.helms@dsl.oregon.gov; Janet Niessner, jniessner@ctclusi.org

**Project Overview**

***Project Synopsis:***

In Oregon’s Coos Estuary, the extent of eelgrass (*Zostera marina*) meadows has decreased substantially since 2005. The project team used remote sensing data to create a water quality time series and map eelgrass extent between the years 2016 and 2023 to better understand the conditions driving eelgrass decline. The team found that remote sensing techniques are viable for visualizing broad water quality trends, but feasibility of mapping eelgrass with NASA and ESA data is limited in the Coos Estuary.

***Abstract:***

The Coos estuary in Southern Oregon supports a variety of habitats, including eelgrass (*Zostera marina*) meadows. Eelgrass meadows provide habitat to local and migratory wildlife, including commercially important fishes, and cultural resources to local communities. These ecosystem services establish eelgrass as an ecologically, economically, and culturally important resource. However, the extent and density of eelgrass meadows within this estuary have declined substantially since 2005, threatening the ecosystem services they provide. NASA DEVELOP partnered with the South Slough National Estuarine Research Reserve and the Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians’ Department of Natural Resources to generate time-series maps of the water quality conditions (chlorophyll-a, turbidity) and eelgrass extent in the Coos estuary from 2016 to 2023 to better understand the conditions driving eelgrass decline. The DEVELOP team used NASA Earth observations including Landsat 8 Operational Land Imager (OLI), Landsat 9 OLI-2, and the European Space Agency’s Sentinel-2 Multispectral Instrument (MSI) to generate these time-series maps. The team faced limitations in the feasibility of detecting eelgrass within the Coos Estuary, including spectral resolution, tidal phase, and turbidity. These limitations indicate additional *in situ* data collection will be necessary for accurate eelgrass assessment. Meanwhile, the team determined it is feasible to assess turbidity and chlorophyll-*a* within the Coos Estuary using remote satellite data. These tools enabled the research partners to assess water quality characteristics within the Coos Estuary at a greater spatial scale and may provide a method of inexpensive preliminary investigation of eelgrass meadow locations.

***Key Terms:***

eelgrass, remote sensing, Sentinel-2, marine heat waves, submerged aquatic vegetation, water quality

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

***Study Location:*** Coos Estuary, OR

***Study Period:*** January 2016 to July 2023

***Community Concerns:***

* Due to climate change, eelgrass meadows have been in decline. This decline has a ripple effect through the decrease of the important functions of eelgrass in the Coos Estuary.
* The Coos Estuary is one of Oregon’s largest estuaries and is home to many eelgrass meadows which act as nursery habitats for commercially important fish, crabs, and clams.
* This eelgrass serves many other ecosystem services to both humans and wildlife. For example, eelgrass acts as a carbon sink, reduces erosion, and produces oxygen.
* Additionally, eelgrass provides a valuable recreation space that promotes community wellbeing and connects the general public with nature.

***Project Objectives:***

* Test the feasibility of assessing eelgrass extent using remote sensing methods
* Produce time-series map of eelgrass extent from 2016 to 2023
* Conduct time-series analyses of water quality conditions (turbidity and chlorophyll-*a*) from 2016 to 2023
* Generate Google Earth Engine tutorial to equip partners with remote sensing methods

**Partner Overview**

***Partner Organization(s):***

|  |  |  |
| --- | --- | --- |
| **Organization(s)** | **Contact (Name, Position/Title)** | **Partner Type** |
| **South Slough National Estuarine Research Reserve** | Alicia Helms, Estuarine Monitoring CoordinatorJenni Schmitt, Watershed Monitoring CoordinatorJennifer Kirkland, GIS Specialist | End User |
| **Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians’, Department of Natural Resources** | Janet Niessner, Water Protection Specialist and Biologist | End User |

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

The South Slough National Estuarine Research Reserve (SSNERR) monitors and conducts research on the ecology and health of the Coos Estuary. Their research primarily consists of water quality monitoring, eelgrass density counts, and watershed management. The Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians’ (CTCLUSI) Department of Natural Resources conserve and manage resources on Tribally-held lands. They focus on habitat conservation and restoration, as well as climate change mitigation and water quality management. Both of these end users rely heavily on *in situ* measurements and field work to obtain data and would benefit from incorporating NASA Earth observations into their methodologies and monitoring strategies.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | NDVI, NDTI, NDCI, SAV | We processed data from Landsat 8 and 9 for our analysis but ultimately used Sentinel 2 data as it has a finer spatial resolution. |  |
| **Landsat 9 OLI-2** | NDVI, NDTI, NDCI, SAV | We processed data from Landsat 8 and 9 for our analysis but ultimately used Sentinel-2 data as it has a finer spatial resolution.  |
| **Sentinel-2 MSI** | NDVI, NDTI, NDCI, SAV | This data was used for all of our analysis, including quantifying eelgrass extent.  |

***Ancillary Datasets:***

* Pacific Marine and Estuarine Partnership West Coast Eelgrass Habitat – Eelgrass extent map geodatabase package
* National Estuarine Research Reserve System Centralized Data Management Office Real Time Monitoring Data – South Slough water parameter *in-situ* data utilized for analyses
* Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians Water Quality Station Data – *In-situ* data of water parameters, used for analyses

***Modeling:***

* Optical Reef and Costal Area Assessment tool (ORCAA) (POC: Hayley Pippin, NASA DEVELOP) – Water quality data acquisition, extraction, and analysis.

***Software & Scripting:***

* ArcGIS Pro 3.1.0 – Classification, indexing, and mapping of multispectral imagery
* R 2023.06.1+524 – Data Plotting with the ggplot2, dplyr, zoo, ggpubr, and patchwork libraries
* Python 3.10.12 – Data plotting with the pandas and matplotlib libraries

***End Product(s):***

|  |  |  |
| --- | --- | --- |
| **End Product(s)** | **Earth Observations Used**  | **Partner Benefit & Use** |
| **Normalized Difference Turbidity Index Time Series Maps** | Sentinel-2 MSI | This product shows our partners the levels of turbidity in the estuary between the years 2016 and 2023 to demonstrate runoff origin and direction. Additionally, the turbidity maps demonstrate water clarity in the estuary and where turbidity restricts both eelgrass photosynthesis potential and the team’s remote sensing data.  |
| **Normalized Difference Chlorophyll Index 3-Year Time Series Maps** | Sentinel-2 MSI | This product shows our partners the levels of Chlorophyll-*a* in the estuary to understand where higher nutrient concentrations and algal blooms are occurring. Additionally, the Chlorophyll-*a* maps provide information about water quality conditions in the estuary and where algae presence restricts the team’s remote sensing data.  |
| **Normalized Difference Aquatic Vegetation Index 3-Year Time Series Maps** | Sentinel-2 MSI | These maps show where submerged aquatic vegetation is present in the estuary. This index is sensitive to photosynthetic organisms beneath the surface of the water and may reveal where eelgrass is likely to be present.​​ |
| **Support Vector Machine Classification Maps** |  Sentinel-2 MSI  | These maps are classifications of eelgrass extent produced from Support Vector Machine classification. The maps show where eelgrass was identified with remote sensing data.  |
| **Modified ORCAA Tool Tutorial** | Sentinel-2 MSI  | This tutorial demonstrates the usage of ORCAA, an interactive tool, which will allow our partners to obtain satellite data, run basic water quality analyses, and display and export figures. This tutorial explains how to utilize this tool, which was created by a previous DEVELOP team, and was modified in Google Earth Engine. |
| **Excel Tutorial** | Sentinel-2 MSI | These interactive spreadsheets allow the partners to easily combine and manipulate their multiple in situ water quality monitoring datasets in CSV format.  |

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

The team demonstrated that using satellite spectral data to remotely sense eelgrass extent in Coos Estuary has limited feasibility. Additionally, the team equipped the research partners with the ability to replicate eelgrass extent maps and improve the accuracy and application of these methods with guiding future directions. In addition to assessing the eelgrass extent, the team conducted time-series analyses of turbidity and chlorophyll-a that informed the partners of spatial and temporal patterns in these metrics. The team instructed the partners in how to conduct these analyses to enable them to continue investigating patterns of water quality change in the Coos Estuary. These analyses will allow the partners to assess the relationships between water quality changes and eelgrass decline as well as identify areas of concern. This will inform land management decisions to prioritize the health and sustainability of eelgrass meadows within the Coos Estuary.

**References**

Jarrin, M. J., Sutherland, D. A., Helms, A. R. (2022). Water temperature and variability in the Coos estuary

and its potential link to eelgrass loss. *Frontiers in Marine Science, 9*. <https://doi.org/10.3389/fmars.2022.930440.>

Orth, R. J., Carruthers T. J. B., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L, Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Olyarnik, S., Short, F. T., Waycott, M., Williams, S. L. (2006). A Global Crisis for Seagrass Ecosystems. *BioScience*, *56(12*), 987–996. <https://doi.org/10.1641/0006-3568.>

Rumrill, S. S. (2007). The ecology of the South Slough estuary: Site profile of the South Sough Estuarine Research Reserve. Oregon Department of State Lands. [https://digital.osl.state.or.us/islandora/object/osl:14084](https://digital.osl.state.or.us/islandora/object/osl%3A14084)