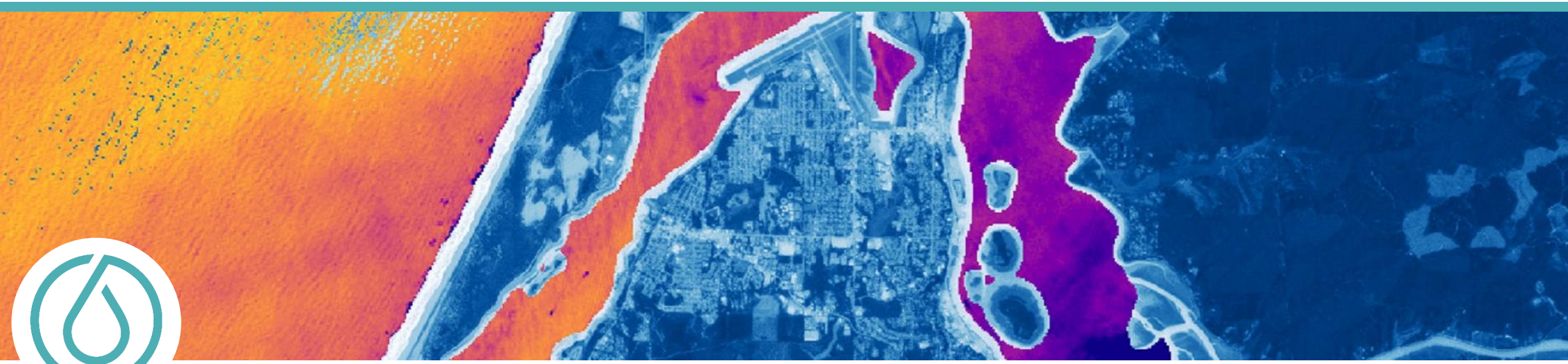
National Aeronautics and Space Administration



South Slough Water Resources

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

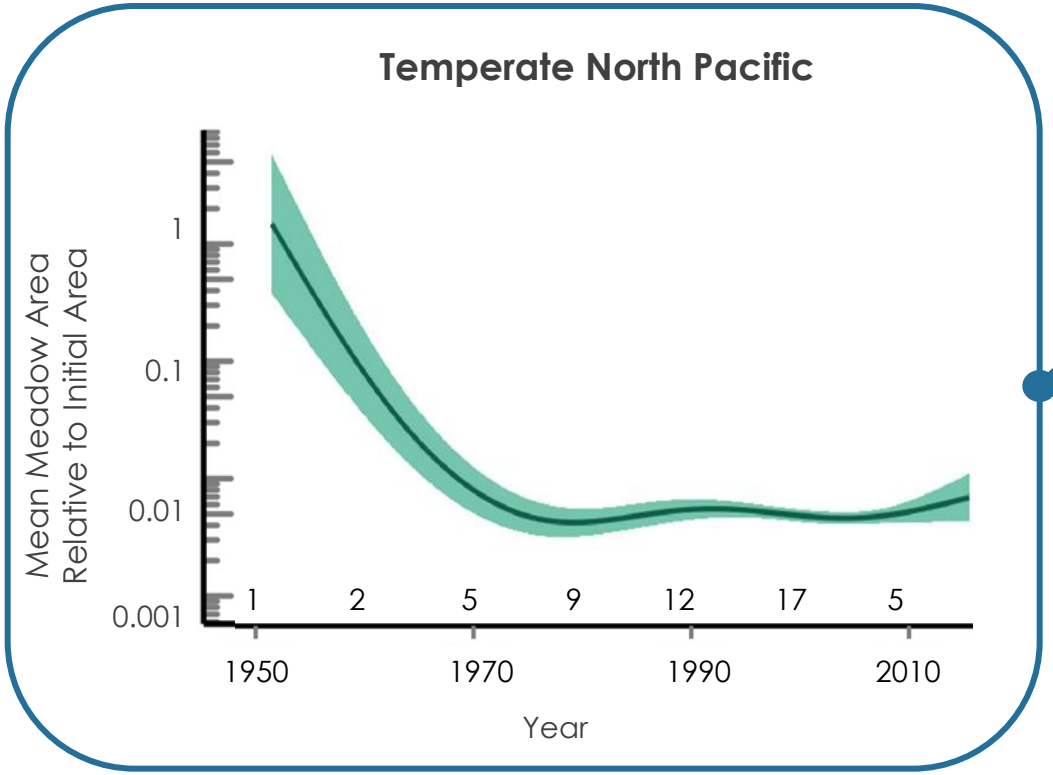
Maya Hall • Gabriel Halaweh • Sean McCollum • Zoë Siman-Tov

25TH DEVELOP ANNIVERSARY

California – Ames | Summer 2023

Background

A History of Decline

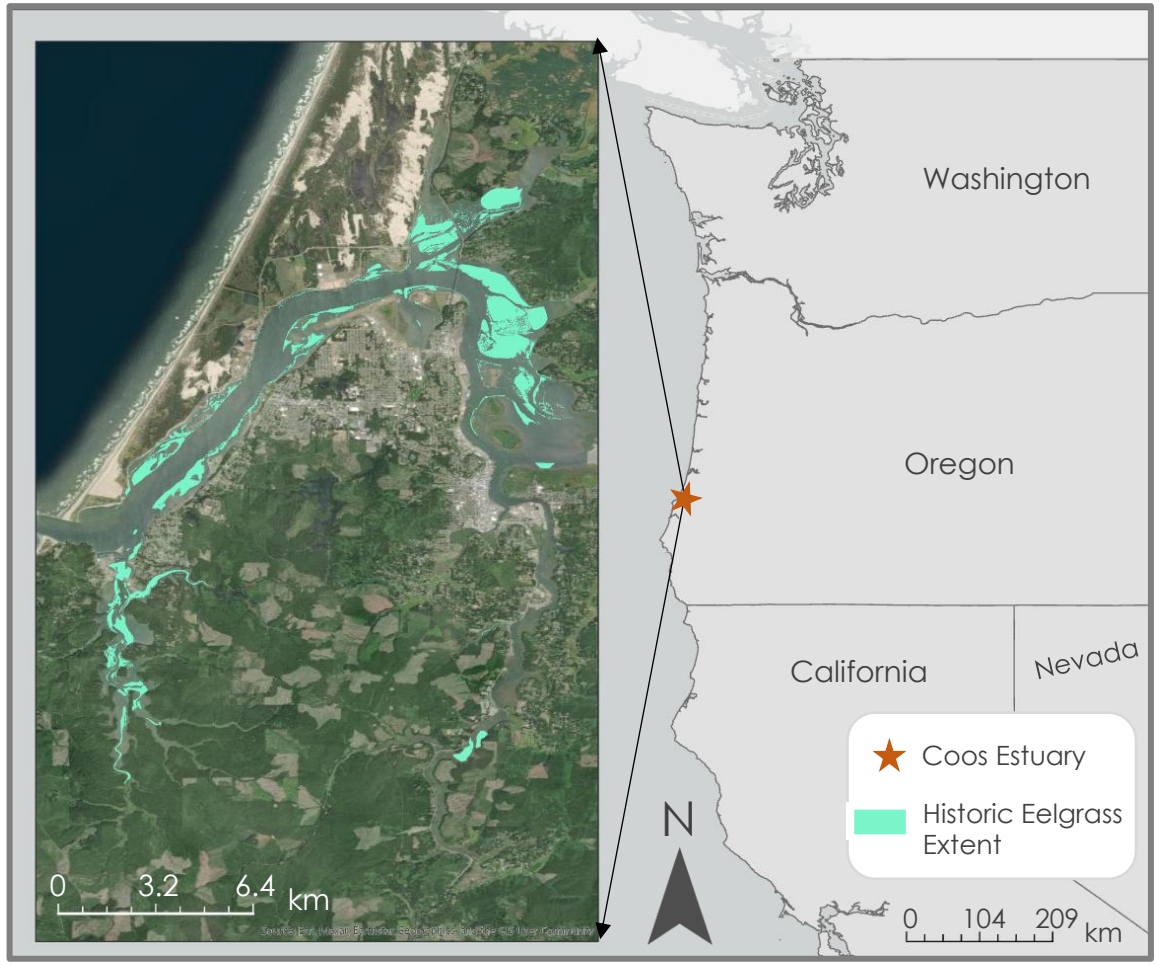


Recent Climate Anomalies

- 2013 – 2016 Marine Heat Wave (MHW)
- El Niño Southern Oscillation (ENSO)
- Record low Arctic sea ice (2018)
- 2021 Heat Wave

Image Credit: Dunic et al. 2021, John Brew

Study Area and Period



Base map - ESRI, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Study Area

Coos Estuary and South Slough

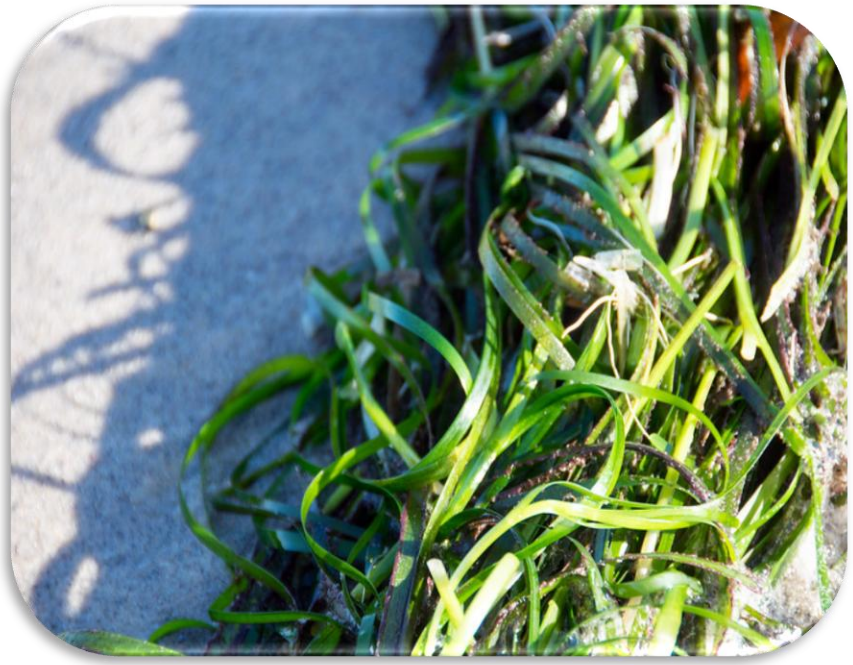
- 54 km^2
- Prior to 2013, eelgrass shoot density average was **33 shoots per m^2**
- After 2013-2016 warm water event, eelgrass shoot density average was **5 shoots per m^2**

Study Period

- 2016 - 2023

Project Partners

South Slough National Estuarine Research Reserve (SSNERR)



Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)

Image Credit: SSNERR (Left), Paul Asman and Jill Lenoble (Right)

Community Concerns

- Habitat Resilience
- Climate Change
- Community Recreation
- Commerical Disruptions

Image Credit: Genet (Diskussion)

Community Concerns

Habitat Resilience

Climate Change

Community Recreation

Commerical Disruptions

Image Credit: South Slough National Estuarine Research Reserve

Community Concerns

Habitat Resilience

Climate Change

Community Recreation

Commerical Disruptions

Image Credit: National Oceanic and Atmospheric Administration

Community Concerns

Habitat Resilience

Climate Change

Community Recreation

Commerical Disruptions

Image Credit: National Oceanic and Atmospheric Administration

Objectives

Use NASA Earth Observations to **analyze** eelgrass presence and **investigate** the drivers of eelgrass decline.

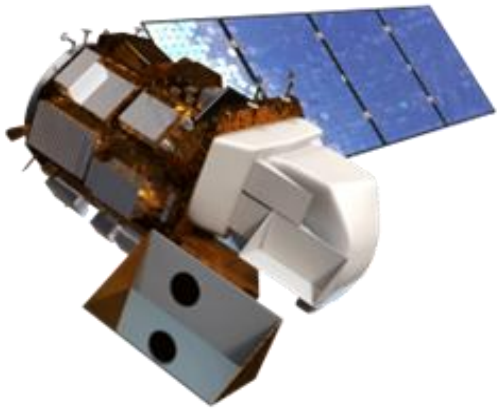
Eelgrass Extent Maps

Water Quality Time Series Analyses

Google Earth Engine (GEE) Tutorial

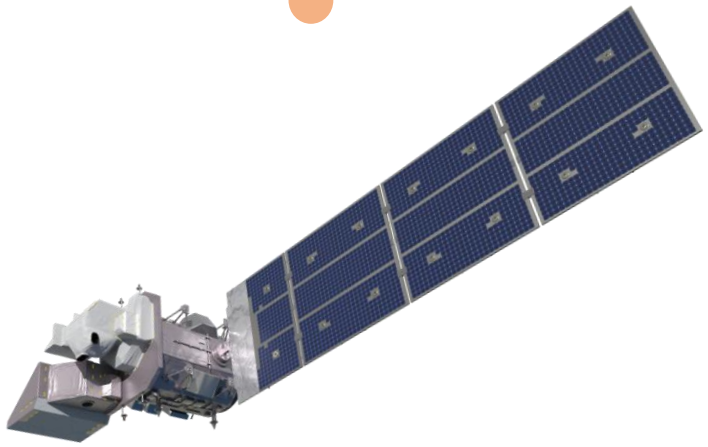
NASA Satellites and Sensors

NASA



Landsat 8 OLI

2013



Landsat 9 OLI-2

2021

European Space Agency

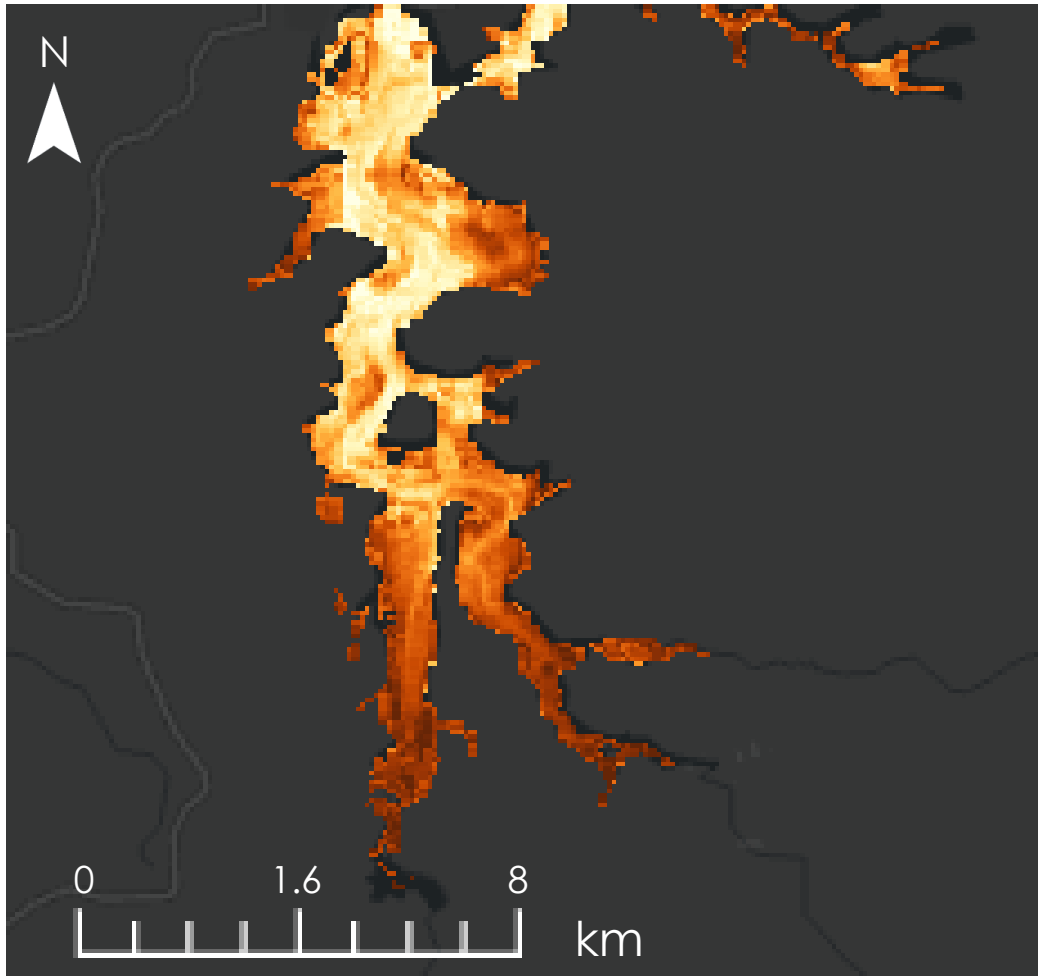
Sentinel-2 MSI

2015

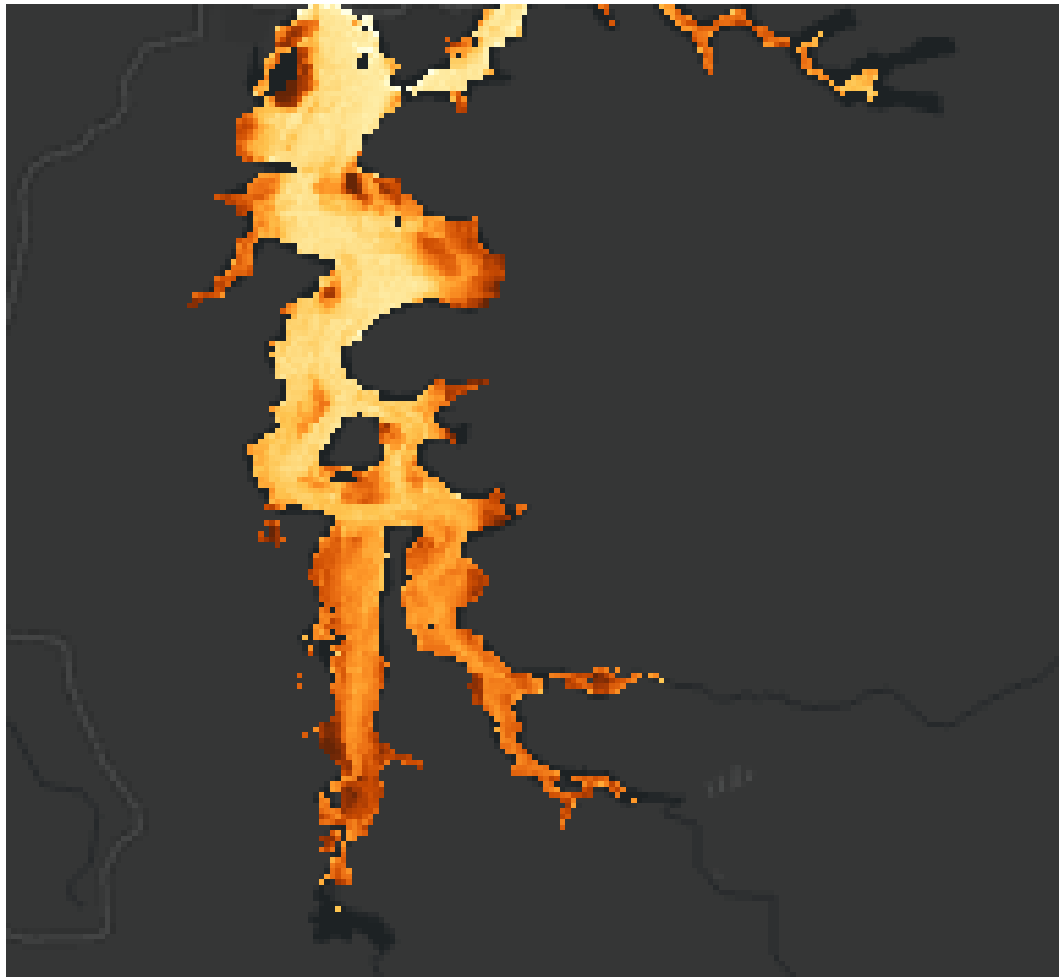
Image Credits: NASA, Rama

Methodology: Satellite Comparison

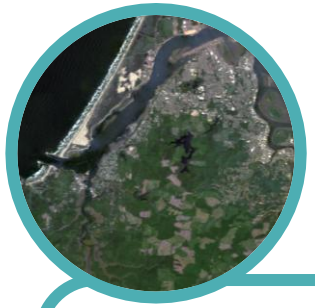
Landsat 8 OLI



Sentinel-2 MSI



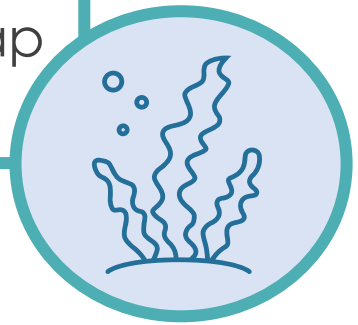
Methodology: Eelgrass Extent Maps

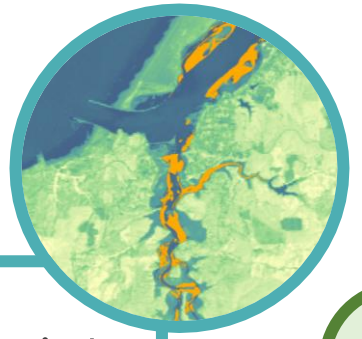


Spectral Data of Study Site

Normalized Difference Aquatic Vegetation Index (**NDAVI**)

Existing **Eelgrass Extent** Map



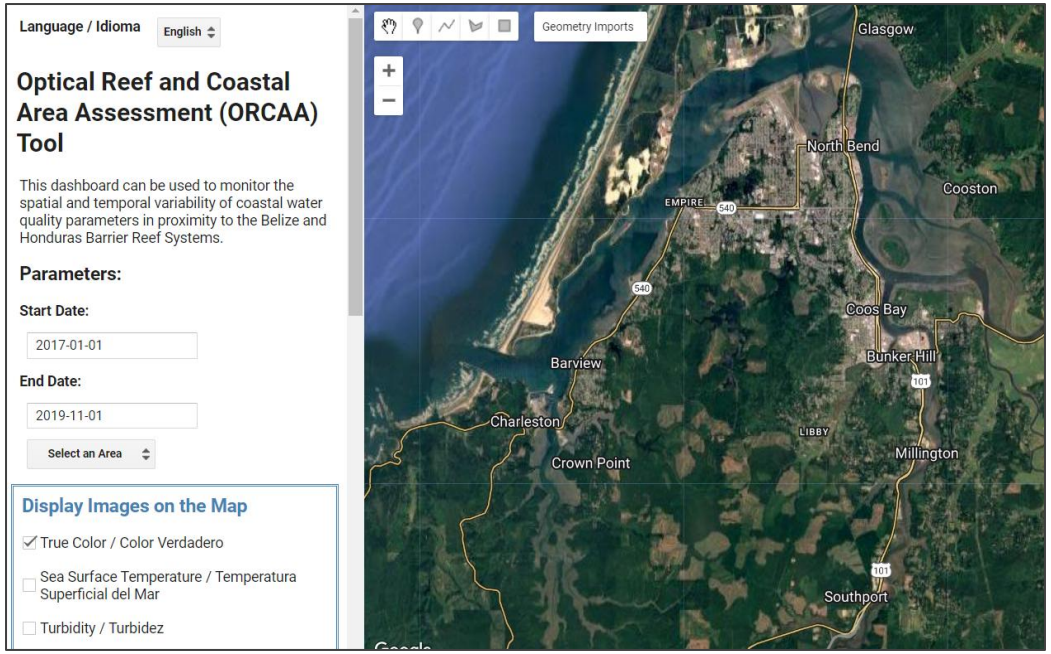


Training Points and Accuracy

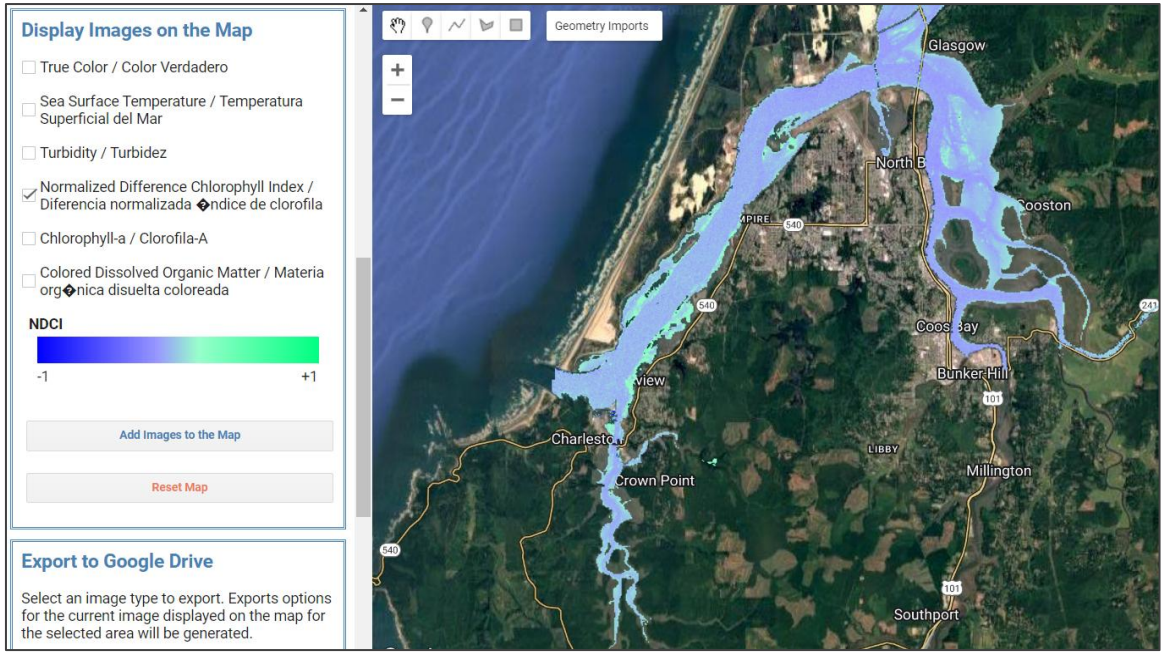
Updated Map Showing Eelgrass Presence

Methodology: ORCAA Tool

User Interface

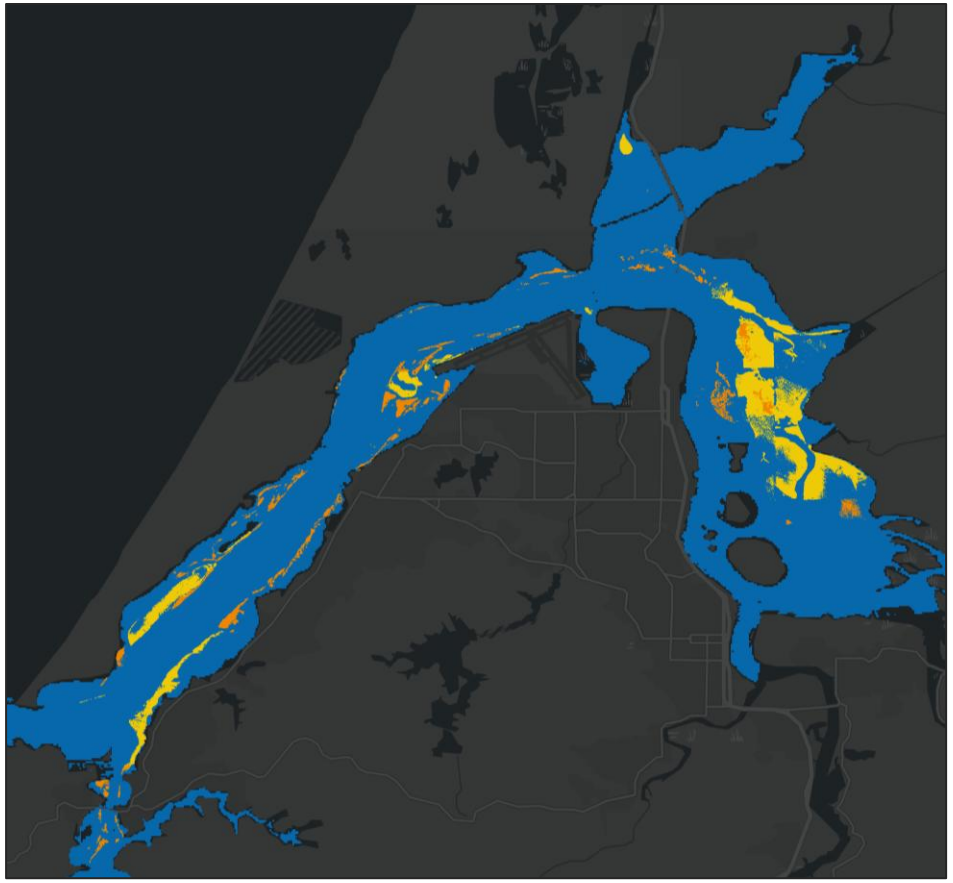


Extracting Data

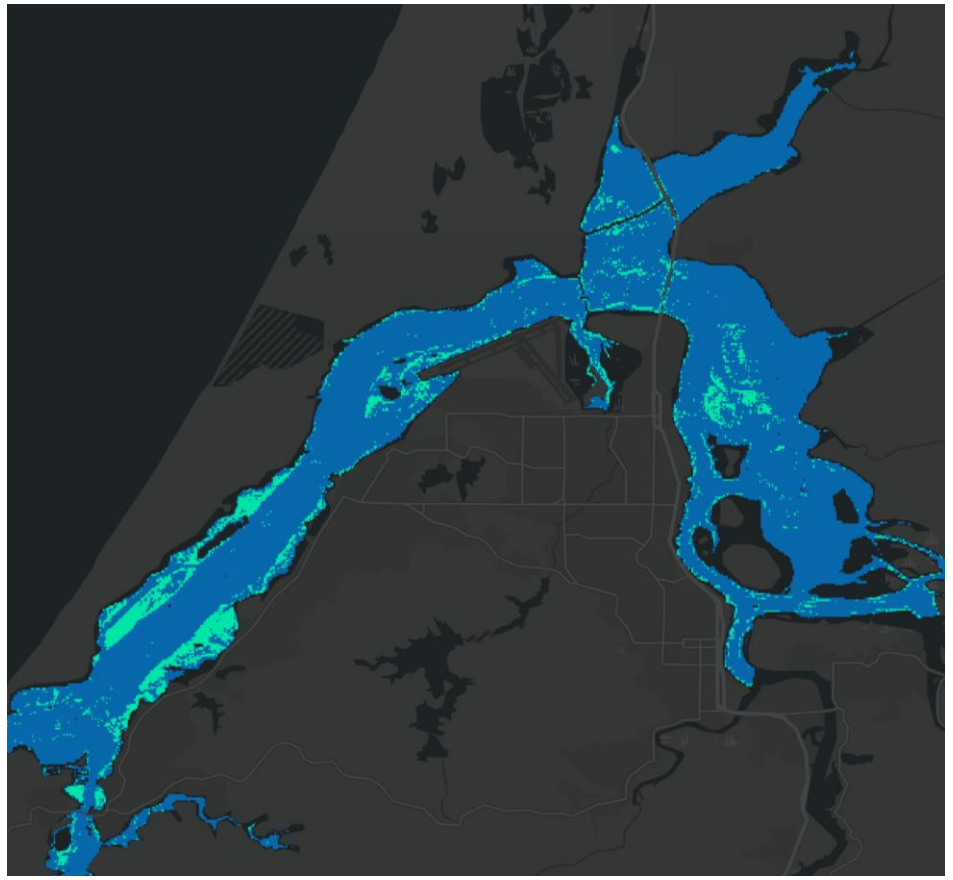


Methodology: Training

Existing Eelgrass Extent 2016



Support Vector Machine



Esri, HERE, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

Methodology: Water Quality Time Series

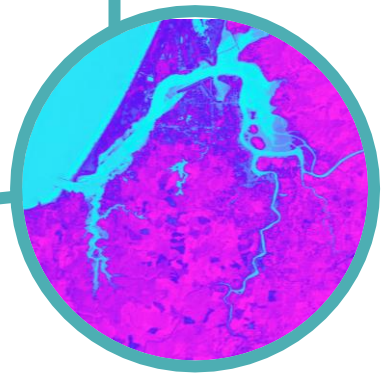
Sentinel-2 & Landsat Imagery

Optical Reef and Coastal Area Assessment (ORCAA) Tool

Normalized Difference **Aquatic Vegetation** Index (NDAVI)

Normalized Difference **Chlorophyll** Index (NDCI)

Normalized Difference **Turbidity** Index (NDTI)

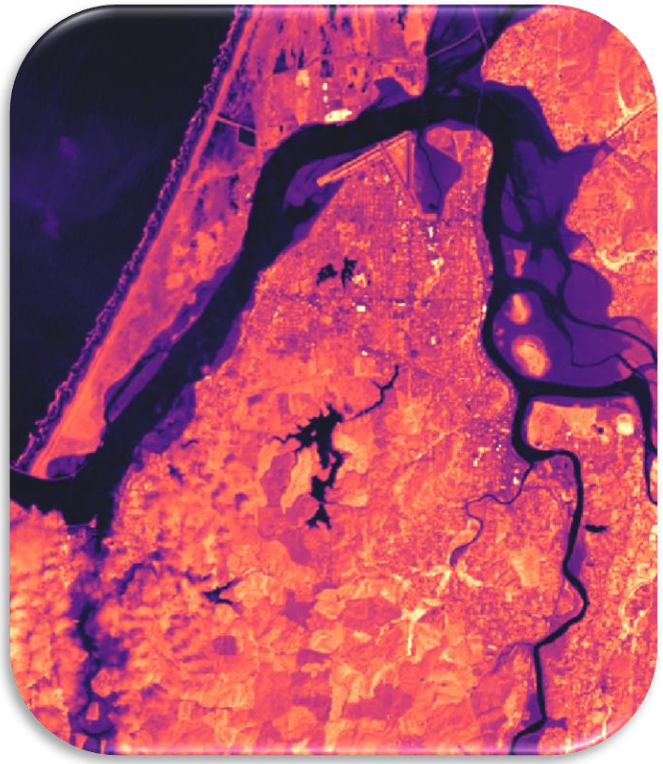


Raster Calculation and Visualization

Final Maps of SAVs, Chlorophyll-a, and Turbidity

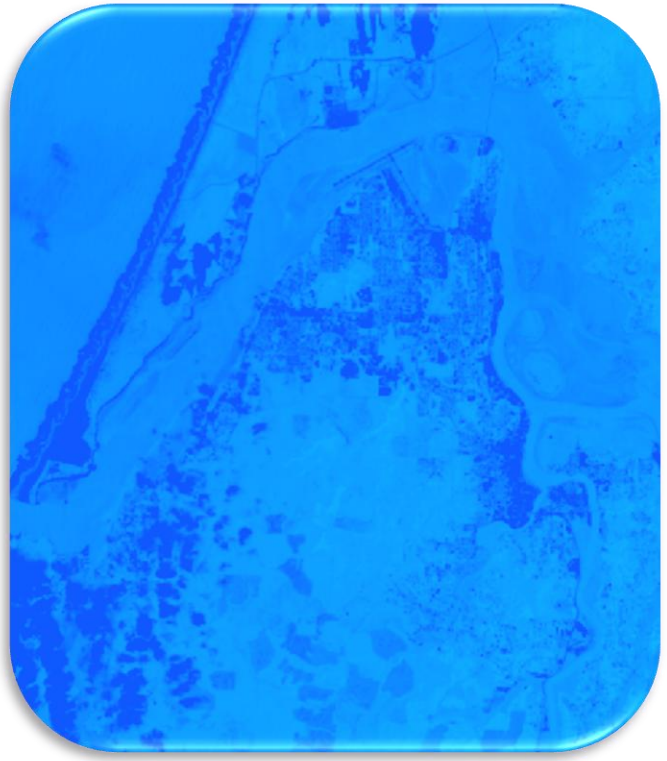
Methodology: Normalized Difference Aquatic Vegetation Index (NDAVI)

Near-Infrared



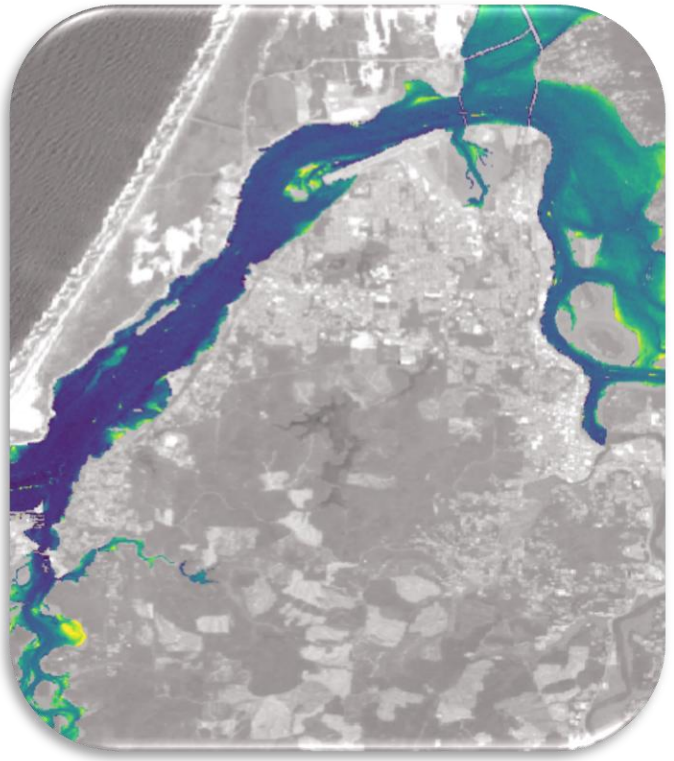
&

Blue



=

Identifies Submerged Aquatic Vegetation (SAV)



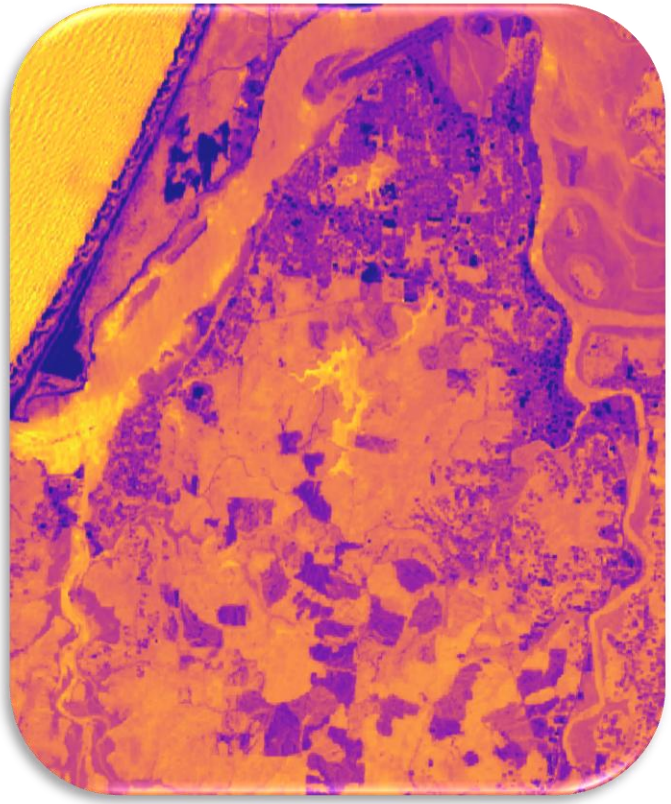
$$\frac{\text{NIR} - \text{Blue}}{\text{NIR} + \text{Blue}} = \text{NDAVI}$$

Less Vegetation — More Vegetation

0 — 1

Methodology: Chlorophyll-A

Red-Edge



&

Red

=

Identifies Chlorophyll-A

$$\frac{\text{Red-Edge} - \text{Red}}{\text{Red-Edge} + \text{Red}} = \text{NDCI}$$

Less Chlorophyll-a — More Chlorophyll-a

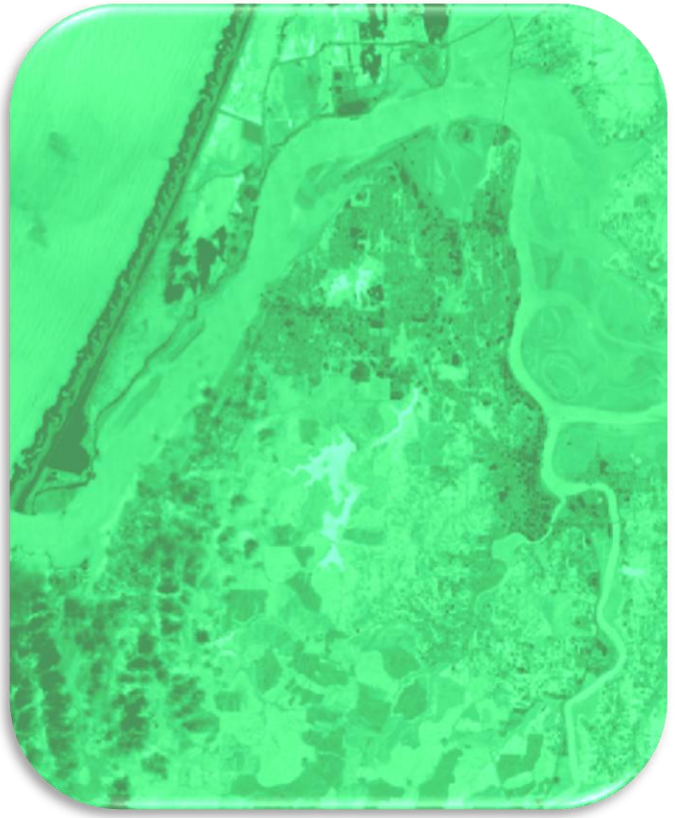
0 — 3

Methodology: Normalized Difference Turbidity Index (NDTI)

Red

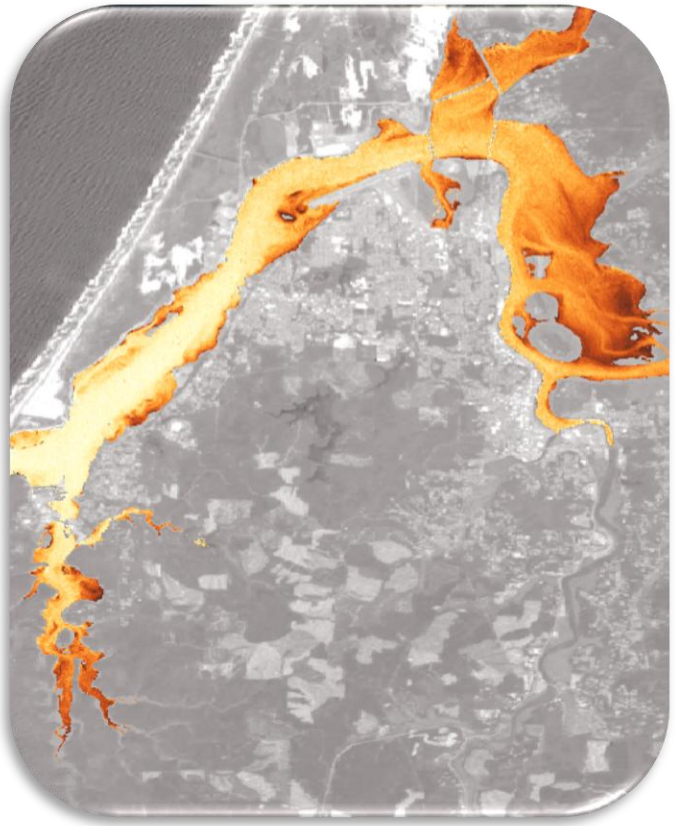
&

Green



=

Differentiates Sediment from Water



$$\frac{\text{Red} - \text{Green}}{\text{Red} + \text{Green}} = \text{NDTI}$$

Less Turbid — More Turbid

0 — 21

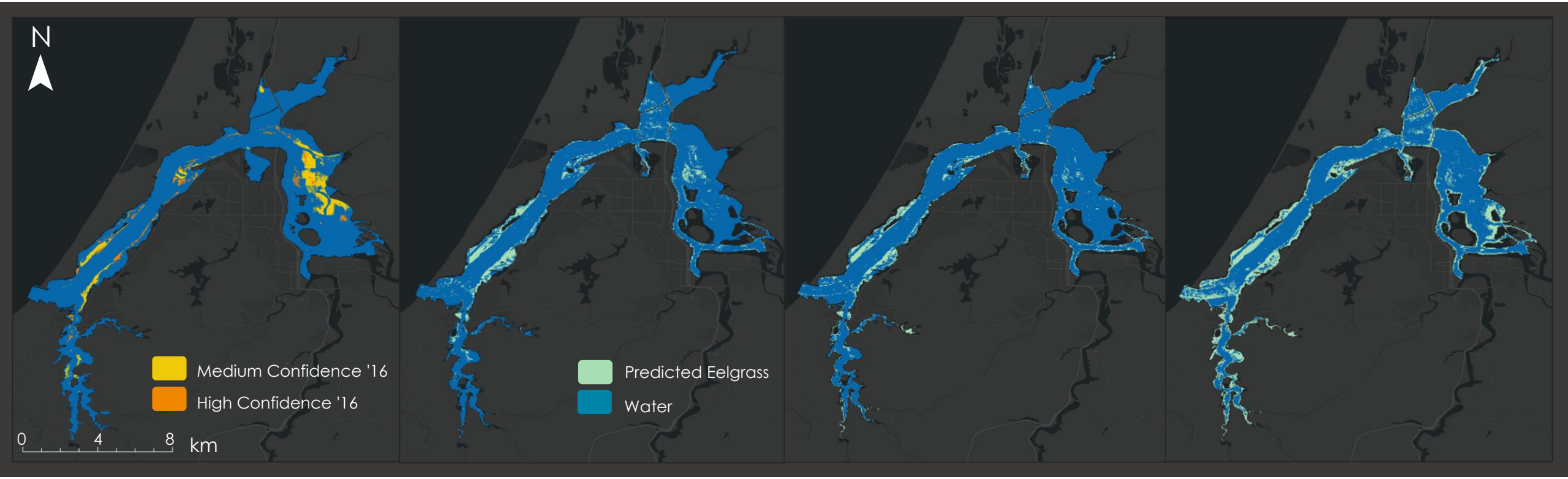
Results: Classification of Eelgrass

2016 Eelgrass Extent

Support Vector Machine

Random Trees

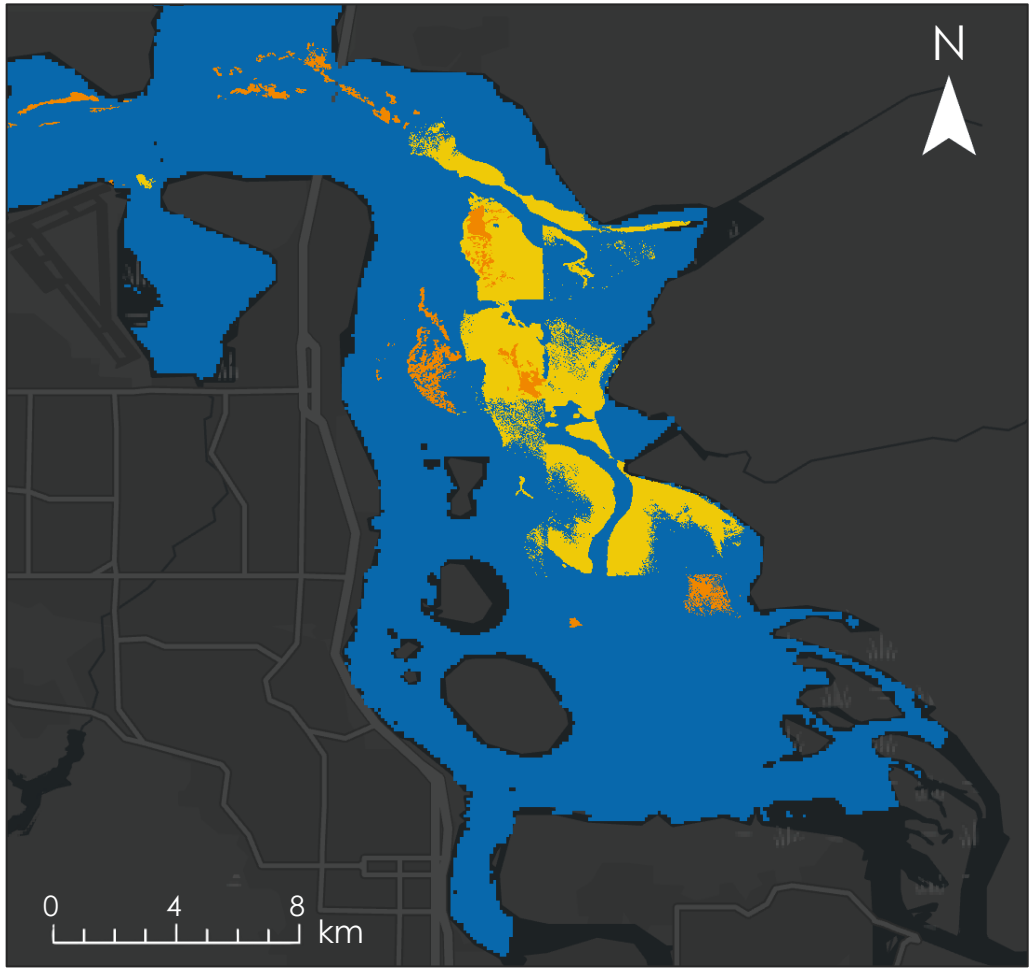
Maximum Likelihood



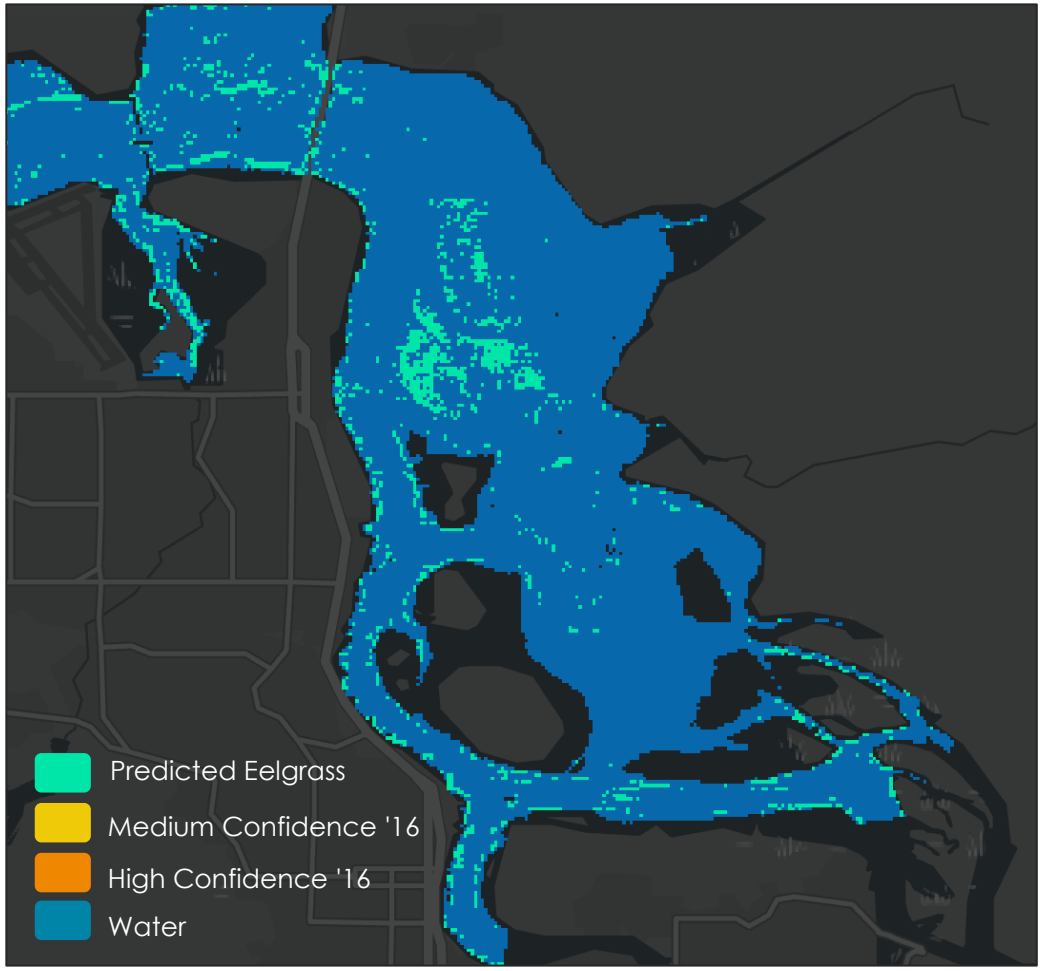
Esri, HERE, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

Results: Eelgrass Classification Accuracy

2016 Eelgrass Extent



Support Vector Machine



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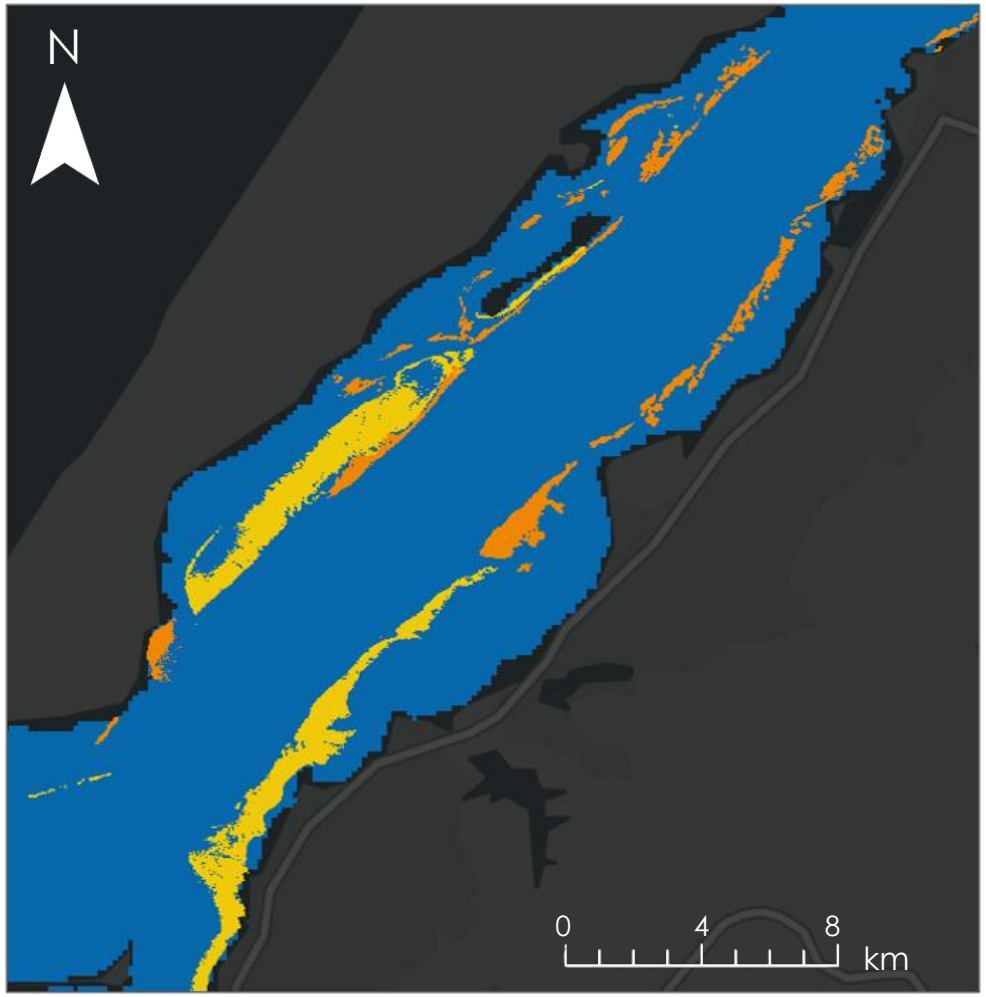
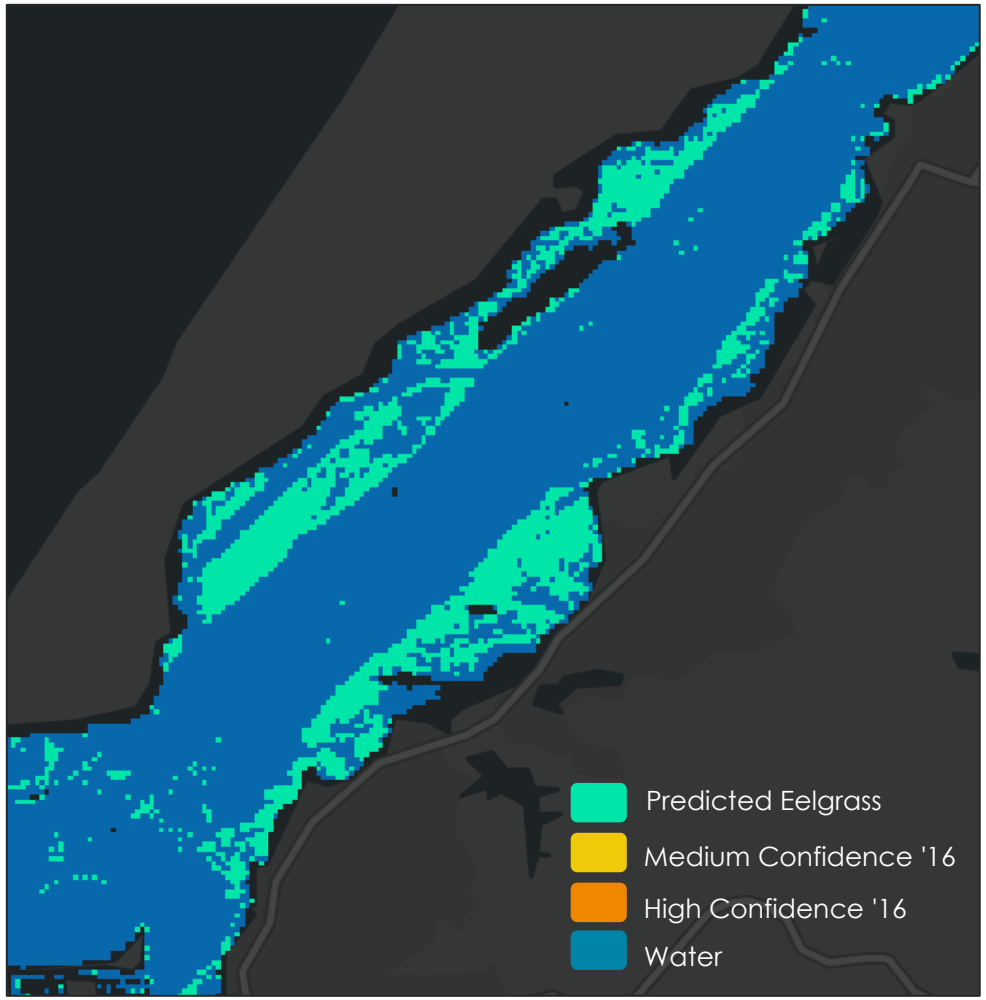
Results: Eelgrass Classification Accuracy

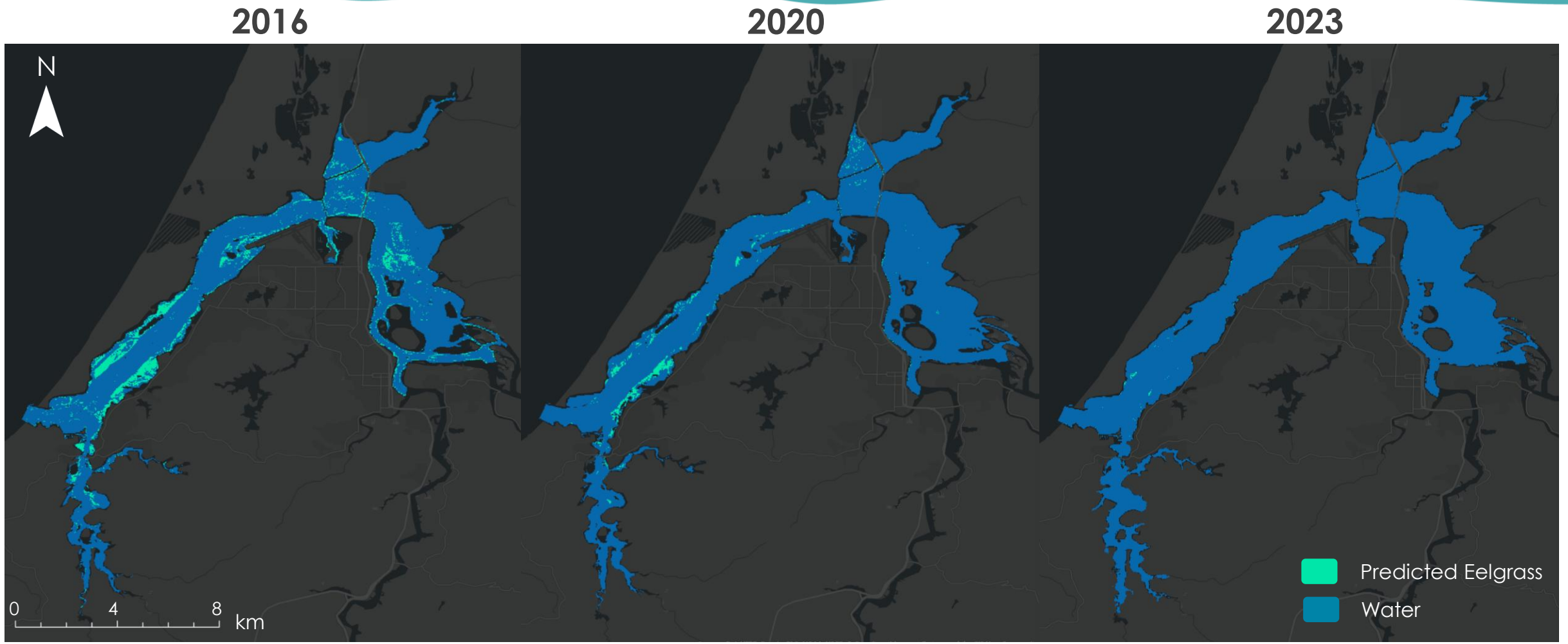
2016 Eelgrass Extent



Support Vector Machine



Results: Three-Year Comparison with SVM



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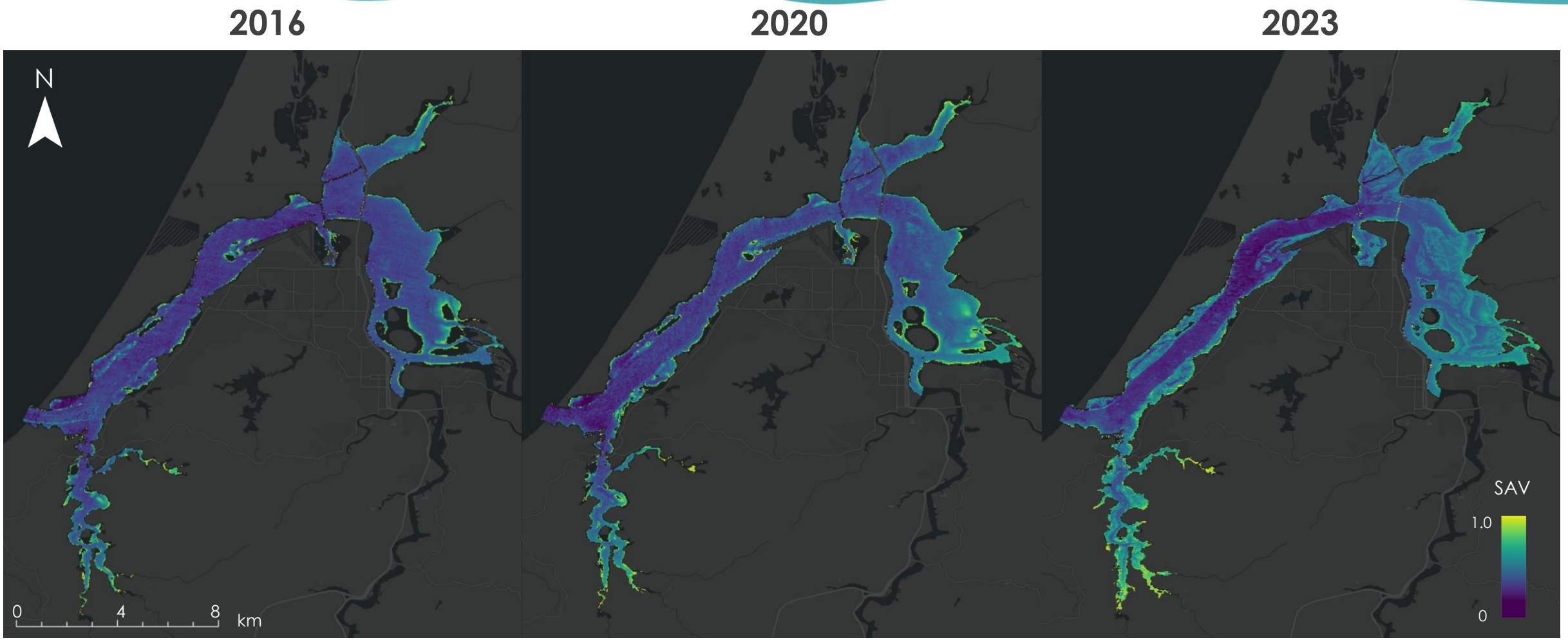
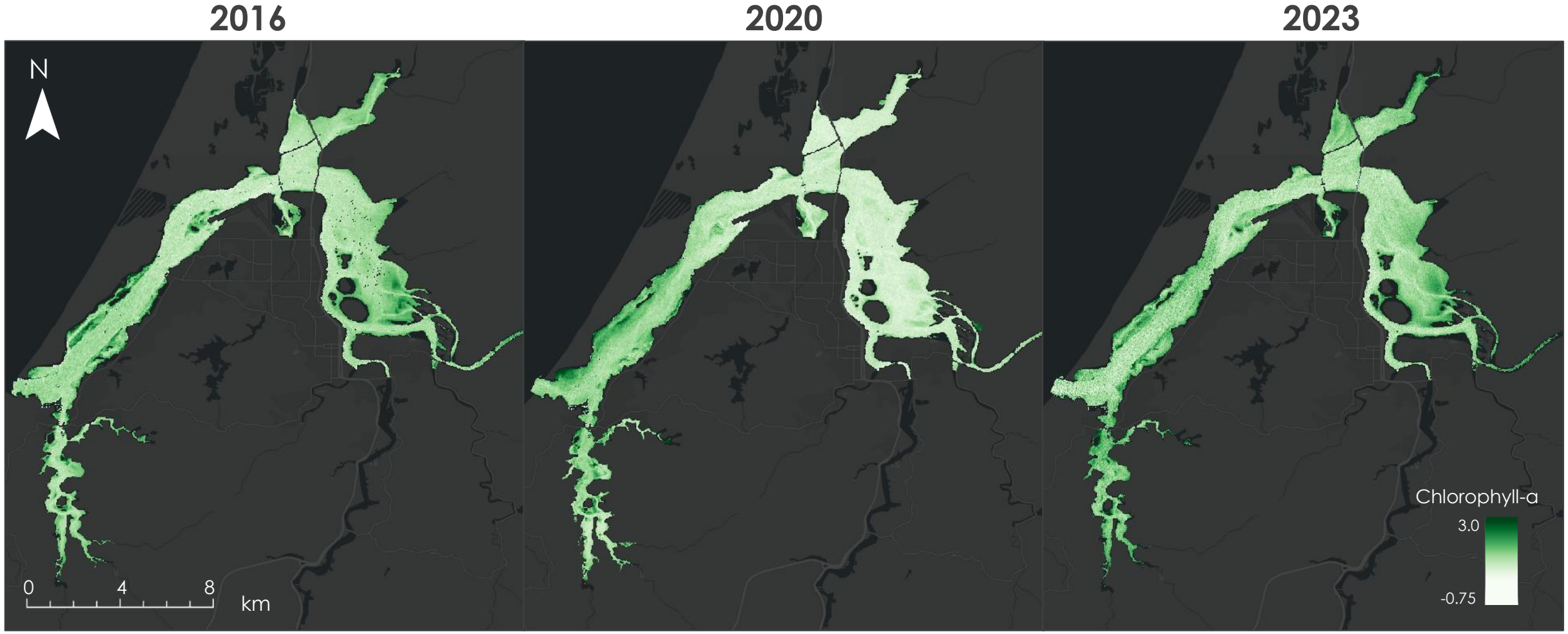
Results: Normalized Difference Aquatic Vegetation (NDAVI)



Esri, HERE, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

Results: Normalized Difference Chlorophyll Index (NDCI)



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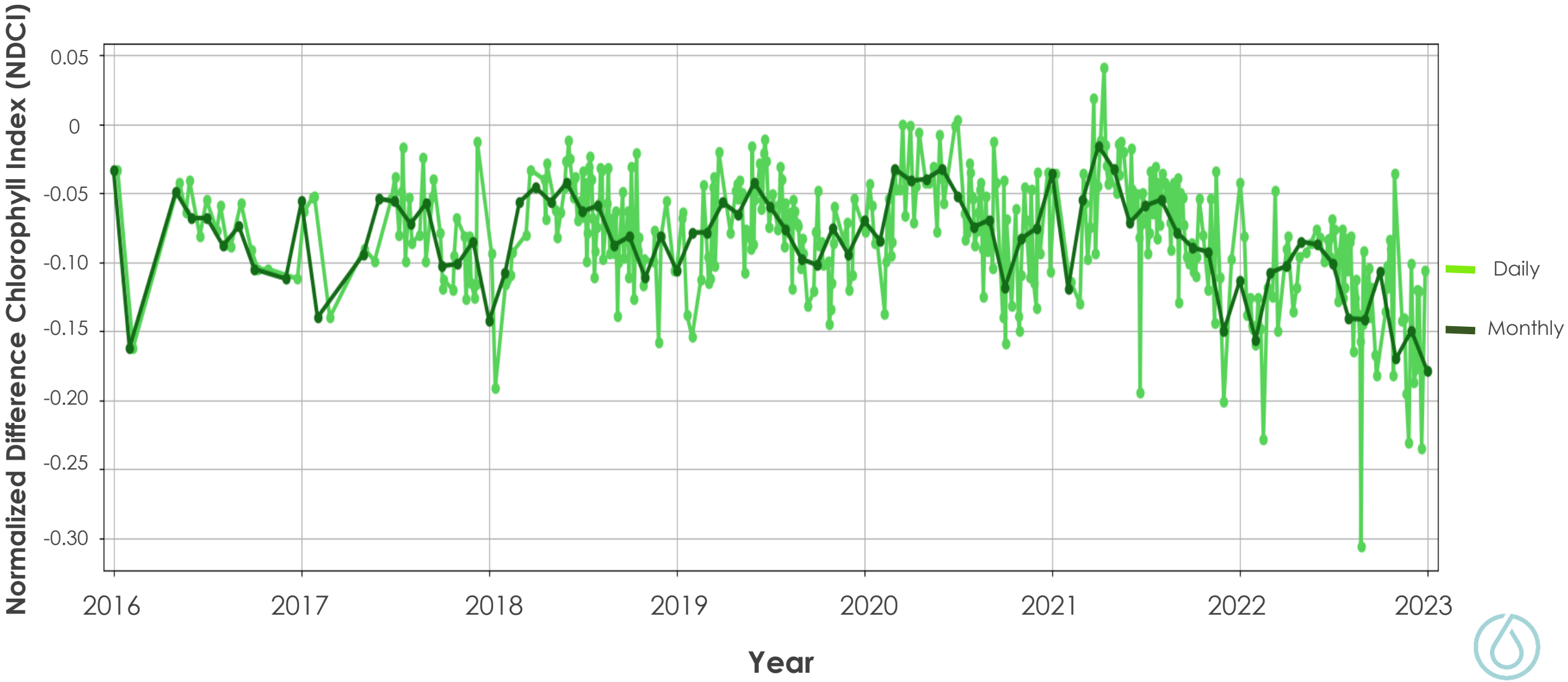
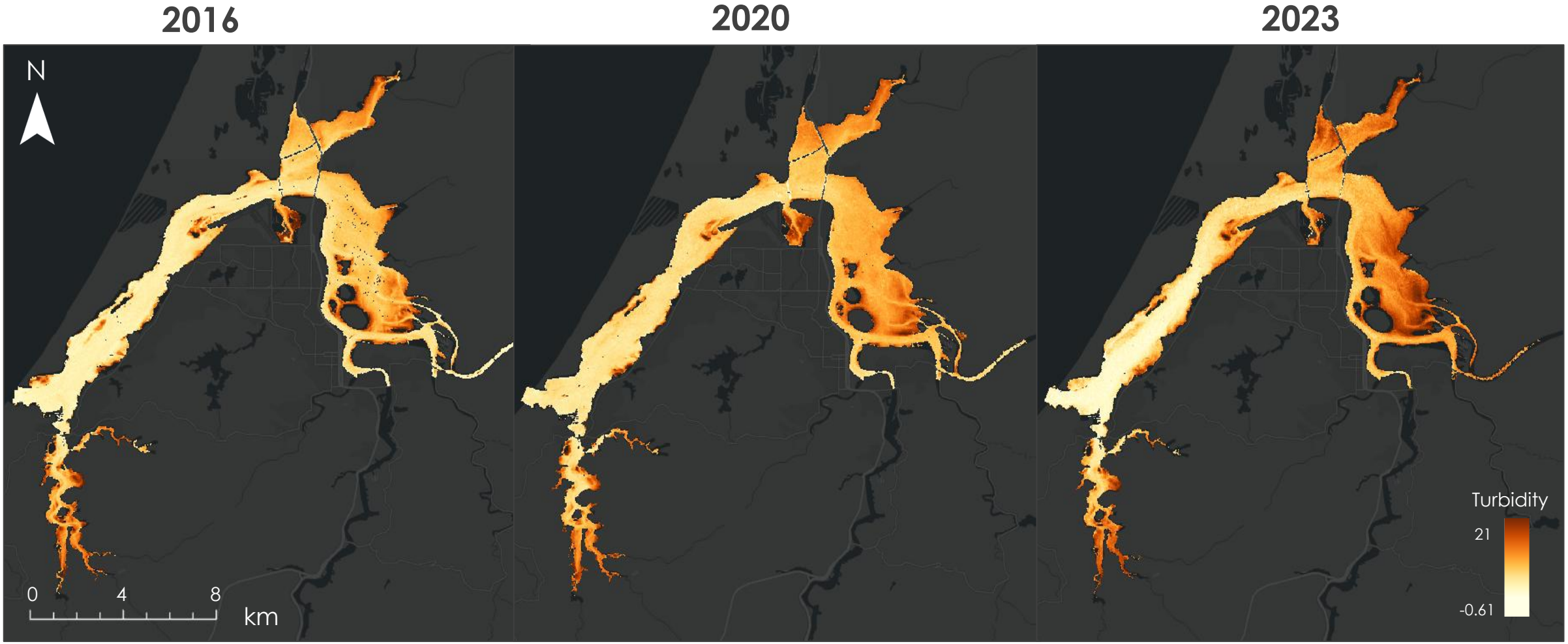
Results: Normalized Difference Chlorophyll Index (NDCI)



Results: Normalized Difference Turbidity Index (NDTI)



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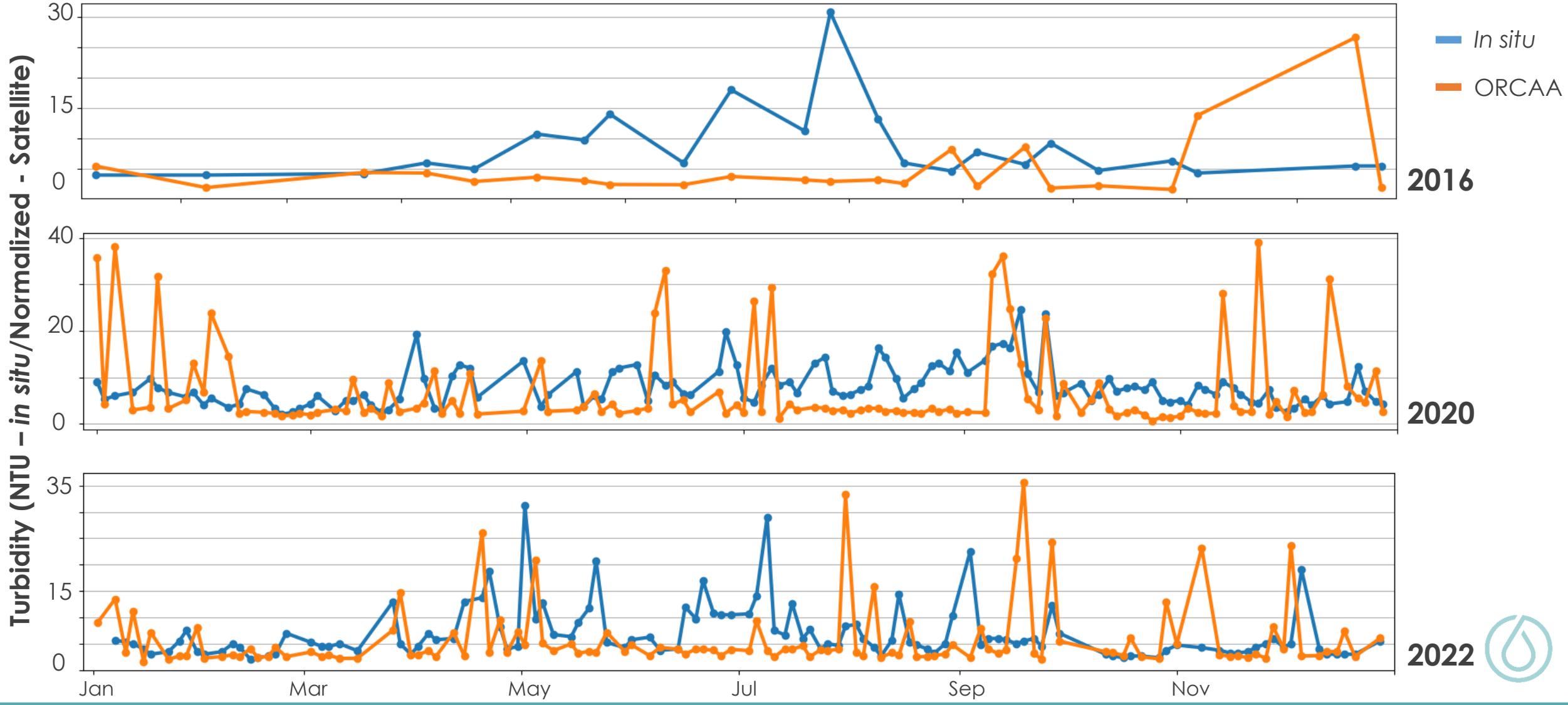
Results: ORCAA and *in situ* Turbidity Data



Conclusions

Satellite remote sensing offers the potential to **visualize broad water quality trends** in the Coos Estuary

Indices such as NDAVI are **useful for exploratory investigations** into potential eelgrass meadows

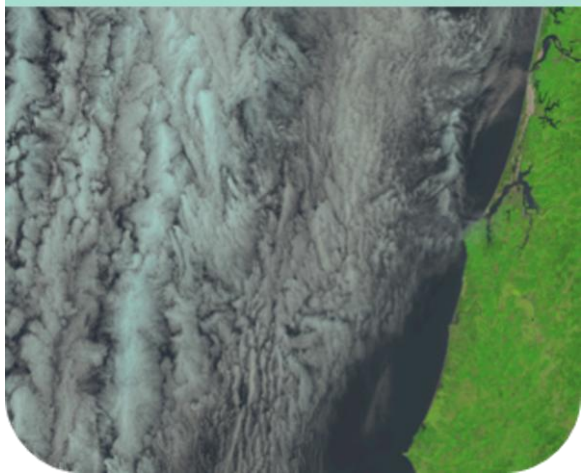
In situ measurements are highly recommended and can **improve eelgrass identification and classification** by satellites

Image Credit: John Brew

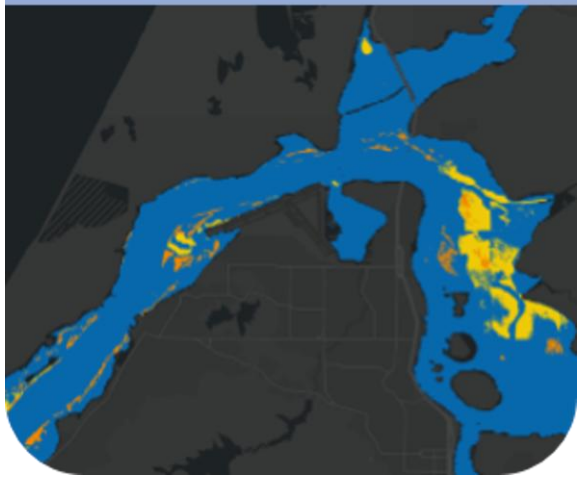
Errors and Uncertainties

Coarse Spatial Resolution

Study Site Conditions



Lack of Recent UAS Ancillary Data

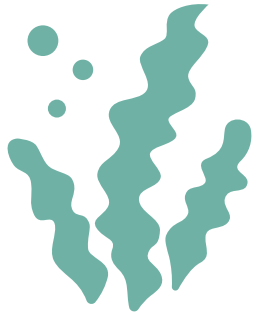


Tidal Influences

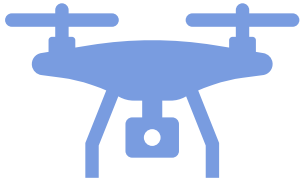
Image Credit: Sam Beebe

Future Work

Integrate **higher resolution** data into our methods



Incorporate **density counts** of eelgrass into analyses



Classify eelgrass using updated **UAS data**

Use **additional estuaries** for algorithm training

Acknowledgments

We would like to sincerely thank our...

Science Advisors

- Dr. Juan Torres-Pérez, Dr. Liane Guild, and Britnay Beaudry

Partners

- South Slough National Estuarine Research Reserve (SSNERR) and the Confederated Tribes of the Coos, Lower Umqua, and Siuslaw Indians' (CTCLUSI) Natural Resources Department
- Alicia Helms, Jenni Schmitt, Jennifer Kirkland, and Janet Niessner

Fellow

- Lisa Tanh, for guiding and supporting this project

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