Analysis of Algae and Aquatic Vegetation Abundance at the Devereux Slough

Sophia Rose Cabral, Delaney O'Donnell, Emma Cardoso, Alison Rickard

University of California, Santa Barbara

Introduction

- The Devereux Slough is a temporary open/closed estuary (TOCE) that provides increased buffer area for storm surges and sea level rise and a wildlife corridor connected to other protected lands.
- We sought out to understand trends in algae and aquatic vegetation growth at the Devereux Slough via close-range and satellite imagery.
- We quantify the temporal shifts in abundance in relation to water quality variables given by constant water loggers.
- Our investigation of photosynthetic activity at the Slough involves analysis of satellite imagery from 2018-2023.
- We hope to elucidate the different trends in aquatic vegetation and algal growth between COPR and NCOS. Understanding the relationship between the nutrient pulses, algal blooms, and aquatic vegetation growth is important for evaluating how the wetland is functioning for filtering nutrients and supporting wildlife.

Figure 1. NCOS Study Sites.
A. Satellite imagery areas of interest (AOIs)
B. Bridge sites with camera stands

Methods

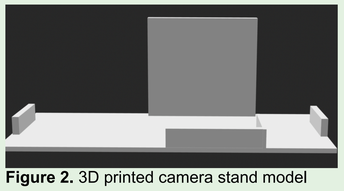


Figure 2. 3D printed camera stand model deployed at NPB, NEC, and NVBR

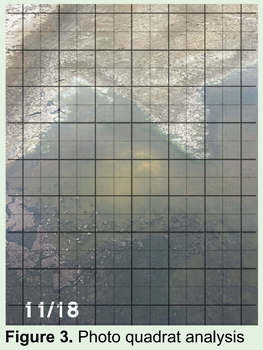


Figure 3. Photo quadrat analysis

$$\frac{\rho_{NIR} - \rho_{BLUE}}{\rho_{NIR} + \rho_{BLUE}}$$

Figure 4. NDAVI formula quantifying photosynthetic activity via surface reflectance (ρ) of blue and near-infrared spectral bands

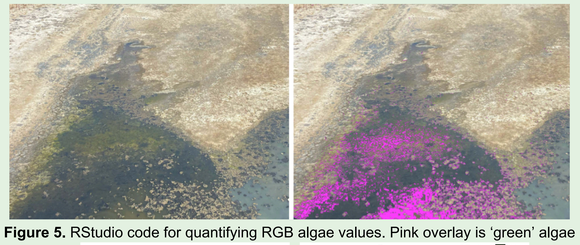


Figure 5. RStudio code for quantifying RGB algae values. Pink overlay is 'green' algae

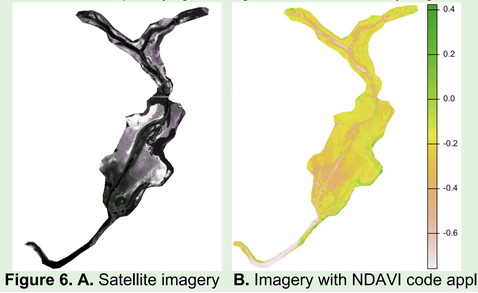


Figure 6. A. Satellite imagery **B.** Imagery with NDAVI code applied

- Photographs were taken across the span of the 2023-2024 academic year at various bridge sites (NEC, NPB, and NVBR) across the slough (figure 1B).
- Camera cradles were designed and created using 3D printing to ensure standardization across photos with QR codes attached to CoastSnap, allowing for a citizen science aspect. Over 120 photos were collected from the community in the span of 4 months.
- Photoquadrats were then utilized after geofixing the images in Adobe Photoshop to analyze surface algae abundance percent frequency across the multiple sites.
- RStudio was used to quantify the fraction of green pixels per image through RGB values, which provides a further insight to algae abundance overtime.
- Satellite imagery was downloaded from PlanetLabs and analyzed to determine broader spatial trends in algal and aquatic vegetation growth.
- ArcGIS was used to create four areas of interest (figure 1A).
- Monthly imagery was downloaded from January 2018 to April 2024.
- RStudio was used to extract the blue and and near-infrared (NIR) spectral bands and apply the normalized difference aquatic vegetation index (NDAVI) formula (figure 4).
- The NDAVI formula exploits chlorophyll's absorption of blue and reflection of NIR spectral bands. It indicates maximum photosynthetic activity at a value of +1 and no activity at a value of -1.
- NDAVI values for individual pixels were calculated and averaged over the given site.

Results

- Mean NDAVI values tend to increase with distance from the ocean.
- NDAVI values are highly variable seasonally. Average percent frequency of algae is highly variable within one month, so monthly analysis of NDAVI may not reflect all shifts in photosynthetic output.
- Photosynthetic activity is decreasing over time at COPR but increasing over time at NCOS.

Figure 7. Average NDAVIs across satellite imagery AOIs

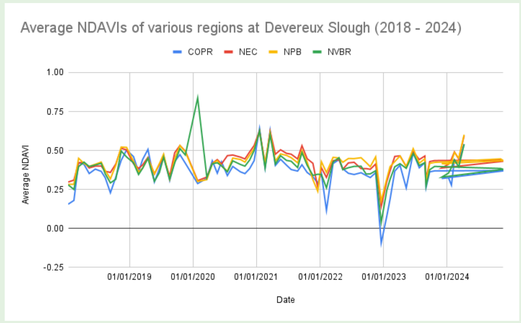


Figure 8. Correlation table utilizing Spearman's rank test to compare bridge site average algae frequency to various water quality variables. The first number in every series is the p-value at the significance level 0.05 and the second number is the Spearman's rho value.

Site Name	Water Temperature (°C)	Specific Conductivity (µS/cm)	Avg ODO (mg/L)
Venoco Bridge	0.458, 0.207	0.169, -0.375	0.411, -0.229
East Creek Bridge	0.098, -0.362		
Phelps Bridge	0.671, 0.120		

Figure 9. Average % frequency of algae abundance utilizing photoquadrats

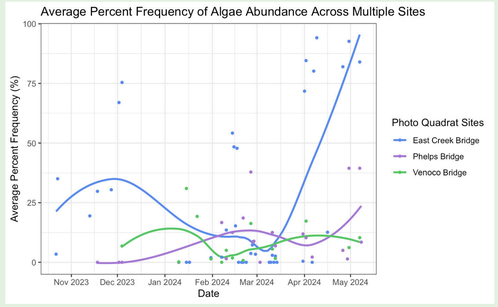
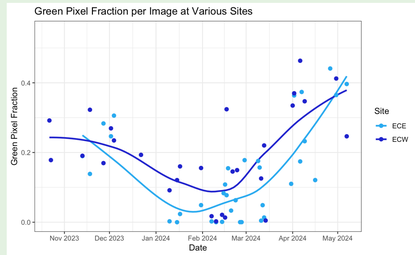
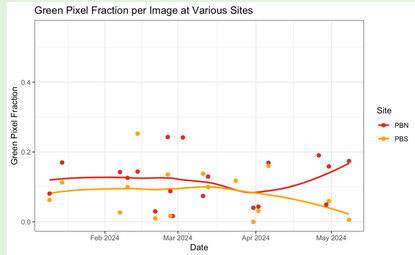


Figure 10. The fraction of green pixels per image at each site. EC = East Creek Bridge. PB= Phelps Bridge. V= Venoco Bridge. The last letter of each site legend corresponds to the compass direction of the photo (north, south, east, or west).





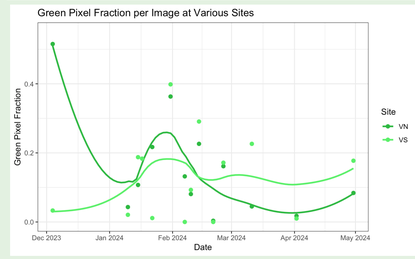


Figure 11. Linear regression equations for satellite imagery AOIs

Site	Linear regression equation	R^2 value
COPR	y = -1.33E-05*x + 0.957	0.008
NEC	y = 7.34E-06*x + 0.1	0.005
NPB	y = 1.32E-05*x + -0.164	0.015
NVBR	y = -1.01E-05*x + 0.847	0.006
NCOS	y = 3.48E-06*x + 0.261	0.001

Conclusions

- Algae abundance across the multiple sites varies greatly as determined by the photoquadrates and RGB pixel analysis, and the correlation of the algae abundance with differing water quality variables is currently being examined. Findings suggest that alone there is no one water quality variable that has the highest correlation with algae abundance, however, it is suggested that the status (open/closed) of the estuary has the highest effect on algae abundance.
- Mean photosynthetic activity trends higher in NCOS than COPR and is increasing over time in NCOS; this may indicate intensified and increasing eutrophication in NCOS. These results present an avenue for future research to determine what water quality metrics correlate with this trend, which is currently being explored.

Acknowledgements & References

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