



HYPERSPECTRAL BIOFILM CLASSIFICATION ANALYSIS TO DETERMINE CARRYING CAPACITY FOR MIGRATORY BIRDS IN THE SOUTH BAY SALT PONDS

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Applied Sciences Related to South San Francisco Bay Ecological Forecasting

- **Community Concerns**

- Provide habitat for endangered animal and vegetation species
- Increase Shorebird habitats for foraging and migration
- Understand changes in vegetation colonization of marsh habitat during the restoration process.



Ecological Forecasting

- **Partners**



San Francisco Estuary Institute



US Fish and Wildlife Service



California Department of Fish and Game



San Francisco Bay Conservation and Development Commission



Water Resources

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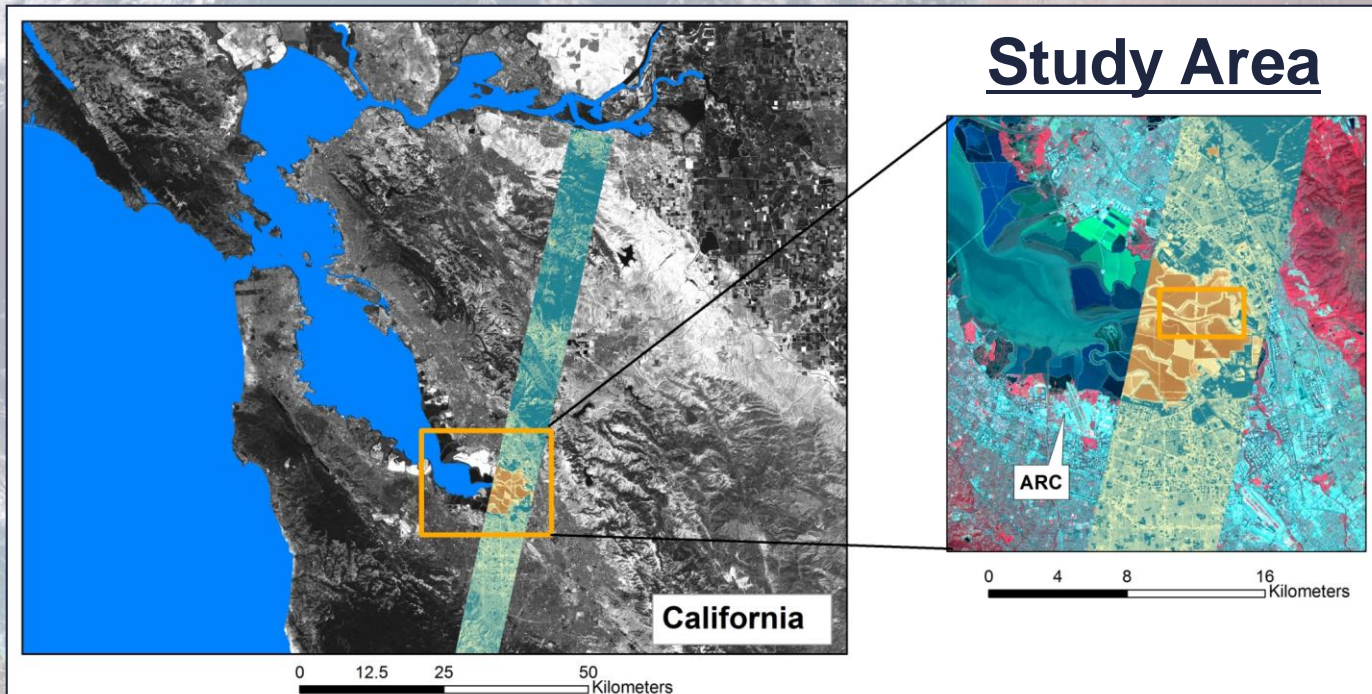
- **Decision Making Process & Partner Needs**

- Use NASA satellite data to map the spatial distribution and density of biofilm.
- Need for improved understanding of biofilm's role within the South San Francisco Bay's wetland ecosystem.

Project Objectives and Study Area

Objectives

- Use GER-1500 spectroradiometer to create Spectral Library of Biofilm
- Monitor the spatial distribution and density of biofilm throughout the South Bay
- Provide a taxonomic classification of the dominant biofilm species in the South San Francisco Bay Area
- Estimate the South Bay Salt Pond Restoration Area's carrying capacity of shorebirds



Field and Laboratory Methodology



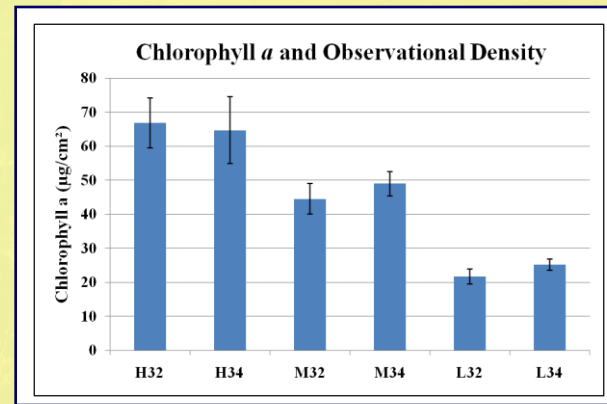
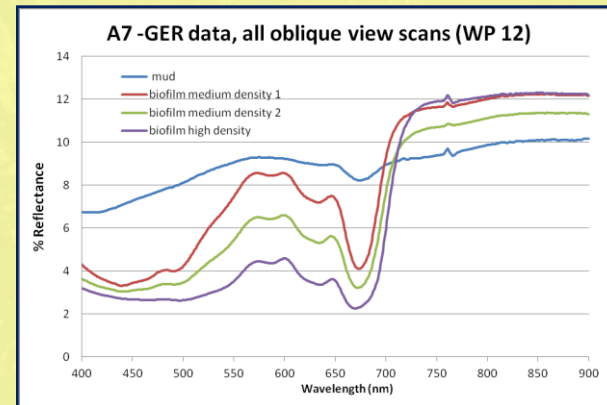
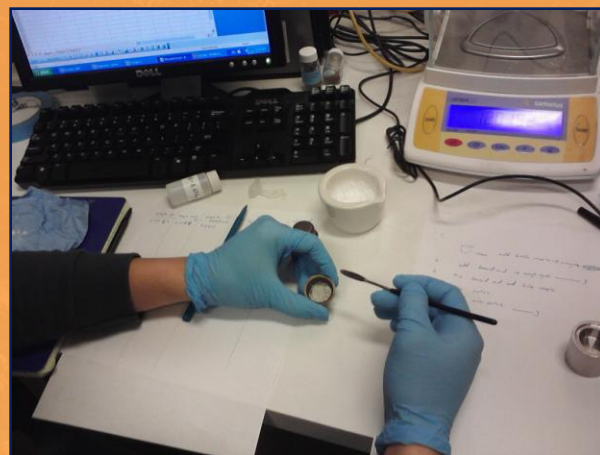
Species Classification



GER Measurements



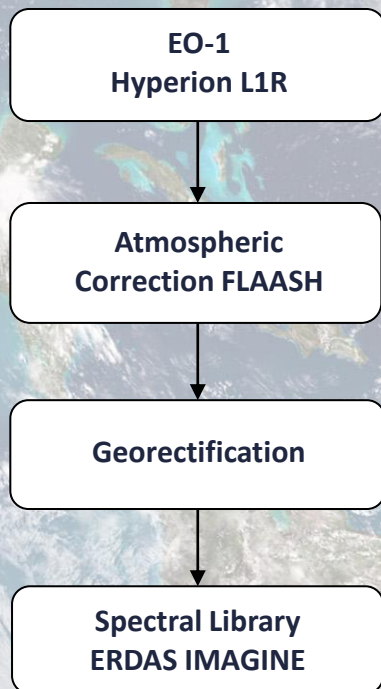
Chlorophyll a Analysis



Remote Sensing Methodology

Sensor	Purpose	Bands Used	Wavelengths (μm)	Resolution (m)	Dates used	Image Source
Landsat 5 TM	Detect Vegetation	3	0.45-0.69	30	8/18/94, 8/22/07, 8/27/09, 7/5/10	Glovis (USGS, 2010a)
IKONOS	Detect Vegetation			1	2008,2009	GeoEye
Hyperion on EO-1	Obtain spectral curve for biofilm	48	426.82-905.05	30	3/26/10, 7/7/10	Glovis (USGS, 2010a)

Hyperion Classification procedure



$$\alpha = \cos^{-1} \frac{\sum_i^n x_i y_i}{\sqrt{\sum_i^n x_i^2} \sqrt{\sum_i^n y_i^2}}$$

Spectral Angle Mapper Classification Algorithm

Where:

n = number of bands

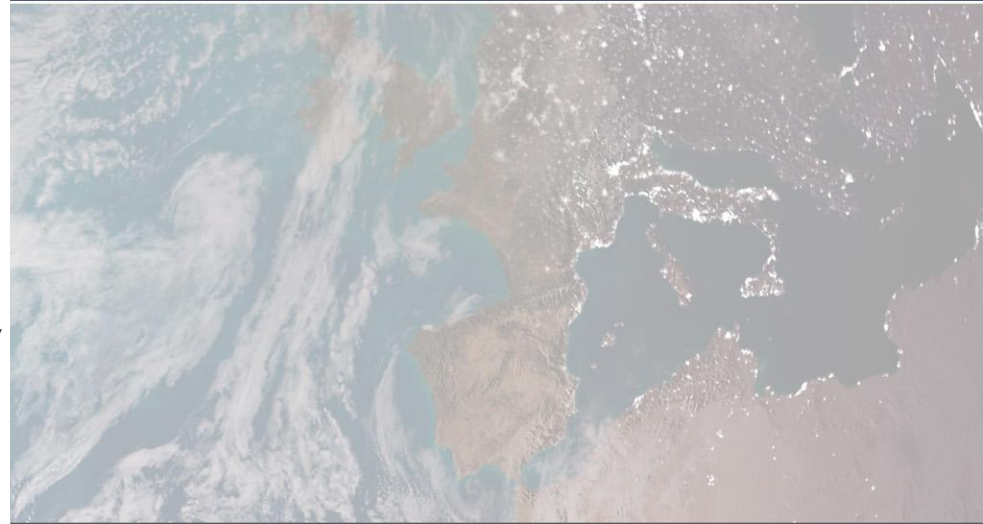
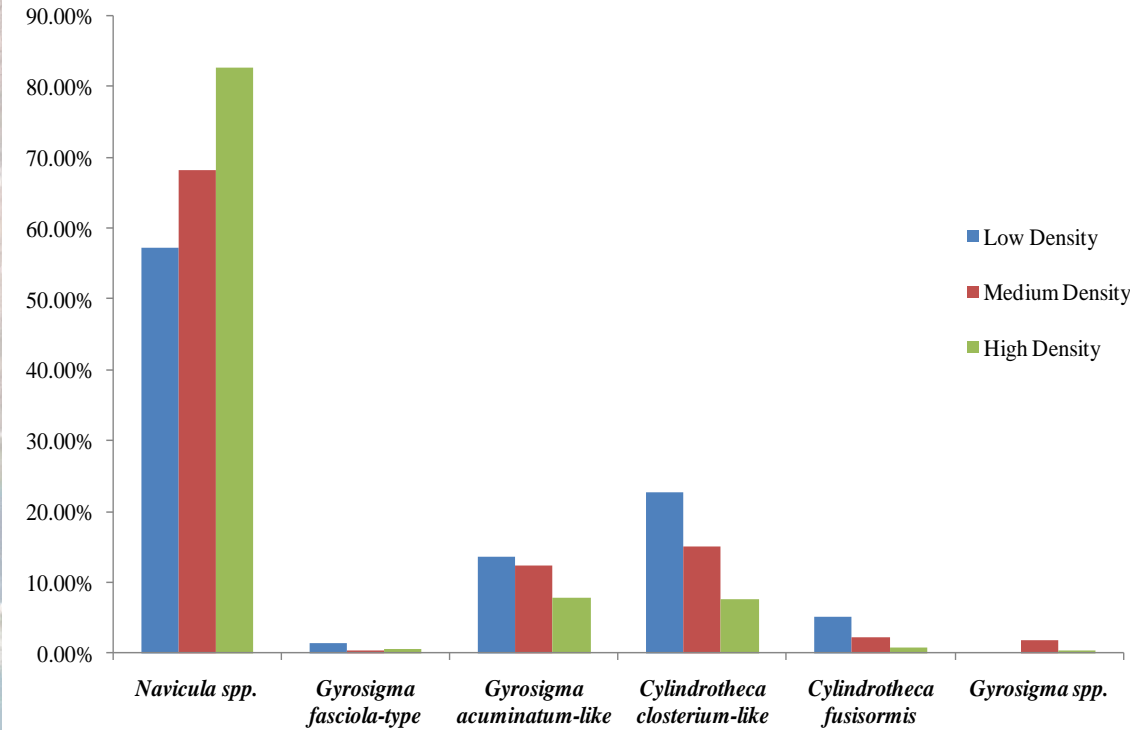
α = angle formed between reference spectrum and image spectrum

x = image spectrum

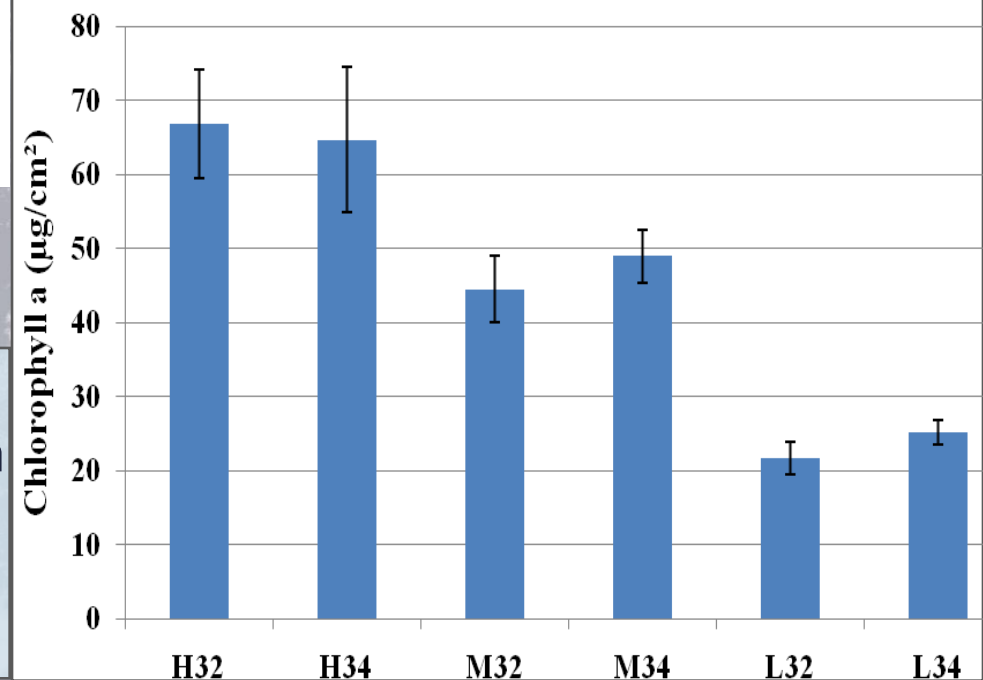
y = reference or target spectrum

Field and Laboratory Lab Results

Percent Distribution of Main Taxonomic Species



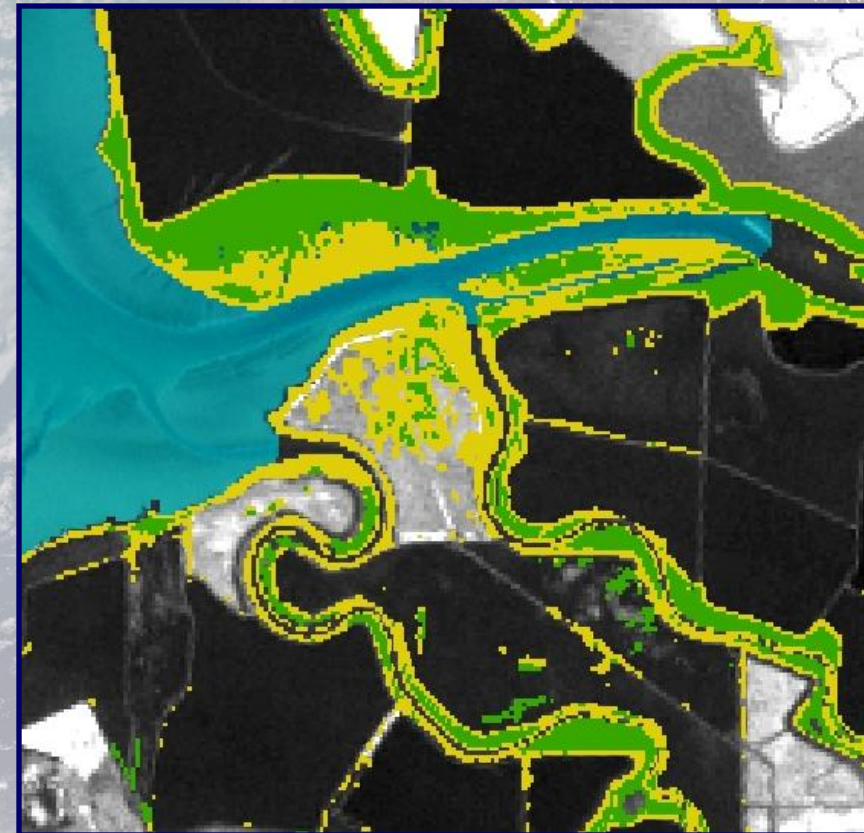
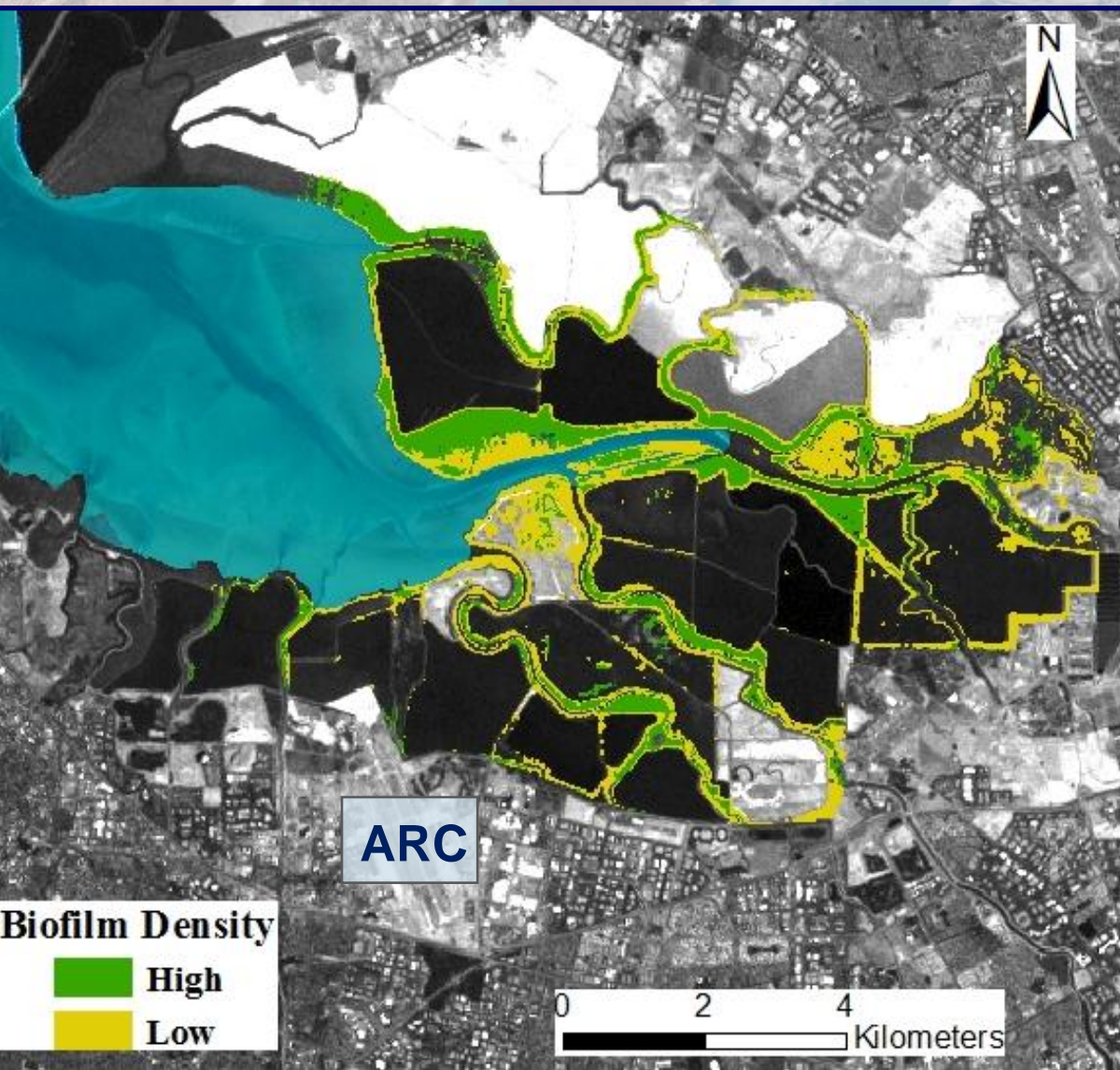
Chlorophyll *a* and Observational Density



H = High Density Biofilm
M = Medium Density Biofilm
L = Low Density Biofilm
32 = Bayside
34 = Pondsides

Remote Sensing Results

Hyperion Classification-Spectral Angle Mapper



Total Area of Biofilm

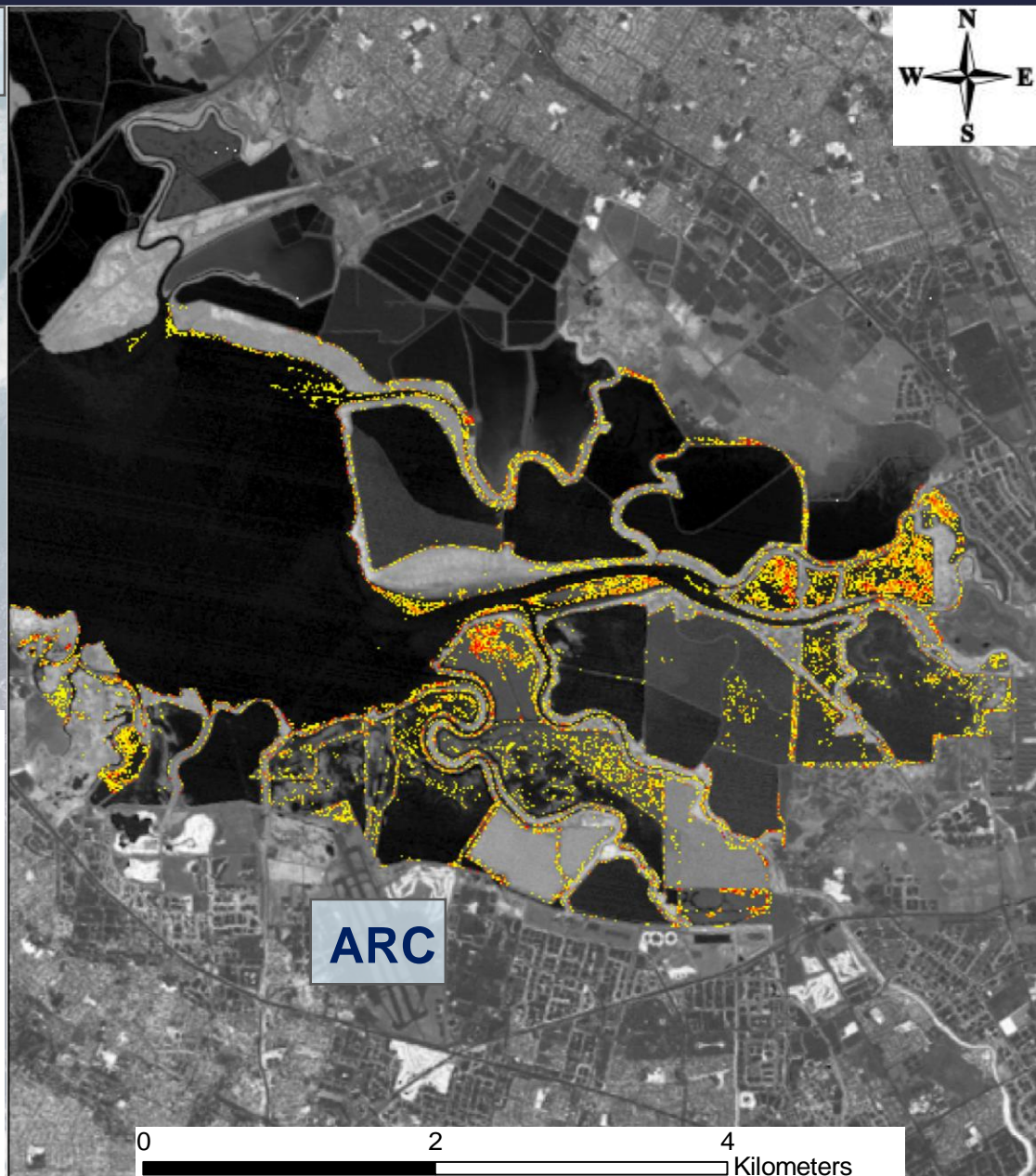
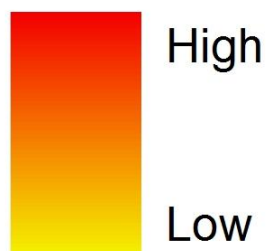
28,641,600 m²

Remote Sensing Results

Landsat NDVI

- Nine Landsat Images mapping the likelihood of biofilm presence
- June, 2006 through July, 2010
- \uparrow Likelihood = \uparrow Appearance

Likelihood of Biofilm Presence



Carrying Capacity Results

$$\text{Carrying Capacity} = \frac{A \bullet B \bullet D}{C}$$

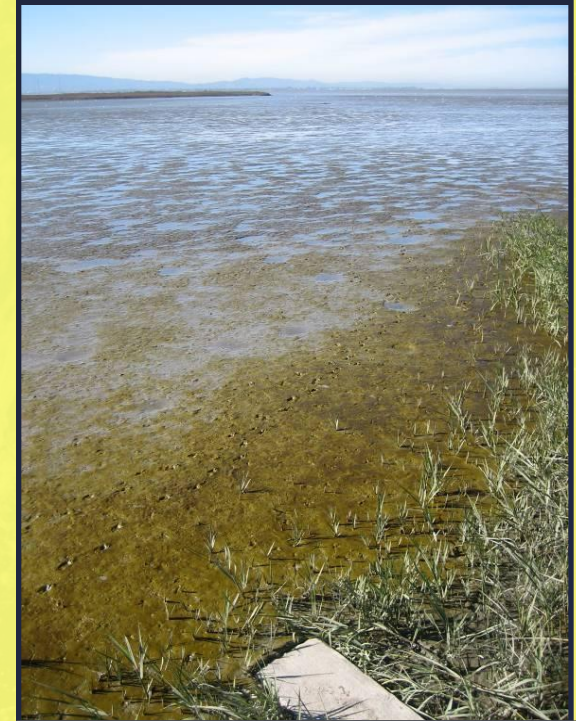
Where:

A = Area of Biofilm (m²)

B = Biofilm Biomass (g C/ m²)

D = Biofilm Energy Density (kJ/g)

C = Bird Consumption Rate of Biofilm (kJ/d bird)

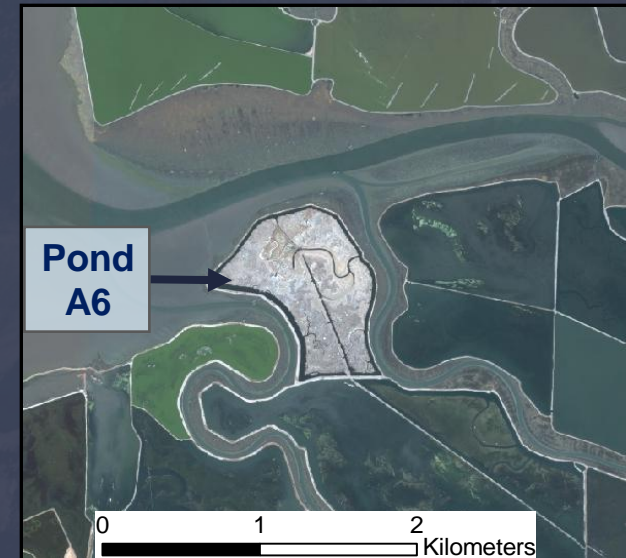


Biofilm on Marshland

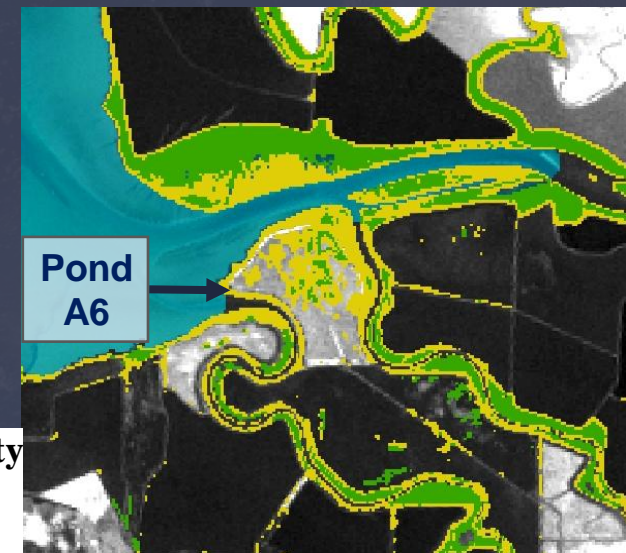
Biofilm in the South Bay Salt Pond Restoration Area, alone, can feed $\approx 200,000 (\pm 25,000)$ shorebirds per day!

South San Francisco Bay Ecological Forecasting Conclusions

- Biofilm has a distinguished spectral signature, which can be identified in satellite imagery.
- Biofilm appears to flourish in tidal, bay-side mudflats where vegetation is unable to grow, such as recently rehabilitated salt ponds.
- The dominant biofilm genus in the South San Francisco Bay Area is *Navicula*.
- Biofilm in the South Bay Salt Pond Restoration Area, alone, can feed $\approx 200,000$ ($\pm 25,000$) shorebirds per day!



Unprocessed Image



Hyperion-Classified Image

Transition to Partner

Partners:



US Geological Survey



San Francisco Estuary
Institute



US Fish and Wildlife Service



California Department of
Fish and Game



San Francisco Bay
Conservation and
Development Commission

Benefits to Partner:

- Spectral library of various biofilm densities.
- Maps of biofilm density and spatial distribution.
- Estimated carrying capacity of South San Francisco Bay for shorebirds.
- Use remote sensing instead of field crew

