National Aeronautics and Space Administration

FY23 Strategic University Research Partnership (SURP)

Automated Mapping of Kelp Forest Productivity for Carbon Storage Estimation

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Background

Kelp forests support highly diverse ecosystems worldwide, such that shifts in their abundance and distribution in association with climate change have significant impacts on the coastal and anthropogenic communities that rely on them. Current assessments are largely conducted via scuba surveys that are limited in space and time and may not be globally representative. To-date, differentiation between kelp species and their contributions to the blue carbon budget are lacking.

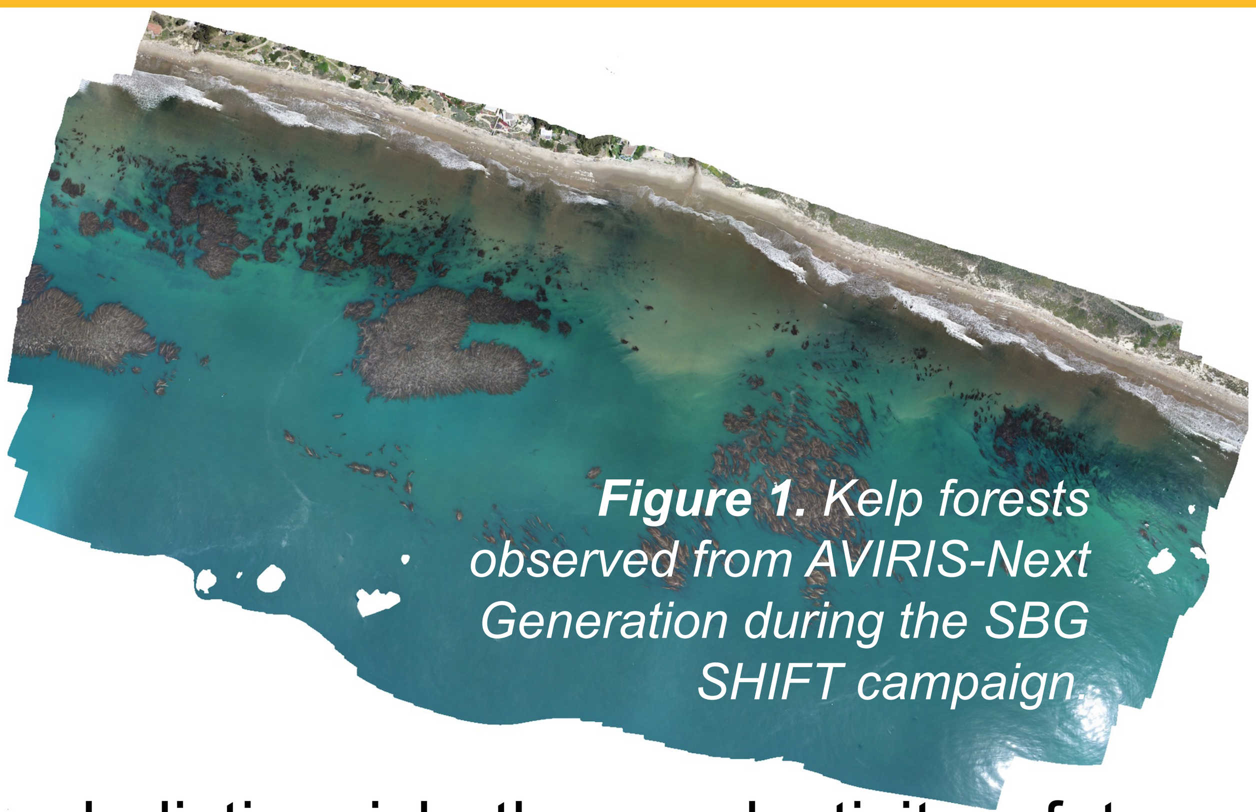

Figure 1. *Kelp forests observed from AVIRIS-Next Generation during the SBG SHIFT campaign.*

Objectives

The objective was to develop automated methodologies to estimate and distinguish the productivity of two nearshore marine foundation species along the coast of California, bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis pyrifera*), from AVIRIS imaging spectroscopy data.

Significance

- First application of imaging spectroscopy to distinguish kelp species and estimate their physiological condition.
- Data and models developed will enable linkage between kelp forest productivity and standing carbon stocks in California, informing a component of the blue carbon budget that has been largely omitted.
- Aligns with the needs and directions of NASA/JPL and our existing and upcoming missions, including the Western Diversity Time Series and the Surface Biology and Geology mission.

Approach & Results

Year 2 of the project focused on refining the methods used for deriving Chl:C and other physiological traits for giant kelp using field samples and imaging spectrometer datasets collected as part of the SHIFT campaign off the coast of Santa Barbara, California in 2022 (Figure 2). Datasets include:

1. 15 mature surface blades were collected monthly from March 2022 to March 2023 from 22 permanent diver plots at the SBC LTER site Arroyo Quemado. 5 blades were randomly sampled from which reflectance was measured and chlorophyll a, chlorophyll c, and fucoxanthin pigments extracted. A separate sample of kelp tissue from each blade was dried at 60°C, and carbon, nitrogen, and hydrogen content was determined.
2. Imaging spectrometer data from a Headwall Nano-Hyperspec sensor mounted on a DJI Matrice 600 Pro drone collected over Arroyo Quemado.
3. Imaging spectrometer data from AVIRIS-NG.

A Chl:C algorithm (Bell et al. 2015) was applied to the AVIRIS-NG and drone-based imaging spectrometer data, but the results show a high degree of spatial variability and noise. We are working on performing match-ups with field data, but the preliminary outputs suggest that a more robust model may be needed for applicability across different spectral datasets and for the derivation of NPP. Therefore, we explored using Partial Least Squares Regression (PLSR) models to quantitatively link the lab spectra with the field-collected canopy traits, including pigments and nitrogen concentration. By separating the field-sampled data into training (80%) and validation (20%) datasets, preliminary PLSR model results show good agreement between predicted chlorophyll a and fucoxanthin versus the trait data from field sampling and laboratory analysis (Figure 2). Next, we will develop relationships between canopy spectra and Chl:C and to derive NPP across each dataset.

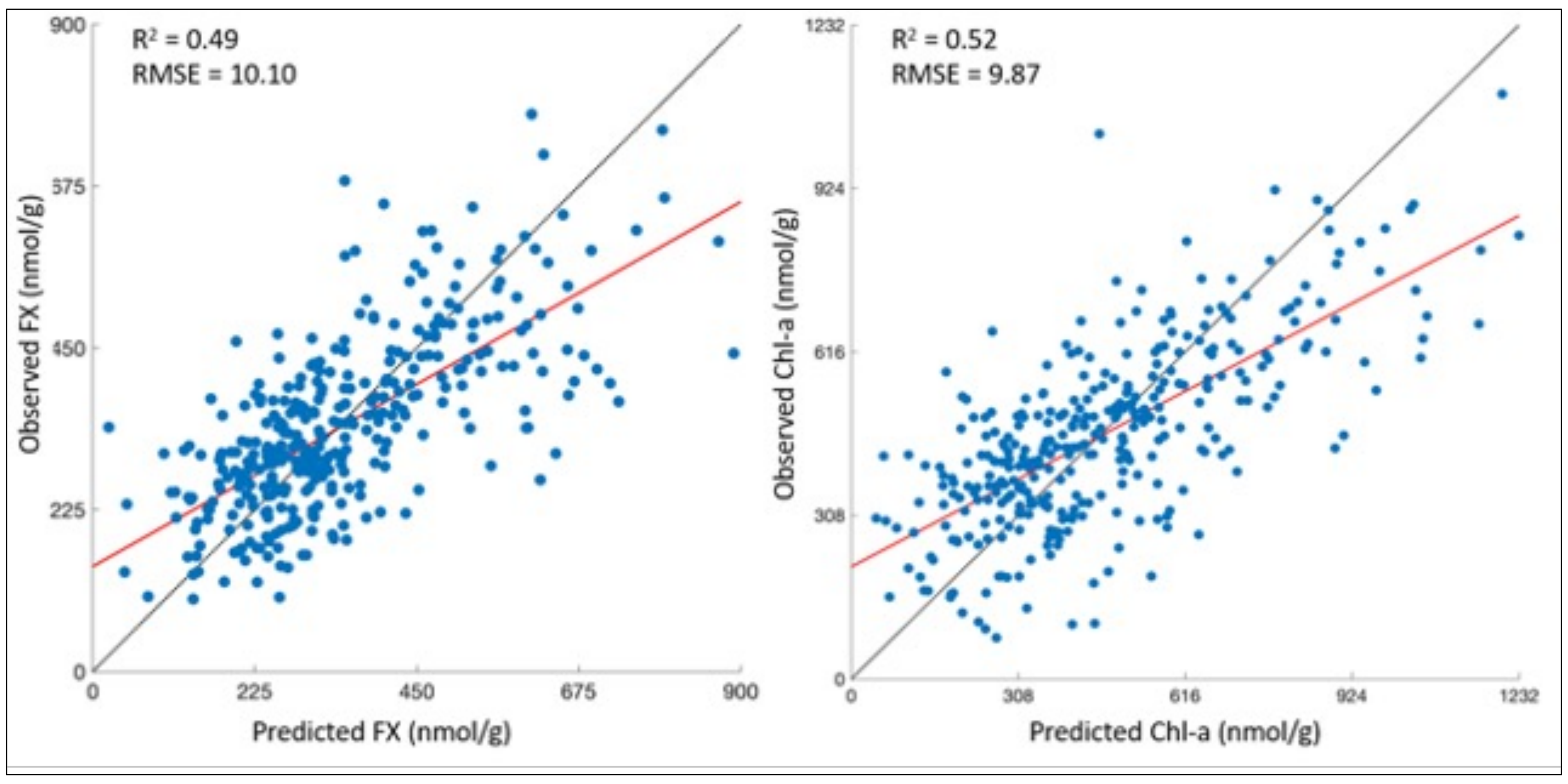

Figure 2. *PLSR model results between field spectra and the pigments fucoxanthin (left) and chlorophyll-a (right).*

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