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Sustaining California’s Underwater Forests:

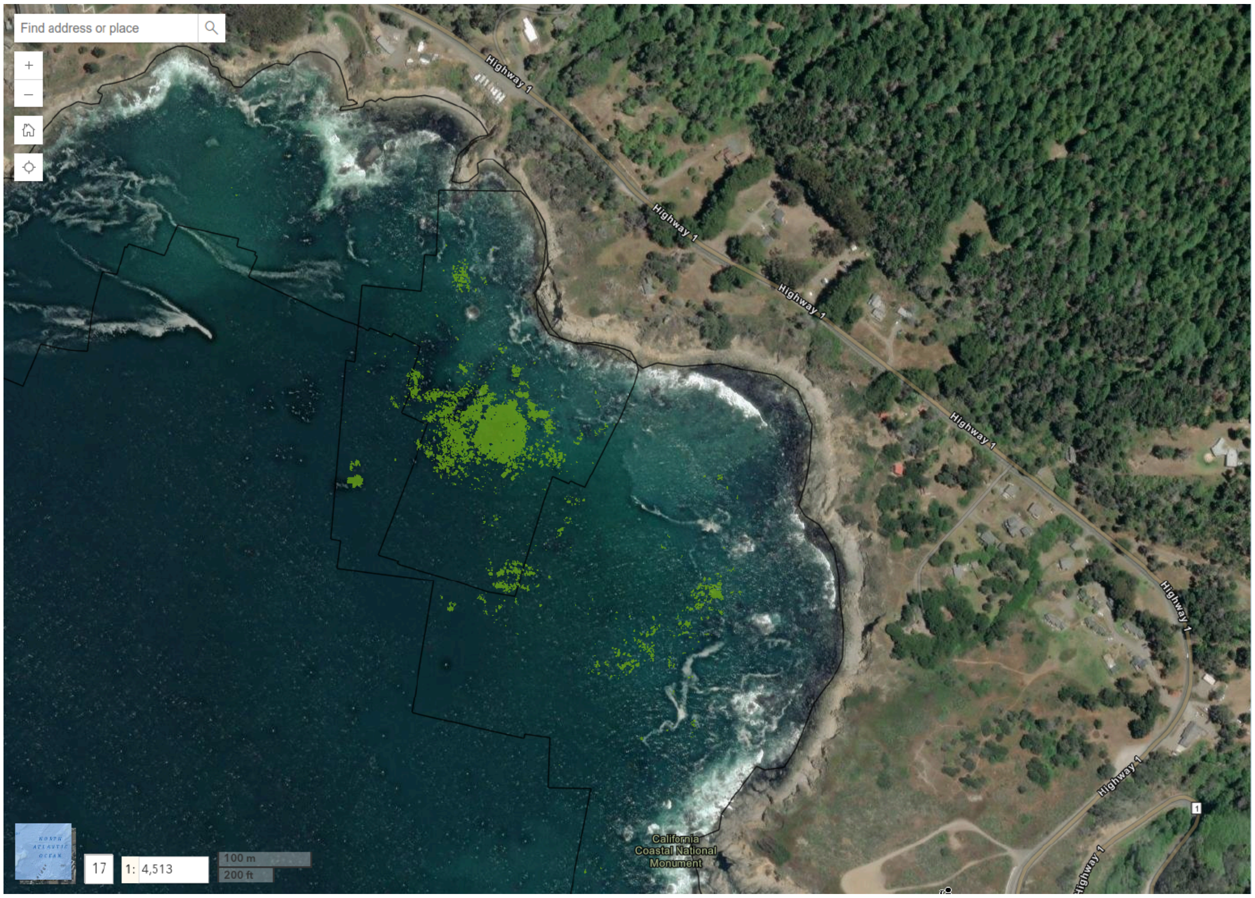
AI-Driven Solutions for Kelp Canopy Mapping

Kelp populations along California's coast have faced a significant decline over recent years due to a combination of ecological stressors. Key contributors include the explosion of pacific purple sea urchin populations, largely due to a reduction in their natural predators, sunflower starfish. These urchins graze on kelp, stripping vast underwater forests and leaving barren seascapes called "urchin barrens." Together, these pressures have led to widespread loss of kelp, endangering biodiversity and the critical coastal ecosystems that rely on these underwater forests for habitat, food, and protection (Zuckerman, 2023).

In 2021, the West Coast Region Kelp Team decided that their number one priority was "how best to conduct annual assessments of kelp forest ecosystem health" (Hohman et al., 2023). We propose monitoring kelp forest shrinkage along California's coastline by using satellite imagery combined with advanced machine learning techniques. By leveraging high-resolution satellite data and using semantic segmentation—a computer vision technique that classifies each pixel in an image into specific categories—we can distinguish kelp forests from other water and land features within these satellite images. This approach enables researchers to create precise maps of kelp coverage each year, allowing for comparisons of area over time, without having to label them by hand. Given that kelp has an annual lifecycle, this year-over-year monitoring is especially valuable, providing insights into the fluctuations in kelp extent due to climate conditions, grazing pressures, and other environmental factors.

Significant research efforts (Cavanaugh et al., 2023) have advanced remote sensing methods for kelp canopy mapping, particularly using high-resolution PlanetScope satellite data, which have contributed valuable insights into kelp distribution along the California coastline. Existing methods, like Naïve Bayes classification, leverage the spectral distinctiveness of kelp in the near-infrared spectrum, improving classification accuracy over more traditional approaches. However, current models have limitations, such as the need for radiometric corrections across PlanetScope sensor cohorts and challenges in consistently detecting low-density kelp. Additionally, previous studies have shown that false negatives remain an issue, especially when kelp coverage falls below the spatial resolution threshold.

Building on these limitations, future research will focus on refining detection models to enhance sensitivity to sparse kelp presence and reduce false negatives. Integrating multi-sensor data, such as optical remote sensing data from NASA's pace-oci, holds potential for improving spatial resolution and temporal consistency, addressing detection biases. Moreover, advancing correction techniques for radiometric inconsistencies and enhancing the adaptability of classification algorithms can facilitate a more nuanced detection of kelp. This approach will not only improve the accuracy of canopy area estimates but also provide a more robust foundation for monitoring and preserving vulnerable marine ecosystems.



Example of what a Ground Truth value could look like, from annual CDFW aerial kelp surveys

Works Cited

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