Otter Zone | San Nicolas Island, CA

A Remote Sensing Analysis of Kelp Forest Density & Distribution During the California Sea Otter Translocation Program

Background

Sea otters serve as a keystone predator in kelp forests, aiding in the balance of the overall ecosystem. They consume invertebrate species such as sea urchins that would otherwise overgraze kelp and other algae. In turn, sea otters rely entirely on kelp forest habitat. The forest provides shelter from predators and rough seas. Otters will wrap themselves in the strong kelp blades to rest, and otter mothers will secure their pups in the kelp canopy while they hunt for prey.

Kelp forest serves as the primary habitat of sea otters. Spanning the coast of California, Giant kelp (*Macrocystis pyrifera)* is the largest species of macroalgae. Kelp forests thrive in nutrient-dense, cold waters, in which they support flourishing underwater coastal ecosystems. The blades of the algae are bolstered by gas-filled bladders, which create dense canopies on the surface for effective photosynthesis. Blades grow from a long stem-like stipe, which fastens into substrate on the ocean bottom to hold the system in place.

The 1850's marked the beginning of the California 'fur rush,' in which sea otters were hunted extensively for their thick, silky pelts. After nearly reaching extinction towards the end of the 19th century, California sea otter populations have since struggled to return to healthy numbers along the coastline. Biologists and governmental agencies have put substantial effort into sea otter rehabilitation and breeding programs, hoping that the species will eventually re-inhabit their original range.

In 1987, San Nicolas island, CA was chosen as the site of a sea otter translocation and recovery program through US Fish & Wildlife Service in which 140 otters were translocated to the island as an outbreeding population. The uninhabited island lies roughly 60 miles off of the mainland coast and is utilized primarily as a US naval base.

San Nicolas island was deemed suitable for this project due to its remoteness as well as its thriving kelp forest ecosystems. However, the sea otter translocation program was discontinued in 2012 after the individuals placed there failed to reach the desired population size, a shortcoming with no known definitive cause.

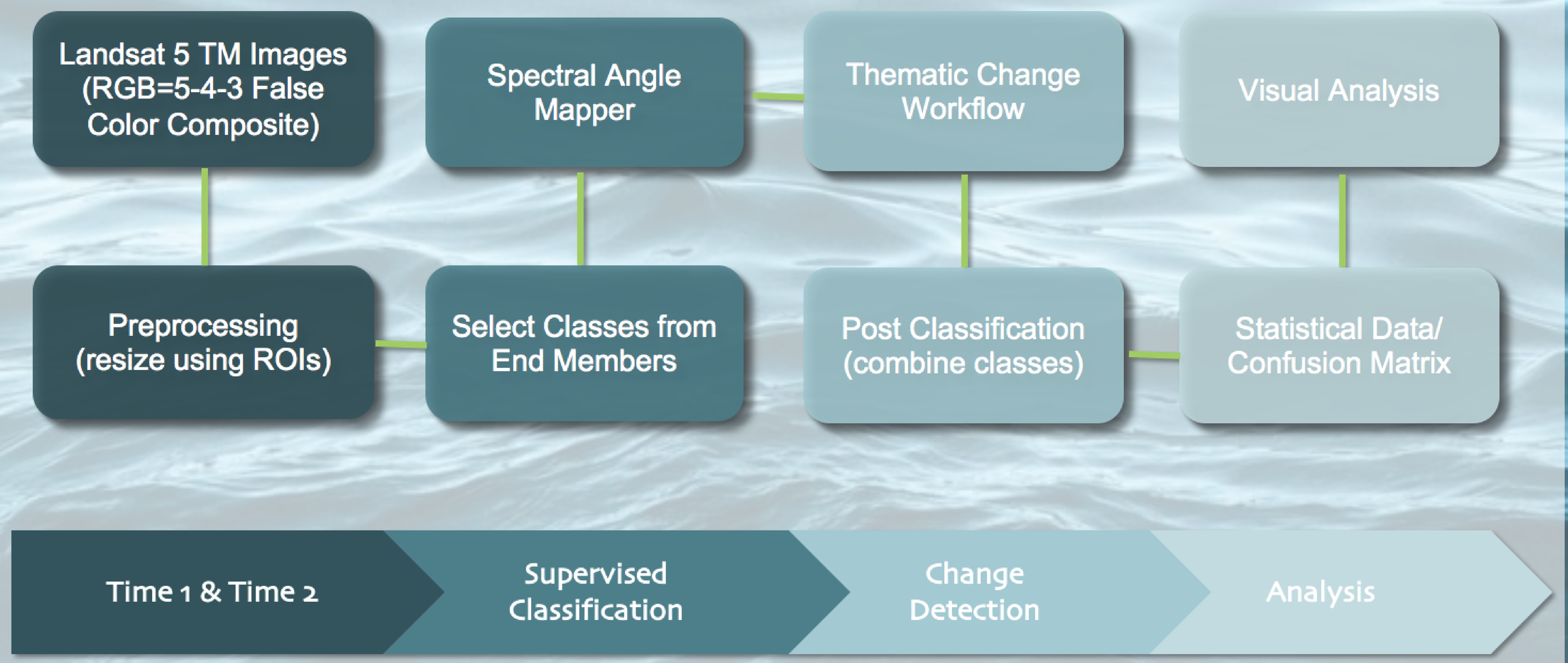
Objectives & Hypothesis

As ocean ecosystems around the world continue to face a changing climate, rising ocean temperatures, and pollution, kelp forest ecosystems worldwide are at risk. We have seen a notable decline in California kelp forest ecosystems in the past few decades, with many becoming less dense and less widely distributed. Kelp forest habitat decline could decrease overall biodiversity in coastal areas and impede the recovery of critical sea otter populations.

My aims for this analysis were to investigate any changes that occurred in the kelp forest ecosystem surrounding San Nicolas island during the length of the sea otter translocation program. As healthy kelp forest ecosystems are critical for sea otter survival, significant change or loss in kelp forest may have contributed to the unsuccessful recovery efforts of the translocated population. I utilized Landsat 5 high resolution multispectral imagery in order to examine kelp forest canopy surrounding San Nicolas island and assess changes that occurred between August of 1994 and September of 2010.

Based on current literature describing kelp forest decline in California, I hypothesize that San Nicolas Island experienced a decline in kelp forest density and a change in distribution between 13 August 1994 and 26 September 2010.

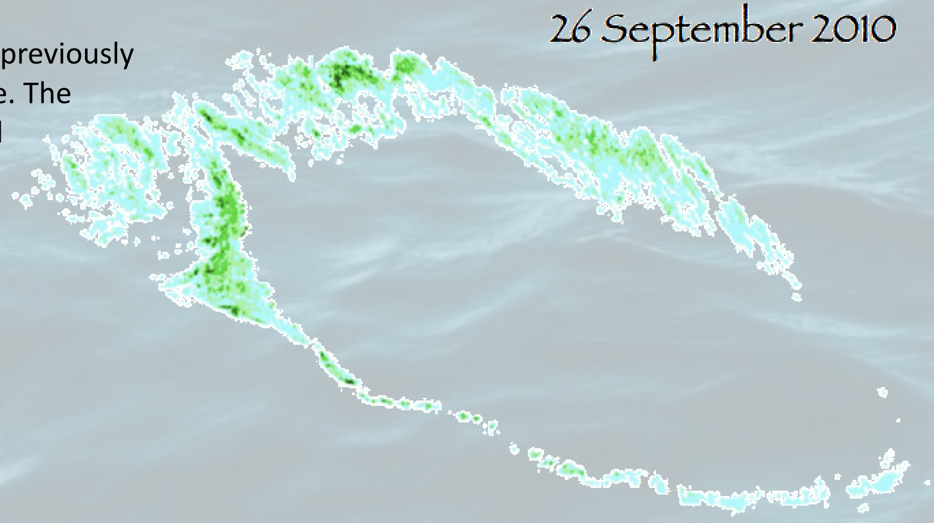
Methodology



Spectral Angle Mapper

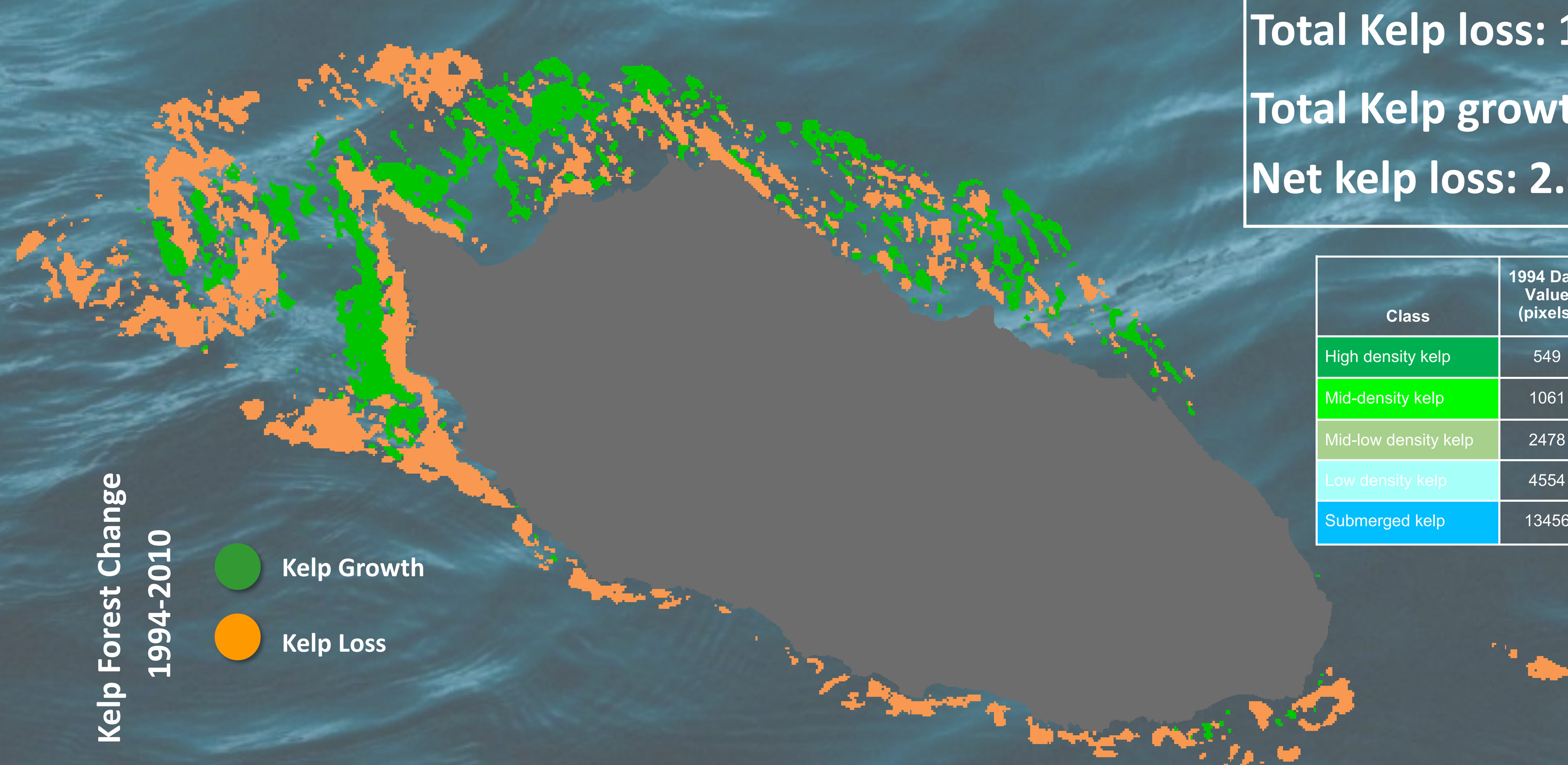
The spectral angle mapper tool was chosen to run the classifications on the two images. Spectral angle mapper is a supervised classification tool that directly compares the image spectra to selected endmembers utilizing an *n*-dimension angle. By illustrating the spectra as vectors in space with the number of bands equivalent to dimensionality, the angle between the spectra can be calculated in order to determine spectral similarity between two images.

I ran the spectral angle mapper tool using the spectral library created from the previously determined classes as the input for the overall classification of each image. The resulting images were classified based on the various predetermined kelp densities: high, medium, medium-low, low, and submerged.



Kelp Forest Density
- High density kelp
- Mid-density kelp
- Mid-low density kelp
- Low density kelp
- Submerged kelp

Kelp Forest Change 1994-2010



Total Kelp loss: 14.1 km^2 (70%)

Total Kelp growth: 11.5 km^2 (58%)

Net kelp loss: 2.6 km^2 (12%)

Class	1994 Data Value (pixels)	2010 Data Value (pixels)	1994-2010 Change (pixels)	% change
High density kelp	549	30	519	-94.54%
Mid-density kelp	1061	237	824	-77.66%
Mid-low density kelp	2478	1470	1008	-40.68
Low density kelp	4554	4591	-37	0.81%
Submerged kelp	13456	13306	150	-1.10%

Conclusions & Discussion

This analysis illustrated areas of change in kelp forest density and distribution surrounding San Nicolas Island. This addresses my research question and hypothesis, confirming that kelp forest loss did occur in the study area between the years of 1994 and 2010 in which the sea otter translocation program was in progress.

This method could be used as an accurate analysis for tracking kelp forest density and distribution over time.

Overall, this project allowed me to apply remote sensing techniques to a topic that I am very familiar with in my field. I was able to acknowledge the usefulness of satellite technology in addressing various environmental issues such as declining habitat, deforestation, sea surface temperature change, and urban sprawl. Through preliminary research of my topic, I was able to discover how satellite technology is currently being utilized in the marine science field and the importance of satellite images in understanding environmental issues on global scale.

Remote sensing tools will be useful in monitoring density and distribution of kelp forests worldwide over time as ocean temperatures continue to rise and marine environments continue to face anthropogenic alteration. Kelp forest ecosystems support high biodiversity and sustain recovering sea otter populations. With invaluable ecological importance to coastal areas, kelp forests require close monitoring over time in order to ensure their prolonged survival.

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Tufts University — Cummings School of Veterinary Medicine

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Data Sources: USGS Earth Explorer, Landsat 5 TM

Image Sources: Blue Ocean Art, Marine Mammal Commission, Ocean Safari Scuba