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Effects of El Niño on Ecological Growth Along Californian and Peruvian Coasts

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Introduction

The complexities of an ecosystem and its dynamic relationships often have multiple factors that simultaneously maintain its balance or influence certain flux periods of growth or decline. Nutrients can be seen as the building blocks of an ecosystem as they provide the essential mineral content for all life forms to take up through trophic level dynamics (MacKenzie, 2008). El Niño storm months are typically from the months of December to February, disrupting the oceanic-atmospheric system in the Tropical Pacific (NOAA-TAO, 2014). This disruption is linked to vast weather and climate events around the globe (NOAA CPC). Unlike La Niña, El Niño is linked to unusually warm temperatures in the Equatorial Pacific (NOAA-TAO, 2014). El Niño causes upwellings along the California coast and displaces its normally warm waters with cool waters from Peru-this also holds true for Peru, in that its typically cold waters are displaced with the warm waters from the California coast during storm months (Jiang et. al., 2005).

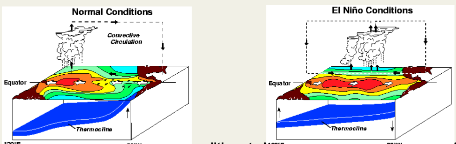
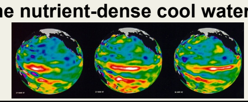


Figure 1. Comparison of El Niño storm conditions to Normal Conditions (courtesy of NOAA-El Niño: Animations and Graphics). These diagrams visualize the extreme change in the thermocline's behavior and the pacific ocean's movement, with a temperature profile.

During El Niño, the thermocline's curve in the water column is reduced, causing dramatic changes in the natural water flow and in sea surface temperatures (Figure 1) (McPhaden, 1999). The cool waters of an upwelling are nutrient-rich and can have a bottom-up influence on a marine ecosystem (Jiang et. al., 2005). The potential bottom-up effects have huge implications for marine life health and ecosystem boosts (Harris et. al., 2009). Should these nutrients be the minimizing factor of the ecosystem-explained by Liebig's law of the minimum-there could be a large flux in the fishing industry, increased opportunities for recreation or education, and an overall increase in marine life health along California's coast (Jerz, 2013). There is also the potential for detrimental effects to be observed along the Peruvian coast due to a reduction in nutrient availability from the flux in water movement and temperatures (Vinueza et. al., 2006). The Peruvian coast was simultaneously studied in attempt to observe potential negative fluxes occurring during the storm months of El Niño (Vinueza etl. Aa., 2006). These potential indicators could lead to observing detrimental effects such as eutrophication or dead zones, depending on the severity of the movement of nutrients.

Research Questions

- **Does El Niño have an effect on ecosystems due to its upwellings (nutrients=bottom-up effect)?**
- **Is nutrient density or availability the limiting factor in the marine ecosystems along the coast of California?**
- **During El Niño, do Peruvian coasts experience detrimental effects from the flux of warm water displacing the nutrient-dense cool water?**



Study Sites and Methods

Study Area:

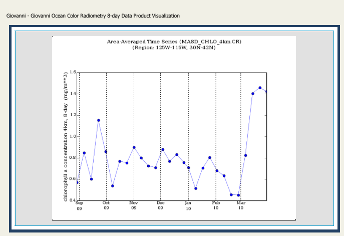
The locations studied were the west coast of California along with the West coast of Peru, extending to the political border of Chile. Remote Sensing technology was used to analyze these two locations with NASA's Giovanni Portal. The parameters for California were -125 West, 42 North, 30 South, and -115 East. The parameters for Peru were -83 West, -3 North, -24 South, and -70 East.

Methods:

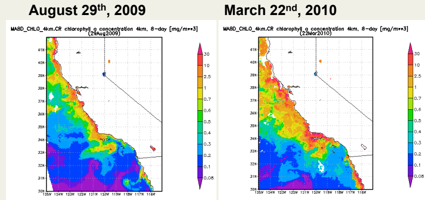
All data is from NASA's Giovanni Portal. Data was collected using the Ocean Color Radiometry Portal, which consists of eight-day data. Parameters from this portal included MODIS-Aqua (4km) to look at Chlorophyll a Concentration and Color Dissolved Organic Matter (CDOM) content. CDOM is raw organic matter in the water and is detected by the absorption of blue spectral wavelengths as well as UV radiation (NASA Earth Data). Chlorophyll a Concentration was studied for a more in-depth examination of nutrient density and signs of trophic level spikes due to nutrient uptake.

Information was also collected from NASA's Giovanni Portal using the Ocean Color Radiometry Online Visual and Analysis Monthly Data. Using the MODIS-Terra sensor (9km) the Sea Surface Temperature (SST) was analyzed at two different frequencies: 11 micrometers and 4 micrometers. Data for both of these frequencies was collected at night to prevent any interference from solar radiation and reflectance or scattering variables. This prevented the need for a further step in pre-processing data to correct for potential variance in solar interference with the sensors. SST was studied to find potential correlation and causation of the CDOM and Chlorophyll a Concentration to storm events, since an overall change in SST is a reining characteristic of ENSO.

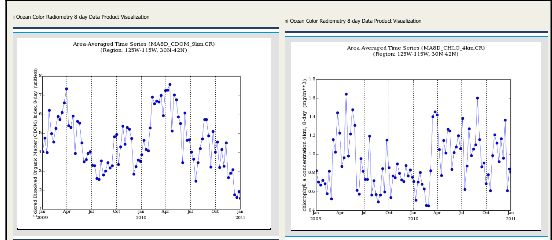
Chlorophyll Concentration (4km) 8 day data: CA



August 29th, 2009 — March 22nd, 2010

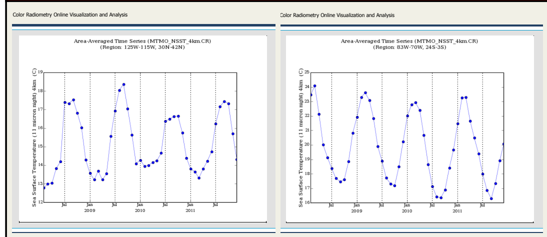


CDOM (9km) & Chlorophyll (4km) Correlation: 2009-2011 CA Data



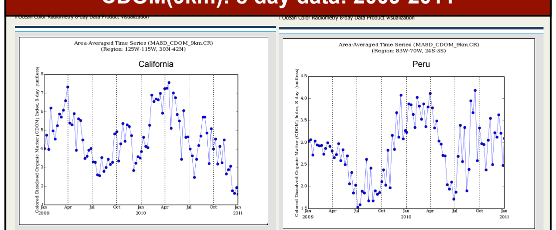
CDOM — Chlorophyll Concentration

SST (4km): 11 microns (Night) Monthly Data: 2008-2011



California — Peru

CDOM(9km): 8 day data: 2009-2011



Conclusions

This research found a definite correlation between CDOM and Chlorophyll a Concentration. This correlation also indicates that nutrient density and availability is a limiting component in the marine life ecosystem along the California coast. Time-series data also confirmed a seasonality differentiation between Peruvian and Californian conditions. Steep inclines and slopes on graphs indicated potential correlation between storm months and parameters with increased quantities such as CDOM and chlorophyll concentrations. Further statistical analysis needs to be conducted to better understand the significance of fluctuations in data to establish a confidence level between anomalies and seasonality.

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