Time, Temperature, Chlorophyll a

Does sea surface temperature affect chlorophyll a concentrations?

A partnership between California Current Ecosystem Long Term Ecological Research (CCE LTER) and Ocean Institute (OI)
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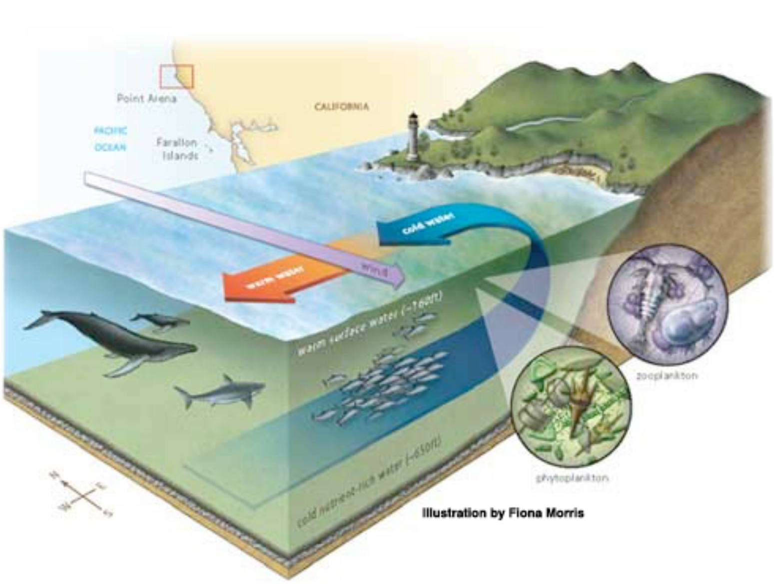
Introduction: Scientists with the California Current Ecosystem Long Term Ecological Research program (CCE LTER) have been collecting data on phytoplankton abundance and chlorophyll *a* concentrations using water sampling techniques for decades. It is time-consuming and expensive to collect these samples offshore, so they are generally collected only once every three months. For the past twenty-five years, scientists have been able to supplement their data collection with satellite images. These images allow scientists to see changes in phytoplankton abundance and chlorophyll *a* concentrations over short periods of time and over large areas of the ocean at once.
Integrating technology like NASA satellites complements CCE LTER's ship-based measurements. These satellites are equipped with SeaWiFS and MODIS remote sensing technology. This technology creates images that help scientists visualize the abundance of phytoplankton in a given area. It works by measuring the color of the ocean surface. Chlorophyll *a* absorbs particular wavelengths of light. Lower concentrations of phytoplankton, and therefore chlorophyll *a,* result in the water appearing more purple or blue. As the concentration of phytoplankton (and chlorophyll *a)* increases, the water appears more green, yellow, or even red. Images of chlorophyll *a* concentrations can be coupled with satellite images of sea surface temperatures (SST) in the same area at the same time. When these two variables are examined together, scientists can assess how increasing sea surface temperatures relates to phytoplankton abundance. Why is this important?

Chlorophyll *a* Concentrations (mg Chl/m³)

Satellite data are analyzed using an equation (or algorithm) that manipulates specific values like ocean color and chlorophyll *a* concentration and translates them into pixel values (like pixels of a photograph). Each pixel represents the chlorophyll concentration from a certain place in the ocean. These pixels are then projected onto a map so that scientists can see how much chlorophyll is in a particular place. A color scale is created to represent a range of values for chlorophyll concentration. Since each pixel represents a specific value, scientists can study an entire image and begin to understand the health of a specific location.

In many instances, phytoplankton abundances are higher in cold, nutrient-rich waters. In the California Current Ecosystem, these nutrient-rich waters are the result of upwelling. Upwelling occurs when the prevailing winds blow south along the coastline. This results in the surface water moving westward away from the coast (caused by Ekman transport). As the warm, surface water moves away from the coast, cold, deep water comes in to fill the space. This deep water is full of nutrients, which allows for large numbers of phytoplankton to flourish. As ocean surface temperatures increase, upwelling tends to decrease. Decreased upwelling can lead to lower phytoplankton abundance. The effects of this decrease can be widespread and change local ecosystem dynamics. In light of this, scientists from the CCE LTER continue to track phytoplankton abundance as an indicator of the health of the California Current Ecosystem.



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Vocabulary:

Abundance: The number of a particular type of organism within a specific community.

Biomass: The amount of living organisms.

Chlorophyll *a:* A pigment that all plants contain, which allows them to perform photosynthesis. It absorbs blue light and emits or fluoresces, red light. This green pigment can be directly measured and is used as the primary indicator of algal biomass.

Ekman transport: The net movement of the surface layer of the ocean in a direction 90° to the right of the direction of the wind.

Nutrients: Elements that are required by phytoplankton for growth. Those of greatest importance are nitrogen, phosphorus and iron.

Photosynthesis: Chemical process by which plants convert light energy into chemical energy (glucose).
$6CO_2 + 6H_2O$ + light energy ➪ $C_6H_{12}O_6 + 6O_2$

Phytoplankton: Microscopic algae that live in water and produce their own food through the process of photosynthesis. Collectively, phytoplankton are the foundation of the marine food web.

Primary productivity: The amount of material (biomass) produced by plants (primary producers) through the process of photosynthesis.

SEAWIFS/MODIS: Sea-viewing Wide Field-of-view (SEAWIFS) Sensor that provides data received from an Earth-orbiting color satellite sensor loaded with Moderate Resolution Imaging Spectroradiometer (MODIS) instrument that collects the data.

Upwelling: The process where by sustained winds move warm surface water offshore and cold, nutrient-rich deep water rises up to replace it.

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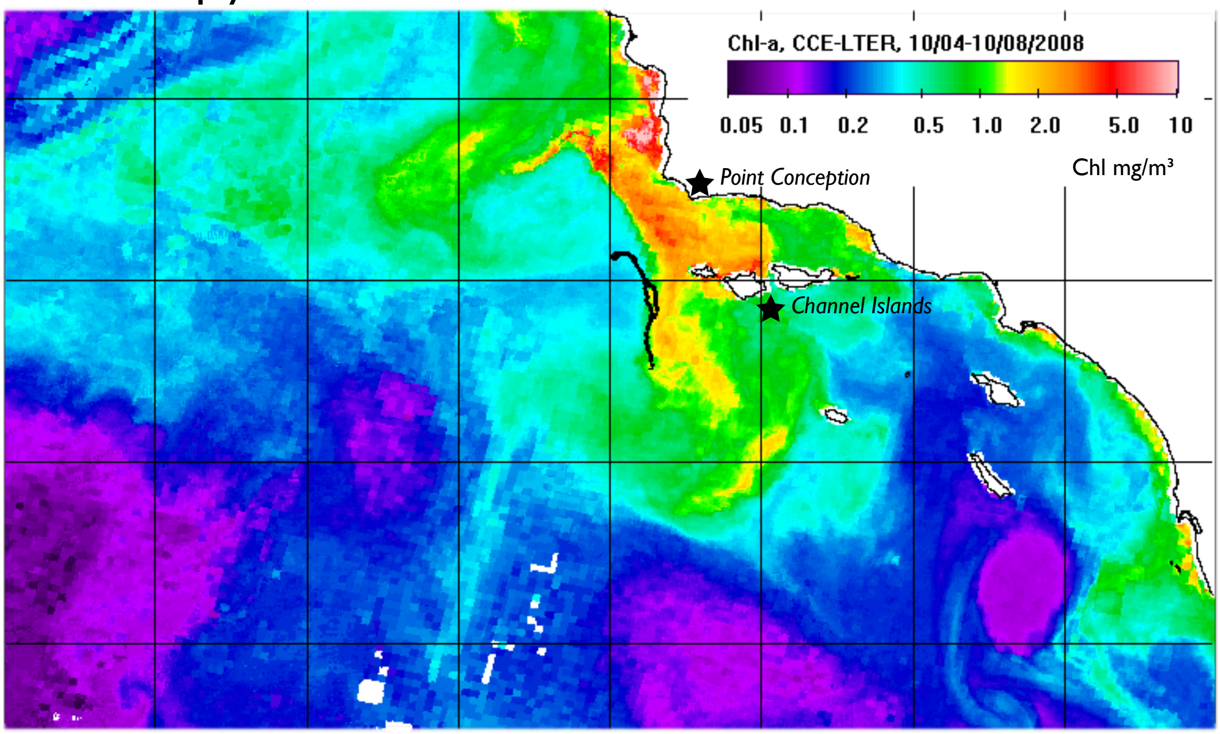
The satellite imagery below is taken using different filters to detect chlorophyll *a* concentrations. When looking at the chlorophyll *a* images, warmer colors indicate higher concentrations of chlorophyll *a* (and thus phytoplankton) and cooler colors indicate lower concentrations. Black lines indicate satellite drifter tracks. Source: http://spg.ucsd.edu/Satellite_Data/California_Current/2008/CCE-LTER/

IMAGE 1a: Chlorophyll *a* concentrations



CCE LTER Satellite Image off the coast of Santa Barbara 10/04/08 - 10/08/08

Phytoplankton ecologists respond to the following:

Write a hypothesis to explain a possible relationship between sea surface temperature, chlorophyll *a* concentration and phytoplankton abundance.

My hypothesis: ____________________

1. Looking at image 1a, describe where chlorophyll *a* concentrations are the highest and where they are lowest.
2. With your partner, write a statement describing why there are many phytoplankton in some areas and few in other areas.
3. Share your findings with the physical oceanographers and together **write a statement** describing what kind of relationship(s) might exist between chlorophyll *a* (**1a**) and sea surface temperature (**1b**).
4. Write a **possible explanation** for why a relationship between the two measurements may exist, and support the explanation with scientific concepts.

Created by: Beth E. Simmons
Education & Outreach Coordinator CCE Long Term Ecological Research (LTER)

STUDENT WORKSHEET

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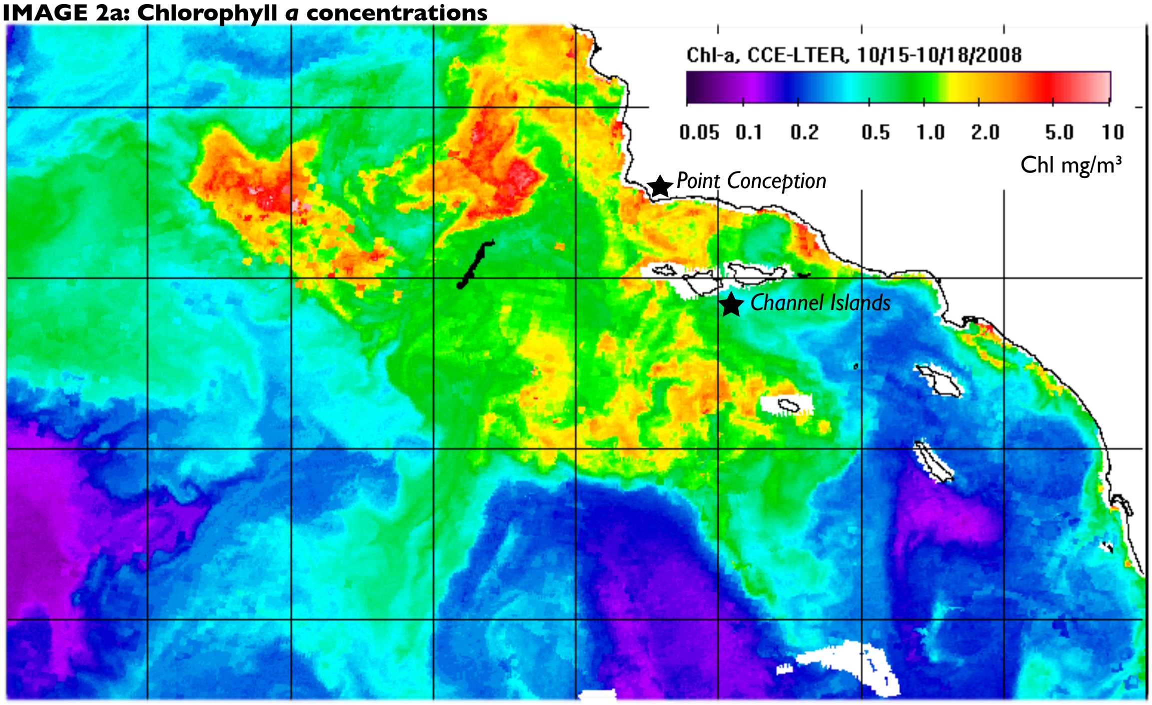
IMAGE 2a: Chlorophyll *a* concentrations



CCE LTER Satellite Image off the coast of Santa Barbara 10/15/08 - 10/28/08

Phytoplankton ecologists respond to the following:

1. Looking at image 2a, describe where chlorophyll *a* concentrations are the highest and where they are lowest.

2. Write a possible explanation for the pattern you see. Why are there many phytoplankton in some areas and few in others?

3. Write a statement describing how images 1a and 2a are different.

4. Based on this satellite image, predict what the corresponding image of SST might look like.

5. As a group, discuss your observations relating chlorophyll *a* concentrations and SST. Answer the following questions on the back side of this paper:

   a. Was your prediction for sea surface temperature correct?

   b. Give a possible explanation as to why images 1a and 2a changed so drastically over such a short time span.

6. Conclusion: Based on the data that have been analyzed, write your scientific findings in a concluding paragraph. Include in this paragraph:

   ✓ Your original hypothesis, and whether it was supported or not, based on the images that you have seen,

   ✓ A statement clearly explaining the relationship that exists between phytoplankton abundance, chlorophyll *a* concentration and sea surface temperature.

   ✓ What influences sea surface temperature changes on a daily, weekly and monthly basis.

   ✓ The long-term effects of increasing sea surface temperatures on phytoplankton abundance.

Created by: Beth E. Simmons © 2009 (Revised 2011)
Education & Outreach Coordinator CCE Long Term Ecological Research (LTER)

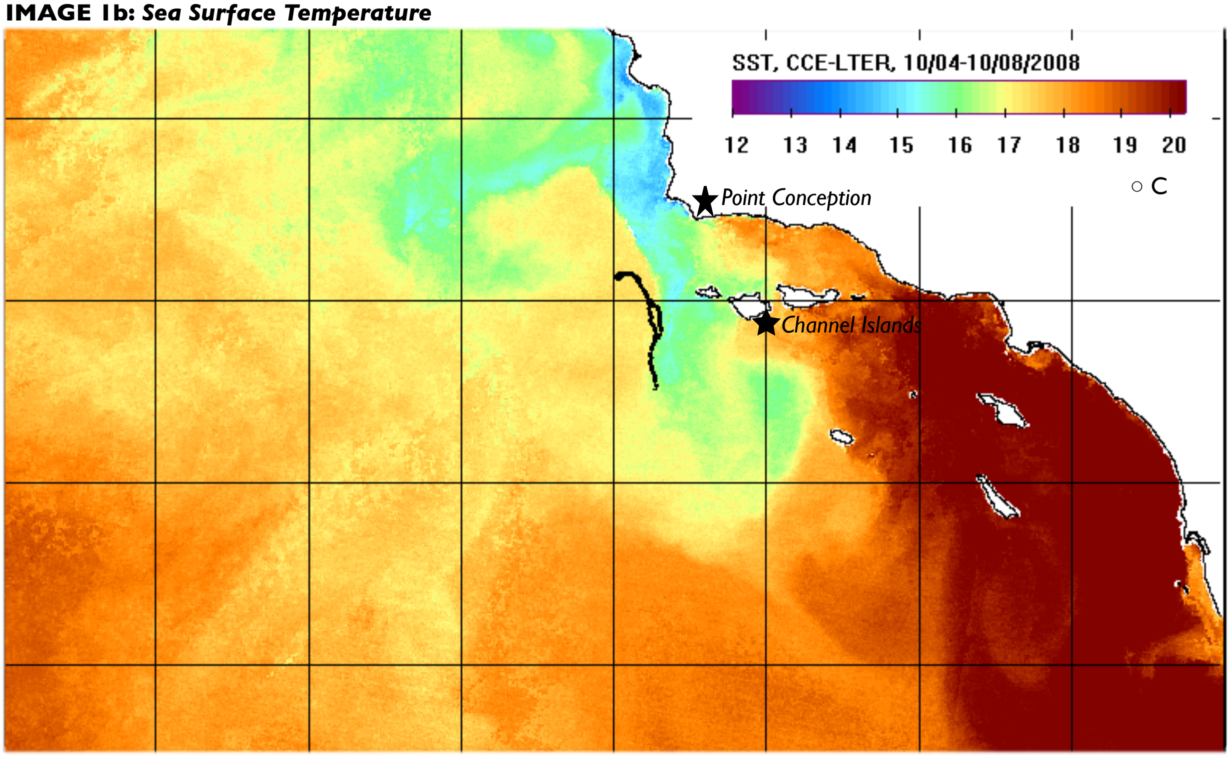
STUDENT WORKSHEET

Time, Temperature, Chlorophyll *a*

Does sea surface temperature affect chlorophyll a concentrations?

The satellite imagery below shows sea surface temperature (SST). Warmer colors indicate warmer sea surface temperatures and cooler colors indicate cooler temperatures. Black lines indicate satellite drifter tracks. Source: http://spg.ucsd.edu/Satellite_Data/California_Current/2008/CCE-LTER/

IMAGE 1b: *Sea Surface Temperature*



CCE LTER Satellite Image off the coast of Santa Barbara 10/04/08 - 10/08/08

Physical Oceanographers respond to the following:

Write a hypothesis to explain a possible relationship between sea surface temperature, chlorophyll *a* concentration and phytoplankton abundance.

My hypothesis: ______________________________

1. Looking at image 1b, describe where sea surface temperature (SST) is the highest and where it is the lowest.
2. Write a possible explanation for the pattern you see. Why is the surface of the ocean warm in some areas and cool in others?
3. Share your findings with the phytoplankton ecologists and together write a statement describing the relationship between sea surface temperature (**1b**) and chlorophyll *a* (**1a**).
4. Write a possible explanation for why this relationship may exist and support the explanation with scientific concepts.

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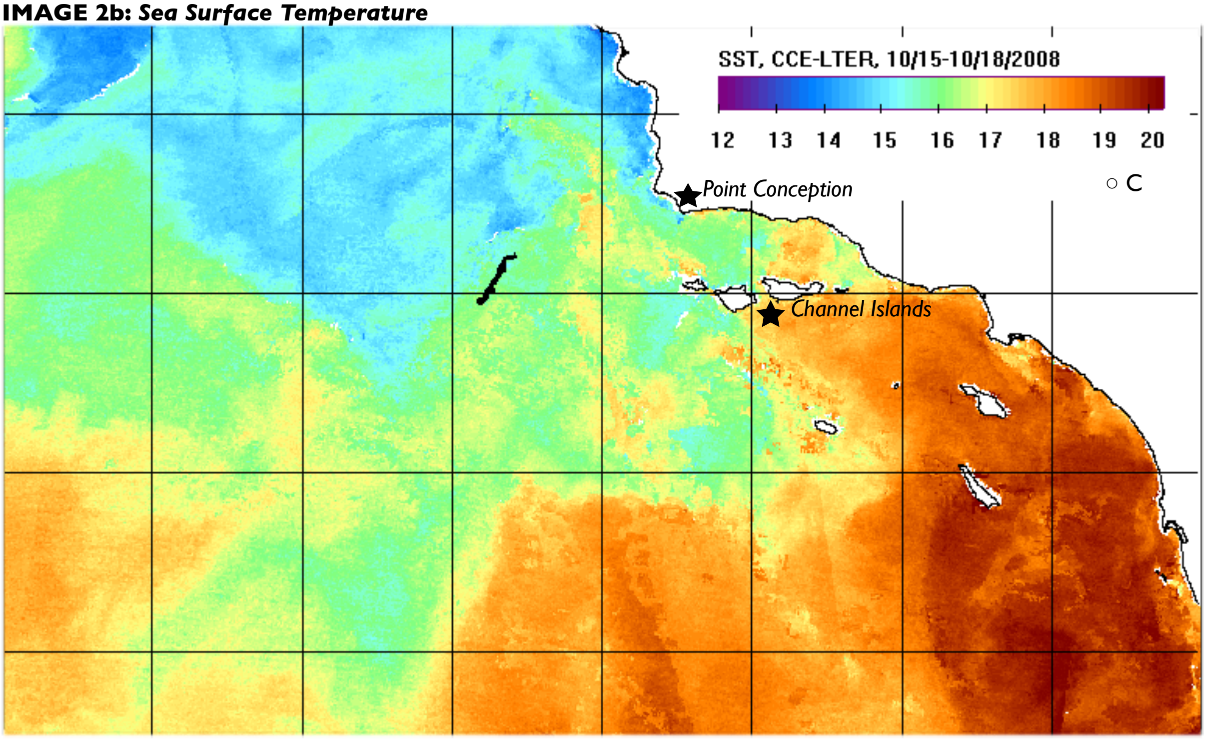
IMAGE 2b: ***Sea Surface Temperature***



CCE LTER Satellite Image off the coast of Santa Barbara 10/15/08 - 10/18/08

Physical Oceanographers respond to the following:

1. Looking at image 2b, describe where sea surface temperature (SST) is the highest and where it is the lowest.

2. Write a possible explanation for the pattern you see. Why is sea surface temperature high in some areas and low in others?

3. Write a statement describing how images 1b and 2b are different.

4. Based on this SST image, predict what the corresponding chlorophyll *a* image might look like.

5. Now, as a group discuss your observations correlating *chlorophyll a* concentrations and SST. Answer the following questions on the back side of this paper:

   a. Was your prediction for chlorophyll concentration correct?
   b. Give a possible explanation as to why images 1b and 2b changed so drastically over such a short time span.

6. Conclusion: Based on the data that have been analyzed, write your scientific findings in a concluding paragraph. Include in this paragraph:

   ✓ Your original hypothesis and whether it was supported or not, based on the images you have seen.

   ✓ A statement clearly explaining the relationship that exists between phytoplankton abundance, chlorophyll *a* concentration and sea surface temperature.

   ✓ What influences sea surface temperature change on a daily, weekly and monthly basis?

   ✓ The long-term effects of increasing sea surface temperatures on phytoplankton abundance.

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