# Chlorophyll -Temperature Time Series Project

A partnership between California Current Ecosystem, Long Term Ecological Research (CCE LTER) & Ocean Institute (OI).

## CCE LTER and OI Bridge Site Science and Education and Outreach

Beth Simmons Education and Outreach Coordinator, CCE LTER, Scripps Institution of Oceanography


Figure 1: Ocean Institute (OI) R/V Sea Explorer floating laboratory for students. (Photo: Beth Simmons)

A unique partnership between the California Current Ecosystem LTER (CCE LTER) and the Ocean Institute (OI) in Dana Point, CA, began in the fall of 2005. Twenty scientists, research assistants, curriculum coordinators, teachers, technicians and students gathered for training on fluorometric chlorophyll analysis at Scripps Institution of Oceanography in San Diego, CA. This unique interface linked long-term scientific research with a long-standing informal science education program. A quintessentially ideal collaboration, it transforms scientific research into authentic learning experiences for students ranging in educational levels from elementary school through college. Students and trained staff from Ocean Institute join in scientific field research aboard one of OI's sampling platforms, the Sea Explorer - a 70-foot floating laboratory outfitted with five distinct teaching areas, video microscopes, touch tanks, viewing aquariums, and state-of-the-art electronics.

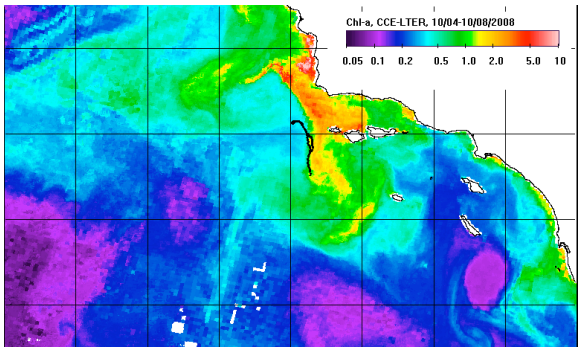


Figure 2: Chlorophyll *a* satellite image from MODIS-Aqua and SeaWiFS, 2008. Black lines indicate satellite drifter tracks in the CCE LTER study site. (Image: Mati Kahru)

**Project Participation:** Schools that participate in the floating labs take part in the time-series collection. Students monitor ocean surface temperature, collect concentrations of **total chlorophyll *a*** (Chl *a* - an accessory pigment found in plants) and **Chl *a*** concentrations larger than 3µm size fraction within a water sample. The samples are collected at depth of 10 m approximately 2 km SSE of the California Cooperative Oceanic Fisheries Investigations (CalCOFI ) station 90.028. Each sample is filtered to extract amounts of chlorophyll *a,* which is a pigment found in all **phytoplankton.** Measuring *chlorophyll a* concentrations allows for the determination of the amount of phytoplankton in different size fractions, including **picoplankton** which are cells <3 µm in size and **nanoplankton**, which range in size from 3µm - 20 µm. This chlorophyll concentration value is used to obtain an estimate of how much phytoplankton is in the area of the ocean being sampled (phytoplankton biomass). Scientists analyze these chlorophyll values to understand phytoplankton over long time scales and track the health of the ocean and the Earth's system. You can access the data collected by the students and scientists at http://cce.lternet.edu/outreach/projects/chlorophyll_project/data_zoo.php.

**Background on the California Current Long Term Ecological Research (LTER)**

The California Current Ecosystem LTER is a part of the Long Term Ecological Research Network . This network consists of 26 different sites, each conducting research on ecological phenomena over long time periods and across a wide range of the North American continent, its bordering seas, a coral reef, and Antarctica. Each site collaborates and investigates ecosystem science, applying it to real world issues. Comparisons are made across the sites and focus on understanding ecosystem science, synthesizing information through long-term studies, informing the broader scientific community, creating a scientific legacy, and educating a new generation of scientists while reaching out to the public.

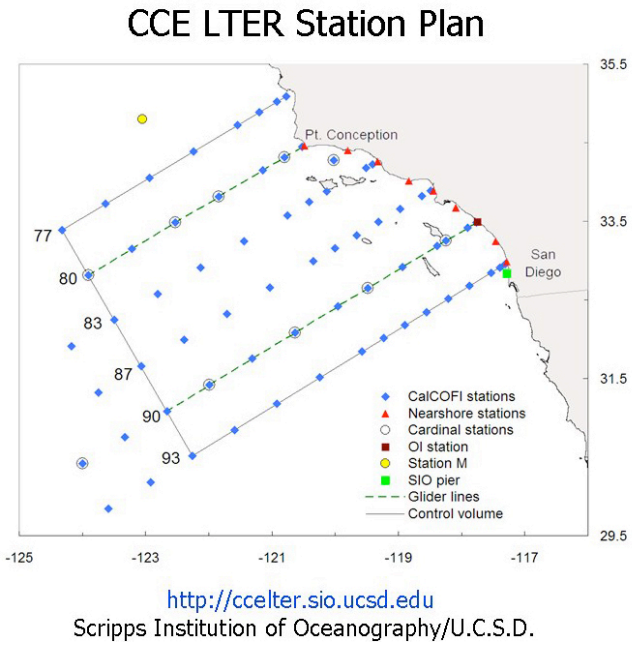


Figure 3: California Current Ecosystem Station Plan with key. (Illustration: CCE LTER)

## What can students learn from a time series collection?

Scientists from Scripps Institution of Oceanography (SIO), together with the Ocean Institute in Dana Point, California, are both contributing to this database of coastal chlorophyll and temperature from a region known as the Southern California Bight within the California Current Ecosystem. The gathering of chlorophyll *a* and surface temperature data forms a time series (a collection of successive data points), and acts as a proxy for phytoplankton community size-structure, providing information about the different size classes of phytoplankton. Using additional measurements like concentrations of ammonium, nitrate, dissolved organic carbon, concentrations of iron and grazers, scientists can relate the chemical, physical, and biological processes governing the phytoplankton communities within the California Current ecosystem. Unlike a single point in time, a time-series offers scientists the ability to put a range of values into context. These consecutive measurements reveal patterns, that based on only a few measurements, would be unclear and often highly variable. Scientists need to determine the degree of change over time, and interpret the cause-and-effect relationships that are hidden. When combined with biogeochemical measurements, (like concentrations of ammonium, dissolved oxygen, dissolved organic carbon, nitrogen and iron), long-term measurements like this for the CCE LTER, contribute to the understanding of how an ecosystem responds to changes in the environment and, how these changes affect the biology of the ecosystem.

Students engaging in understanding a time-series uncover the basic data that make up the scientific world, and witness how scientists go about their work. These exercises were designed to help students engage in the 'nature of science' by *collecting* relevant evidence, *using* logical reasoning and *applying* their understanding as they make sense of the California Current Ecosystem. Students will analyze a temperature time-series from a 60-year record as a means of understanding that *physical characteristics within a system govern biological responses.* So, temperature data collected over space and time can reveal a pattern and act as a precursor to what is happening within the structure of a marine community. This data can be a possible indicator to the health of an ecosystem.

After engaging with the time-series analysis, students will begin to investigate types of phytoplankton found within the CCE. Since phytoplankton are vital primary producers at the base of marine food webs, their production over time is connected to ecosystem health. Since Chlorophyll *a* is found in all phytoplankton, it

can reveal what an ecosystem is doing over time when it is studied alongside a sea surface temperature time series. It can also reveal the type and abundance of plankton in an area. And, plankton have a direct impact on the entire pelagic food web. These connected exercises afford students an opportunity to contribute to a database alongside scientists, experience scientific field work, and understand the interdisciplinary nature of science. This entire collection of experiences should encourage students to ask questions about regional oceanic conditions and perhaps even raise questions they may have on global issues in oceanography.

**Description of Lessons:** To further explore the relationships between phytoplankton, chlorophyll *a* and ocean temperature these student-centered inquiry investigations were designed to flexibly fit into existing curriculums and offer educators the opportunity to further clarify state science standards for their students. They may be used individually to enhance understanding, or all together for a more thorough analysis of the complexity within a marine ecosystem. Each lesson has a similar approach and combines a general understanding of the value of long-term interdisciplinary research with the fundamental aspects surrounding the nature of science for scientific literacy. The lessons highlight the joint efforts between Scripps Institution of Oceanography, the CCE LTER program and Dana Point Ocean Institute.

Each activity demonstrates how scientists approach real-world investigations by utilizing data from both the CCE LTER program and the OI's Chlorophyll/Temperature Time-Series project. They also combine inquiry science methods and best practices in teaching and learning. All activities align with state and national science education standards for 9-12th grade Life Science, Biology, Marine Science or Environmental Science classes. Included at the end of each investigation are extended resources, reading materials and references to encourage students to reflect on their own learning process and make connections to larger global concepts.

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**Outline of Lessons:**

1. **Time Series: Expand your perception of data:** Review techniques useful to scientists as they analyze series of data using the Scripps Pier temperature time series data.

2. **Plankton Identification & the California Current Ecosystem:** What are plankton? Are all plankton the same?

3. **Plankton and the Food Web:** What role do phytoplankton play in the CCE LTER Pelagic Food Web?

4. **Plankton and $CO_2$:** What impact do phytoplankton and zooplankton have on $CO_2$, dissolved oxygen and pH levels in a marine environment?

5. **Time, Temperature and Chlorophyll *a*:** Does sea surface temperature affect chlorophyll *a* concentrations?

6. **pH, $CO_2$ and the Fate of Shelled Organisms:** What is the relationship between pH, $CO_2$ and shelled organisms?

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**Alignment:** In an effort to promote the interdisciplinary nature of science, we have also included ways in which these studies align with both the Essential Principals and **Fundamental Concepts for Ocean Literacy** and the **National Science Education Standards (NSES)**. Many of the basic science concepts from these studies are interrelated to ones you may already be encouraging in your science classes.

| **Essential Principles of Ocean Literacy →**<br>**NSES (9 - 12) ↓** | | **1. Earth: One Big Ocean Many Features** | **2. Ocean shapes Earth** | **3. Influence on weather and climate** | **4. Habitable** | **5. Ocean supports great diversity of life and ecosystem** | **6. Interconnectedness Humans and the Ocean** | **7. Ocean is Unexplored** |
|---|---|---|---|---|---|---|---|---|
| **Unifying Concepts and Processes** | Systems, order Organization; Evidence, models and explanation | | | | | | | |
| **Life Science** | Interdependence of Organisms | | | | | ✓ Lesson 2<br>✓ Lesson 4<br>✓ Lesson 3<br>✓ Lesson 5<br>✓ Lesson 6 | | |
| **Physical Science** | Chemical Reactions | | | ✓ Lesson 6 | | | | |
| **History of Nature and Science** | Nature of Scientific Knowledge | | | | | ✓ Lesson 2<br>✓ Lesson 4<br>✓ Lesson 5<br>✓ Lesson 6 | | ✓ Lesson 5<br>✓ Lesson 1 |
| **Personal and Social Perspectives** | Environmental Quality | | | | | | | |
| **Science and Technology** | Understanding @ science and Technology | | | | | | | ✓ Lesson 5 |
| **Science as Inquiry** | Abilities necessary/ Understanding | | | | | ✓ Lesson 2<br>✓ Lesson 4<br>✓ Lesson 6<br>✓ Lesson 3<br>✓ Lesson 1<br>✓ Lesson 5 | | ✓ Lesson 5<br>✓ Lesson 1 |

## California Current Ecosystem Long Term Ecological Research (CCE LTER)

The CCE LTER Education and Outreach program strives to enhance public awareness and understanding of marine pelagic ecosystems, and provide suitable opportunities for public education and interpretation. The CCE LTER is a coastal upwelling biome and one of the most productive ecosystems in the world. We train undergraduates, graduate students and postdoctoral scholars across interdisciplinary boundaries. CCE LTER is a great resource for both scientific and educational resources. The site provides education programs ranging from hands-on field experiences for students to professional development opportunities for teachers. Our outreach and public programs involve local and national events. We welcome partnerships with local schools, community-based organizations and volunteers in both formal and informal educational environments.


## CURRICULUM WRITER

Beth Simmons, CCE LTER

## HIGH SCHOOL CORRESPONDENTS

Christy Millsap, Rancho Bernardo High School

## EDITORS

Mark D. Ohman CCE LTER, lead primary investigator
Alison Cawood CCE LTER, graduate student

## THIS CURRICULUM WAS DEVELOPED AND PRODUCED FOR:

The CCE LTER Education & Outreach Program
Scripps Institution of Oceanography
University California San Diego
9500 Gilman Drive
La Jolla, CA 92093-0218
http://cce.lternet.edu/outreach/


## CREDITS