Day 01: Friday, May 24: *Heading to the California Upwelling Zone (CUZ that's where the plankton are!)*

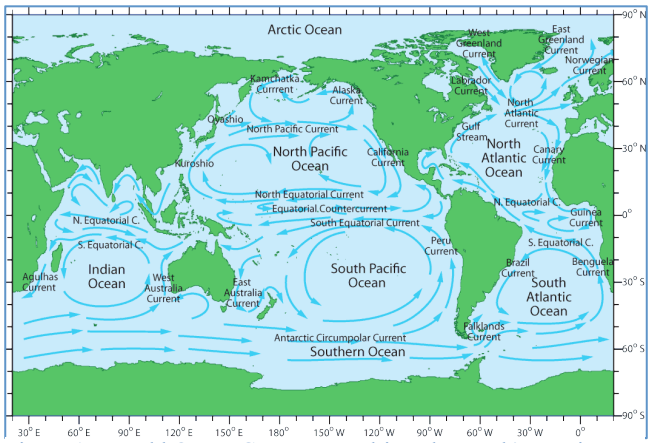

Figure 1 - World Ocean Currents are driven by Earth's rotation and the uneven heating and cooling of the oceans.

Welcome to PUPCYCLE! (Phytoplankton UPwelling Cycle) For the next 14 days, I will be working with researchers from the University of North Carolina – Chapel Hill, the University of British Columbia (Canada) and Humboldt University as they explore the relationship between coastal upwelling and phytoplankton. Upwelling currents are driven more by local conditions and winds as opposed to the global ocean currents (shown in Figure 1) that are driven more by Earth's rotation and the uneven heating and cooling of the world ocean. I will be focusing on the ocean currents (local and global) along the eastern boundary of the North Pacific Ocean since these currents will have the most impact on our research.

The California Current flows southward along the coast of California, bringing cold water from the Polar region toward the Equatorial region farther south. This current is also referred to as an Eastern Boundary current. The Pacific Ocean has 2 main Eastern Boundary currents (shown in Figure 2): the California Current along the coasts of California and Baja, Mexico and the Humboldt Current flowing northward along the borders of Peru and Chili. Eastern Boundary currents flow shallower, broader, and slower than the Western Boundary Currents, like the Kuroshio (near Japan) and the Gulf Stream in the Atlantic, which are deeper, narrower, and faster flowing currents.

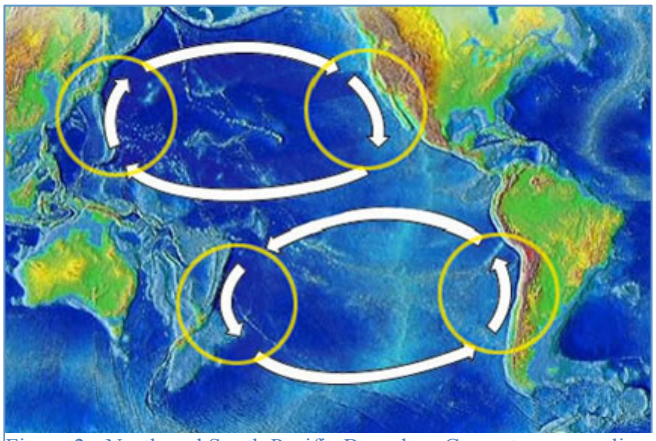
Figure 2 - North and South Pacific Boundary Currents surrounding the North and South Pacific Gyres


Figure 3 – Seafloor bathymetry along the northern California coast includes areas with a wide and narrow continental shelf

The other characteristic associated with Eastern Boundary currents is the appearance of upwelling. Applying what we know about Eastern Boundary currents with a closer look at the bathymetry along the California coast will provide a better understanding of upwelling processes. Bathymetry refers to the "lay of the land" or the shape of the seafloor found beneath Earth's oceans. Figure 3 reveals areas of narrow and wide continental shelf where the scientists will be focusing their research. This area is referred to as the California Upwelling Zone. Upwelling occurs when the prevailing winds push warmer surface water away from the coast and allow deeper colder water to rise, bringing lots of nutrients toward the surface. These nutrients fuel the growth and reproduction of phytoplankton and support the aquatic food web that relies on the plankton for survival.

Today's Video: Live Feed Friday (Facebook)
Video from the ship's stern during transit from Newport, OR

Today's Certificate Challenge: Look at the World Ocean Currents map (Figure 1) and see if you can identify the Eastern Boundary currents for the Atlantic Ocean.

Miriam Sutton, M.A., NBCT
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Day 02: Saturday, May 25: *Phytoplankton Chillin' with the UCBC!*

The *R/V Oceanus* continued to face heavy seas as we steamed toward our first Incubation Site along the California Upwelling Zone (CUZ). The CUZ is concentrated along the California coastline as noted in 74. As winds move surface waters away from the coastline, colder water rich in nutrients moves toward the surface. Researchers onboard the R/V Oceanus are conducting experiments to observe the response of phytoplankton in this region. (More on that tomorrow.) Phytoplankton are the plants of the sea and their need for sunlight to complete photosynthesis dictates that they hang out near the surface. These microscopic organisms also need nutrients in order to survive. That's where upwelling provides assistance. Nutrients that run-off from land join other dissolved organic material (DOM) and mix with the chemicals in seawater to create all the nutritional requirements needed to sustain the aquatic food web. Much of this material sinks to the seafloor where it remains until an upwelling event occurs. Figure 5 illustrates the type of upwelling events that occur along the CUZ. These upwelling events occur seasonally and an event may last for several days. When the winds subside or change direction, the upwelling also subsides and gives rise to a period of **relaxation** in the water column. The relaxation period can persist in an area of upwelling for days or weeks. The interaction between these upwelling and relaxation periods is referred to as the ***Upwelling Conveyor Belt Cycle*** (UCBC). This cycle is setting for our research expedition. Scientists are searching for a column of water that is currently experiencing a UCBC Relaxation phase to collect the phytoplankton being used in the Incubation Site #1 experiments.

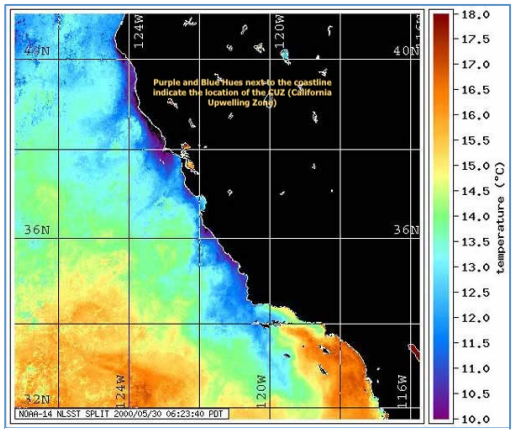

Figure 4 – Water temperatures are typically colder adjacent to shore than further offshore for most of the California coastline north of Pt. Conception—the bend in the coastline at 34.5 N. [*Image courtesy of Sanctuary Quest 2002, NOAA/OER.]*

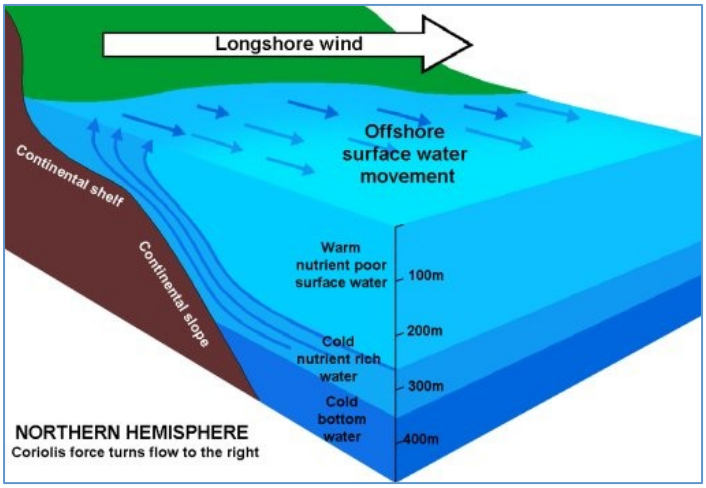

Figure 5 – Upwelling events occur when winds push warmer surface water away from the coastline and deeper nutrient-rich water moves toward the surface. [*Image credit: https://seos-project.eu/oceancurrents/oceancurrents-c04-s01-p01.html*]

PUPCYCLE 2019 is the first sea experience for many of the students onboard and today provided some time to adjust to their sea legs while also practicing some of the protocols they will be using once their experiments begin. The students will collect the phytoplankton by launching and retrieving a CTD through the water column. (See Figure 6) A **CTD** measures **C**onductivity, **T**emperature, and **D**epth while also housing 12 niskin bottles. These bottles look like thick grey PVC pipes with spring closures. The bottles are open on deployment allowing water to flow through as the equipment is lowered through the water column using a crane system on the R/V Oceanus. Once the selected depth is reached, a computer signal from the ship triggers the seals to snap shut on both ends, capturing the water and microscopic organisms inside.

Figure 6 – Marchetti Lab students launch and recovery the CTD equipment they will use to collect water samples containing millions of phytoplankton. *[Image credit: Miriam Sutton]*

Today's Certificate Challenge: Using Figure 5 – California Upwelling Zone, where do the nutrients found in the deep ocean originate?

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Day 03: Sunday, May 26: *The Phytoplankton Players*

The *Roaring 40s* of the Southern Hemisphere appeared to have moved northward this weekend, tossing the R/V Oceanus over 10+feet waves as the location for Incubation Site #1 held us captive near a Low Pressure cell moving toward the Pacific Northwest. The researchers are collecting phytoplankton at about 90 meters depth from a wide shelf region for the first Incubation Site. They have been practicing protocols and collecting data profiles to be sure the site is actually experiencing a Relaxation phase. The main players in their research are shown in Figure 7 and include Diatoms, Dinoflagellates, Haptophytes (commonly referred to as Coccolithophores), and Chlorophytes (commonly known as green algae). Each of these is a single-celled organism classified as autotrophic because of their ability to photosynthesize and produce their own food. Some varieties of *Dinoflagellates* are also heterotrophic (engulf other prey) and are also famous for causing *Harmful Algal Blooms* (HABs) such as *Red Tide*, which can devastate shellfisheries. *Diatoms* are eukaryotes (meaning they have a nucleus) that survive in fresh and salt water. They are key primary producers for the aquatic food web and live in "glass" shells derived from the silicates they absorb from the water. 100,000 species of diatoms are currently known. They are found in 2 shapes (pennate and centric) and can form long chains during upwelling events. *Haptophytes* make their shells, or hubcap-shaped plates, from the calcium carbonates absorbed from the water. There are currently 300 species of Haptophytes identified, *Emiliania huxleyi* being the first to have its genome published. Haptophytes tend to flourish in environments where other phytoplankton struggle to survive. Chlorophytes (green algae) are one of the most diverse groups, existing as single-cellular or multi-cellular and are often found in colonies. Spirogyra (a freshwater variety) and Ulva (sea lettuce) are two of the most commonly known. Together, with other forms of phytoplankton, these microscopic marvels reduce the levels of carbon dioxide from the atmosphere while producing oxygen for all living organisms. They also provide the base for the aquatic food web, providing key nutrients for larger zooplankton (including fish larvae), krill, larger fish, and even whales.

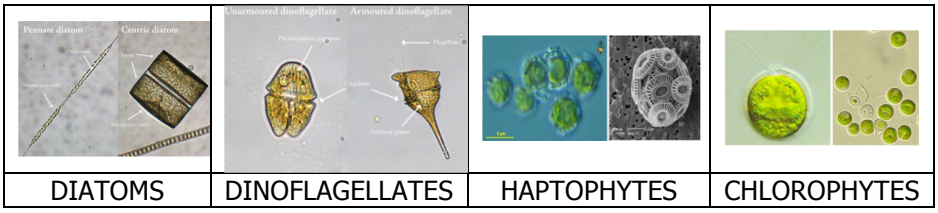

Figure 7 – One of the objectives for PUPCYCLE 2019 is to observe the gene expression and growth rate in these groups of phytoplankton as they respond to upwelling events. *[Image credit: http://oceandatacenter.ucsc.edu/PhytoGallery/dinos%20vs%20diatoms.html; https://slideplayer.com/slide/8282411/; https://moritz.botany.ut.ee/~olli/aldoc/07Chloro0.pdf]*

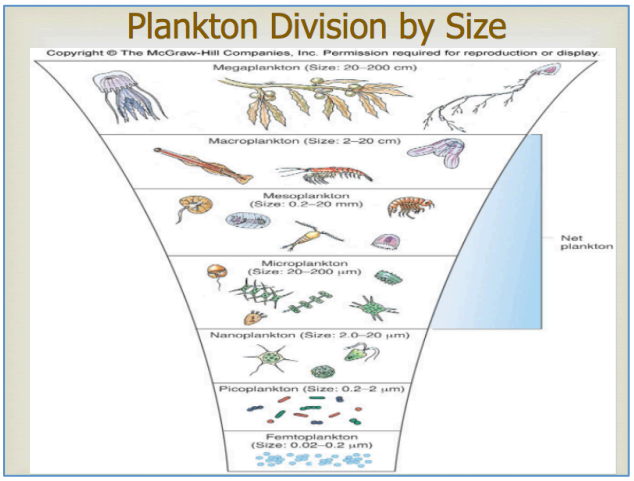

Figure 8 – One teaspoon of seawater can contain millions of microscopic organisms, ranging from copepods and diatoms to bacterium and viruses. *[Image credit: https://slideplayer.com/slide/7066146/]*

The phytoplankton being collected during PUPCYCLE 2019 range in size from 2.0 microns to 200 microns. The scale shown in Figure 8 provides a comparative size distribution of the microbes being investigated to other marine organisms we are more familiar with, such as jellies, seaweed, and krill. The researchers will use filtration systems and mass spectrometry to collect and identify the microscopic species of interest. Several scientists and their research will be featured during PUPCYCLE 2019, affording a better understanding of their research and how their findings apply to the world in which we live.

Today's Certificate Challenge: Marine microbes, like diatoms and green algae, provide much needed oxygen essential to life on Earth. Some microbes can become toxic to the environment resulting in large blooms referred to as _____.

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Day 04: Monday, May 27: *Express Yourself, Bacteria!*

Bacteria were the first forms of life on Earth, dating back to 3.8 billion years ago during the Archaean Eon. These single-celled prokaryotes (containing no nucleus) have thrived in some of the harshest conditions and survived the 5 mass extinctions recorded in Earth's past. Bacteria, like many other microbes, have a bad reputation as pathogens, or disease-causing agents. In reality, 90% of bacteria are helpful and most other species, including humans, could not survive without these microscopic workhorses. Their short life span is filled to capacity with tasks ranging from the decomposition of decayed matter to the "fixation" of nitrogen for plant absorption to the production of 50% of the oxygen for our atmosphere. "We just learned the importance of these marine bacteria some decades ago," said Nataly Guevara, a researcher onboard the R/V Oceanus who is keeping an eye on these fundamental contributors during PUPCYCLE 2019. She added, "While most people relate to the importance of monitoring the many species of plants and animals visible to the naked eye, many of the microbial communities are overlooked." Out of sight, out of mind.

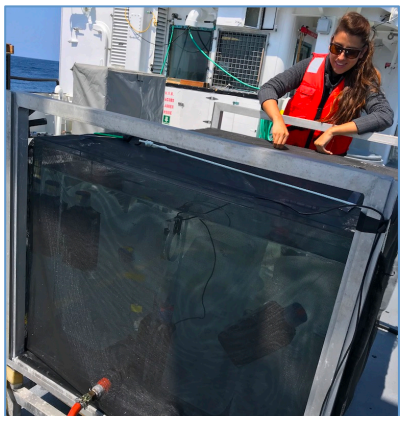

Figure 9 – Nataly Guevara places her sealed samples inside the Incubation system. *[Photo Credit: Miriam Sutton]*

Nataly designed 2 sets of experiments to analyze the responses of these deep microbial communities and how their carbon-processing abilities are altered once they are upwelled and exposed to surface conditions. Her investigation began with the collection of bacteria from the deep-water samples brought up at midnight Monday morning. Some of her samples were sealed in dark containers to simulate the environment in which they were found while others were sealed in containers where diffused light (similar to the light found in surface water) could interact with the bacteria. In addition to controlling the bacteria's exposure to light, Nataly is also controlling the temperature to simulate either colder deep water or warmer surface water. Controlling these variables will allow Nataly to isolate the response of the bacterial communities over the next 4 days. The second phase of Nataly's investigation will use samples collected during an active upwelling cycle the PUPCYCLE team plans to follow in the next few days. Being able to control variables with Incubation experiments will be compared to observations from bacterial communities that are exposed to all variables found in an active upwelling event.

Nataly will be using bioinformatics technology to identify the bacteria; analyzing their genes to identify different types of bacteria found within the community; recognizing "who" is actually in the water sample and in what abundance (e.g., decomposers, nitrogen fixers). Her next objective is to analyze the bacterial degradation (or decomposition) of Dissolved Organic Carbon (DOC) found throughout the water column. DOCs comprise one of the largest carbon pools in the ocean and it is the bacteria that degrade DOC into useable energy that supplies all the trophic levels, from the Chlorophytes, Haptophytes, Dinoflagellates, and Diatoms all the way up to the mighty Blue Whale. This latter analysis will allow Nataly to observe which genes the bacteria are expressing under various environmental conditions; those she is controlling with the Incubation experiments and the conditions experienced by the bacteria during natural upwelling conditions.

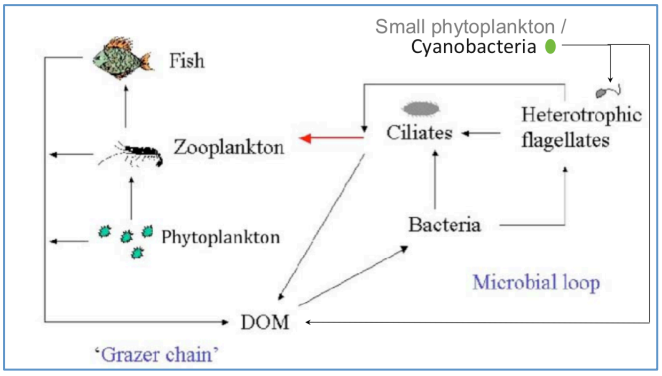

Figure 10 – A simplified version of the Microbial Food Web illustrates the cycling of Dissolved Organic Matter/Carbon through the various trophic levels. [*Image credit: Modified from http://www.ucl.ac.uk/~ucbt212/chapter5.htm*]

Nataly Guevara, was born in Ecuador and completed her undergraduate degree in Biotechnology and Biology at the University of San Francisco at Quito (Ecuador). She then moved to Bremen, Germany for her Master's degree in Marine Microbiology at Max Planck Institute and is now a doctoral candidate at the University of North Carolina – Chapel Hill.

Today's Certificate Challenge: Bacteria, Diatoms, and many other microscopic organisms have the ability to select and change their expression of _____ based on environmental conditions.

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Day 05: Tuesday, May 28: *Insights into PUPCYCLE 2019*

A science meeting was held after dinner to discuss the logistics for the remainder of the research cruise with everyone in attendance, unlike the first attempt when heavy seas kept most of the science crew in their bunks struggling with seasickness. Calmer seas the past two days have allowed more time for us to gain our sea legs and we enjoyed getting to know the crew of the R/V Oceanus and each other. I had a few minutes to chat with Adrian Marchetti, the Chief Scientist for PUPCYCLE, to review some of his goals and objectives for the cruise. Adrian's primary goal is to determine how specific groups of phytoplankton respond to the Upwelling Conveyor Belt Cycle (UCBC) and how phytoplankton will be affected by changing ocean conditions.

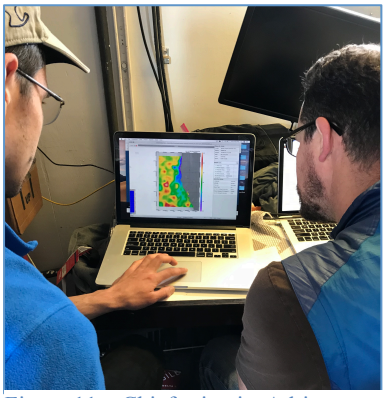

Figure 11 – Chief scientist Adrian Marchetti (right) and Ben Freiberger (left) locate possible upwelling sites using satellite imagery. [*Image credit: Miriam Sutton*]

Adrian hypothesizes that, "Diatoms are uniquely adapted to thrive under UCBC conditions compared to other phytoplankton groups." He also notes that, "diatoms adaptability may be altered by ocean acidification and low iron availability." During PUPCYCLE 2019, the researchers are using RNA-sequencing to analyze the expressed genes of phytoplankton during various stages of the UCBC. This allows the scientists to observe which genes are being expressed in response to the different stimuli associated with upwelling: light, temperature, and nutrient availability (including iron). The incubation systems, or bioassay experiments, facilitate these observations by allowing the scientists to control the various stimuli, (i.e., variables) throughout the various stages of the UCBC. The researchers are also observing the physiological response of the phytoplankton throughout the UCBC by measuring their uptake rates of Nitrate (NO_3) and carbon (C). Nitrates are a key nutritional component for phytoplankton that promotes growth rate, which will also be measured. Iron is also a key nutritional requirement for phytoplankton and the scientists are observing the variations in molecular and physiological responses during the UCBC based on the availability or limitation of iron in the natural marine environment.

The California Upwelling Zone contains broad and narrow continental shelf regions that have very different physical, chemical, and geologic features. These differences generate large variations in the productivity between these two regions. Narrow shelf regions (the location for Incubation Site #2) are more likely to run out of iron (Fe) before NO_3. Fe-limited environments reduce the ability of diatoms to take up nitrate and other important nutrients. Higher iron concentrations are found along broad continental shelf regions (the location for Incubation Site #1) and this abundance increases the consumption of nitrate and other nutrients, allowing large chain-forming diatoms to flourish.

Figure 12 – Large chain-forming diatoms flourish in aquatic environments where iron is readily available. [*Image credit:* Emily Pierce, using the onboard FloCam]

The incubation/bioassay experiments provide the scientists with a "snapshot" of the community and their responses to the UCBC conditions based on the location of each incubation site. Continuous data is also being recorded from the microbial community using a FIRe Fluorometer System as the R/V Oceanus transits along the California Upwelling Zone. This continuous data set allows researchers to measure the amount of fluorescence being emitted by the microbial communities throughout the various study regions. When iron is available (broad shelf regions), diatoms absorb light and produce energy mostly in the form of photochemical energy. When iron is limited (narrow shelf regions), diatoms cannot absorb the light and repel the light as fluorescence of a different wavelength. The FIRe System measures this fluorescence. In addition, underway sensors are also measuring dissolved oxygen and NO_3 concentrations. Analyzing these nutrients will provide the researchers with a continual assessment of the health status of the phytoplankton community in relation to their chemical environment.

Today's Certificate Challenge: The California Upwelling Zone (CUZ) is found off the coast of California where variations in the width of the continental shelf contain different levels of key nutrients for phytoplankton and the aquatic food web. Which type of shelf results in an increased abundance of iron to support this food web?

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Day 06: Wednesday, May 29: *On the Cutting Edge of Metabolomics*

There are several groups of scientists on the R/V Oceanus and each group has specific research goals for which they are collecting data during the 2-week cruise. Although each group has independent objectives, their research overlaps throughout. One of the key areas of overlap falls under the new scientific realm of Bioinformatics. Bioinformatics breaks genomics down into deeper divisions and is changing our understanding of living organisms. Most of us became familiar with genomics after the turn of the century when the human genome was decoded. Scientists have since delved further into the DNA molecule with transcriptomics, determining when genes are turned "on" or turned "off". This is often referred to as gene expression. Transcriptomics is the RNA-sequencing being used by Nataly Guevara (*Day 4 – Express Yourself Bacteria!*) for the bacteria communities she is investigating and by Adrian Marchetti (*Day 5 – Insights in to PUPCYCLE 2019*) for the phytoplankton communities he is investigating. The next level in bioinformatics is proteomics, which looks at the proteins that result in the various gene expressions. Some of these proteins produce molecules that can aid in the bioavailability of iron to diatoms, and attempts to understand the chemical compounds being produced falls under the emerging field of metabolomics. This is where the work of Travis Mellett (University of South Florida) is focused, trying to draw connections between the molecules and the organisms in the chemical environment in which they are found.

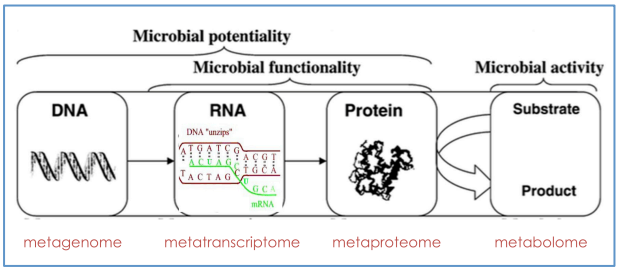

Figure 13 – Bioinformatics is changing what we know about genomics as scientists explore deeper aspects of the DNA of living organisms. [*Image credit: Maron et al 2007 Microb Ecol; peer.tamu.edu*]

Travis' focus during PUPCYCLE 2019 is to investigate the biogeochemistry of trace metals, like iron (Fe), found along the California Upwelling Zone (CUZ). In particular, Travis hopes to draw connections between the molecules connected to Fe and the gene expression of diatoms as they follow the UCBC (Upwelling Conveyor Belt Cycle) along broad and narrow shelf regions. By tracking an active upwelling event, Travis is observing the molecular responses of diatom communities to determine if certain species of diatoms have adaptations allowing them to out compete other species during upwelling. As noted in the previous entry, narrow shelf regions of the coastline have limited iron availability because run-off from land has less area for accumulation before being transported into the deep ocean. Fe-limited environments reduce the ability of diatoms to take up nitrate and other important nutrients. When the diatoms have limited iron availability, they become stressed. Travis wants to know how the diatoms handle this stress and adapt to the Fe-limited environment. Metabolomics protocols will allow him to assess the biogeochemical responses of diatoms to Fe-limited marine environments. In addition, Travis wants to know if other molecules in their environment drive the responses of the diatoms or if the diatoms are willingly expressing certain genes to create the molecules necessary for survival.

Figure 14 – Travis Mellet (University of South Florida) and Adrian Marchetti (UNC-CH) are assisted by R/V Oceanus Marine Tech: Kate Kouba as they deploy a deepwater tube to pump trace metal samples to the ship. [*Image credit:* Miriam Sutton]

Travis' research is on the cutting edge of furthering our understanding of the interaction between genes and the chemical environment in which organisms live. Much of his investigation is based solely on curiosity because so little is currently known about metabolomics. What we do understand is that plants and phytoplankton take up enormous amounts of carbon during photosynthesis and store additional amounts of carbon as the decay and sink to the seafloor. Travis' research is helping us understand how the marine plant kingdom takes up the carbon molecules in the sea as trees do on land.

BIO INFO: Travis Mellett was born in the San Francisco Bay area. He completed his undergraduate degree (double major) in Earth Sciences and Environmental Studies at the University of California – Santa Cruz before continuing his doctoral studies in Chemical Oceanography at the University of South Florida. He will begin his post-doc at Humboldt State University after PUPCYCLE 2019.

Today's Certificate Challenge: What division of Bioinformatics is the focus of Travis' research?

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Day 07: Thursday, May 30: The Bubble Lab

We started the day offshore and southwest of the Oregon – California state line collecting more water samples from a broad shelf region of the California Upwelling Zone. Each research group uses a variety of methods for collecting their water samples, based on the organisms or particles they are investigating. The Phytoplankton scientists use the CTD (described on *Day 02: Saturday, May 25: Phytoplankton Chillin' with the UCBC!*) and an Underway System that draws water from the surface continuously during the research cruise through tubing that feeds directly into their instruments on the ship. Each sample of water from the CTD is transferred to containers and taken to the shipboard lab for filtration. Filters capture the microorganisms and are sealed in small vials before being flash-frozen using liquid nitrogen. (Figure 15) The Underway System provides a steady stream of water to the FIRe Machine and other sensors as they monitor the phytoplankton and nutrients found during the R/V Oceanus' transits between each study site. (See *Day 05: Tuesday, May 28: Insights into PUPCYCLE 2019*)

Figure 15 – Logan Whitehouse (UNC-CH) adds liquid nitrogen to a freeze-dried container. After filtration, the filters are sealed and flash frozen and stored in -80 C degrees for RNA-sequencing (transcriptomics and proteomics) after the cruise. [*Image credit: Miriam Sutton*]

The scientists studying trace metals and dissolved particulates use different equipment to collect their water samples. Claire Till (Humboldt State University) is investigating 13 trace metals found in seawater. Seven of these are micronutrients used by marine organisms and include: Iron (Fe), Manganese (Mn), Copper (Cu), Cobalt (Co), Cadmium (Cd), Nickel (Ni), and Zinc (Zn). The additional six trace metals are not micronutrients in the aquatic food web but can provide insights into other oceanic processes, such as scavenging, where dissolved elements attach to other dissolved particles before sinking. These include: Lead (Pb), Gallium (Ga), Cerium (Ce), Yttrium (Y), Lanthanum (La), and Scandium (Sc). Claire noted that much remains to be learned about the trace metals adding, "Scandium is chemically similar to iron but is not a nutrient." She suspects that Scandium might act as a substitute for iron, causing interference in the iron uptake by diatoms and other phytoplankton. Claire is hoping to learn more about Scandium during PUPCYCLE 2019 to see if this type of relationship exists.

Figure 16 – Kate Kouda (foreground) guides the ship's line as Ben Freiberger and Matt Hurst attach the GoFlo® bottle to collect water samples. [*Image credit: Miriam Sutton*]

Since many of the metals they study are also found in the ship and shipboard materials, the scientists use specially designed equipment, including a Teflon-coated GoFlo® system to keep these metal contaminants away from their samples. The GoFlo® system is designed to collect water through a GoFlo® bottle (similar to the CTD Niskin bottle) attached to a nonmetal line and lowered into the water column. Once the selected depth has been reached, a signal is activated for the GoFlo® bottle to close and capture the water. However, rather than receive an electrical signal from a computer through wiring on the ship, the bottle is triggered to close using a "messenger," which is a heavy plastic device that is added to the line and then released to slide down the line until it hits the GoFlo® bottle, triggering the bottle to close and sealing the water sample inside. After retrieval, the filled bottles are removed from the line and taken to the "Bubble Room" where researchers prepare the samples for storage and transport off the ship at the end of the cruise. The trace metal analyses will take place at the university's "bubble room" after the cruise. The dissolved and particulate samples will be filtered and/or prepped for storage for analysis after the cruise.

Figure 17 – Claire Till, Matt Hurst, and Travis Mellett prepare their water samples inside the "Bubble Room". [*Image credit: Miriam Sutton*]

BIO INFO: Claire Till was born in Newton, MA and received her undergraduate degree in Chemistry from Bates College (Lewiston, ME). She completed her PhD at the University of California – Santa Cruz in Ocean Sciences and is currently at Humboldt State University.

Today's Certificate Challenge: Why are the Trace Metal and Dissolved Particulate researchers conducting their data collection inside the "Bubble"?

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Day 08: Friday, May 31: Halftime at PUPCYCLE 2019

The 2nd half of PUPCYCLE 2019 started with a new game plan as the R/V Oceanus altered navigation and charted a new course, heading south toward Monterey Bay, California. Although the California Upwelling Zone (CUZ) covers the extent of California's coastline, active upwelling events do not tend to be synchronous throughout the region. An area along the northern coast might be experiencing an active upwelling event while a region along the central coast might be experiencing a relaxation phase where upwelling has subsided temporarily. This is the situation occurring on the PUPCYCLE 2019 cruise. The researchers integrate several different data sets to determine the best location for each incubation site. In addition to taking continuous water samples from the Underway System and periodic launches of the CTD for water profiles (*see Day 07: Thursday, May 30: The Bubble Lab*), the scientists also download updated satellite images showing sea surface temperature and fluorescence. Sea surface temperature (SST) data identifies areas where upwelling is occurring by displaying cooler SST near the coastline and warmer SST offshore from the coastline, indicating the displacement of warmer surface water by colder water from depth. (*Figure #18 – Satellite Imagery*) Fluorescence is an indicator of chlorophyll production and serves as a measure of ocean productivity. This also provides evidence of active or relaxed upwelling areas. Merging all of these data sets together allows the scientists to locate active upwelling or relaxation sites within the CUZ. Water samples of phytoplankton for Incubation Site #1 were collected earlier in the cruise along a broad shelf region of the CUZ and during a relaxation phase of upwelling. The second set of water samples are to be collected along a narrow shelf region of the CUZ that is also experiencing a relaxation phase of upwelling. The site originally chosen for Incubation Site #2 is currently experiencing an active upwelling event so the scientists have chosen to move southward based on updated satellite imagery indicating the region near Monterey Bay, known as Big Sur, is experiencing a relaxation phase of upwelling.

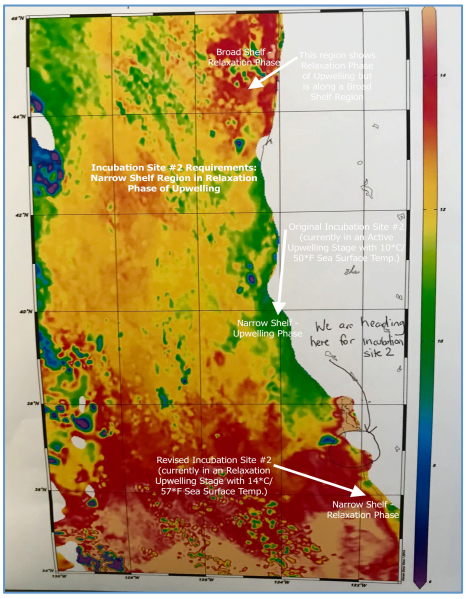

Figure 18 – Satellite imagery assists scientists in locating areas of the California Upwelling Zone (CUZ) that are currently experiencing Active and Relaxation Phases of upwelling. [*Map source: Ocean Data View*]

During this halftime break from deploying sampling equipment into the Pacific, the researchers are continuing to filter, prep, and store samples from Incubation Site #1 for phytoplankton-related measurements along with RNA sequencing after the cruise. The PUPCYCLE Log also continues in hopes that the information being shared here, and the supporting live feeds and images posted to the Science by the Sea® social media platform, provides you with a virtual experience of the 2-week cruise aboard the Research Vessel Oceanus. Today's Challenge Question has been modified for our halftime intermission, so grab a bag of popcorn and check your current knowledge and understanding with this brief "Halftime Assessment":

"Halftime Assessment"

1. Where are we?
2. Why are we here?
3. What parameters support upwelling?
4. What is the difference in water chemistry between upwelling along broad and narrow shelf regions?
5. What are the breakdown divisions of Bioinformatics?
6. What are the various types of equipment used onboard for collecting water samples?
7. What are some of the challenges of conducting scientific research while at sea?
8. What are some of the perks of conducting scientific research while at sea?

Answers:

1.

2.

3.

4.

5.

6.

7.

8.

Today's Certificate Challenge: (See Halftime Assessment)

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