Project Whale Citizen Science

Plankton Monitoring Investigation

Learning modes:

Next Generation Science Standards (NGSS): LS1-5, LS2-1, LS2-2, LS2-4, LS2-5, LS2-6, LS2-7, ESS2-5, ESS3-1, ESS3-3, ESS3-4, ETS1-1, ETS1-2

Crosscutting Concepts: cause and effect, stability and change

Goal:

Students will understand the important role of plankton in the food system and how it affect human food sources. By collecting data on local plankton populations and participating in authentic research, students become functioning Citizen Scientists in the field. Their science identities are cultivated as they take an active role in protecting California’s coast. The data they collect will be entered into a database where it can be accessed by scientists and resource managers; it can also be accessed and analyzed back in their classroom to continue the Citizen Science process.

Objectives:

1. Demonstrate how to follow written scientific protocols and accurately use scientific equipment such as a plankton net, to collect a plankton sample.
2. Identify three higher level STEM skills that they will have to use during the cruise and relate how they might use these skills again in another context.
3. Have students understand the importance of citizen science as a useful tool for scientific data collection
4. Students will understand that plankton form the basis of the marine food web with phytoplankton living near the surface and zooplankton migrating daily following a food- predator evasion cycle. When phytoplankton populations grow too rapidly, certain kinds can have a toxic effect on marine wildlife and humans.

**Background: Plankton form the foundation of the food web and the balance of their populations is required in order to maintain a healthy marine ecosystem.**

“Plankton is broad classification for any marine organism that cannot swim against currents, waves or tides.”[[1]](#footnote-1) Of the plankton, the most abundant are phytoplankton, the primary producers that use photosynthesis and zooplankton, primary consumers that feed on phytoplankton. These microscopic creatures create the fundamental basis of the marine food web.

Just like terrestrial plants, phytoplankton need sunlight, nutrients and water to photosynthesize. In a marine environment, water is obviously an abundant resource. For access to sunlight, phytoplankton often live in the surface waters. It is estimated that up to 50% of the world’s oxygen is produced by phytoplankton during their photosynthesis cycle. As part of the ocean water current cycle, cold water from the ocean depths rises up carrying with it important nutrients. Scientists have been closely monitoring ocean temperatures. Levels of phytoplankton tend to decrease as water temperatures warm. Massive fluctuations in phytoplankton levels could have dire consequences not just for marine life who rely on them for food (like whales), but for humans too, as every creature relies on oxygen for survival.

Although plankton are considered drifters, they can swim up and down the water column. In fact, this is hypothesized to be a predator-evasion survival adaptation. Called diurnal vertical migration (DVM), zooplankton travel up from the ocean depths to the surface to feed on phytoplankton that have basked in the sun, photosynthesizing all day. Visual predators use sunlight in order to see their prey, so zooplankton live in the lower levels of the ocean during the day and then at night come to the surface to feed on the phytoplankton. This creates the largest food web migration in the world.

Every drop of water contains plankton. “Specific species of zooplankton occupy particular marine habitats. Each species is uniquely adapted to factors like light, temperature, turbulence, and salinity in its environment…Zooplankton are highly responsive to nutrient levels, temperatures, pollution, food that is not nutritious, levels of light, and increases in [predation](http://en.wikipedia.org/wiki/Predator)…Zooplankton are also affected by levels of pH, heavy metals, calcium, and aluminum. Nutrients like nitrogen and phosphorus will affect the prey of zooplankton (like algae, protozoa and bacteria), indirectly affecting zooplankton survival.” [[2]](#footnote-2)

Often referred to as the ocean soup, “occasionally, phytoplankton can grow very fast and form very dense populations or “blooms”. Some of the blooms can be harmful to their environment by various means and are commonly referred to as Harmful Algal Blooms (HABs).”[[3]](#footnote-3) One of the two major types of HABs is when phytoplankton blooms form populations so dense that when they decay, they deplete the oxygen from the water that can have a cascading effect for the survival of nearby fish and invertebrates. The second type is commonly known as Red Tide because of the red-brown pigments which often cause the water to appear red, but this indicator sign is a misnomer as the water does not have to become red in order to become toxic to the environment and humans, nor are they associated with tides. “HABs occur naturally, but human activities that disturb ecosystems seem to play a role in their more frequent occurrence and intensity. Increased nutrient loadings and pollution, food web alterations, introduced species, water flow modifications and [climate change](https://coastalscience.noaa.gov/category/coastal-change/climate-impacts-on-ecosystems/) all play a role. Studies show that many algal species flourish when wind and water currents are favorable. In other cases, HABs may be linked to “overfeeding.” This occurs when nutrients (mainly phosphorus and nitrogen) from sources such as lawns and agriculture flow into bays, rivers, and the sea, and build up at a rate that “overfeeds” the algae that exist normally in the environment. Some HABs appear in the aftermath of natural phenomena like sluggish water circulation, unusually high water temperatures, and extreme weather events like hurricanes, floods, and drought.”[[4]](#footnote-4) Global warming is projected to increase the frequency and intensity of severe weather phenomena which will affect the types of plankton species present and the population density.

Humans are primarily exposed to naturally occurring toxins produced by HABs through the consumption of contaminated seafood products. Ingestion of contaminated seafood can be life threatening, as they are powerful nerve poisons. Although there are different toxigenic species all over the world, the primary ones monitored by the California Department of Public Health are Paralytic shellfish poisoning (PSP) toxins and domoic acid. They often have no taste or odor and cleaning or cooking the shellfish will not remove or destroy the toxins. Domoic acid was first detected in California in 1991. “An investigation into the deaths of hundreds of seabirds in Monterey Bay led to the identification of domoic acid as the cause. This neurotoxin was not previously known to exist anywhere along the west coast of the U.S. Domoic acid was identified in the anchovies and sardines on which the seabirds had been feeding. Further investigation discovered an abundance of the diatom *Pseudo-nitzschia* in the stomachs of the fish. Analysis of the fish gut contents revealed high concentrations of domoic acid. Although this toxin is less potent than the PSP toxins, it has become of increasing concern because the blooms of diatoms that produce this toxin have been of greater frequency and longer duration than most PSP events over the past 10 years. In addition, domoic acid has had dramatic impacts on marine mammal and seabird populations along the coast.”[[5]](#footnote-5)

In order to avoid these toxins that build up in shellfish, California has an outright ban on recreational mussel harvesting from May 1- October 31st. This is the period during which PSP and domoic acid is most likely to build up in their tissues. These bans do not apply to commercially harvested shellfish as they comply to stricter State and Federal regulations which ensure that only safe and wholesome shellfish are available to the consumer.

The California Department of Public Health Marine Biotoxin Program coordinates a volunteer-based monitoring effort for toxic phytoplankton along the entire California coastline. Project Whale Citizen Science is a participating member of the phytoplankton monitoring program. Today we will be using a very fine and fragile nylon mesh and do a vertical net tow in the bay to collect a sample of phytoplankton. That sample will be sent to a laboratory where it will be tested for the presence of toxin-producing species. Additional information is recorded such as the non-toxic species present to help evaluate long-term trends in species composition. In cases where unsafe levels of toxin-producing phytoplankton are present in samples, CDPH may issue a public alert or close a commercial shellfish growing area to prevent toxic seafood from entering the marketplace.

Methods:

“A phytoplankton net and rope is provided to all program participants, unless they happen to have access to one already. The net is made of a very fine and fragile nylon mesh: the mesh size is 20 micrometers, which is small enough to capture our toxin-producers and most other species present. The net is gently lowered into the water via the attached rope and allowed to sink to a depth of 10 to 50 feet, depending on the sampling location. The loose end of the rope is always secured to the pier or other structure to avoid losing it! The net is slowly retrieved and, as it reaches the surface, allowed to descend to the sampling depth again. We recommend three to five of these vertical net tows, depending on the sampling depth and the density of cells present that day. Following the final tow, the net is retrieved and the sampling bucket at the bottom of the net is detached. The contents of the sampling bucket are poured into the sampling bottle provided, which contains a small amount of preservative. The sample is then placed in the mailing canister along with the completed laboratory sample submission form, which contains the relevant sampling information (date, time, location, depth, etc.). The canister can then be sent to our laboratory via the U.S. Postal Service (postage is prepaid by CDPH).” [[6]](#footnote-6)

CA Dept. of Public Health Laboratory analysis procedure:

“All samples arriving at CDPH are examined with light microscopy for the presence of the toxin-producing species. Additional information is recorded on other common, non-toxic species to help evaluate long-term trends in species composition and shifts in dominant groups (diatoms versus dinoflagellates). The field and lab observations provide a valuable snapshot of current trends in the phytoplankton community. This information is immediately used as necessary to guide additional sample collection in areas of concern. Over the years there have been numerous occasions in which the phytoplankton observations alerted program scientists to the early stages of a toxic bloom. Subsequent focus on the affected region revealed the presence of toxin and allowed CDPH to alert the public via a health advisory press release or to close a commercial shellfish growing area to prevent toxic seafood from entering the marketplace. In fact, many of the certified shellfish growers in California voluntarily collect phytoplankton samples and conduct the field observations because this valuable information helps them manage their harvest activities to ensure the safety of their product. Finally, the laboratory identifications and the volunteers’ field observations are recorded in the program database for subsequent reporting and analysis. Each participant's contribution is essential to piecing together a picture of the distribution of toxic and nontoxic phytoplankton along the California coast.”[[7]](#footnote-7)

1. Read through the Field Sampling Protocol Phytoplankton Monitoring Program document.
   1. Sections 3, 4 & 5 pertain to the collection, preservation, and field note taking for the sample. Follow the protocols laid out in the document.

Conclusion:

At the end of this lab, students should understand their role as citizen scientists contributing to scientific data collection that helps the state ensure the safety of shellfish harvested in California. Additionally, the collection of data to help scientists understand the marine food web and the variety of factors that effect it. Much of this science is new and emphasis on the importance of early data collection is key. A study from UC San Diego notes: “Due to the limited funding provided for biotoxin monitoring in California, voluntary collaborations with diverse community members will continue to be essential for expanding monitoring and, thus, improving seafood safety in the state” and “through this project and ongoing efforts of the CDPH Biotoxin Monitoring Program, we have illustrated how a collaborative network of volunteers from fishing and coastal communities can provide data useful for more robust evaluations of HABs in California. Resulting data have helped to identify potential factors important to evaluating the risks associated with HABs (domoic acid blooms specifically).”[[8]](#footnote-8)

1. <https://www.nationalgeographic.org/media/plankton-revealed/> [↑](#footnote-ref-1)
2. <http://marinebio.org/oceans/zooplankton/> [↑](#footnote-ref-2)
3. <http://www.sccoos.org/data/habs/abouthabs.php> [↑](#footnote-ref-3)
4. <https://www.noaa.gov/what-is-harmful-algal-bloom> [↑](#footnote-ref-4)
5. <https://www.cdph.ca.gov/Programs/CEH/DFDCS/Pages/FDBPrograms/FoodSafetyProgram/PhytoplanktonMonitoringProgram.aspx> [↑](#footnote-ref-5)
6. <https://www.cdph.ca.gov/Programs/CEH/DFDCS/Pages/FDBPrograms/FoodSafetyProgram/PhytoplanktonMonitoringProgram.aspx> [↑](#footnote-ref-6)
7. <https://www.cdph.ca.gov/Programs/CEH/DFDCS/Pages/FDBPrograms/FoodSafetyProgram/PhytoplanktonMonitoringProgram.aspx> [↑](#footnote-ref-7)
8. <https://caseagrant.ucsd.edu/sites/default/files/CulverEtAl_CFRWBiotoxin_FinalReport.pdf> [↑](#footnote-ref-8)