

Ocean Acidification and Carbon Cycle



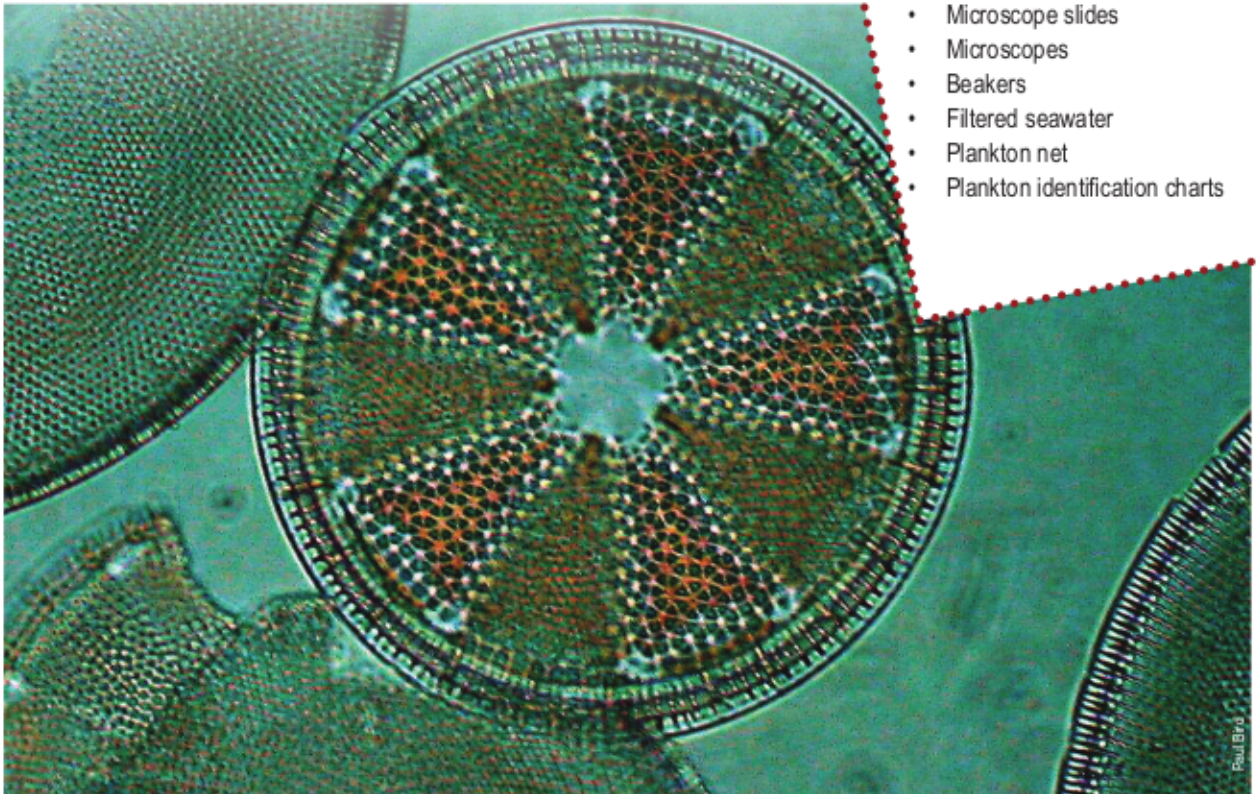
The aim of this activity is to investigate the impacts of ocean acidification and expand your understanding of the ocean's role in the carbon cycle. You will collect and identify plankton from sediments, algae and the water column and explore chemical changes that occur in an elevated CO₂ environment.

Time

Three hours (one hour field, two hours lab)

Tools

- Sample jars with lids
- Pipettes
- Microscope slides
- Microscopes
- Beakers
- Filtered seawater
- Plankton net
- Plankton identification charts



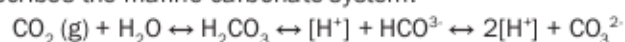
Diatom Actinopterychus sp.

Background

One of the most important elements for all life on earth is carbon. It provides the framework and structure upon which every living thing on our planet is built, from the largest whale to the simplest single celled plankton in our oceans.

As gaseous carbon dioxide (CO₂) from the atmosphere comes in contact with the ocean's surface, it dissolves. A proportion of this reacts with seawater, forming carbonic acid (H₂CO₃) while the remainder exists as a dissolved gas and is used by marine organisms such as phytoplankton and other marine plants for photosynthesis.

The amount of CO₂ that will dissolve in the ocean is determined by Henry's Law and provides the basis for a simplified equation that describes the marine carbonate system.



The carbon dioxide (CO₂), carbonic acid (H₂CO₃), bicarbonate (HCO₃⁻), and carbonate (CO₃²⁻) represent the total dissolved inorganic carbon present in our oceans. All three forms are vital for the biological processes occurring in the ocean. It is the carbonate ions (CO₃²⁻) that act as the buffer by their reactions with the hydrogen ions that prevent any large changes in pH from occurring in our oceans.





Many marine plants and animals concentrate calcium ions within their tissues to produce solid calcium carbonate, in the forms of aragonite and calcite, for their shells and skeletons. The beautiful calcified skeletons of plankton such as diatoms and forams can be easily viewed through a microscope. When these marine organisms die, their skeletons and the organic material in the tissues fall through the ocean as marine snow, taking the carbon dioxide that is fixed within their organic structures with them. Below ~4000m, high acidity causes these remains to dissolve back into the ocean waters. Through upwellings, the carbonate ions are cycled back to the surface to be used again for the building blocks of life. At certain depths the ocean is saturated with ions. These saturation horizon depths vary with the conditions of the ocean and are ultimately tied to the concentration of carbon dioxide in our atmosphere.

Field activity

During this activity you will collect plankton and microscopic organisms from three different parts of a reef or coastal environment.

1. Find an area on the reef flat, beach or sand flat that has discoloured sediments covered in seawater.
2. Collect a sample of the sediments with some seawater and seal the jar.
3. Leave some room at the top to shake the contents.
4. Find a living common algae that you can identify from the reef flat, beach or sand flat.
5. Extract a sample of the algae and seal this in a jar.
6. Using a plankton net, trawl through the water for 10 minutes and seal the collected plankton in a jar.

Lab activity

1. Looking at the sediment sample you collected in the field:
 - a. shake the jar and allow the sediments to settle, then tip off the sea water into a plastic beaker
 - b. wash the sediments with filtered seawater and repeat this process twice
 - c. using a pipette, extract a small amount of the seawater and place onto the microscope slide and view under the microscope
2. Looking at the algae sample you collected in the field:
 - a. add filtered sea water to the algae, seal it and gently shake
 - b. tip the water into a plastic beaker and repeat this process twice
 - c. using a pipette, extract a small amount of the seawater, place on a microscope slide and view it under a microscope
3. Looking in the water column sample you collected in the field:
 - a. wash the plankton net with filtered seawater to improve extraction of microorganisms
 - b. tip the jar into a clean plastic beaker
 - c. using a pipette, extract a small amount of the seawater, place on a microscope slide and view it under a microscope
4. Use books, websites and plankton charts to assist you in identifying what you have found and note the abundance of plankton.
Draw and identify two dominant plankton from each section, using identification charts.
5. Take two equal sub samples of plankton-filled seawater from each substrate type. Add 10ml of filtered seawater to one sub sample, add 10ml of soda water, vinegar or another dilute acid in the other. Leave the samples to sit for half an hour. Now use the pipette to prepare a slide of normal plankton and acidified plankton. (This is an extreme case of acidification that does not reflect current realities).
6. Collect two samples of calcareous algae, place one in dilute acid and the other in filtered seawater overnight. Observe any visible changes in the two samples.





| Plankton drawings – Sediment | |
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| Plankton drawings – Algae | |
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| Plankton drawings – Water column | |
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Questions

1. Where were the plankton most abundant and why?
2. What functions does plankton perform in reef and other marine environments?
3. Suggest how we could gain a better understanding of the fluctuations of population numbers of plankton throughout the day.
4. How would the concentration of nutrients (nitrogen and phosphorous) affect plankton populations?
5. What role does plankton play in the carbon cycle?
6. What is aragonite and how is this important for marine organisms?
7. What is ocean acidification and what are the potential effects on primary productivity in the ocean?
8. What are the expected changes in ocean chemistry, particularly in the southern ocean and how is this related to the increased partial pressures of carbon dioxide?
9. How could changes in ocean temperature magnify the effects of ocean acidification on marine ecosystems?

Research projects

1. What is Redfield's ratio and how does this relate to the growth of marine plants?
2. What is the relationship between the concentration of phytoplankton and the global surface currents?
3. How does phytoplankton make clouds?
4. What is the response by plankton to increased nutrient inputs from land based activities?
5. Is it possible that we may see an explosion in planktonic life forms due to 'carbon fertilization'?
6. What is the potential of using nutrients to enhance the uptake and sequestration of carbon dioxide within the marine environment?
7. If we change the bottom chemistry of the oceans through increased carbon dioxide concentrations, how will this impact the surface waters?
8. Investigate the reasons why scientists are so concerned about ocean acidification.
9. How could changes in ocean temperature magnify the effects of ocean acidification on marine ecosystems?

References

- Reid et al. (2009) Coral Reefs and Climate Change: The guide for education and awareness. CoraWatch, The University of Queensland, Brisbane. (See A Basic Ocean page 34, Productive Seas page 56, Ocean Acidification page 68 and Coral Growth page 92)
- Veron JEN et al. (2009) The coral reef crisis: The critical importance of <350 ppm CO₂. Marine Pollution Bulletin 58:1428–1436. (supplied on CD)
- Acid Test (movie) Natural Resources Defense Council; www.nrdc.org/oceans/acidification/
- A Sea Change (movie); www.aseachange.net/
- European Project on Ocean Acidification; www.epoca-project.eu
- Ocean Acidification Network; www.ocean-acidification.net
- Climate Shifts; www.climateshifts.org

