Channel Islands National Park and Channel Islands National Marine Sanctuary

Ocean Acidification Curriculum

Student Workbook

This is a series of lessons exploring the effects of ocean acidification on Channel Islands National Park and Channel Islands National Marine Sanctuary. It was developed for the National Park Service’s Teacher Ranger Teacher Program, in collaboration with and with support from the National Oceanic and Atmospheric Administration’s Office of National Marine Sanctuaries. These lessons are in the public domain and cannot be used for commercial purposes. Permission is hereby granted for the reproduction, without alteration, of these lessons on the condition its source is acknowledged.
Channel Islands National Park and
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In Cooperation with the National Park Service’s Teacher-Ranger-Teacher Program, and NOAA
Lesson 1: Producers and Consumers in the Channel Islands National Marine Sanctuary

In the waters of Channel Islands National Marine Sanctuary, a baby abalone crawls along a piece of giant kelp that is swaying gently in the ocean current. As it moves along, it slowly eats pieces of kelp for a delicious meal. Meanwhile, a garibaldi fish swims by, eating phytoplankton as it goes. Out of the dark, a sea lion darts in quickly and snaps up the garibaldi for a dinner on the go.

The kelp, abalone, phytoplankton, garibaldi and sea lion are all part of an ocean food web. The food web contains different types of consumers and producers. Producers are organisms that make their own food through photosynthesis. This means that they use the sun's energy, carbon dioxide and water to make their own food. Examples of producers in the ocean are phytoplankton (tiny plant-like organisms), kelp, algae and marine plants.

Consumers are organisms that need to eat other living things in order to survive. Some examples of consumers in the Channel Islands National Marine Sanctuary are abalone, sea stars, coral, fish, sea lions, sharks, whales, crabs and lobsters.
Lesson 1: Biodiversity in the
Channel Islands National Park and Marine Sanctuary

Warm-Up Questions:
1. List several types of **producers** found in Channel Islands National Park and Marine Sanctuary.

   ___________________________________________________________
   ___________________________________________________________
   ___________________________________________________________

2. List several types of **consumers** found in the Channel Islands National Park and Marine Sanctuary.

   ___________________________________________________________
   ___________________________________________________________
   ___________________________________________________________

Pre-Video Question:
What is “biodiversity?”

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   ___________________________________________________________
   ___________________________________________________________

Channel Islands Live Dive:
In the chart below, write down all of the organisms you see during the Channel Islands Live Dive clip. Classify them as producers or consumers.

<table>
<thead>
<tr>
<th>Producers</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

How many producers did you count? __________________________
How many consumers did you count? __________________________
| Anchovy | Anchovies swim in large schools near the surface of the ocean, with sometimes over a thousand fish swimming together. This helps protect them from predators such as salmon, sea lions and pelicans.  
Anchovies get their energy by eating plankton (zooplankton and phytoplankton). |
|---|---|
| Zooplankton | Zooplankton are animals that use the water currents to drift in the ocean. Different types of animals make up zooplankton, such as copepods and jellyfish.  
While most zooplankton is microscopic, some can be up to meters long!  
Zooplankton get their energy from eating phytoplankton. |
| Phytoplankton | Phytoplankton are microscopic plants or plant-like organisms that use sunlight to make their own food, through the process of photosynthesis.  
Phytoplankton are important because they provide us with a large amount of the world's oxygen. |
<p>| <strong>Harbor Seal</strong> | Harbor seals are true seals and do not have an external ear flap. They move swiftly underwater propelling themselves with undulating hind flippers, yet they are slow and awkward on land. Harbor seals get their energy from squids, anchovies, rockfishes, and octopi. |
| <strong>California Sea Otter</strong> | Sea otters have very dense fur to help keep them warm in the cold ocean water. Sea otters are known for their grooming behavior which is essential for keeping their thick insulating coat of soft fur clean. Sea otters get their energy by eating crabs, snails, urchins, clams, abalones, mussels. |
| <strong>California Sea Lion</strong> | Sea lions like to stick their flippers in the air to help them regulate their body temperature. Sea lions get their energy from eating squid, fish, and octopus. |
| Common Dolphin | Common dolphins are often seen in large groups “riding the waves” behind boats on the way out to the Channel Islands. They are one of the most numerous dolphins in the world. These playful dolphins get their energy from eating fish and squid. |
| Humpback Whale | Humpback whales have baleen in their mouths instead of teeth. Baleen is made out of the same material as our fingernails. They take in huge amounts of water and filter it through their baleen to catch their favorite foods; krill (zooplankton) and anchovies. |
| Bat Ray | Bat rays use their wing-like flaps to help catch their food. They use their wings and also their strong teeth located on the underside of their bodies to dig into the sand in order to catch clams, shrimp and worms. They also eat crabs and fish. |</p>
<table>
<thead>
<tr>
<th>Cancer Crab</th>
<th>Cancer Crabs are scavengers and predators. They use their claws to help catch prey such as snails, abalone, oysters and barnacles. They also will eat dead organisms at the bottom of the ocean floor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giant Kelp</td>
<td>Giant kelp is a type of algae that grows fast and tall, it can even grow up to two feet per day! Giant kelp can create huge underwater forests that provide important habitats for many animals. Giant kelp uses energy from the sun to create its own food through the process of photosynthesis.</td>
</tr>
<tr>
<td>Human</td>
<td>While humans do not actually live in the ocean, we do have a huge impact on our ocean through our actions. We use the ocean for transportation, food and recreation. Humans consume many living things in the ocean including invertebrates, kelp and fish.</td>
</tr>
<tr>
<td>Octopus</td>
<td>Octopus can change colors to camouflage with its surroundings, to hide from predators and to sneak up on its prey.</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sea Lettuce</td>
<td>Sea lettuce is a type of green algae that gets its name because it looks like lettuce.</td>
</tr>
<tr>
<td>Abalone</td>
<td>Some species of abalone have almost become extinct due to overfishing by humans and disease.</td>
</tr>
<tr>
<td>Rockfish</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>There are many types of rockfish, some that live in shallow water and some that live in the deep ocean.</td>
<td></td>
</tr>
<tr>
<td>Rockfish get their energy by eating zooplankton, phytoplankton, crabs, and other fish.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Great White Shark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great white sharks have an excellent sense of smell and can smell a drop of blood in 25 gallons of water. They also have many sharp serrated teeth.</td>
</tr>
<tr>
<td>This helps them catch prey such as fish, octopus, bat rays, sea lions, seals, small whales, sea otters, sea turtles, and carrion (dead animals).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Orca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most orcas live and hunt in pods or family groups. They use distinct sounds to communicate with one another.</td>
</tr>
<tr>
<td>Orcas get their energy by eating fish, squid, birds, seals, sea lions, dolphins and other whales.</td>
</tr>
</tbody>
</table>
**Eel Grass**

Eel grass is a type of flowering plant that lives in the ocean. It gets energy from the sun, using photosynthesis to create its own food.

Eel grass provides important habitat for many animals. It also helps filter pollution out of the water and to absorb carbon dioxide that enters the ocean.

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**Deep Sea Coral**

There are many types of coral found in the deep waters off of the Channel Islands.

Deep sea coral are animals. They feed by stretching out tentacles to catch tiny particles floating by, such as plankton (zooplankton and phytoplankton) and decayed matter.

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**California Spiny Lobster**

Spiny lobsters live in kelp forests and surf grass beds. Catching lobsters is popular among fishermen, but if left alone some lobsters can grow over 3 feet long!

They get their energy by eating plankton, snails, crabs and clams.
Brittle Star

Brittle stars use their arms to catch food. If a brittle star loses one of its arms, it can grow back.

Brittle stars get their energy from plankton, decayed matter and small crustaceans.

Garibaldi Fish

The Garibaldi is the official marine fish of California. Garibaldis are very territorial fish and will attack other fish that come into their area.

Garibaldis get their energy by eating worms, sea anemones, crabs, shrimp, sea stars, sponges and algae.

Leopard Shark

Leopard sharks usually live in shallow waters. They feed along the bottom of the ocean floor.

They get their energy by eating clams, fish eggs, crabs, fish, worms, and sometimes even bat rays and octopus.
<table>
<thead>
<tr>
<th><strong>Brown Pelican</strong></th>
<th>Brown pelicans nearly became extinct because of DDT, a type of pesticide. The brown pelican population is recovering and the birds use the Channel Islands as a nesting area. The brown pelican gets its energy by eating fish such as anchovies.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>California Sheephead Fish</strong></td>
<td>California sheephead are an unusual fish that can change gender, from female to male during their lifetime. This fish has strong teeth to eat food such as snails, crabs, sea urchins and lobsters.</td>
</tr>
<tr>
<td><strong>Giant Black Sea Bass</strong></td>
<td>Giant black sea bass can become quite giant, with some growing to over 7 feet long and weighing over 250 pounds! The giant black sea bass eats shrimp, small sharks, crab, lobsters, anchovies, squid and other fish.</td>
</tr>
<tr>
<td>Brown Turban Snail</td>
<td>The brown turban snail makes its home in the kelp forest. It eats by using its radula, or tongue. The brown turban snail gets its energy by eating kelp, other types of algae and some phytoplankton.</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>California Mussels</td>
<td>California mussels attach themselves to rocks using a very strong thread-like material that they create. Mussels will filter ocean water through their shells to catch plankton and other tiny particles to eat.</td>
</tr>
<tr>
<td>Common Market Squid</td>
<td>Common market squid have eyes similar to human eyes. The use their tentacles to draw food into their sharp beaks. They eat crabs, small fish, and other crustaceans.</td>
</tr>
<tr>
<td><strong>Gray Whale</strong></td>
<td>Gray whales have their babies in the warm waters of Baja California. From there they migrate north, all the way to the waters off of Alaska. Gray whales get their energy from scooping crustaceans from the mud bottom.</td>
</tr>
<tr>
<td><strong>Sea Urchin</strong></td>
<td>Sea urchins feed using a 5 toothed structure known as “Aristotle’s lantern” They get their energy by eating algae, such as kelp. One of the main predators of the sea urchin is the sea otter.</td>
</tr>
<tr>
<td><strong>Pteropod</strong></td>
<td>Pteropods are sometimes called “sea butterflies.” These tiny creatures are related to snails. Pteropods eat plankton. They are an important food source for many marine animals.</td>
</tr>
</tbody>
</table>
Lesson 2: Upwelling Lab Data Sheet

Diagram 1-1 Ocean Zones

Part 1: Pre-Lab Questions

Look at Diagram 1-1 Ocean Zones

1. Which zone of the ocean do you think has the warmest water? Explain your reasoning.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Which zone of the ocean do you think has the coldest water? Explain your reasoning.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
3. What forces could move the surface water in the sunlit zone?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. If the surface water is moved, how might that affect the temperature in the sunlight zone? Explain your reasoning.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Part 2: Post – Experiment Explanation

Explain and diagram how cold and warm water move as a result of upwelling. What else might be carried to the surface besides cold water?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Make a prediction:
Colder, deeper water in the ocean is very nutrient rich. Where might those nutrients come from?
Make a prediction using the hypothesis model: I believe that . . .

I believe that:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Lesson 3: Isolation, Currents, and Upwelling: Factors that Make the Channel Islands Unique

The Channel Islands National Park and Channel Islands National Marine Sanctuary, located off the coast of Southern California, are rich in biodiversity. *Biodiversity* means that there is a wide variety of life on the Channel Islands and in the ocean surrounding the islands.

There are several factors that contribute to the many types of unique and wonderful organisms found on and around the Islands. One of these factors is the location of the islands. The Channel Islands are located in the ocean off the coast of California and have never been connected to mainland California. Organisms arrived by swimming, drifting or flying. That means that organisms on the island have had time to evolve and change over time, separate from similar organisms on the mainland.

An example of this is the island fox. The island fox is related to the gray fox, which is found on the mainland of California. However, the island fox is much smaller in
size and genetically different to its mainland relative. There are over 100 endemic plants and animals on the Channel Islands, which means that they are only found in that particular area and no place else in the world. The Island fox is an example of an animal that is endemic to the Channel Islands.

Santa Cruz Island Fox

Another factor that makes the Channel Islands unique is the meeting of two ocean currents. Having an area with warm water on one side and cool water on the other creates a boundary that contributes to the biodiversity in the waters around the islands. Anacapa and Santa Cruz Islands have warmer waters because of currents moving up from Baja California, and are home to warm water fish and other marine species that migrate from these southern waters. The waters around Santa Rosa and San Miguel experience cool nutrient-rich water that is the product of upwelling.
Upwelling has important impacts on marine life around the islands. It typically occurs during the spring and summer when wind moves the warmer sunlit surface water further offshore. To replace the warm water that has moved, colder, nutrient rich water from the deep ocean moves up towards the surface. The nutrients brought up from the deep ocean, along with sunlight, allow algae, such as giant kelp, and aquatic plants to thrive and grow at incredible rates.

The upwelled water also helps create large phytoplankton blooms. Phytoplankton, which are plant-like organisms, are the base of many food webs and support a variety of marine life such as fish, marine mammals, and seabirds. Upwelled colder water also carries more oxygen and carbon dioxide than warmer water. Animals, such as fish, use the oxygen to “breathe” through their gills and survive. Plants, algae and phytoplankton use carbon dioxide, water and sunlight to make their own food in a process called photosynthesis.

All of these factors; upwelling, isolation of the Islands, and the meeting of two ocean currents contribute to the biodiversity on both land and in water in The Channel Islands National Park and National Marine Sanctuary.
Lesson 3: Currents and Isolation Student Worksheet
Mapping Sea Surface Temperatures (SST): Create a colored SST map.

Above is a satellite-derived Sea Surface Temperature (SST) of the Southern California Bight from September 30, 1995. (AVHRR data) All measurements are in degrees Celsius.

Temperature Key:
Warmer      Cooler

<table>
<thead>
<tr>
<th>17 °C</th>
<th>16°C</th>
<th>15°C</th>
<th>14°C</th>
<th>13°C</th>
<th>12°C</th>
<th>11°C</th>
<th>10°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>O</td>
<td>Y</td>
<td>G</td>
<td>B</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The mnemonic ROY G BIV is used to remember the colors in order from the warmer long wave, to the cooler, short wave colors. Use a yellow/orange for 15°C and a green/blue for 17°C.
Mapping Sea Surface Data Temperatures: Create a colored SST map. (continued)

1. Is the surface ocean temperature the same in all areas of the Santa Barbara Channel?

2. What do you think causes different temperatures around the islands?

3. How do you think the different temperatures affect the organisms that live in Channel Islands National Park and Channel Islands National Marine Sanctuary?

Reading

1. Number each paragraph.
2. In paragraph #1, highlight the definition of “biodiversity.”
3. In paragraph #2, does the author say that the Channel Islands have ever been connected to mainland California?

4. In paragraph #2 the author mentions different ways animals might have arrived to the Channel Islands. Draw a picture of a fox traveling to the island in one of these ways:

5. In paragraph #3, what is the island foxes’ mainland relative?

6. In paragraph #4, what do warm water currents from Baja bring with them to the Channel Islands?

7. In paragraph #4, why is the water around Santa Rosa Island cold?

8. In paragraph #5 and #6, what are two types of organisms that grow very well in upwelled water?

9. In paragraph #6, highlight the three things plants, algae and phytoplankton need for photosynthesis.
Reflection

Explain how upwelling, ocean currents, and any other factors affect the marine life in the Channel Islands National Park and Channel Islands National Marine Sanctuary. Quote evidence from the reading and your lab activities to support your answers.

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Lesson 4: What Exactly is Ocean Acidification?

<table>
<thead>
<tr>
<th>1. Humans have been releasing carbon dioxide (CO$_2$) into the atmosphere in large quantities since the Industrial Revolution. CO$_2$ is released during combustion: when we drive our cars, power our houses and factories, use electricity, burn things, and cut down trees.</th>
<th>2. The ocean acts as sponge and absorbs about 30 percent of the CO$_2$ from the atmosphere. However, as levels of CO$_2$ rise in the atmosphere, so do the levels of CO$_2$ in the ocean.</th>
<th>3. This is not great news for our ocean or the organisms that make their home there. When CO$_2$ mixes with seawater, a chemical reaction occurs that causes the pH of the seawater to lower and become more acidic. This process is called ocean acidification.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Even slight changes in pH levels can have large effects on marine organisms, such as fish and plankton.</td>
<td>5. Ocean acidification also reduces the amounts of calcium carbonate minerals available to shell-building organisms, such as plankton, oysters, coral, and sea urchins, to build and maintain their shells and skeletons.</td>
<td>6. The damage to these shell-building organisms can have a negative ripple effect throughout the entire ocean food web.</td>
</tr>
</tbody>
</table>

After you read each section, create a colorful illustration to represent each panel of the story.
Lesson 5: Lab-The Effects of Ocean Acidification on Shelled Organisms

Pre-Lab Questions
1. What chemical compound is the ocean absorbing that is causing it to become more acidic?
   ____________________________________________________________
   ____________________________________________________________

2. Where is this chemical compound coming from?
   ____________________________________________________________
   ____________________________________________________________

3. What types of marine organisms have shells? List at least three.
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

4. Think about how ocean acidification can affect you, your friends, or your family.
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

Lab Materials
- chalk
- water
- vinegar
- paper towels
- pH paper
- beakers
- scale
Lab Procedure

1. Determine the pH of the water and vinegar by placing one pH strip in each liquid.
2. Compare the colors of the pH paper to the key on the pH box.
3. Record the pH levels of the water and the vinegar.
4. Write down what the water, white vinegar, and chalk represent.
5. Create a hypothesis for what you think will happen to chalk #1 and chalk #2 after it has been placed in the water or vinegar. Explain your reasoning.
6. Weigh chalk #1 and record the weight in grams.
7. Weigh chalk #2 and record the weight in grams.
8. Place chalk #1 in the water. Place chalk #2 in the white vinegar. Observe the chalk and record your observations - first after 1 minute and then again after 5 minutes.
9. After 5 minutes, take the chalk out of each liquid. Try not to get them mixed up!
10. Weigh each piece of chalk again and record the weight.
11. Subtract the new weight of each chalk from the original weight (after the chalks were in the liquid). Record the difference.
12. Clean-up lab and write your conclusion.

Lab Questions

1. What does the water represent in this lab?
   __________________________________________________________

2. What does the white vinegar represent in this lab?
   __________________________________________________________

3. What does the chalk represent in this lab?
   __________________________________________________________

4. The pH of the water: _________________________

5. The pH of the white vinegar: ___________________
**Hypothesis:** What will happen to the chalk when it is placed in the acidic liquid (vinegar) compared to when it is placed in water? When the chalk is placed in the acidic liquid (vinegar) it will

___________________________________________________________

because _________________________________________________

When the chalk is placed in water it will _______________________

___________________________________________________________

because____________________________________________________

7. Record the weights of each chalk before and after the lab:

<table>
<thead>
<tr>
<th></th>
<th>Chalk #1 (water)</th>
<th>Chalk #2 (vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalk weight (dry)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalk weight (after being in the liquids)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much mass did each piece of chalk gain or lose?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. **Observations**

<table>
<thead>
<tr>
<th>Observations</th>
<th>Chalk #1 (in water)</th>
<th>Chalk #2 (in white vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 1 minute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After 5 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

9. Was your hypothesis supported? Why or why not?

   My original hypothesis was that

   ___________________________________________________________
   ___________________________________________________________
   ___________________________________________________________
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10. Create an argument, using evidence from this lab and the ocean acidification cartoon (that you made in the last lesson), for how ocean acidification will affect shelled organisms, such as coral, oysters, or crabs:

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Lesson 6: Photosynthesis and the Ocean

Take a deep breath. You just inhaled oxygen, along with other gasses. Where did this oxygen come from? Organisms such as plants, trees, algae, kelp and phytoplankton create oxygen when they make their own food in a process called photosynthesis. Photosynthesis involves taking energy from the sun, along with carbon dioxide and water to create a chemical reaction. The products of this reaction are oxygen and glucose (food). Organisms that make their own food through photosynthesis, such as kelp, phytoplankton and plants, are called producers because they produce their own food. The phytoplankton are tiny plant-like organisms that are the basis of most food webs in the ocean.

Producers contain chlorophyll, which helps them gather energy from the sun. Ocean producers, such as phytoplankton, also get nutrients from upwelling that occurs in the ocean. Upwelling is when warmer water on the surface of the ocean is moved by the wind. Then nutrient rich cold water moves up from the deep ocean towards the surface.

The oxygen that is released from producers during photosynthesis helps sustain life on Earth. Without oxygen, we would not be able to survive. Did you know that we get over half of our oxygen from the ocean?

Photosynthesizing organisms in the ocean, such as kelp, algae, marine plants, and phytoplankton, are also important to consider when thinking about the effects of ocean acidification, which is the increase in carbon dioxide uptake in our ocean. How will these producers be affected by increasing carbon dioxide levels in the ocean?

A Channel Islands Marine Food Web
Lesson 6: pH Factors in Different Ocean Ecosystems
Part 1: See-Think-Wonder

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>See</th>
<th>Think</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antarctica</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kelp Forest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coral Reef</td>
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<td></td>
</tr>
</tbody>
</table>
Part 2: Abiotic and Biotic Factors

<table>
<thead>
<tr>
<th>Abiotic (Non-Living) Factors</th>
<th>Biotic (Living) Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
</tbody>
</table>

Part 3: Photosynthesis in the Ocean

1. Where does most of our oxygen come from?
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

2. What are examples of producers in the ocean?
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

3. Below, draw and label a picture of photosynthesis in the ocean. Include the words: carbon dioxide, sunlight, water, oxygen and glucose.
Lesson 7: Comparing pH Levels in Different Ocean Ecosystems

Abiotic and biotic factors in temperate, arctic and tropical ecosystems

<table>
<thead>
<tr>
<th>Abiotic (nonliving) factors</th>
<th>Biotic (living) factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
</tbody>
</table>

Ecosystem comparison of pH levels- Understanding graphs: The three graphs represent actual pH data collected from three different ecosystems: tropical, temperate, and polar. This is called time-series data.

1. What do the X and Y axes represent?
   
   X axis ______________________________________________________
   
   Y axis ______________________________________________________
2. The Y axis is the same across all three graphs and the X is different for each graph. What does this mean?

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

3. What is the range for the Y axis (pH units)? ____________________________

4. What is the range for the X axis (number of days)? _______________________

5. How might different times or seasons of the year affect the pH levels of that ecosystem?

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

6. Do you think the time of day impacts what the observed pH was? Why?

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

**Graph interpretation**

7. What is the range of pH for each ecosystem? You can use a ruler to estimate.

Antarctica: ______________________

Kelp forest: ____________________

Coral reef: ____________________
8. How do the graphs differ numerically (ranges of pH, highest and lowest values)?

____________________________________________________________________________________________________

____________________________________________________________________________________________________

9. Which ecosystem has the biggest shift in pH? __________________________________________________________

10. Which ecosystem has the most regular, or repeatable, pH level?

____________________________________________________________________________________________________

Mystery Graph

These graphs are from the same location. The graph on the left is for pH, and the graph on the right is for temperature.
11. Describe the **pH** variability on the mystery graph (pH range, pH max, etc.).

_________________________________________________________________________________________________
_________________________________________________________________________________________________

12. Describe **temperature** variability on the mystery graph (temperature range, maximum temperature, etc.).

_________________________________________________________________________________________________
_________________________________________________________________________________________________

13. Hypothesize which ecosystem these pH data came from and describe the evidence behind your reasoning.

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

14. What could be the biotic and abiotic sources of pH variation in this graph? Explain your reasoning.

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
Lesson 8: Solutions to Ocean Acidification: What Can I Do?

Part 1:

1. In the activity, was your card a carbon source or carbon sink? Explain your answer.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. If everyone lived like you, how many planet Earths would it take to provide enough resources?

________________________________________________________________________
________________________________________________________________________

3. What is one thing you can do to help reduce your carbon footprint?

________________________________________________________________________
________________________________________________________________________

Part 2:

4. Carbon Pollution and Solutions

<table>
<thead>
<tr>
<th>Carbon Pollution</th>
<th>Carbon Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td>4.</td>
</tr>
</tbody>
</table>
A. Group members (4-6):

B. **Brainstorm** – What is your message?

Our message is:

Who is your audience? Be specific.

How are you going to communicate this message?

We will communicate this message by:

Brainstorm in the space below:

C. **Project** What is your project? ________________________________
### Carbon Sinks and Sources Cards

<table>
<thead>
<tr>
<th>Oil Platform</th>
<th>Airplane</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Oil Platform" /></td>
<td><img src="image2.png" alt="Airplane" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Train</th>
<th>Steamboat</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Train" /></td>
<td><img src="image4.png" alt="Steamboat" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volcano</th>
<th>Barbeque and Charcoal</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Volcano" /></td>
<td><img src="image6.png" alt="Barbeque and Charcoal" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cement Truck</th>
<th>Channel Island Fox</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image7.png" alt="Cement Truck" /></td>
<td><img src="image8.png" alt="Channel Island Fox" /></td>
</tr>
<tr>
<td>Factory</td>
<td>Cut down trees</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><img src="image" alt="Factory" /></td>
<td><img src="image" alt="Cut down trees" /></td>
</tr>
<tr>
<td>Electricity</td>
<td>Car</td>
</tr>
<tr>
<td><img src="image" alt="Electricity" /></td>
<td><img src="image" alt="Car" /></td>
</tr>
<tr>
<td>Tanker Ship</td>
<td>Fire</td>
</tr>
<tr>
<td><img src="image" alt="Tanker Ship" /></td>
<td><img src="image" alt="Fire" /></td>
</tr>
<tr>
<td>Wood burning stove</td>
<td>Humans</td>
</tr>
<tr>
<td><img src="image" alt="Wood burning stove" /></td>
<td><img src="image" alt="Humans" /></td>
</tr>
<tr>
<td>Dead fish.</td>
<td>Motorcycle</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td><img src="image1" alt="Image of a fish" /></td>
<td><img src="image2" alt="Image of a motorcycle" /></td>
</tr>
<tr>
<td>The ocean</td>
<td>Shells</td>
</tr>
<tr>
<td><img src="image3" alt="Image of the ocean" /></td>
<td><img src="image4" alt="Image of shells" /></td>
</tr>
<tr>
<td>River</td>
<td>Phytoplankton</td>
</tr>
<tr>
<td><img src="image5" alt="Image of a river" /></td>
<td><img src="image6" alt="Image of phytoplankton" /></td>
</tr>
<tr>
<td>Kelp</td>
<td>Soil</td>
</tr>
<tr>
<td><img src="image7" alt="Image of kelp" /></td>
<td><img src="image8" alt="Image of soil" /></td>
</tr>
<tr>
<td>Glacier</td>
<td>Atmosphere</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td><img src="image1.png" alt="Glacier" /></td>
<td><img src="image2.png" alt="Atmosphere" /></td>
</tr>
<tr>
<td>Forests</td>
<td>Compost</td>
</tr>
<tr>
<td><img src="image3.png" alt="Forests" /></td>
<td><img src="image4.png" alt="Compost" /></td>
</tr>
<tr>
<td>Wetlands</td>
<td>Flowering Plant</td>
</tr>
<tr>
<td><img src="image5.png" alt="Wetlands" /></td>
<td><img src="image6.png" alt="Flowering Plant" /></td>
</tr>
<tr>
<td>Grass</td>
<td>Channel Island Spotted Skunk</td>
</tr>
<tr>
<td><img src="image7.png" alt="Grass" /></td>
<td><img src="image8.png" alt="Channel Island Spotted Skunk" /></td>
</tr>
<tr>
<td>Power Plant</td>
<td>Santa Cruz Island Buckwheat</td>
</tr>
<tr>
<td>-------------</td>
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</tr>
<tr>
<td><img src="image1.png" alt="Power Plant" /></td>
<td><img src="image2.png" alt="Santa Cruz Island Buckwheat" /></td>
</tr>
<tr>
<td>Island Oak Tree</td>
<td>Car Engine</td>
</tr>
<tr>
<td><img src="image3.png" alt="Island Oak Tree" /></td>
<td><img src="image4.png" alt="Car Engine" /></td>
</tr>
</tbody>
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