

Unit: Ecology Chapters: 4 and 6 Week: 2

Effects of Ocean Warming

Intended Class: Biology I

Intended Grade Level: 9-10

Time Allotment: One, 55-minute class period

Background Information:

Students should have a basic understanding of Earth's climate and the role that humans have in changing that climate. Students should understand that Greenhouses gases such as water vapor, carbon dioxide, methane and ozone, trap heat against Earth's surface, and the more greenhouse gases we have in the atmosphere, the more temperatures across the globe will rise. Students should be familiar with the carbon cycle and the role humans play in that cycle.

When sunlight enters Earth's atmosphere, much of it enters as visible light. About 30% of that visible light will be reflected off of the Earth by light colored objects such as clouds, ice, snow, etc. This is called albedo. The other 70% is absorbed by darker colored liquids, solids and gases that make up our planet's surface. When dark colored objects absorb visible light, they reemit that energy into infrared radiation which we feel as heat. Visible light that is reflected is allowed to pass back through the atmosphere, however, some of the infrared radiation is not allowed to escape and is trapped against Earth's surface by greenhouse gases. Without greenhouse gases, Earth's surface would be about -18°C, too cold to sustain life. However, the recent problem is that these gases are becoming more numerous in our atmosphere, allowing less infrared radiation escape and causing more to be trapped therefore heating the surface of the planet.

Water vapor accounts for the majority of the greenhouse gases in the atmosphere however it is beyond human control. Humans contribute drastically to the amount of methane, and even more so, to the amount of carbon dioxide gas in our atmosphere. Burning of fossil fuels for energy is the most drastic of the contributions by humans. Carbon dioxide levels have risen 30% over the last 200 years and are continuing to increase at an exponential rate. With the increase in carbon dioxide levels, we have also seen a resulting rise in temperature of Earth's surface. The surface of the Earth has increased about 1°F (0.6°C) over the past century. While water temperature does not change as drastically as land temperatures due to water's high heat capacity, we have seen a small increase in ocean temperature of 0.18°F (0.1°C) during that time. Even such a small change in sea surface temperature has made for some drastic changes with implications of more effects still to come.

Objective:

Students will be able to describe why warmer sea surface temperatures will cause sea level rise.

Students will be able to identify species most affected by higher sea surface temperatures.

Student will be able to explain the effects of higher sea surface temperatures on weather patterns.

Students will be able to describe how sea level rise will contribute to reductions in biodiversity due to invasive species.

Standards:

Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Materials:

- Ocean Warming PowerPoint Presentation
- Thermometer
- Capillary tube
- 1, 250mL Erlenmeyer flask
- Rubber stopper for Erlenmeyer flask with 2 holes
- Blue cardstock
- Expo marker
- Desk lamp
- Water
- Blue food coloring

Anticipatory Set: (10 minutes)

Ask the students what they know about what effects climate change will have on the ocean. Guide students towards thinking about the rise in sea surface temperatures that will accompany climate change. Ask the class if they have heard about the sea level rising and parts of our beaches will be underwater. Ask them what they think might contribute to this rise in sea level. Most will probably answer with melting of polar ice caps, glaciers, etc. Take a survey on the board. How many students think that sea level will rise because of melting sea ice (the ice that floats on the surface)? Record number on the board. Ask the students how many think that sea level will rise because of melting land ice, the non-floating kind like Antarctica and glaciers and ice sheets? Record the number on the board. Finally, ask the students how many think that sea level will rise because water expands when it gets warmer (like your fingers on a hot day).

Record the number on the board. Tell students that they will find out if they are right in just a few minutes.

Set up the demo for thermal expansion at the front of the room. Fill up Erlenmeyer flask with water (almost to the top). Put a few drops of blue food coloring into the water to turn it blue (this makes the demo easier to see). Put stopper on top of flask and insert the thermometer into one hole and the capillary tube into the other hole. Set at the front of a room under a desk lamp. Before beginning the demo, ask a student to come up to the front and mark the water line on the capillary tube with the Expo marker and record the temperature. Finally, turn on the desk lamp and shine it directly on the flask to warm the water. Let the demo sit while beginning the presentation.

Teaching Input: (40 minutes)

Lecture to the students using the PowerPoint presentation and notes provided. Students will answer the questions on the attached student handout during the lesson.

Slide 1: Title slide

Slide 2: Review the Greenhouse effect with the students. When sunlight enters Earth's atmosphere, much of it enters as visible light. About 30% of that visible light will be reflected off of the Earth by light colored objects such as clouds, ice, snow, etc. This is called albedo. The other 70% is absorbed by darker colored liquids, solids and gases that make up our planet's surface. When dark colored objects absorb visible light, they reemit that energy into infrared radiation which we feel as heat. Visible light that is reflected is allowed to pass back through the atmosphere, however, some of the infrared radiation is not allowed to escape and is trapped against Earth's surface by greenhouse gases. Without greenhouse gases, Earth's surface would be about -18°C , too cold to sustain life. However, the recent problem is that these gases are becoming more numerous in our atmosphere, allowing less infrared radiation escape and causing more to be trapped therefore heating the surface of the planet.

Slide 3: The problem with the greenhouse effect is that we are currently adding more greenhouse gases to the atmosphere resulting in trapping of more heat. This is a graph called the Keeling Curve. Data for the Keeling Curve has been collected since 1958 at the top of Mauna Loa volcano on the big island of Hawaii. This graph shows a steady increase in carbon dioxide levels since 1954 with seasonal fluctuations of high and low carbon dioxide levels. Photosynthesis in the spring account for lower atmospheric carbon dioxide levels (autotrophs are taking it in) and higher atmospheric carbon dioxide levels in the winter as lower light levels and die-off of photosynthetic organisms account for less carbon dioxide being removed from the atmosphere. The resulting trapping of more heat by increased greenhouse gas levels is referred to as climate change.

Slide 4: Current data on the global averages. Point out that some places are actually cooling (which is why it called climate change and not global warming) and that lowers the average. These numbers are not staggering, but given the data, this is a fairly speedy rate of increase. We have also linked air temperature

to greenhouse gas emissions and we have never seen emissions as high as they are currently, which leads to questions of just how high the air temperature (and resulting ocean temperature) will get.

The analogy can be made between the planet and our bodies when ill. When we are sick and fighting an infection, our body temperature increases. Even the smallest increase from 98.6 °F to 99 or 100°F is an indication that our bodies are not functioning properly. The same could be said for the planet. While the temperature anomalies are not drastic (yet) they are an indication that something is wrong and should be addressed.

Slide 5: As the air temperatures rise, so do the water temperatures. This graph shows the data recorded from NASA of the changes in sea surface temperature since 1880. As you can see, there are ups and downs seasonally, and even yearly, with El Niño and La Niña events in between (warmer sea surface temperatures are generally El Niño events, and cooler temperatures are La Niña events). The bottom line of this image is the general trend in sea surface temperature data, which is increasing since 1880. What will this increase in sea surface temperatures mean for plankton?

Slide 6: Map of anomalies (differences from normal) in sea surface temperatures in 2006. Red shows temperatures upwards of 3.8°C while the greens and blues show temperatures that are actually cooler than average temperatures. Point out that the area warming faster than any other is the Arctic. Ask students what this will do to the ice if the surrounding waters are warmer. Ask the students what melting ice will do to the amount of albedo (reflection of sunlight). Obviously, less ice will lessen the amount of the sun's rays that are reflected therefore increasing the amount absorbed. It is these absorbed sun's rays that turn into infrared radiation that the greenhouse gases trap and contribute to the rising global temperatures.

Slide 7: Warmer Earth temperatures are definitely linked with warmer sea surface temperatures. Some of the possible effects of these warmer sea surface temperatures are outlined on this slide. Warmer sea surface temperatures could result in a loss of coastline and beaches due to sea level rise. We can also expect to see fewer species, especially those that rely on sea ice for hunting and/or hiding from predators. Weather patterns might also change and we are already seeing stronger and more frequent storms. Finally, the changing sea surface temperatures will result in a loss of biodiversity (variety of living organisms) due to the impacts of invasive species.

Slide 8: Refer back to how many students thought that melting of land ice would cause sea level rise. Click on the link to watch the video. They were right. Melting of land ice will cause a rise in sea level. Refer back to those that voted for floating ice. Click the link to watch the video. Melting of floating/sea ice will not contribute to sea level rise. Refer back to those that voted for thermal expansion. Leave the thermal expansion demo alone for now. Check it at the end of the lesson. The more time it goes, the better the results.

Slide 9: This map shows the percent coverage of Arctic ice taken at the same time in 1979 and then 28 years later in 2007. It is easy to see from this image that there is far less ice covering the Arctic waters now than in previous years.

There are also more gaps in the ice sheets towards the right-hand side of the image. Ask students what that might mean for animals that live there. (Breaks up their hunting grounds and fragments their habitat so they have less area to hunt and live within.)

Slide 10: Statistics on current sea level rise. As the climate has warmed following the end of a recent cold period known as the “Little Ice Age” in the 19th century, sea level has been rising about 1 to 2 millimeters per year due to the reduction in volume of ice caps, ice fields, and mountain glaciers in addition to the thermal expansion of ocean water. If present trends continue, including an increase in global temperatures caused by increased greenhouse-gas emissions, many of the world’s mountain glaciers will disappear. For example, at the current rate of melting, most glaciers will be gone from Glacier National Park, Montana, by the middle of the next century (fig. 1). In Iceland, about 11 percent of the island is covered by glaciers (mostly ice caps). If warming continues, Iceland’s glaciers will decrease by 40 percent by 2100 and virtually disappear by 2200.

Slide 11: Melting of the current Greenland ice sheet would result in a sea-level rise of about 6.5 meters; melting of the West Antarctic ice sheet would result in a sea-level rise of about 8 meters. A sea-level rise of 10 meters would flood about 25 percent of the U.S. population, with the major impact being mostly on the people and infrastructures in the Gulf and East Coast States

Slide 12: The US agency NOAA (the National Oceanic and Atmospheric Administration) puts the economic value that coral reefs provide economic services such as jobs, food and tourism estimated to be worth as much as \$375 billion each year. Corals are animals that have a symbiotic relationship with a photosynthetic algae called zooxanthellae. When ocean temperatures get too high for the coral, they release their zooxanthellae and eventually starve to death leaving behind just the white calcium carbonate skeleton they secrete. This is called coral bleaching. You can imagine what this will do to countries that rely on coral reefs for tourism dollars and the effects this will have on the food chain if a major food source such as coral disappears. The top two pictures show healthy reefs, while the bottom picture shows a bleached reef. Notice the lack of fish and other animals in the bleached reef picture.

<http://www.globalissues.org/article/173/coral-reefs>

Slide 13: The polar bear is affected by both the reduction of sea ice and loss of its primary food source, ringed seals. These bears use the sea ice as a platform for hunting, resting and raising their young. Bears hunt the seals that usually hide in the holes within the ice and they grab them when they come up through these holes. The reduction of sea ice throughout the Arctic due to climate change, has reduced the number of ringed seals and increased the amount of energy that polar bears must expend for their next meal. This leaves the bears with less energy for reproduction and fewer cubs are being born and surviving to adulthood as a result. The U.S. Geological Service stated in a 2007 report that the population of 22,000 bears would decrease by two-thirds by the year 2050 due to this reduction in sea ice. In 2008, the U.S. Fish and Wildlife Service listed the polar bear as a threatened species under the Endangered Species Act.

Slide 14 – Six of the seven recognized species of sea turtle are already listed as endangered under the Endangered Species Act. Female sea turtles come ashore to the beach they were born on to lay their eggs. Male sea turtles rarely if ever come ashore. Due to rising sea levels, many turtle nesting beaches are eroding away causing the turtles to lose their nesting sites and the eggs to drown in higher tide periods (these are air-breathing animals after all). Bonaire, the Great Barrier Reef and the Maldives are some of the more popular turtle nesting sites that are being greatly impacted due to climate change, having a direct effect on turtle reproduction. Rising temperatures (on land) increase the risk that the eggs will be incubated at temperatures that exceed the upper limit for viable eggs (34 degrees C) therefore decreasing the number of hatchlings. This rising temperature also has an effect on the sex of the turtles. The sex of an incubating reptile (as turtles are) is determined by the temperature in the nest. In warmer temperatures, more female turtles are born, skewing the sex ratio of the turtles and further affecting their reproduction. Some nesting beaches for Loggerhead turtles in Florida are already seeing nests that produce 90% female turtles. A temperature increase of an additional 1 degrees C could mean no males at all will be produced here.

Slide 15 - As water temperatures rise, evaporation allows the storms to escalate from small storms, to larger, more powerful storms quickly. In the past 35 years, the number of category 4 and 5 storms have increased, as have sea surface temperatures. Hurricanes need warm, moist air in order to continue so warmer sea surface temperatures fuel these larger storms.

Slide 16 – Increased evaporation especially in the summer months lead to increased periods of drought and also extended fire seasons. The national drought experienced in 1999-2002 was the worst we have seen in 40 years. The 2006 fire season reported 100,000 fires and over 10 million acres burned. To spend these resources on firefighting costs an estimated \$1 billion per year.

Go back to the demo and have a student come up and describe the water level compared to where it started. The water should have risen in the capillary tube showing that as water heats up, it expands and takes up more space accounting for much of the rise in sea level. So the students that voted for thermal expansion of water as a cause of sea level rise were also correct in their hypothesis.

Closing (2 minutes)

Slide 17 - The effects listed here are just a few of the possible effects of ocean warming on our planet. Warmer sea surface temperatures could also affect the migration patterns of some organisms taking them to places they don't normally exist. These organisms might not make it in these new locations and might die off, but if they survive, they will alter the food chain of the ecosystem they invaded. This has effects all the way up the food chain and could cause us to see the loss of many more species. Some of these species, like mosquitoes may

be disease carrying organisms, now taking their disease to areas of the world that did not have to deal with it previously. We are likely to see increased cases of malaria, yellow fever and even Dengue fever. The small changes we are seeing thus far pale in comparison with what could happen, but they are an indication that change is happening. We must address this change in hopes of putting a halt to some of these issues.

Lesson Reflection:

The demo really does need to sit for the entire time of the lesson. Otherwise, there is too small of a change in the water level to make an impact on the students. The lamp also must have an incandescent bulb, ideally of 100 watts or higher to create enough heat to warm the water. I also found that placing the flask on the dark blue piece of paper contributed to faster heating of the apparatus.

During the lesson, the students were interested and asked many questions about the melting ice and what would happen. I found that I also had to tell the students that the penguins and polar bears do not live in the same habitat. This was something that was difficult for them to understand. They didn't understand why polar bears are "the poster child for climate change" while the penguins seem to get very little recognition. I also made sure they understood that in order to get a message to the public and try to get them to help, companies and agencies are going to use larger animals that people find cuter, rather than those that are smaller (like krill) but still might be affected. The note sheet was easy for them to fill out and kept them engaged during the presentation. My students needed more explanation of the differences between land and sea ice. I found this website helpful; <http://nsidc.org/cryosphere/seaice/> in trying to explain it.

References:

Fact sheet on sea level and climate change - <http://pubs.usgs.gov/fs/fs2-00/>

Land ice satellite picture -

<http://mpe2013.org/images/sea-ice-arctic-sep1979-sep2007/>

Sea surface temperature anomaly map -

<http://www.giss.nasa.gov/research/news/20060925/>

Sea surface temperature graph -

<http://www.giss.nasa.gov/research/news/20060925/>

Keeling Curve -

<http://www.bitsofscience.org/big-arctic-melting-record-6233/>

Greenhouse Effect diagram -

<http://www.grida.no/publications/vg/africa/page/3110.aspx>

Coral Reefs and Ocean Warming - <http://www.globalissues.org/article/173/coral-reefs>

Loss of Species Statistics –

http://www.neaq.org/conservation_and_research/climate_change/effects_on_ocean_animals.php

Changes in Weather Pattern information -

www.nrdc.org/globalwarming/fcons/fcons1.asp

Name: _____ Date: _____ Period: _____

Effects of Ocean Warming Notes

1. Do you think melting of land ice, melting of sea ice, or thermal expansion of water will contribute more to sea level rise and why?

Answers will vary

2. Why are greenhouse gases important to have in Earth's atmosphere?

They trap heat. Without them Earth would be too cold for life.

3. What does the Keeling Curve show?

Steady increase in carbon dioxide levels since 1954.

4. How much have global temperatures risen in the past century?

1.1°F or 0.6°C

5. How much have global sea surface temperatures risen in the past century?

0.18°F or 0.1°C

6. List three possible effects that warmer sea surface temperatures could have on our planet.

1) Sea level rise

2) Loss of species

3) Changes to weather patterns

7. Will melting of land ice cause sea levels to rise? Why or why not?

Yes, this block of ice was not already in the water and therefore had not already displaced a volume of water.

8. Will melting of sea ice cause sea levels to rise? Why or why not?

No, the volume of water has already been displaced by the ice whether it is in solid or liquid form does not matter.

9. Will thermal expansion of water cause sea levels to rise? Why or why not?

As water molecules warm, they expand and take up more room. Therefore, the same amount of water at a warmer temperature will take up more space than that at a colder temperature.

10. Was your hypothesis correct about which would cause more sea level rise correct?

Answers vary

11. What has happened to the level of land ice in the Arctic from 1979 to 2007?

It has decreased.

12. How much does sea level rise per year?

1-2 mm

13. How much will melting ice sheets increase sea level? How much will melting glaciers increase sea level?

Ice sheets = 80m

Glaciers = 0.5m

14. How much of the U.S. would be affected by a sea level rise of just 10m?

This would flood about 25% of the US population and affect mainly the Gulf and East Coast states.

15. What happens to corals (and their zooxanthellae) as ocean temperatures rise?

Corals release their symbiotic zooxanthellae and bleach (die).

16. What could a decrease in the world's coral reefs mean for humans?

Loss of fish (to eat), lost tourism dollars, lost medicinal prospects. Etc.

17. How is less sea ice affecting the polar bears?

Bears are being forced to swim greater distances to find enough ice to hunt and rest and are starving and drowning.

18. What are three effects of warmer sea surface temperatures on sea turtles?

1) Loss of nesting beaches

2) Fewer eggs hatch due to warmer temperatures

3) More females born than males.

19. What are two possible changes in weather patterns that warmer sea surface temperatures could cause?

1) stronger and more frequent hurricanes

2) frequent droughts and fires

20. What can be done to slow or stop these changes from happening?

Answers will vary but students should discuss changes that they can make that reduce their carbon emissions to reduce greenhouse gases.