The Tip of the Iceberg

Objectives: Understanding climate science is a massive undertaking that many people believe is too big a task for them to tackle. This activity is designed to take little bites out of their uncertainty and give them a framework on which to build an understanding of climate science. This activity seeks to address very basic questions many people have, the first ones that should be cleared up in order to move forward in understanding climate science. Is this (the climate projections) within the realm of possibility? Is there historical context for understanding global warming? Has it happened before? How does it compare – sea level, rate of change, climate forcing agents, etc.?

Time needed: 10 – 30 minutes

Target age: middle-high school and adults

Materials needed:
- dry erase markers
- images of North America (or other point of reference) at different times, including present, that illustrate different sea levels, labeled for time period (see **Additional Resources** for site that offers images)
- maps for reconstructing sea level using fossil sampling; can be a recognizable political boundary, i.e. Alabama, or a made-up area. Map #1 should show boundaries with points that can be used as reference points, i.e. rivers, counties, lat./long. or grid lines. Map #2 should show the same area, but with sampling stations. Map #3 should be the same area with the same sampling stations, identifying sampling stations at which marine fossils from a particular period are found, i.e. Cretaceous marine assemblages.
- (Note that these materials are an aid to this activity, and they are helpful, but not essential) a set of oyster shells and oyster fossils from a changing coastline, along with maps identifying collection sites. For example, fossil oyster shells from an inland county, the present coastline, and an offshore site from a single estuary system that changes over time.

Description: Ask participants whether they think about climate change, whether they've heard it in the news, and whether they think the projections are within the realm of possibility. Then ask whether the earth has ever gone through warm periods during which temperatures were similar to the projections. Show them the images of the changing earth and ask them to find an image in which sea level was higher than present and lower than present. Note that both situations exist. Then ask them to put the images in chronological order and note that sea level has risen and fallen at different points in history, and that continents have moved. Ask participants how these earth images were constructed for different points in history. Discuss methods scientists use for reconstructing past sea levels/climates (fossils, ice cores, sediments, etc.). Show the oyster shells and fossils. Discuss the fact that oysters are an estuarine species – they only grow where there is a significant freshwater inflow, so they can be used to trace past coastlines. Next, show participants the map of the area you want to reconstruct a past coastline for. Ask them what information they could use to do this. People often associate the study of prehistoric times with fossils, and indeed, they could use marine fossils from a particular time period to reconstruct the coastline. Lead participants in a discussion about sampling. Using a dry-erase marker, draw a

handful (~ 3-5) of scattered samples on Map #1. Ask if they can draw in the coastline. Make the point that, in order to draw in a coastline with a reasonable level of precision, many sample sites are required. Show Map #2, which has enough sample sites. Ask participants what is required next. They would have to analyze the fossils for particular organisms or assemblages that would place the site on the coast at the right time. This has been done on Map #3. Once the sample sites are identified, the coastline comes into focus. Ask participants to draw in the coastline. Discuss the fact that this is one tool of many that scientists use to reconstruct past climates.

Extensions: Discussion could include a look at what it would mean for coastal residents (human and nonhuman) and ecosystems if sea level rises. A new coastline could be drawn in with dry-erase markers. Discuss, in rough numbers, how many people would be displaced by a sea-level rise of x amount. Discussion could include the contribution of melting ice, how much water is frozen in icecaps, etc. Discuss the contribution of thermal expansion. Discuss solar energy and the effects of greenhouse gases. Discuss the contribution of the ocean to absorption and distribution of heat. Discuss modern technologies for measuring and compiling sea level, temperatures, atmospheric gases, etc. Discussion could include whether measures should be taken to prevent climate warming.

Standards:

National Science Education Standards:

Unifying Concepts and Processes – Evidence, models, and explanation; Change, constancy, and measurement

5-8

Science as Inquiry – Abilities necessary to do scientific inquiry

Science and Technology – Understandings about science and technology

Science in Personal and Social Perspectives – Populations, resources, and environments; Natural hazards; Science and technology in society

History and Nature of Science – Science as a human endeavor

9-12

Science as Inquiry – Abilities necessary to do scientific inquiry

Science and Technology – Understandings about science and technology

Science in Personal and Social Perspectives – Natural resources; Natural and human-induced hazards; Science and technology in local, national, and global challenges

History and Nature of Science – Science as a human endeavor; Historical perspectives

Ocean Literacy: Essential Principles and Fundamental Concepts:

1. *The Earth has one big ocean with many features.* – a. The ocean is the dominant physical feature on our planet Earth – covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic.; d. Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea Level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.
2. *The ocean and life in the ocean shape the features of the Earth.* – b. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.
3. *The ocean is a major influence on weather and climate.* – f. The ocean has had, and will continue to have a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water.
6. *The ocean and humans are inextricably interconnected.* – d. Much of the world's population lives in coastal areas.; f. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).
7. *The ocean is largely unexplored.* – e. Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems.; f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Extensions Standards:

NSES:

5-8

Physical Science – Properties and changes of properties in matter; Transfer of energy
Life Science – Populations and ecosystems; Diversity and adaptations of organisms
Science and Technology – Abilities of technological design
Science in Personal and Social Perspectives – Risks and benefits

9-12

Physical Science – Structure and properties of matter; Motions and forces; Interactions of energy and matter
Life Science – Biological evolution
Earth and Space Science – Energy in the earth system; Geochemical cycles
Science and Technology – Abilities of technological design
Science in Personal and Social Perspectives – Personal and community health; Population growth

Ocean Literacy:

3. *The ocean is a major influence on weather and climate.* – a. The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.; b. The ocean absorbs much of the solar radiation reaching Earth. . . ; e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.; g. Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.
6. *The ocean and humans are inextricably interconnected.* – e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores, and rivers). . .; g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.
7. *The ocean is largely unexplored.* – d. – New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

For sea level images:
http://www2.nau.edu/rcb7/nam.html

www.polartrec.com/files/resources/activity/34711/docs/seaice.pdf

www.scientificamerican.com/article.cfm?id=arctic-ice-melts-cause-rising-sea

http://www.climate.noaa.gov/