POLAR EXPLORER SEA LEVEL RISE

The Polar Regions, the Arctic and Antarctica, are far away from us geographically, but you have heard that they are connected to us through the Earth's climate system. As a Polar Explorer you are interested in collecting evidence from Earth's climate system that is connected to changing sea level. Your goal is to determine connections to the Polar Regions. Use the 3 grids below to collect your data, and the questions to analyze it.

**WHAT MAKES SEA LEVEL (SL) CHANGE?**

| ITEM MEASURED | TIME PERIOD | TOTAL TIME | BEGINNING MEASURE | ENDING MEASURE | TOTAL CHANGE | INCREASE/ DECREASE |
|---|---|---|---|---|---|---|
| Average Sea Surface Temp. | | | | | | |
| Atmosphere Temperature | | | | | | |
| Ocean heat content | | | | | | |
| Ocean Expansion | | | | | | |
| Polar Meltwater Contributions | | | | | | |

1. The items listed in Column #1 are observations of what is happening on our Earth. What types of measurements are included?

2. Identify if the measurements were *Increasing* or *Decreasing* and explain what this means for future SL.

3. Which measurements from Column #1 are **factors that cause** SL to change?

4. Which items from Column #1 are **measurements of the resulting** SL change?

5. Review the time range covered in each of the measurements. Explain if you feel this is sufficient or insufficient to understand the trends being observed?

6. Use the evidence you collected in your table to develop a hypothesis about what makes SL change.

7. Identify any polar connections you found between sea level rise and the Polar Regions?

**NOW TRAVEL BACK THROUGH TIME TO SEE HOW FAST SEA LEVEL (SL) CAN CHANGE**

| ITEM MEASURED | TIME PERIOD | TOTAL TIME | BEGINNING MEASURE | ENDING MEASURE | TOTAL CHANGE | INCREASE/ DECREASE |
|---|---|---|---|---|---|---|
| SL Trend own Location | | | | | | |
| SL Last 8000 yrs (Humans) | | | | | | |
| SL 21,000 yrs.to present (LGM) | | | | | | |
| SL 125,000 yrs to present (Eemian) | | | | | | |
| *Predicting the future | | | | | | |

***** This calculation is listed in ***cm***

1. This chart is a table of changes in sea level over a range of times. What were the shortest and longest periods of time reviewed?

2. List the measure(s) that were *Increasing* and explain why.

3. List the measure(s) that were *Decreasing* and explain why.

4. Think about the **shapes** of the sea level graphs you reviewed. Why might using only a beginning and ending measurement not be the best way to look at how fast SL can change.

5. How does the last column showing SL 'predictions' for the next 100 years compare to your first column showing changes from 1900 to 2013?

6. Identify any connection you found between these measurements and the Polar Regions?

7. **BONUS QUESTIONS:** One way to look at how quickly SL has changed involves calculating the ***rate of change*** per year for each column. You will record this in the last column of the table along with your 'Increase' or 'Decrease'.
   **Rate of change = Total Change/Total Time**
   To compare your answers you will need to convert all into meters

8. Analyze your ***Rate of Change.*** Does the evidence suggest SL has changed quickly in the past?

**HOW MUCH ICE IS THERE AT THE POLES?**

| ITEM MEASURED | AMOUNT SEA LEVEL RISE |
|---|---|
| GREENLAND ICE SHEET | |
| WEST ANTARCTIC ICE SHEET | |
| EAST ANTARCTIC ICE SHEET | |
| TOTAL SEA LEVEL RISE AVAILABLE FROM THE POLES | |

The final set of questions focuses on the **potential** of the Polar Ice Sheets.

1. You have recorded the amount of Sea Level (SL) rise available from each of the polar ice sheets. Complete your chart by adding them together. Consider future **potential**. How significant a role do you see polar ice sheets playing in SL rise? Explain your answer.

2. Your Polar Exploration is drawing to an end. What will you say to convince your colleagues that it is important to FOCUS ON THE POLES when studying climate!

## Vocabulary

**Anomaly –**A method of measurement that scientists often use to show change, it measures differences compared to the average for a period of time.

**Geologic Time** – A way of organizing the timing and relationship of events that have occurred throughout Earth's ~4.5 billion year history. Note that Sea Level does NOT remain constant throughout geologic time.

**Elevation** – The height of a geographic location above a fixed reference point.

**Sea Level** – The height of the sea surface which varies by time and place. Sea level is affected by waves, wind and currents, atmospheric pressure, tides, topography, and even gravitational attraction due to the presence of mountains & large amounts of ice!

**Observation:** When discussing Earth data this refers to data collected from measurements. For sea level these include observations from tide gauges (from the1850s) and more recently from satellites (starting in the late 1960s).

**Proxy:** A preserved chemical or physical characteristic from the past that can be used to understand past conditions when direct measurements are not available.

**Prediction:** Estimates based on prior data and understanding?

**Temperature Anomaly:** A change from the long-term average temperature and generally shown as the ***difference*** between the two temperatures. Anomalies are a method of normalizing data collected across various areas and conditions.

**Last Glacial Maximum (LGM):** Refers to the peak of the last glacial period or ice age when ice sheets were at their maximum size ~25,000 years ago. Much of the northern hemisphere was covered with ice sheets causing sea levels to be ~120 m lower.

**Eemian:** The most recent interglacial, or warm period ~125,000 years ago, when temperatures were 3-5° warmer and melting polar ice added close to 8 meters of water into the global oceans.

**Glacial/Interglacial:** In Earth's history we experienced periods of extreme cold, often referred to as ice ages or glacial periods, and warmer periods occurring between times of glacial action referred to as interglacial periods.

POLAR PARTNERSHIP

**Frequently Asked Questions?**

1. Q. Does melting sea ice have anything to do with sea level rise?
    a. Sea Ice is already resting in the water so when it melts it does not directly affect sea level.

2. Q. Do calving or melting Ice Shelves in Antarctica affect sea level rise?
    a. Ice Shelves, like sea ice are already floating so when they calve or melt they do not directly affect sea level, however, when they are in place they stabilize and hold the ice sheet on the land behind them. Melting ice shelves are weakened and the land ice will often speed up and push forward once the ice shelf is gone. The additional land ice added to the global ocean does affect sea level.

3. Q. Does the Ozone hole affect glacial melting?
    a. Ozone is a layer in the Earth's upper atmosphere that blocks out the Sun's ultraviolet rays. These rays do not contribute directly to melting glaciers or warming. However recent studies have suggested that the hole in the ozone has increased Antarctic winds causing that continent to remain much colder than it might be otherwise. As the ozone hole closes over the next few decades these studies suggest Antarctica will begin to warm.

4. Q. How does storm surge relate to sea level rise?
    a. Storm surge is the high-energy wave action that comes with large storms. These waves are often larger and more powerful than normal waves would be. As sea level rises the waves will also rise becoming more of a problem for coastal regions.

5. Q. How are the maps in this activity made?
    a. These maps are data that has been put into a spatial format. Each map is really data that has been linked to a geographic location. Since much of the data varies by specific region or location viewing it as a map is useful.

6. Q. How do we gather the evidence for the changes?
    a. We use several methods of collecting data about our changing Earth: **Direct measurements** include individual instruments such as tide gauges that are carefully referenced in location and depth so they can record small changes, argo floats that are placed in the ocean to collect data through sensors, and satellites that circle in space collecting measurements from the Earth below. **Indirect measurements** are used to gather data about the past. These are called ***proxy measures*** and include, but are not limited to, examining ice cores, tree rings, plankton (forams and diatoms), pollen, corals, sediments.