Thermal Expansion and Sea Level Rise
Grade level: 6-8, with extensions for 9-12

Students investigate how thermal expansion of water might affect sea level.

Content Standards
California Science Content Standards for Public Schools
Earth Science: Grade 6 – 3c,d;4d
Investigation and Experimentation: Grade 6 – 7a,c,d,e,h: Grade 7 – 7c,e: Grade 8 – 9a:
Grade 9–12: 1d,g,i,k,l,m

Learning objectives
1. Students will be able to describe the change in water level when the water is exposed to heat.
2. Predict the impact of rising sea level on coastal areas.

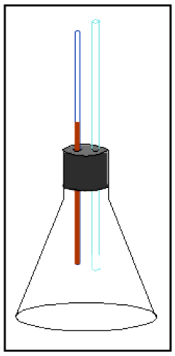
Background
If global temperature increases, many scientists have indicated that an increase in sea level is one of the most likely secondary effects. Two factors will contribute to this accelerated rise in sea level.

First, although the oceans have an enormous heat storage capacity, if global atmospheric temperatures rise, the oceans will absorb heat and expand. This is called thermal expansion. A greater volume of ocean water due to thermal expansion will lead to a rise in sea level. Second, rising temperatures will cause the ice and snowfields to melt, thereby increasing the amount of water in the oceans. It should be noted that only the melting of land-based ice and snow will increase sea level. The melting of floating ice will not affect sea level. This can be demonstrated to your students by partially filling a glass container with ice and water and marking the water level on the glass. When the ice cubes melt, note that the water level has not changed.

Throughout Earth history there have been periods of glaciation followed by warming trends in which the glaciers retreated towards higher latitudes and higher altitudes. At present, glaciers throughout the world are retreating and the amount of snow and ice at the poles is shrinking. The present interglacial warm period began about 14,000 years ago. At that time sea levels were about 75 to 100 meters lower than they are today. The sea level rose rapidly (up to 1 meter per century) as massive amounts of snow and ice melted.

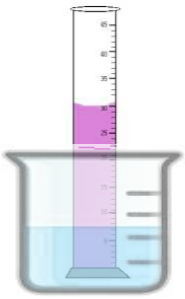
Today the rate of sea level rise is much slower at 15-17 centimeters per century. However, the rate of sea level rise is increasing as the rate of global warming increases. An accelerated rate of sea level rise would inundate coastal wetlands and lowlands, increase the rate of shoreline erosion, cause more coastal flooding, raise water tables, threaten coastal structures, and increase the salinity of rivers, bays and aquifers.

Materials
For each group of 3 students:
1. conical flask (125 or 250 ml)
2. two-hole cork
3. 2 thin, glass tubes
4. long thermometer
5. 1 portable, clamp-on reflector lamp, with 150 Watt floodlight



6. food coloring
7. small ruler (to measure cm)
8. 1 permanent marker
9. ethyl alcohol and water
10. stopwatch

Activity:
1. Place the thermometer and glass tube into the cork as shown in the picture above, making sure there is an airtight seal.
2. Fill one flask with cold water (to improve visibility, dye can be added).
3. Place the cork (with tube and thermometer) into the mouth of the flask. The water should rise a short way up the glass tube.
4. Have a student report the starting temperature of the water and mark the water level on the glass tubes with the marker. Be sure to use the bottom of the meniscus when marking water levels.
5. Ask students to predict what will happen to the water level when exposed to heat. Form a hypothesis or multiple hypotheses.
6. Place the flask under the lamp. (Lamp should be aimed towards middle of the flask, not the top.)
7. Assign roles in the group: 1) observer who marks the water level in the tube at each time interval; 2) timekeeper who keeps time and reads temperature changes at each time interval; and 3) a recorder of the temperature information at each time interval.
8. Turn on the lamp, and record temperature on the data sheet over one minute intervals for each flask.
9. When time is completed and water has cooled, take out tube with marks and use ruler to measure volume increases for each corresponding time interval. Record on data sheet.
10. Repeat steps 1-9 using ethyl alcohol.
11. Once both experiments are completed, graph the results. Use different colors for each solution.



Note: This may also be done with a graduated cylinder. Fill a narrow 10ml glass graduated cylinder with 9 ml of colored water at room temperature. Place it in a clear container of very hot water and record the volume every minute for 5 minutes. When the volume has stopped increasing, place the cylinder in a container of ice water and record the volume each minute. Discuss as outlined below.

Discussion:
After a noticeable change has occurred, ask and discuss these questions:
12. As the water and ethyl alcohol warmed, what happened to the amount of space they occupied?
It increased as seen by the rising level of water in the small tube. Tell them that a volume increase caused by heat is called thermal expansion.
13. If the water in the oceans becomes warmer, what will happen to the volume of the oceans?
The amount of space occupied by the oceans will increase and cover up some of what is now dry land. In other words, the level of the sea or ocean will rise.
14. What was the difference between the thermal expansion of the water vs. the ethyl alcohol? Why did this occur, and what does that tell you about the thermal conductivity of water?
The ethyl alcohol takes a shorter amount of time to expand, and water is unique in that it takes a greater amount of heat to expand to that same volume. Therefore, it takes a tremendous amount of heat to raise the sea level.
15. How will the change in ocean volume affect coastal areas?
Some areas will be under water. Coastal cities, wetlands, beaches, and roads may be damaged.
Source: Adapted from Global Climates - Past, Present, and Future. EPA Report No. EPA/600/R-93/126

http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_thermalexpand.html