

POLAR EXPLORER SEA LEVEL APP

Complete an Investigation #1

1. What is Sea Level: Elevations Beneath the Sea

Locate the area offshore of New York and New Jersey. This is called the New York Bight.

- *What is the range for the depths in this area?*

Now locate the Hudson Canyon.

- *What is the deepest depth you can find in the Hudson Canyon?*
- *What connection could the **New York Bight** have to Sea Level?*
- *Now consider the **Hudson Canyon**, what connection could it have to Sea Level?*

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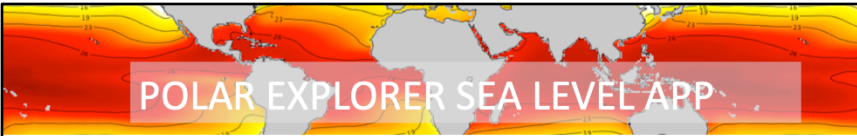
New York Bight: A ‘bight’ means a ‘bend’ in the shoreline and is identified in the map by the light blue protected wedge shaped indentation of shallow coastal waterfront along New York and New Jersey. You can clearly see the rigid continental shelf where the shallow light blue bight turns into deeper dark blue water. The depths in this area range from about -1 to -100 meters. Areas near the deeper ocean edge of the continental shelf can be deeper than -150 meters. (The negative indicates that it is below sea level.)

Hudson Canyon: Deep submarine canyon that begins at the mouth of the Hudson River and runs across the continental shelf into the Atlantic Ocean. In some areas, the Hudson Canyon reaches depths of > -2100 meters. Largest known submarine canyons on the East coast and one of the largest in the world,

How do the New York Bight and the Hudson Canyon relate to sea level rise?

Background to provide your students:

New York did not always look as it does today! 20,000 years ago, when earth was in an ice age, the massive Laurentide ice sheet covered a large portion of the northern United States and almost all of Canada (millions of square kilometers). The amount of water on earth is a constant, with water moving between 3 main reservoirs ice,



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Complete an Investigation #2

1. Why Does Sea Level Change: What is the role of the ocean: Internal Ocean Temperature (Present)

Zoom down into the ocean.

- *At what depth do the last two visible areas of warmer ocean water disappear? Can you identify those ocean features? How does ocean temperature relate to sea level rise?*

Explore the ocean temperatures at different depths.

- *As you dive down in the layers of ocean water, at what depth does the majority of warm water appear to stop? How could this be significant in thinking about future sea level rise?*

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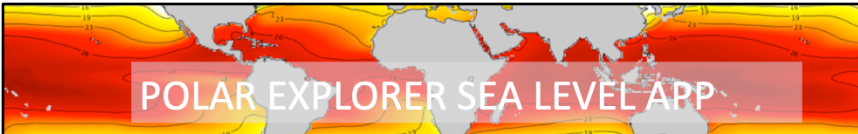
At what depth do the last two visible areas of warmer water disappear in the ocean? Can you identify those ocean features?

The last two persistent warm water ocean features are the **Gulf Stream** and the **Red Sea**. The Gulf Stream is fed by warm water moving up from the Caribbean, and formed by strong winds (Trade Winds and the Westerlies) that churn the water into a gyre. The flow organizes into a strong current in the Gulf of Mexico, where it gets its name, and then runs along the east coast of North America in the North Atlantic Ocean.

The Red Sea is a seawater inlet with a single connection to the Indian Ocean on the southern end. This is a highly salty small body of water, sandwiched in between Africa and Saudi Arabia. Both of these features are still visible up to 500 meters depth.

How does ocean temperature relate to sea level rise (SLR)?

Ocean temperature relates to sea level rise through the process of thermal expansion. As water heats up, the H₂O molecules begin to excite/vibrate and expand. Until recently thermal expansion was the main driver of SLR. However, as the atmospheric temperatures increase and oceans warm, ice sheets and glaciers are



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Complete an Investigation #2.5

1. Why Does Sea Level Change: What is the role of the ocean: Internal Ocean Temperature (Present)

Now, focus on the polar regions...

Zoom down in the ocean around Greenland & West Antarctica

- *What happens to the ocean temperature as you increase in depth?*
- *At what depth is the water around Greenland the coldest? And the warmest? What about Antarctica?*
- *How does it differ from the Atlantic and Pacific Oceans?*
- *Brainstorm ideas on what might be happening.*

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What do you notice about the ocean temperature as you increase in depth?

As you increase in depth around the polar regions, both the southern tip of Greenland and around West Antarctica, the water gets colder right at the surface and then warms slightly until you get down to about 1000 meters where it starts to cool again. Be sure to relick on the location since it will hold the previous values as you drop down unless you do.

How does it differ from the rest of the world's oceans?

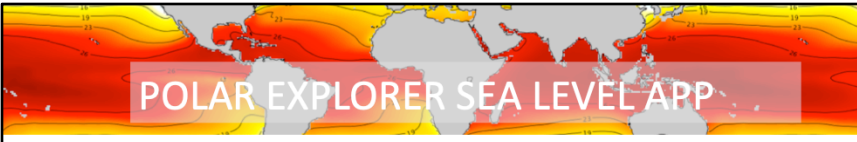
As we saw in the previous activity, increasing in ocean depth resulted in colder water for the rest of the world's oceans.

At what depth is the water the coldest/warmest in Greenland around West Antarctica?

The depth where the majority of the water surrounding these regions is the coldest is **50 to 100 meters down**. The depth where the majority of the water surrounding these regions is the warmest is **500 to 1000 meters down**.

Can you create a hypothesis to explain this?

The surface water surrounding Greenland & West Antarctica is cold from glacier and



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Complete an Investigation #3

1. Why Does Sea Level Change: What is the role of the atmosphere: Temperature change over last 5 years

Click through different areas of the map.

- *Where is the warming occurring at the greatest rate?*
- *How might this affect sea levels?*

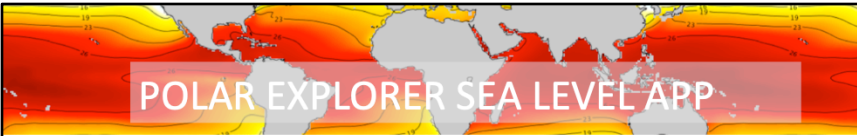
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Where is the warming occurring at the greatest rate?

Atmospheric warming is occurring at the greatest rate in the Arctic (north pole). A major cause is polar feedbacks. Loss of glacial ice on land, and sea ice on the Arctic Ocean is reducing the albedo (white reflective quality that ice provides) and causing more heat energy to be absorbed than reflected back to space. The more dark land and ocean that opens up the faster this process occurs.

How might this affect sea levels?

The exponential warming of the Arctic is melting the ice sheets and glaciers (land ice) contributing to SLR. Historically, thermal expansion was the main driver of SLR. However, as the atmospheric temperatures increase, ice sheets and glaciers are now contributing about the same amount to SLR as thermal expansion.



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Complete an Investigation #5

1. Where is sea level changing now: Tide stations recording rising or falling

Review the tide gauges and click around to see what some of the values are.

- *See if you can locate where sea level rising the most?*
- *Consider different Earth processes. Can you create a hypothesis to explain this?*
- *Where do you find sea level is falling?*
- *Consider different Earth processes. Can you create a hypothesis to explain this?*

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Where do you find sea level rising the most?

From the existing tide station data, **Eugene Island in Louisiana** is rising the most in the United States and in the World at **9.65 mm/year**.

Can you create a hypothesis to explain this?

Sea level rise is driven by thermal expansion and the melting of ice sheets and glaciers. The first thing that is important to identify is that sea level is not rising uniformly across the world. Therefore, this refutes the “bath tub” model that when you add more water to the world’s oceans from melting ice (like filling up a bathtub), that sea level will rise evenly. Since Eugene Island, Louisiana is already so close to sea level, they are extremely vulnerable to sea level rise. The combination of subsiding land due to compaction of delta plain deposited during the Holocene, erosion, and the rising of seas are part of the equation and will continue to threaten Louisiana with water damage.

Where do you find sea level is falling?

It appears that sea level is falling in a variety of places around the world, but it is primarily falling in the Arctic region. Sea level is “falling” the most in **Skagway, Alaska** at **-17.59 mm/year**. * Alaska is a complex situation (see Note below) so before you



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Complete an Investigation #6

1. Where is sea level changing now: Regions vulnerable to future coastal flooding

Zoom into the east coast of the U.S. and the Gulf of Mexico.

- *What are the areas that are most severely impacted by flooding?*
- *How might this impact the residents in these areas? Name at least 3.*
- *What do you see that surprises you?*

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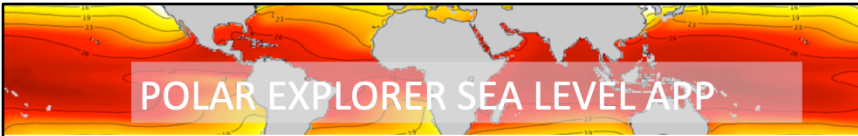
What are the areas that are most severely impacted by flooding?

The areas that are most severely impacted by flooding are Louisiana (and the Gulf of Mexico), Florida, Georgia, North and South Carolina, and Virginia.

How might this impact the residents in these areas?

The residents in these areas are directly impacted by residential flooding. If their houses are located in a flood zone, they are vulnerable to nuisance flooding (flooding with high tides and excessive rain), storm surges, and sea level rise. Coastal flooding also impacts the economics of the area (tourism, imports/exports, inability to complete outdoor work, etc.). Flooding and standing water could increase vector borne diseases by mosquitos. In areas of agriculture, excess rain and flooding can ruin crops. Flooding and storm surge can cause expensive damage to infrastructure. It can also destroy public transportation (i.e. subways in NYC) and cause serious delays and halts to transportation as a whole (i.e. car traffic, airlines, trains). In extreme flooding cases, injury and death are a consequence. These are just a few examples of the consequences of coastal flooding. Important to note that coastal flooding doesn't just impact the area at risk; it can indirectly impact the country as a whole!

What do you see that surprises you?



Complete an Investigation #7

1. Who is vulnerable: Population density

Compare the “population density” map to the “tide stations recording rising and falling” map.

- *How does this map relate to sea level rise?*
- *Hypothesize area of highest vulnerability (i.e. which areas have high-density population and are vulnerable to sea level rise)?*
- *Are there possible mitigation strategies that you can think of for the high density and vulnerable populations?*

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How does this map relate to sea level rise?

Majority of the areas of extreme sea level rise correspond to high population density.

Which areas have high-density population and are vulnerable to sea level rise?

Areas of high population density correspond with high sea level rise such as some parts of Japan, Philippines, parts of eastern China, parts of India, Yemen, the states along the Gulf of Mexico, east coast (especially the northeast) of the United States. Areas that are particularly vulnerable are developing, low- and lower-middle income countries that suffer from rising seas and have high population density.

Are there possible mitigation strategies that you can think of for the high density and vulnerable populations?

Some possible flood mitigation strategies include raising the foundation of houses or putting houses on stilts, raising roads, storm water pumps, seawalls, and natural barriers (i.e. marshes, mangroves, corals, oyster beds) and flood management (i.e. maintaining the natural environment so the soil absorbs the flood water, permeable pavement, vegetation islands, rain gardens, green roofs, etc.). In some cases, retreat is the best option because the area will continually flood year after year and cause costly damage and death.



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Complete an Investigation #8

1. Who is vulnerable: Human impact on Earth

Compare the “Human Impact on Earth” map to the “Population Density” map.

- *What do you think about this map, does anything about this map surprise you?*
- *Does this map generate any questions?*
- *How does it relate to the population density map?*
- *How might it relate to sea level rise?*

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What do you think about this map, does anything about this map surprise you?

Does this map generate any questions?

This map is an index of the human influence on the Earth with 0-1 (green) being the least impacted and 80-100 (black) showing extremely high impact.

Students maybe surprised by some of the high or low impact of some areas throughout the world.

Some students may wonder how this map was generated: “To compute the index, a range of areas are included, merging our effect on different types of biomes or ecosystems (such as how humans have affected or altered ecosystems like tropical forests, or deserts), with that of larger overall human influences on Earth such as settlements, access, landscapes transformation (deforestation) and infrastructure (paving) For each area, these factors are consolidated into this one index measurement.”

This is a good time to spark discussion about the data and the map. Zooming into your own community consider the impact level and discuss how it might have ended up with that rating. Are there changes that could be made to reduce the impact?

How does it relate to the population density map?