Bridge DATA – Sea Level Trends: Ocean Front Property, An "Immerging" Market www.marine-ed.or/bridge/sealeveltrends.html

written by Miriam Sutton, Newport Middle School, Carteret County, NC, & Lisa Ayers Lawrence, Virginia Sea Grant, Virginia Institute of Marine Science

Credits: This activity was developed as part of the MBARI EARTH 2009 Workshop.

Summary
This lesson is designed as an introductory activity to an exploration in global climate change. Students will access real scientific data and follow the scientific method to investigate and compare long-term changes in sea level from different coastal locations around the United States.

Objectives

- Locate ocean observing data using computer skills and the Internet.
- Use spreadsheet software to enter the correct formula and calculate the average sea level change for a given location.
- Generate a line graph to illustrate sea level trends for a given location.
- Observe and identify variations in sea level trends across the United States.
- Communicate results during class discussion.

Vocabulary
Climate, Fossil fuels, Global climate change, Global warming, Greenhouse gases, Sea level

Introduction
What is climate change? For decades, we've been hearing the terms "global warming" or "global climate change," but what do those terms mean to each of us? How is our world changing and why?

On a piece of paper, have each student brainstorm 1) changes we're seeing as a result of global climate change and 2) causes of global climate change they have heard about. Have the students share and discuss what they

Grade Level:
9-12

Lesson Time:
1-2 hrs.

Materials Required:
Sea Level Graphs (pdf)
Sea Level Spreadsheet (Excel)
Fast Delivery Data Instructions (pdf)
Research Quality Data Instructions (pdf)

National Science Standards
Science as Inquiry
Abilities necessary to do scientific inquiry (K-4, 5-8, 9-12)

Earth and Space Sciences
Structure of the earth system (5-8)
Energy in the earth system (9-12)

Science in Personal and Social Perspectives
Populations, resources and environments (5-8)
Natural hazards (5-8)
Risks and benefits (5-8)
Environmental quality (9-12)
Natural and human-induced hazards (9-12)
Science and technology in local, national, and global challenges (9-12)

Related Resources
Coral reef, Physical oceanography, Climate, Ocean Observing Systems, Technology

wrote down.

Global climate change is the variation of the earth's average climate — in other words, significant changes over decades in the earth's temperature, precipitation, wind. etc. Global warming refers to the increase in the earth's average atmospheric temperature, just one variable of the earth's climate. The earth has always experieced natural changes in climate, however scientific evidence shows that the current change in climate far exceeds what models show would be caused by natural factors alone. Overwhelming evidence identifies human activities as a significant factor in today's climate change.

How are humans exacerbating, or increasing the severity of, climate change? With the start of the industrial revolution in the late 1700s, fossil fuels were burned to power new machinery. Burning fossil fuels releases carbon dioxide, a major greenhouse gas, into the atmosphere. These gases trap the sun's heat in the earth's atmosphere, causing atmospheric temperatures to rise. Carbon dioxide and other greenhouse gases, such as water vapor and methane, are naturally present in the atmosphere but are increasing in volume due to human activities. Over the past 20 years, U.S. greenhouse gas emissions from human activities have increased by 14%, primarily due to carbon dioxide emissions from the production of electricity . A close second and third source for these gases are transportation and industry, respectively.

The average global increase in atmospheric temperature over the past century is slightly over 1 °F, but in the United States, temperatures have increased faster than the global average. Parts of the United States have experienced an increase in average air temperature of 4 °F over the past century . With the increase in temperatures, we are also seeing a change in other elements of climate. For instance, as temperatures rise, evaporation increases. What goes up must come down — so precipitation increases as well. But like many of the effects of global climate change, the changes are not equally distributed around the world. While some areas may have an increase in severe storms and flooding, other areas will experience more drought.

Another effect of climate change is a change in sea level. Sea level (the average height of the ocean's surface relative to land) experiences natural fluxuations from small scale seasonal changes like springtime runoff to long term decadal changes due to ocean circulation and El Niño. In addition to these natural changes, sea level around most of the world is rising due to the effects of global warming. Why does this cause sea level to rise? As air temperatures increase, ice in glaciers and icebergs melt, increasing the amount of water in the oceans and thus causing sea level to rise. And, as air temperatures rise water temperatures rise. When water temperatures rise, water molecules expand also causing sea level to rise. But as with many of the effects of climate change, sea level change is not consistent around the globe. In the following activity, we will look at sea level data from different US coastal cities to investigate if/how sea level is changing in that region.

Data Activity

Using data from the University of Hawaii Sea Level Center we will determine if sea level is changing in different coastal cities of the United States. For this activity, you can use data for select cities already downloaded, graphed and ready for analysis, or have students download and/or graph data themselves for cities they select (instructions provided).

Before accessing the graphs or data, have students develop hypotheses that address their prediction on sea level changes for their location.

Option #1: Ready To Go Graphs
To use the sea level data already downloaded and graphed by the Bridge, click on the city name to download the graph in pdf format for analysis.

- Portland, ME
- Charleston, SC
- Key West, FL
- Galveston, TX
- San Francisco, CA
- Seward, AK
- Hilo, HI

Option #2: Downloaded Data, Ready To Graph
To have students graph (using Excel) already downloaded data for the above cities, download the following Excel spreadsheet and refer to the graphing section in the Fast Delivery Data Instructions below.

- Sea Level Spreadsheet (Microsoft Excel)
- Fast Delivery Data Instructions (pdf) - Begin with step #9.

Option #3: Download and Graph Sea Level Data
The following instructions will walk you through, step-by-step, downloading and graphing sea level data using Microsoft Excel.

Go to the University of Hawaii Sea Level Center website. Click on the map to zoom into your location of choice. Click on your station of choice. Stations with a blue dot offer **Fast Delivery Data** (recommended). Stations in white offer only **Research Quality Data**. Once you have selected your station, use one of the following sets of instructions to download and graph your data.

- Fast Delivery Data Instructions (pdf)
- Research Quality Data Instructions (pdf)

Analyzing Graphs

Once students have completed or downloaded the graphs, have them estimate the average annual sea level change by:

1. Approximating the sea level value at the start of the trend line (Start Value).
2. Approximating the sea level value at the end of the trend line (End Value).
3. Subtract the Start Value from the End Value then divide by the number of years. This gives you the average annual sea level change in millimeters.

Discussion Questions

- Did your city experience a change in sea level? If so, was it increasing or decreasing? By how much?
- Did your findings support or refute your hypothesis about sea level change for your location?

- Of the cities examined, how many experienced rising sea level? How many experienced falling sea level?
- What was the greatest average annual sea level change? What part of the country did this occur?
- What was the smallest average annual sea level change? What part of the country did this occur?
- Compare your estimates with the trends found at the NOAA Tides & Currents: Sea Level Trends. Did your calculations match NOAA's?
- How might the change in sea level affect the people living in these areas? If the trend continues, how much will sea level rise/fall in the next 20 years? 50 years? 100 years?
- What can be done to stave off further sea level rise? How will this affect the ecosystem?

Additional Resources

- EPA's Climate Change Report Powerpoint
- Understanding Sea Level Change
- VIMS White Paper: Planning for Sea Level Rise and Coastal Flooding

OCEAN LITERACY PRINCIPLES

#1. The Earth has one big ocean with many features.

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 a as sea water expands and contracts when ocean water warms and cools.

#3. 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.

E. Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.

#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.

A. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.

D. Much of the world's population lives in coastal areas.

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). In addition, humans have removed most of the large vertebrates from the ocean.

F. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).

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.

B. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

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.

Instructions for Working with the Sea Level Activity Data (Fast Delivery Data)

1. Go to the University of Hawaii Sea Level Center Website (http://uhslc.soest.hawaii.edu/uhslc/data.html)
2. Click on the map to zoom into your location of choice. Click on your station of choice.
3. If available, select **Fast Delivery Data** (RECOMMENDED). If Fast Delivery Data is not available, select **Research Quality Data**.
4. Right click **Monthly Data** and select *Save Link As*. Name your data text file (eg SanFran.txt)
5. Open Microsoft Excel and open your data file (remember to display ALL file types). The Text Import Wizard will open.
6. Text Import Wizard
   - Step #1: select **Fixed Width**. Next.
   - Step #2: drag and insert new column lines to divide your data into columns. If you used, Fast Delivery Data, the columns will be:
     - Station #
     - Station Name
     - Year
     - January – December sea levels values (12 columns)
     - Note: The very last column *may* have an artifact symbol at the end of the data value. If so, put a column line between the number and the symbol to cleave that from your data.

     Click next.
   - Step #3: Finish
7. Label your columns and save the file as an Excel file.
8. Any data point with a value of 9999 means there is no data for that month. Do a search all and replace "9999" with a blank or empty cell (do not use a "0" value).
9. Find the yearly average sea level value by averaging the January through December values for each year.
10. Create a line chart of your average yearly values.
    - Highlight your yearly values and click on the chart wizard icon in toolbar.
    - Select the *Line chart, Sub-type with data points*. Next.
    - Select **Series in columns**. Under the *Series* tab, click on the icon by the *Category (x) axis labels* and highlight the years values from your data sheet. Next.
    - Select your chart options. Next.
    - Place your chart as a new sheet. Finish.
11. On your chart, adjust the axis as necessary. Recommend major gridlines every 25 mm and minor tick marks at 5 mm. Reduce the y-axis scale to only what is necessary.
12. Right click on your data line and select **Add Trendline**, **Linear**. OK.
13. Calculate the average annual sea level change.
    - Approximate the sea level value at the start of your trend line (Start Value)
    - Approximate the sea level value at the end of your trend line (End Value)
    - Subtract the Start Value from the End Value then divide by the number of years. This gives you the average annual sea level change in millimeters.

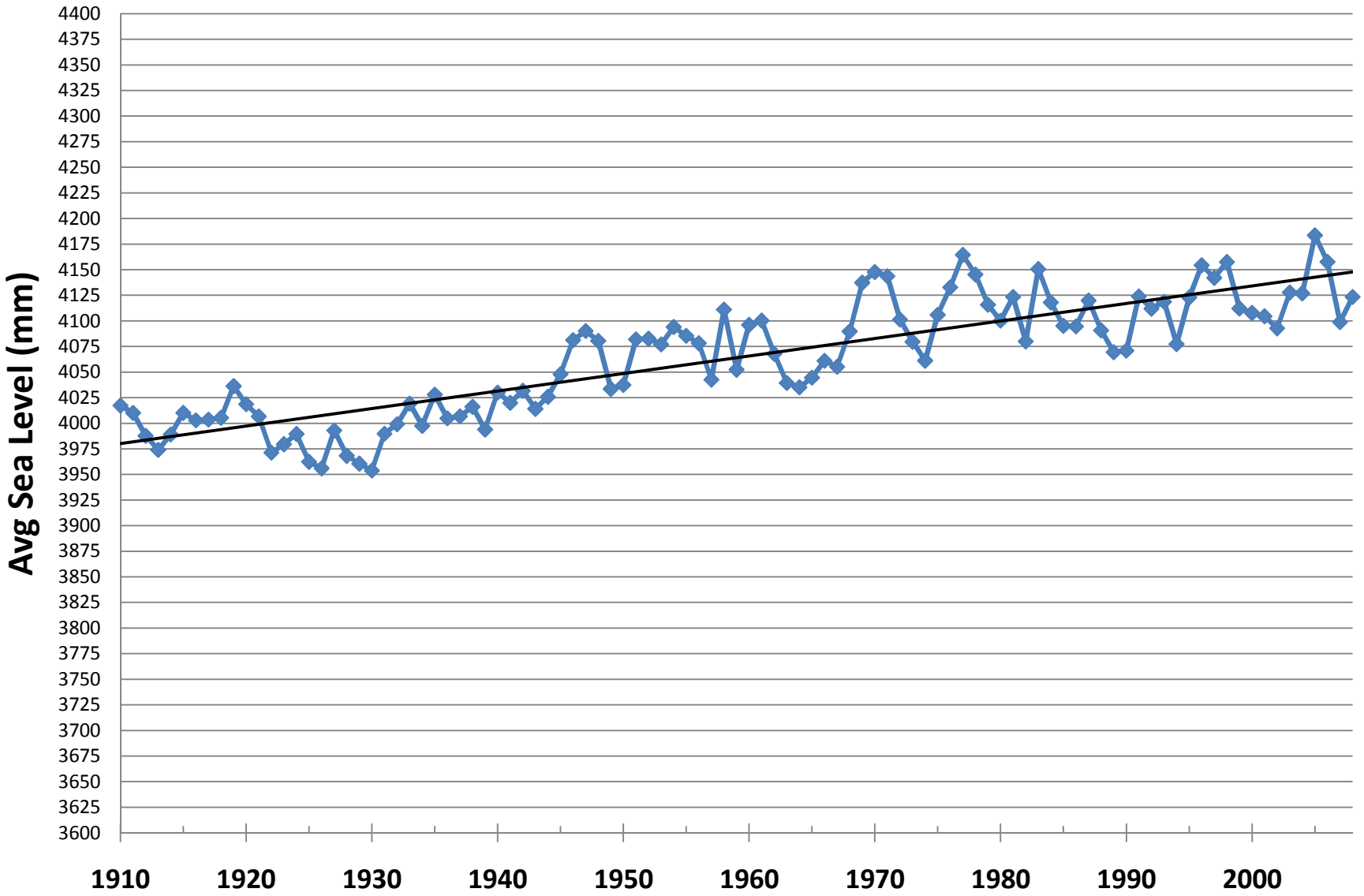
Instructions for Working with the Sea Level Activity Data (Research Quality Data)

1. Go to the University of Hawaii Sea Level Center Website (http://uhslc.soest.hawaii.edu/uhslc/data.html)
2. Click on the map to zoom into your location of choice. Click on your station of choice.
3. If available, select **Fast Delivery Data** (RECOMMENDED). If Fast Delivery Data is not available, select **Research Quality Data**.
4. Right click **Monthly Data** and select *Save Link As*. Name your data text file (eg SanFran.txt). NOTE: Research Quality Data divides displays each year on two lines. The first line of each year has months January – June and the second line has July – December. In addition to the sea level values for each month (4 digit number) is also the number of missing days for that month (2 digit number). In order to more easily manipulate this text file in Excel, we will first edit the data in Microsoft Word.
5. Open Word and open your data file (remember to display ALL file types). First, switch your page layout from Portrait to Landscape.
6. Edit your data to put each year on one line. Be sure to delete the station number, name, year and which half of year (2) that would be between the first six months and the second six months of each year. Save your data keeping it in text format.
7. Text Import Wizard
   - Step #1: select **Fixed Width**. Next.
   - Step #2: drag and insert new column lines to divide your data into columns (ignore the first line of heard information). If you used, Fast Delivery Data, the columns will be:
     - Station #
     - Station Name
     - Year
     - Sea levels values for each month (4-digit number)
     - Number of missing days for each month (2-digit number)
     - Note: The very last column *may* have an artifact symbol at the end of the data value. If so, put a column line between the number and the symbol to cleave that from your data.

     Click next.
   - Step #3: Finish
8. To clean up your data, delete all the columns that display the number of missing days (now a 1-digit number usually 0-2). Label your columns and save the file as an Excel file.
9. Any data point with a value of 9999 means there is no data for that month. Do a search all and replace “9999” with a blank or empty cell (do not use a “0” value).
10. Find the yearly average sea level value by averaging the January through December values for each year.

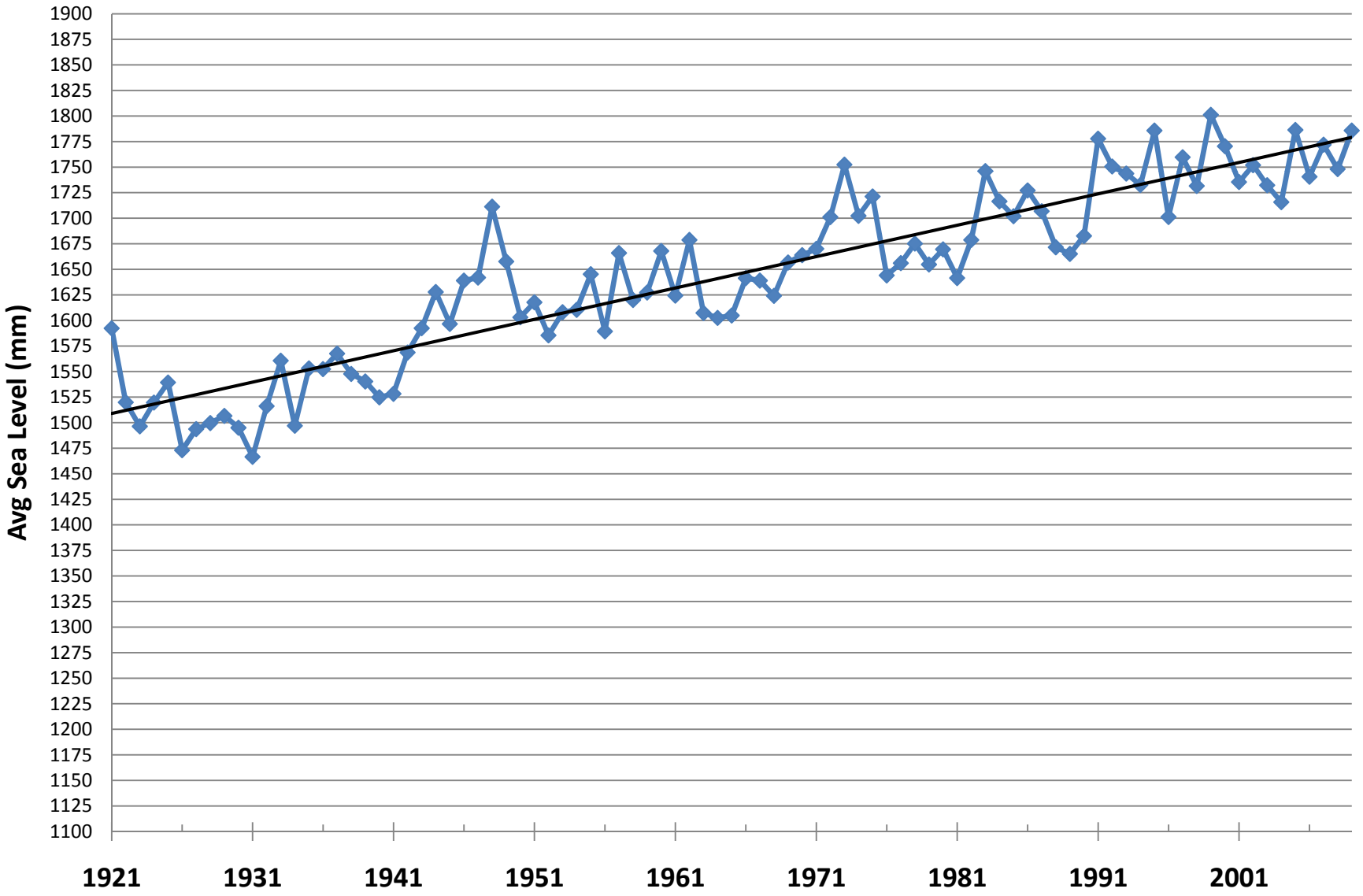
11. Create a line chart of your average yearly values.
    - Highlight your yearly values and click on the chart wizard icon in toolbar.
    - Select the *Line chart, Sub-type with data points*. Next.
    - Select **Series in columns**. Under the *Series* tab, click on the icon by the *Category (x) axis labels* and highlight the years values from your data sheet. Next.
    - Select your chart options. Next.
    - Place your chart as a new sheet. Finish.
12. On your chart, adjust the axis as necessary. Recommend major gridlines every 25 mm and minor tick marks at 5 mm. Reduce the y-axis scale to only what is necessary.
13. Right click on your data line and select **Add Trendline**, **Linear**. OK.
14. Calculate the average annual sea level change.
    - Approximate the sea level value at the start of your trend line (Start Value)
    - Approximate the sea level value at the end of your trend line (End Value)
    - Subtract the Start Value from the End Value then divide by the number of years. This gives you the average annual sea level change in millimeters.

Average Annual Sea Level for Portland, ME
1910 - 2008



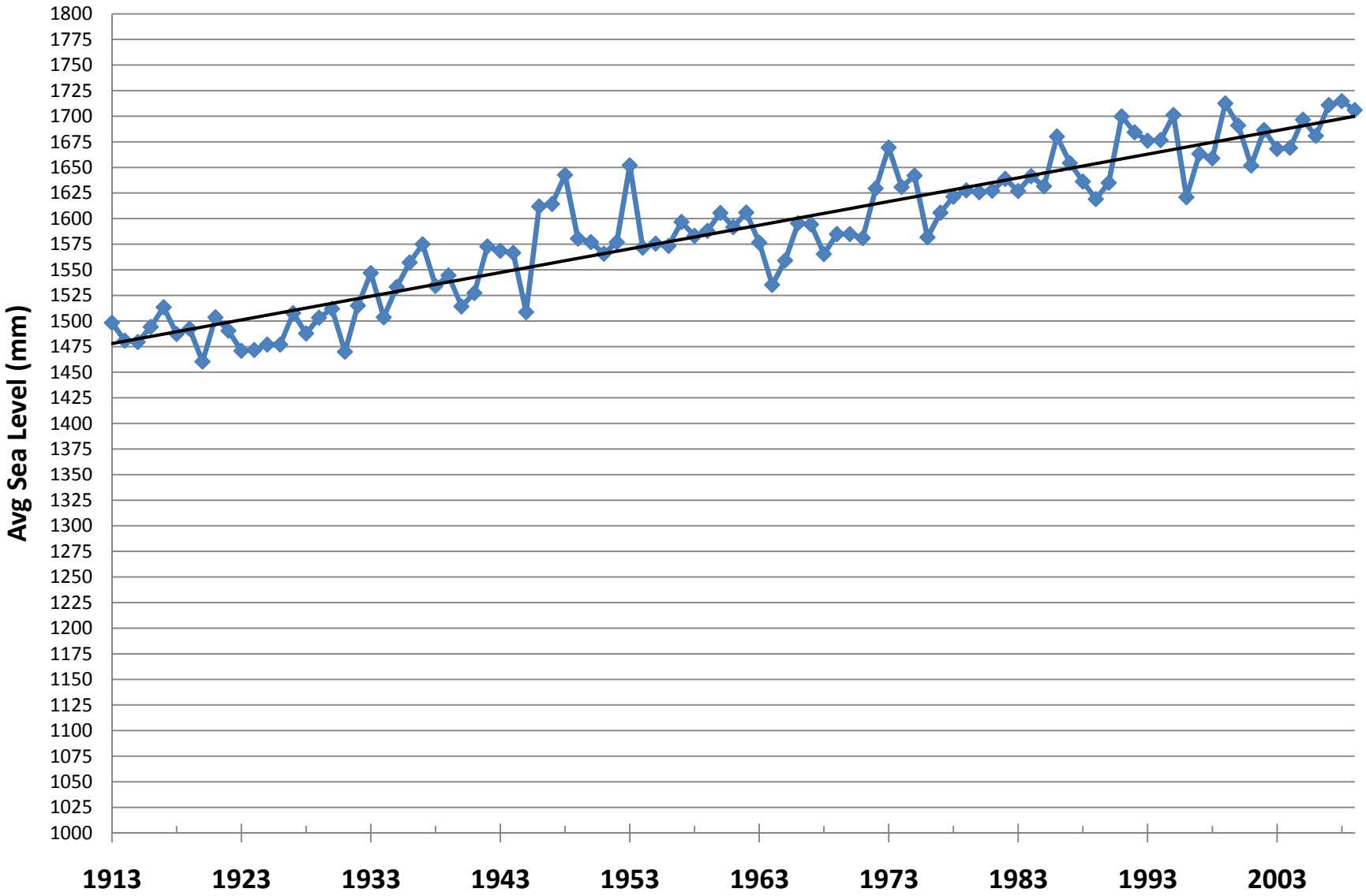
Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for Charleston, SC
1921 - 2009



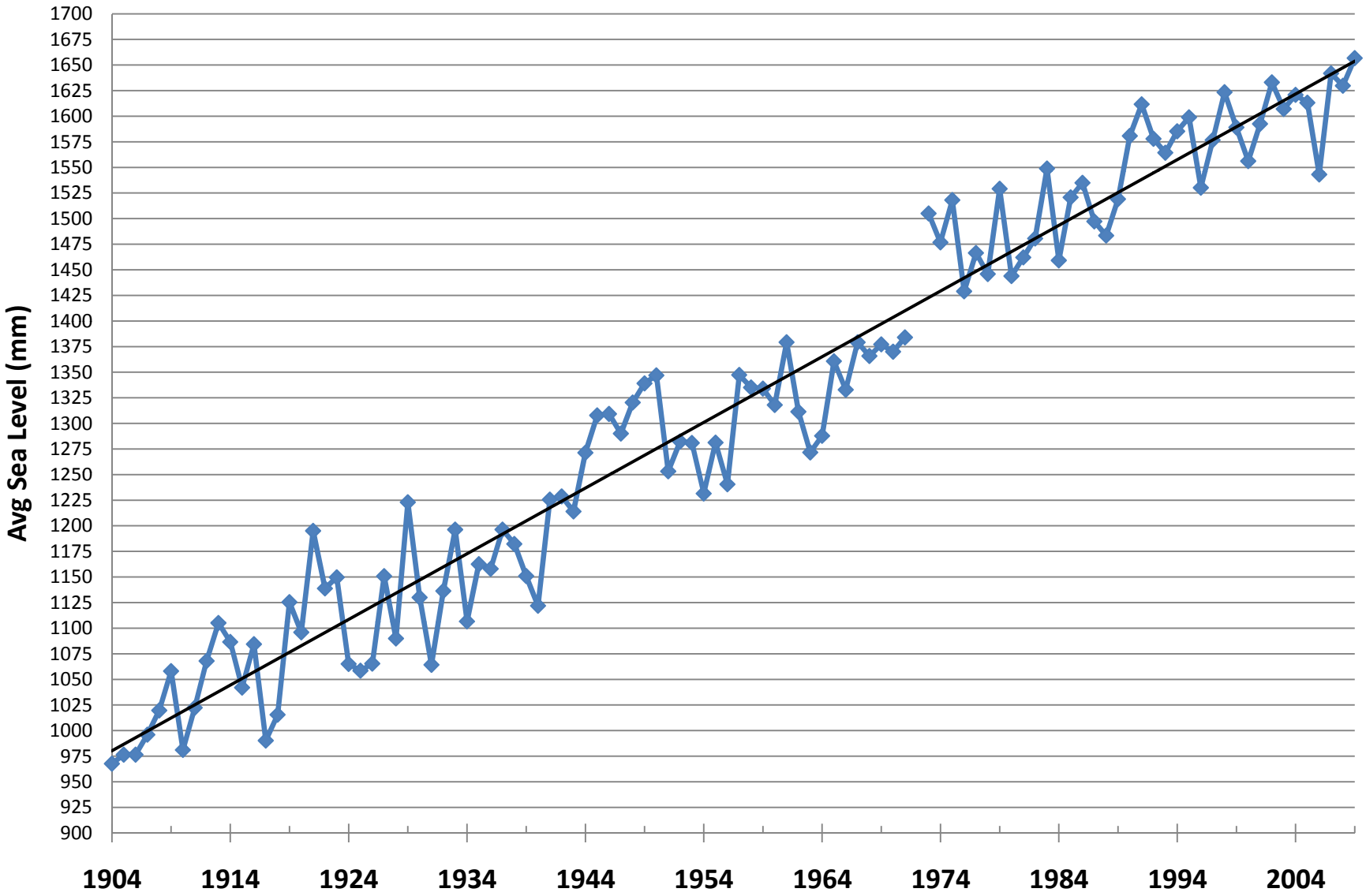
Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for Key West, FL
1913 - 2009



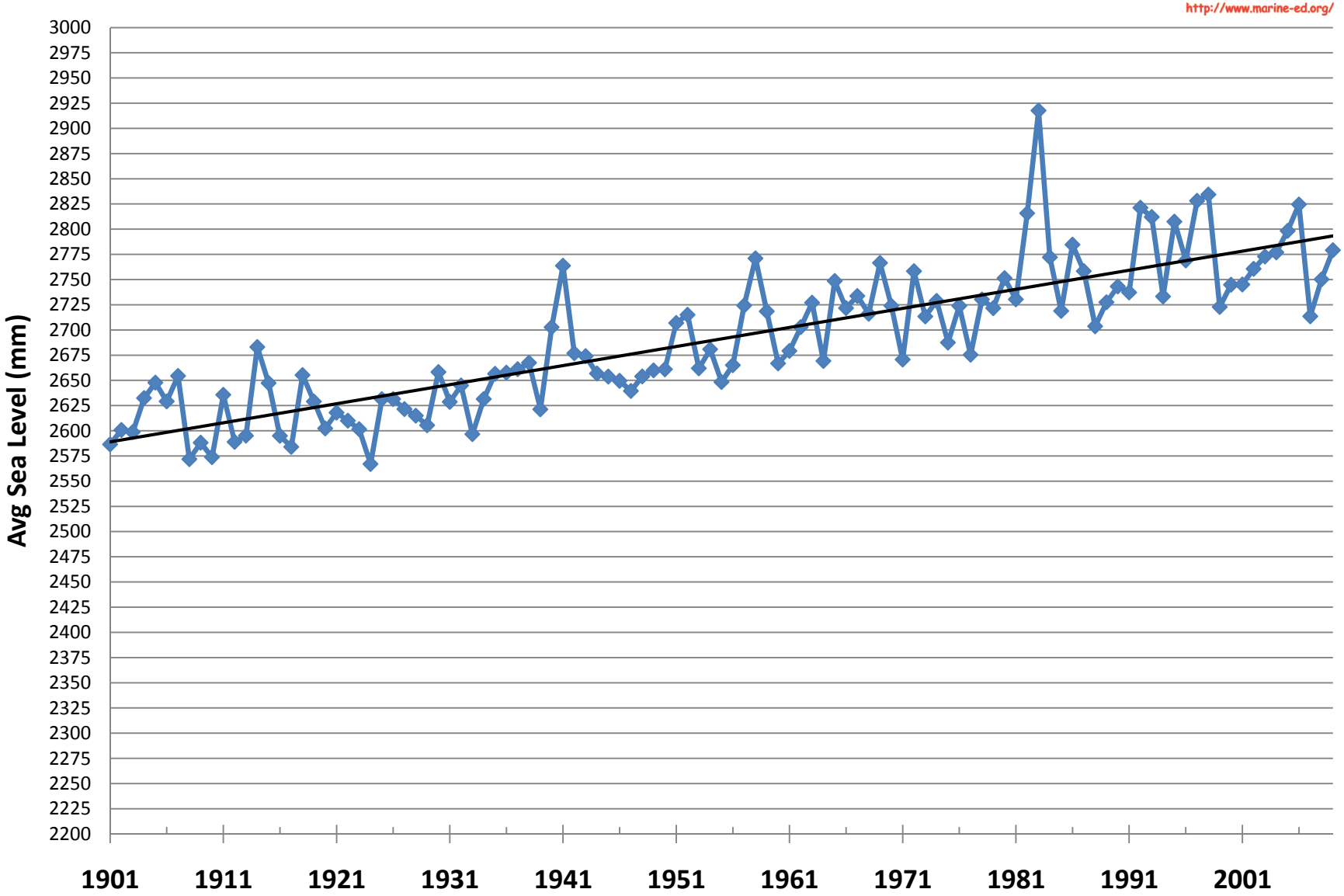
Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for Galveston, TX
1904 - 2009



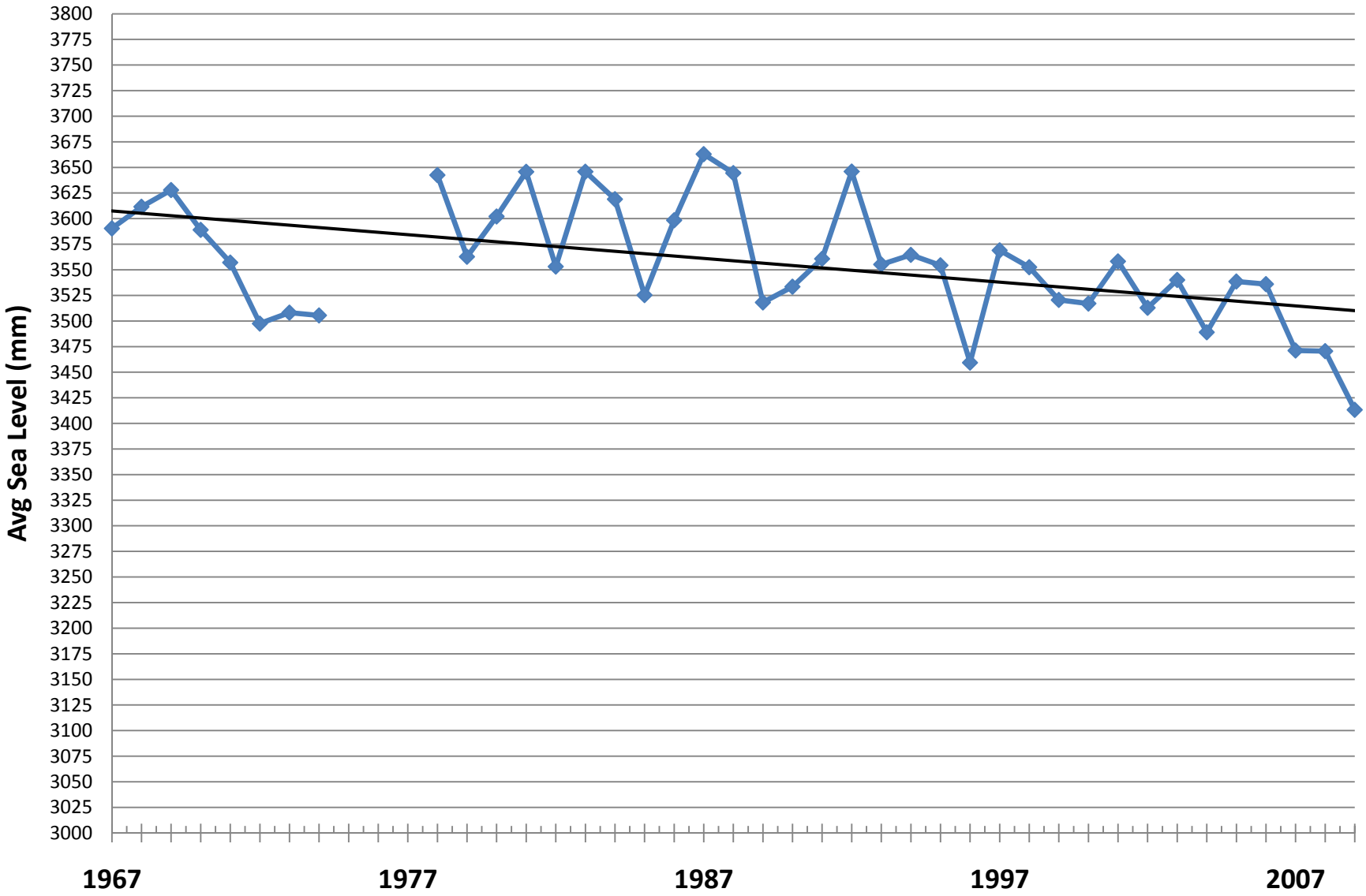
Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for San Francisco, CA
1901 - 2009



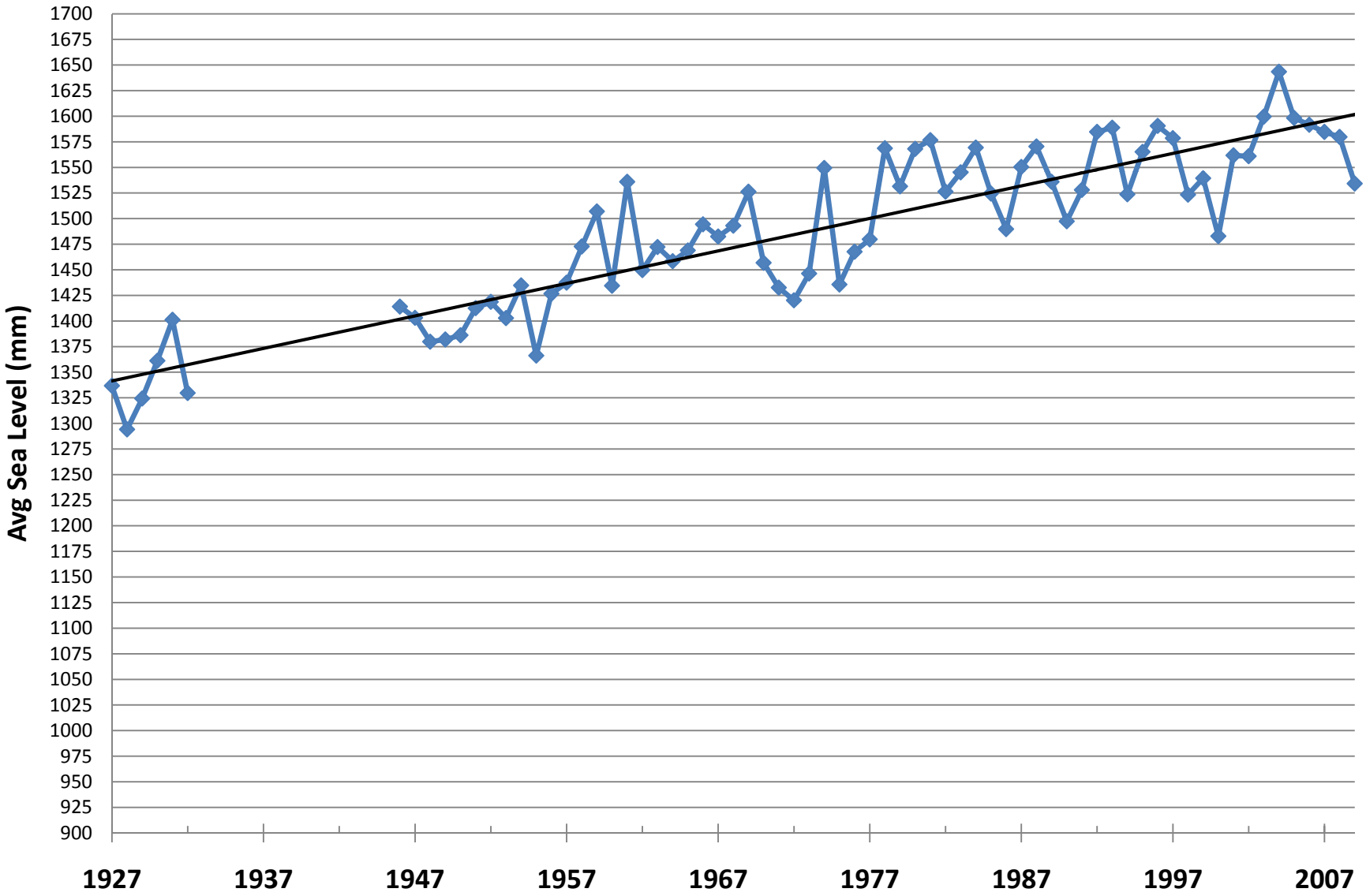
Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for Seward, AK
1967 - 2009



Bridge Sea Level DATA (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0910.html)
Data from the Univ. of Hawaii Sea Level Center

Average Annual Sea Level for Hilo, HI
1927 - 2009



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