Investigation 1B

Data In Action

Objectives

To learn about the ocean, we need to display the scientific information available to us. Maps and globes represent the physical location, as we already learned, while scientific diagrams, including bar charts, line graphs, and scatter plots, are used to compare variables. Contour plots combine maps and diagrams to show how variables are distributed geographically, allowing us to find additional patterns.

In this investigation, we will:

- Examine a bar chart, line graph, and scatter plot to determine the relationship of their variables
- Create a contour plot using a sample of bathymetry data

Graphs

While tables list data numerically, graphs visually represent it, allowing us to see relationships between variables. The horizontal axis (x-axis) shows the independent variable, while the vertical axis (y-axis) shows the dependent variable. Graphs make identifying patterns, trends, and comparisons easier, helping us interpret and analyze data efficiently. Bar charts are a simple, easy way to view and analyze data when the data is organized into categories. **Figure 1B-1** is an example bar chart with the type of marine mammal labeled along the bottom.

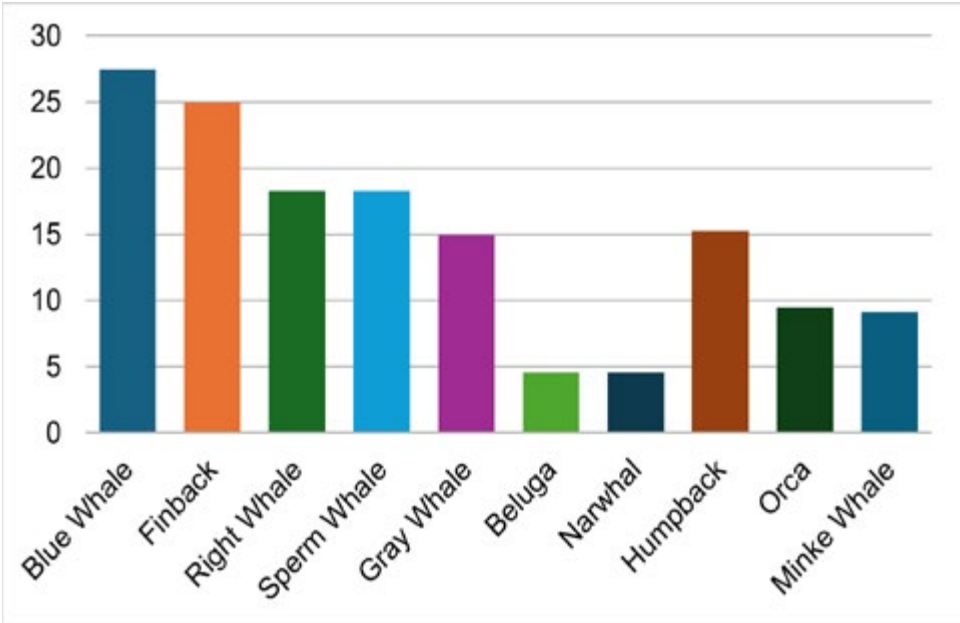

Figure 1B-1. An example bar chart of marine mammals with axes that are not labeled. [Adapted from Smithsonian]

1. Which of the following can you not tell from Figure 1B-1?

    a. The blue whale has the highest value
    b. The beluga and narwhal are tied for the lowest value
    c. What value is being measured
    d. How many marine mammals are being compared

While Figure 1B-1 makes it easy to compare these categories, the data it presents are impossible to interpret as the values are not labeled with a name or the unit in which they were measured.

Figure 1B-2 is the same bar chart as Figure 1B-1, with the title and axis labeled. We can now tell what data is being presented and interpret it accordingly.

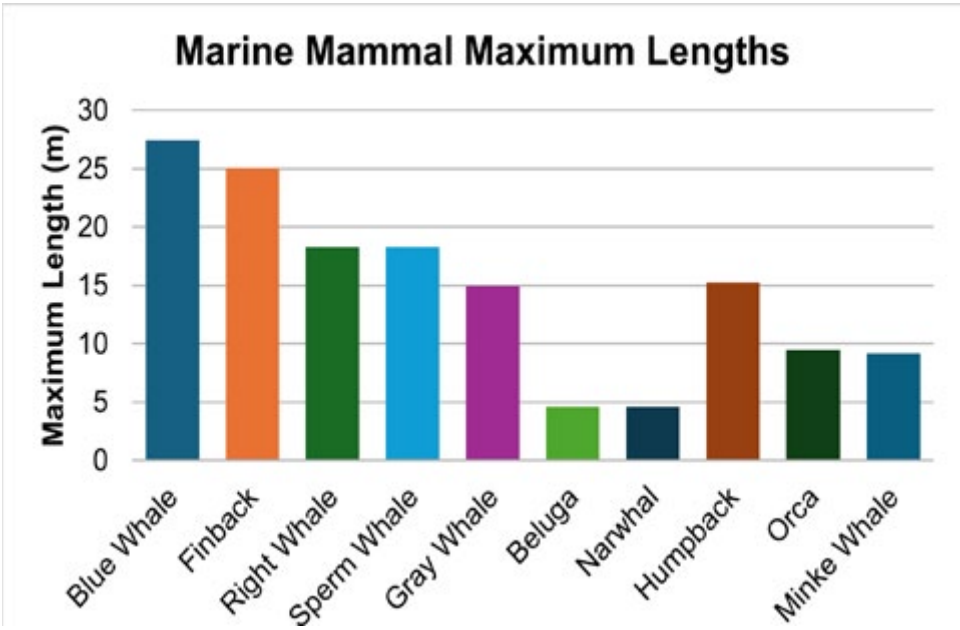

Figure 1B-2. Example bar chart of marine mammal maximum lengths. [Adapted from Smithsonian]

2. Figure 1B-2 shows that we are actually comparing the maximum _____ of marine mammals.

    a. weight in kilograms
    b. song volume in decibels
    c. length in meters
    d. speed in meters per second

3. With this context, you can tell that the blue whale is the _____ while the beluga and narwhal are tied for _____.

    a. heaviest at 27.5 lbs. ... lightest at 4.5 lbs.
    b. loudest at 27.5 db ... quietest at 4.5 db
    c. longest at 27.5 m ... shortest at 4.5 m
    d. fastest at 27.5 m/s ... slowest at 4.5 m/s

The incorrect answer choices in questions #2 and #3 have units that don't match the units shown on the bar chart. It's crucial to read all the labels carefully so you can understand what you are comparing.

A **line graph** is especially useful when you want to display changes or trends over time. It shows how one variable changes in relation to another, typically time, making it easy to observe patterns, increases, decreases, or fluctuations. Line graphs are especially helpful for comparing multiple data sets or tracking continuous data. **Figure 1B-3** shows the change in global mean, or average, sea level compared to the 2000–2020 mean sea level, which is 0 in the graph. This data was collected by satellites and is compared to data from coastal water gauges to ensure accuracy.

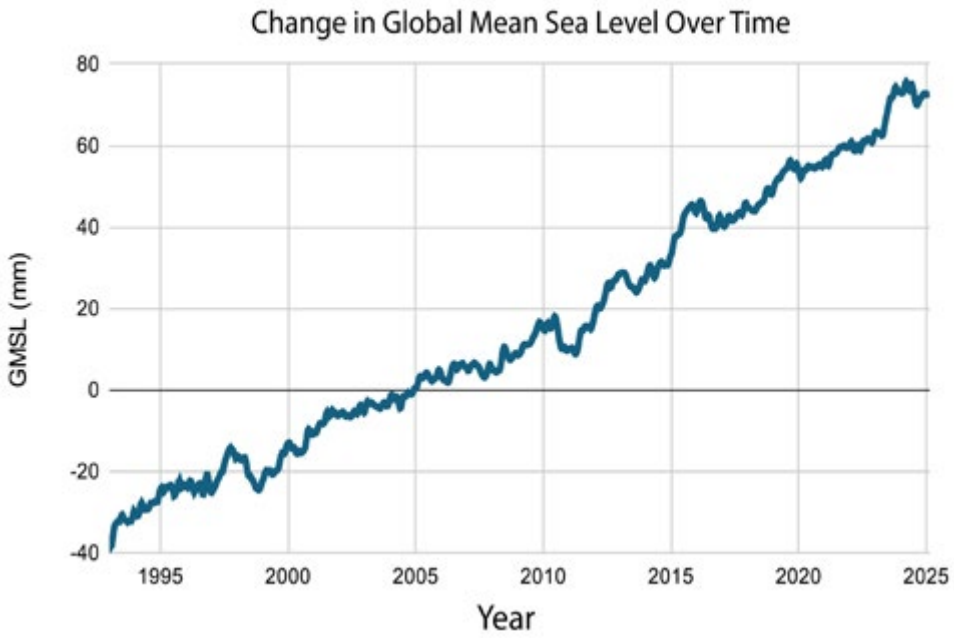

Figure 1B-3. AExample of a line graph of the anomalies in global mean sea level (mm) for 1993–2025. [Data from NASA]

4. You can determine a lot of information from Figure 1B-3. First, examine the axis labels. You can tell that satellites have been measuring sea level for _____ yrs and that it is measured in _____.

   a. 22 ... inches
   b. 22 ... centimeters
   c. 32 ... kilometers
   d. 32 ... millimeters

5. It is also easy to tell the **range**, the difference between the minimum and maximum values, of the mean sea level over this period. It varied from approximately 40 mm below the 2000–2020 mean to approximately _____ mm above it. This is a range of _____.

   a. 58 ... 98 mm (9.8 cm)
   b. 66 ... 106 mm (10.6 cm)
   c. 75 ... 115 mm (11.5 cm)
   d. 80 ... 120 mm (12.0 cm)

6. Most importantly, the line graph in Figure 1B-3 shows the trend in global mean sea level, which has

_____ since 1993.

a. increased
b. decreased
c. not changed
d. increased then decreased

Like a line graph, scatter graphs are useful for showing the relationship between two variables if neither of the variables is time. Each point on the graph represents a pair of values, helping to identify trends, patterns, or correlations, including whether one variable increases or decreases as the other changes. Scatter plots are especially helpful for spotting clusters, outliers, or linear and non-linear trends in data. They are commonly used in science to explore cause-and-effect or associations between measured factors. **Figure 1B-4** is a scatter graph showing how the average sea surface temperature (SST) in °C in the equatorial Atlantic changed with longitude in 2024.

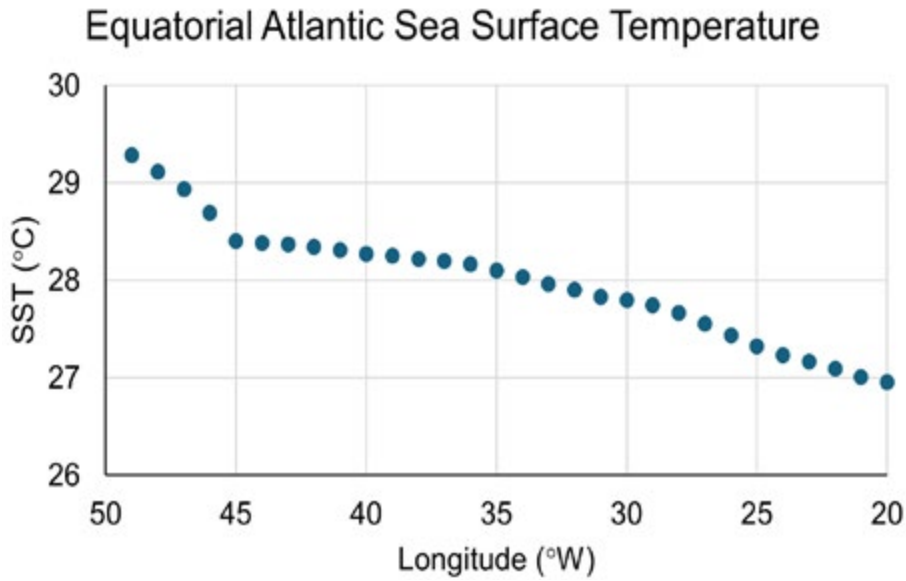

Figure 1B-4. Example of a scatter graph showing the average 2024 sea surface temperature (°C) along the equator from 50°W to 20°W in the Atlantic Ocean. [Data from NOAA]

In Figure 1B-4, longitude is the *independent variable*, or the variable that is predetermined or not determined by the other variable, plotted along the x-axis. We will examine how the dependent variable, in this case SST, changes as we move east or west along the equator. On the graph, longitude is shown with the west on the left and the east on the right.

7. From Figure 1B-4, you can see the maximum temperature of 29.3°C was at _____°W, while the minimum temperature of 27.0°C was at _____°W.

   a. 49 ... 20
   b. 45 ... 30
   c. 30 ... 45
   d. 20 ... 49

8. In 2024, the average SSTs in the equatorial Atlantic had a range of _____°C.

a. 1.7
b. 2.3
c. 27.0
d. 29.3

9. According to Figure 1B-4, the SST in the equatorial Atlantic generally _____ from west to east.

a. increases
b. stays the same
c. decreases

This trend in SST may have many causes, including ocean currents, wind patterns, or ocean oscillations. A scatter graph like this one may reveal a trend, pattern, or correlation, but not the potential causes.

Contour Plots

Contour plots are graphical representations used to visualize three-dimensional data on a two-dimensional plane. They are particularly useful for showing variations in a variable over a spatial area, such as elevation on topographic maps, temperature, pressure, or salinity. Contour plots consist of contours or isolines connecting points of equal value, effectively illustrating geographic patterns in the data. The titles of these lines are usually prefaced with iso-, which comes from the Greek word isos, meaning “equal” or “same.” Isolines representing the same temperature are termed *isotherms*, pressure lines are isobars, and salinity lines are *isohalines*. A contour plot may include lines, shading, or both to show these variations.

On a *bathymetric map*, we analyze depth measurements by drawing lines where equal water depth is shown to reveal horizontal patterns. These lines are called **isobaths** because every point on the line has the same depth. Each isobath separates areas of shallower water from areas of deeper water.

Figure 1B-5 shows the depths in the Port of San Diego in meters (m). On the map, consider each depth value to have been observed at the center of the plotted number.

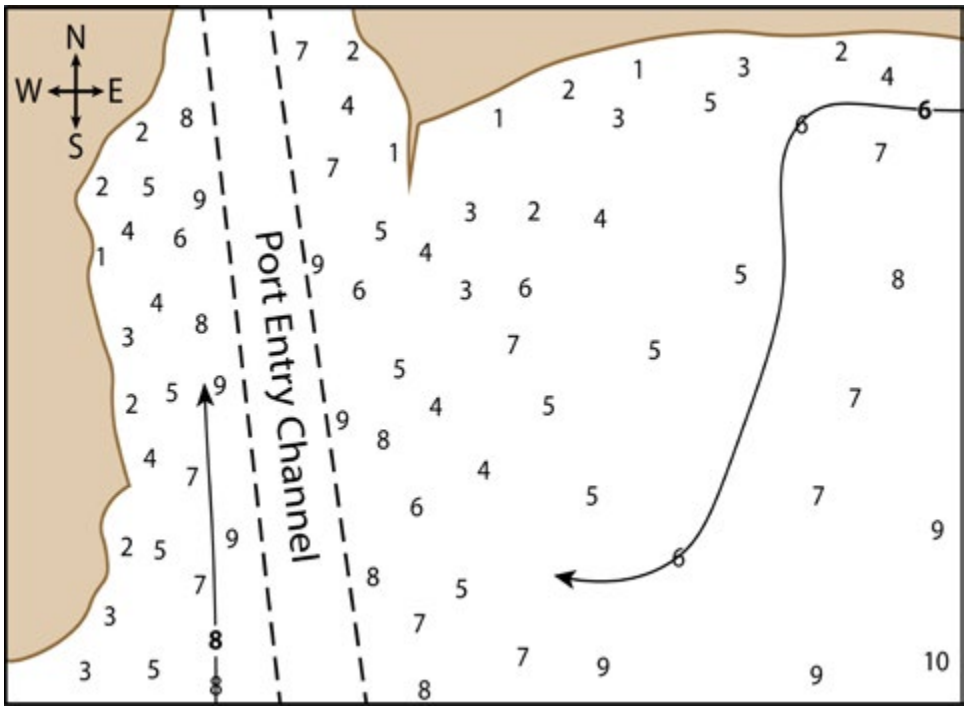

Figure 1B-5. Map of the Port of San Diego with depth in meters (m). Parts of the 6 m and 8 m isobaths have been drawn. [Adapted from NOAA]

Click on Figure 1B-5 to open it in a new tab. This allows you to either print it or draw on it with an online tool.

One of the 6 m and 8 m isobaths have already been started for you. **Complete the depth analysis by drawing the 2-m, 4 m, 6 m, and 8 m isobaths**. Draw each isobath using the following directions.

Drawing Isobaths

These rules apply to any type of contour plot.

a. Always draw an isobath so depth readings greater than the isobath's value are on one side and lower values are on the other side.
b. When positioning isobaths, assume a uniform change between neighboring stations. For example, a 4 m isobath would be drawn halfway between 3 and 5.
c. Adjacent isobaths tend to be shaped alike. The isobath you draw will align with the curves of its neighbors.
d. Continue drawing an isobath until it reaches the boundary of the plotted data or closes by connecting to its starting point. In this case, all isobaths will be closed.
e. Isobaths never stop within a data field. They never fork, touch, or cross one another.
f. Isobaths cannot be skipped if their values fall within the range of water depths reported on the map. Isobaths must always appear in sequence. For example, there must always be a 6 m isobath between the 4 m and 8 m isobaths, even if no values between 4 and 8 are plotted on the map.
g. Label all isobaths with the value or, for an enclosed value, create a break in the circle for the value.

10. Contour lines, including isobaths, have a consistent contour interval, meaning an equal number of

units between each contour. It is important to choose an appropriate contour interval to provide the most useful resolution for data analysis: too small an interval, such as 1 m would clutter the map, while too large an interval, such as 5 m, would not adequately define the depth pattern. In this case, the contour interval was _____ m.

a. 2
b. 3
c. 4

A gradient in a bathymetric map represents the rate of change in depth over a distance. It indicates how steep or gradual the underwater slope is. Steeper gradients are shown by closely spaced contour lines or rapid changes in depth values, while gentler gradients have widely spaced contours or gradual depth changes. Gradients help identify features like underwater cliffs, slopes, or flat valleys.

11. The isobath pattern you drew on Figure 1B-5 shows a more shallow gradient or gentle slope on the _____ side of the port's entry channel.

    a. eastern
    b. western

12. The port's entry channel has a flat bottom because it is regularly dredged to remove sediment build-up. From the isobath pattern, you can infer that the channel is _____ m deep.

    a. 2
    b. 5
    c. 10
    d. 20

We will use graphs and contour plots throughout the manual, so understanding these concepts is essential to staying afloat.

Summary

Graphs visually represent data, making it easier to identify patterns and analyze relationships between variables. Bar charts simplify comparisons between categories, while line graphs show changes over time, allowing you to compare multiple data sets and track continuous changes in a variable. Like line graphs, scatter graphs visualize the relationship between two variables, making it easy to spot trends, clusters, and potential correlations in scientific data. Contour plots use lines or shading on a map to visualize variations in a variable over an area, effectively showing geographic patterns in three-dimensional data. Though there are many types of contour plots, bathymetric maps show how water depth changes with each line, or isobath, separating areas of shallower water from deeper water. The distance between isobaths shows the gradient or steepness of the seafloor.

References

Figure 1B-1 – Smithsonian National Museum of Natural History, 2018: What is the largest whale? A cetacea size comparison chart. Accessed 8 April 2025, https://ocean.si.edu/ocean-life/marine-mammals/what-largest-whale-cetacea-size-comparison-chart.

Figure 1B-2 – Smithsonian National Museum of Natural History, 2018: What is the largest whale? A cetacea size comparison chart. Accessed 8 April 2025, https://ocean.si.edu/ocean-life/marine-mammals/what-largest-whale-cetacea-size-comparison-chart.

Figure 1B-3 – NASA, 2025: Vital signs of the planet: Sea level. Accessed 8 April 2025, https://science.nasa.gov/

earth/explore/earth-indicators/sea-leve/.

Figure 1B-4 – NOAA View Global Data Explorer, 2025: Yearly Sea Surface Temperature. Accessed 8 April 2025, https://www.nnvl.noaa.gov/view/globaldata.html#SURF.

– NOAA ArcGIS, 2025: Investigating El Niño using data in the classroom. Accessed 8 April 2025, https://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=7a6ff2dc781041bcad-7f790a719a42dd.

Figure 1B-5 – NOAA Nautical Charts, 2025: Approaches to San Diego Bay. Accessed 8 April 2025, https://www.nauticalchartsonline.com/chart/zoom?chart=18772OG.