Lesson 4: Maps As Scientific Tools– Student Version

Lesson Objectives: At the end of the lesson, students will be able to

- This lesson is designed to reinforce the basic skill sets and concepts introduced in Lessons 1-3 of this module. Students will use the steps of the Geographic Approach to explore data sets and images in a scientific manner.
- Collect data about the height of physical features, use contour lines and the GeoMapApp grid to visualize features, and use the Distance Profile Tool to explore physical features.
- Use GeoMapApp as a tool to examine data sets related to Sea Ice Extent in the Arctic.
- Use the Digitizer Tool to collect data about whale locations and estimate the depths associated with randomly selected points.

Background:

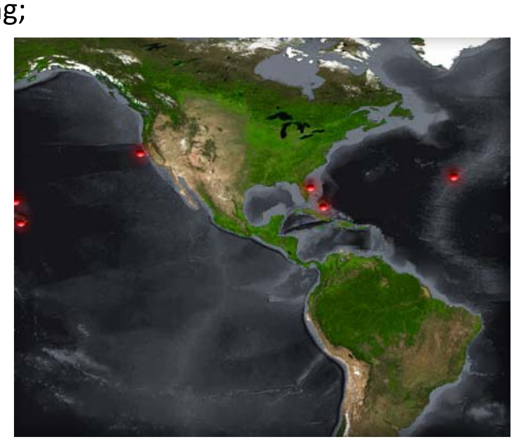
In this lesson, you will use the basic GeoMapApp skills you learned in Lessons 1, 2 and 3 to explore scientific questions using maps and digital mapping products. You will be presented with 3 scientific questions, and tasked with using your skill base and The Geographic Approach to discover an answer. You will also be asked to communicate your findings with a visual diagram in a PowerPoint presentation, report or webpage.

The term "map" can be defined in many ways, including;

1. Map, (noun). a geographic diagram a visual representation that shows all or part of the Earth's surface with geographic features, urban areas, roads, and other details

2. Map, (verb). to discover something and create a visual representation of it

3.On the map (slang) so as to be famous or important.



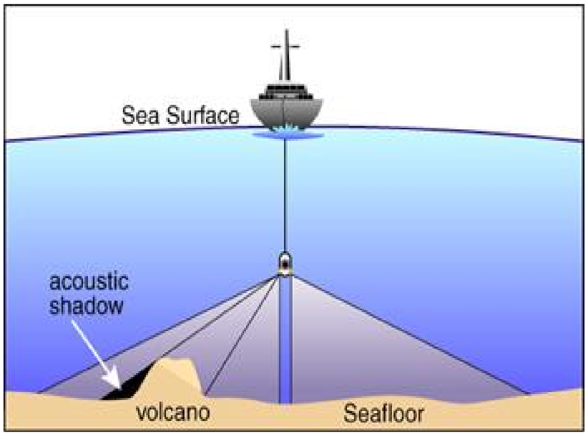


Figure 1. Seafloor data collection process.

Figure 2. Scientist using a data visualization

As you learned in Lesson 2, Journey Across the Pacific, scientists are now able to collect detailed data about the ocean floor from tools such as single beam, mutli-beam and side scan sonar instruments (Figure 1). The data is processed and analyzed back in the laboratory by trained technicians and research scientist, as seen in Figure 2 where Dr. Dawn Wright (a.k.a. *Deepsea Dawn*) studies an image of an underwater volcano on her computer.

Figure 3. The Geographic Approach provides the necessary framework for approaching a scientific problem with GIS analysis.

"Geography, the science of our world, coupled with Geographic Information Science (GIS) is helping us better understand the earth and apply geographic knowledge to a host of human activities, "says Jack Dangermond, Co-founder and President of Environmental Systems Research Institute, a leader in computer mapping software. "The outcome is the emergence of **The Geographic Approach**—a new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet. This approach allows us to *create* geographic knowledge by measuring the earth, organizing this data, and analyzing and modeling various processes and their relationships.

The Geographic Approach also allows us to *apply* this knowledge to the way we design, plan, and change our world."

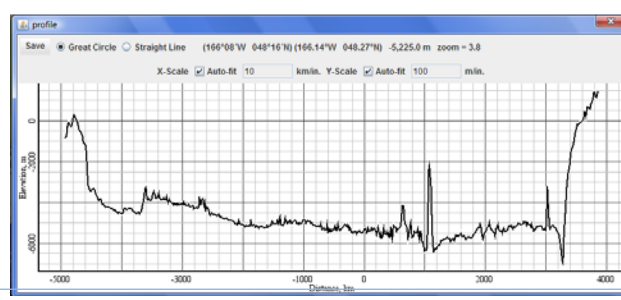
As a methodology, The Geographic Approach is used for location-based analysis and decision making. GIS professionals typically employ it to examine selected geographic datasets in detail, which are combined for the comprehensive study and analysis of spatial problems. This methodology parallels the well-known scientific method and includes a research-focused, iterative process for examining diverse datasets and uncovering potential solutions. GIS augments the analytic process, helping give people a clearer understanding of complex problems that often include geographic components. This in turn allows better decision making and more opportunities to conserve limited resources, as well as improves the way we work. Many experienced GIS professionals intuitively begin their projects with a structured methodology of this nature. But for those new to GIS technology, these five steps will provide a defined and proven approach.

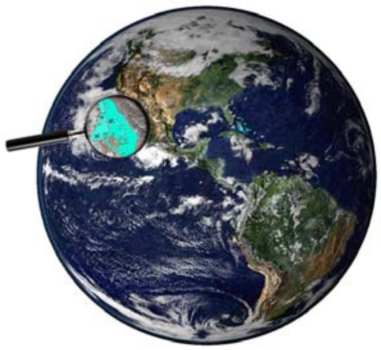
Step 1: Ask

Approaching a problem geographically involves framing the question from a location-based perspective. What is the problem you are trying to solve or analyze, and where is it located? Being as specific as possible about the question you're trying to answer will help you with the later stages of The Geographic Approach, when you're faced with deciding how to structure the analysis, which analytic methods to use, and how to present the results to the target audience.

Step 2: Acquire

After clearly defining the problem, it is necessary to determine the data needed to complete your analysis and ascertain where that data can be found or generated. The type of data and the geographic scope of your project will help direct your methods of collecting data and conducting the analysis. If the method of analysis requires detailed and/or high-level information, it may be necessary to create or calculate the new data. Creating new data may simply mean calculating new values in the data table or obtaining new map layers or attributes but may also require geoprocessing.





Step 3: Examine

You will not know for certain whether the data you have acquired is appropriate for your study until you thoroughly examine it. This includes visual inspection, as well as investigating how the data is organized (its schema), how well the data corresponds to other datasets and the rules of the physical world (its topology), and the story of where the data came from (its metadata). Since the data ultimately selected for your analysis depends on your original question or questions, as well as the results that you are seeking and how those results will be used, your examination may be dependent on how precise the data must be to answer the original questions.

Step 4: Analyze

The data is processed and analyzed based on the method of examination or analysis you choose, which is dependent on the results you hope to achieve. Understanding the nature of the question you asked is critical so that you can correctly interpret the results. Do not underestimate the power of "eyeballing" the data. Looking at the results can help you decide whether the information is valid or useful, or whether you should rerun the analysis using different parameters or even a different method.

Step 5: Act

The results and presentation of the analysis are important parts of The Geographic Approach. The results can be shared through reports, maps, tables, and charts and delivered in printed form or digitally over a network or on the Web. You need to decide on the best means for presenting your analysis. You can compare the results from different analyses and see which method presents the information most accurately. And you can tailor the results for different audiences. For example, one audience might require a conventional report that summarizes the analyses and conveys recommendations or comparable alternatives. Another audience may need an interactive format that allows them to ask what-if questions or pursue additional analysis. Yet another audience may simply need to know how the results affect them or their interests.

The Geographic Approach provides the necessary framework for GIS analysis and helps ensure accurate, verifiable results. By carefully documenting, archiving, and sharing your results and methodology, other researchers receive the opportunity to verify your findings.By applying The Geographic Approach to help us solve complex problems, we can make better decisions, conserve resources, and improve the way we work.

The Top of the World

You have probably learned that the biggest mountain on Earth was Mount Everest! Mount Everest does hold a world record, but not as the biggest mountain. Everest is the highest elevation on land, but it is only a single peak in an entire mountain range (Figure 4).

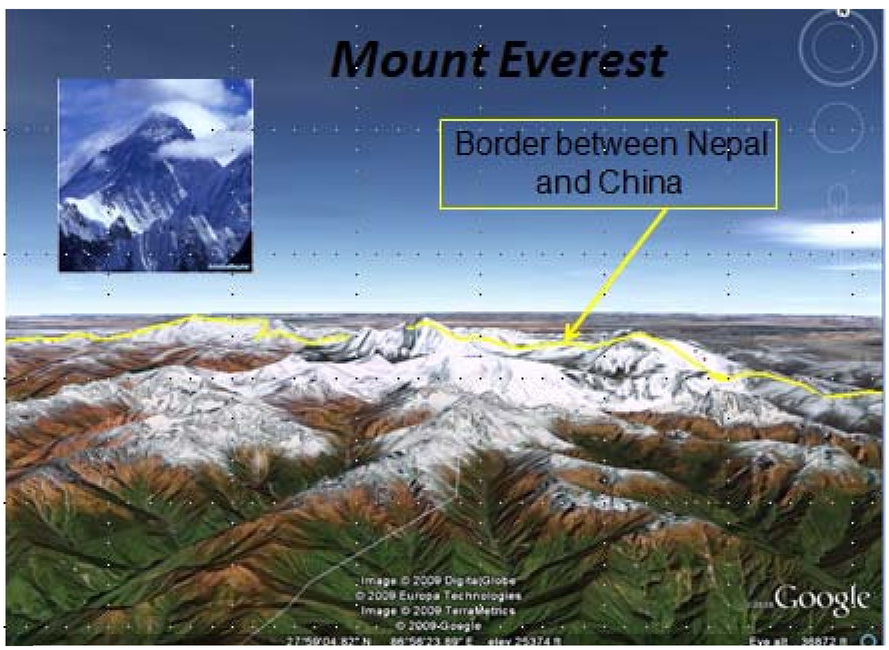
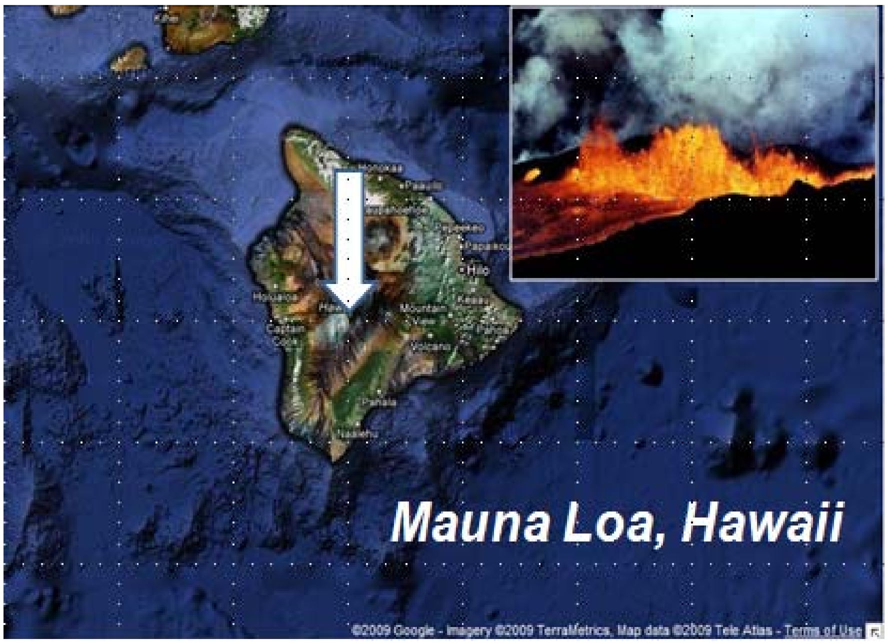


Figure 4. Mount Everest image created with Google Maps, showing political border and photograph.

Mountain Born of Fire

Mauna Loa is a single mountain on the island of Hawaii. The island of Hawaii is actually an island made up of five volcanoes which "blend" together because of their closeness to each other, making a single island.



Only about 13,448 ft/4100m of Mauna Loa are above sea level, so it may not seem like a very tall mountain. But, when you start measuring Mauna Loa from its true base on the bottom of the ocean, in the Hawaiian Trough, the total height exceeds that of Everest by over 3/4 of a mile. Mauna Loa is Hawaiian for "Long Mountain", probably because of its long, gently sloping shape. If you want to get really technical, Mauna Kea, a neighbor of Mauna Loa on the same island of Hawaii, is actually the *tallest* mountain in the world. Mauna Kea is about 350 ft/107m taller than Mauna Loa, but its mass doesn't compare to that of Mauna Loa. Mauna Loa takes up a lot of space because its mass is 9,700 cubic miles/40,000 cu km of mountain.

What makes Mauna Loa such a big mountain is the way it was formed. As part of the Hawaiian islands, Mauna Loa is a volcano, just like many others found on the island chain. The volcanoes in the Hawaiian islands are different from the cone-shaped, explosive, "fire breathing" dynamos that most of us think of when volcanoes come to mind. Mauna Loa is one of many **shield** volcanoes that make up the Hawaiian Islands. These are volcanoes that, compared to their more violent companions, erupt slowly and quietly. What really distinguishes a shield volcano is its shape - they are usually much wider than they are tall. Shield volcanoes are created when red hot lava oozes out from cracks, or **fissures** in the earth's crust.

In the case of the Hawaiian Islands, the fissures were in the ocean floor. The lava cools as it comes in contact with the ocean water. The newly deposited lava raises the level of the ocean floor just in the area around the fissure. Over time, and many oozing eruptions, a gently sloping **seamount** forms. A sea mount is, quite simply, a mountain on the floor of the ocean, only the top doesn't reach above the surface. Over a million years, or more, lava slowly builds up the sea mount until the top reaches above the surface of the sea. When this happens, it finally earns the title of island.

Exercise 4: Maps as Scientific Tools

In the following Explorations, you will move through the 5 steps of the Geographic Approach and use maps as tools in scientific discovery.

<u>Exploration 1: Compare Mount Everest and Mauna Loa with maps.</u>

Mount Everest is in the Himalayan Range that is part of the border between Nepal and China. Mauna Loa is located on the Big Island of Hawaii in the Pacific Ocean. Search for coordinates using Google to help you locate these geographic features in GeoMapApp.

Step 1: Ask. What is the tallest mountain in the world? Where is it located?

Step 2: Acquire data.

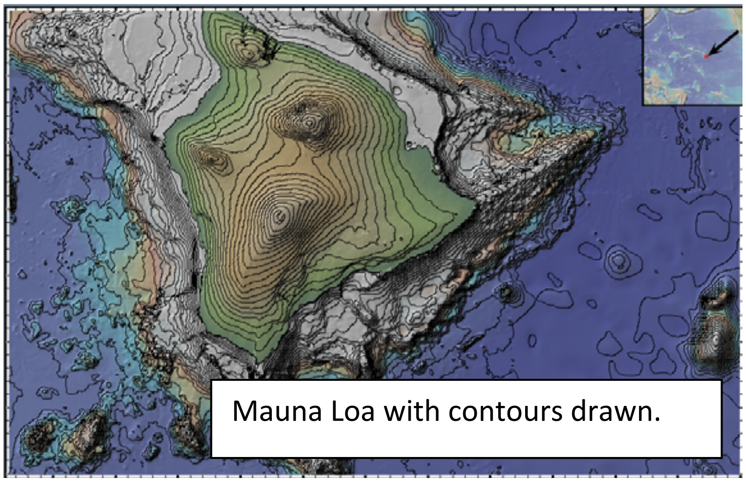
A. Using GeoMapApp, measure the physical features of Mount Everest and Mauna Loa.

Question 1. Fill in the table below.

	Mount Everest	**Mauna Loa (above sea level)**	**Mauna Loa (from base on sea floor)**
Height in meters			
Height in feet			
Relative Geographic Location*			
Absolute Geographic Location**			

***Relative Geographic Location: describe the location of the feature relative to other features, continents, countries, oceans,** etc.

****Absolute Geographic Location: describe the location of the feature using latitude and longitude coordinates.**



Mauna Loa with contours drawn.

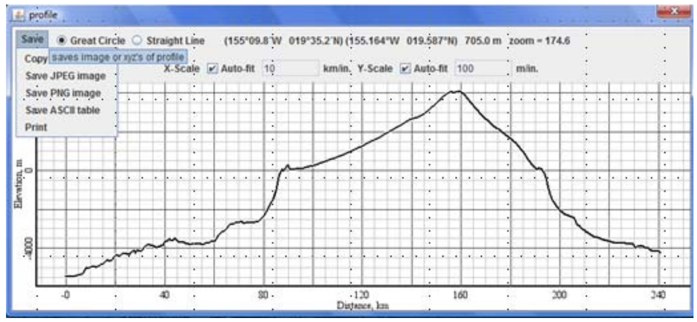
B. Using the Distance Profile Tool, create a Distance Profile of Mount Everest and one of Mauna Loa. Be sure to show the extent of Mauna Loa above and below sea level.

User Tip: Use the mouse cursor to find the coordinates of the features. Use the Distance Profile Tool to find the elevations.

User Tip: Add the Contours to your map using the Show/Hide Grid button and the Contour Interval button to better visualize where the base of Mauna Loa is under the ocean.

1. Draw your profile through the highest point on the mountain. (Be sure to drag to sea level for both profiles and to the base of Mauna Loa located under sea level.

2. **Save your profile by selecting the Save button inside the profile window.** Select Save → Save JPEG image → Navigate to your working folder and give your file an appropriate file name.



Step 3: Examine the data.
Eyeball the data you have collected. Examine the map locations and profiles of Mount Everest and Mauna Loa.

Step 4: Analyze. Reread the question you asked in Step 1 and consider the results you have found.

Step 5: Act. Create a layout showing where in the world the tallest mountain above sea level and below sea level is located.

1. **Create a GeoMapApp layout that shows the location of Mount Everest and Mauna Loa.**

2. **Save your Map Layout.** Select File → Save Map as Image/Grid file… → Save .jpeg image (Navigate to your working directory and save the file with an appropriate name).

3. **Open up Microsoft Powerpoint.**

4. **Add your saved map image (.jpeg file) to a Powerpoint slide.**

5. **Label your slide with the names and elevations of Mount Everest and Mauna Loa.**

6. **Write a one paragraph summary of your findings and basic facts explaining your map image.**

Exploration 2: Research ice changes around Antarctica using maps.

Step 1: Ask. How does the sea ice around Antarctica change from month to month?

Question 2: When do you think there will be more sea ice, in January or June?

Step 2: Acquire data. We'll explore 2 methods of answering the question; Qualitative and Quantitative.

1. Launch GeoMapApp. Double click on the GeoMapApp icon on your desktop.

2. Choose a map projection. Select the appropriate projection for the datasets you will use and the area of the world you are most interested in viewing. For this exercise, select the projection option, 'South Polar'.

3. Maximize your GeoMapApp session. Move your mouse over the corner of your map window until it turns into a double headed arrow, click and drag to resize the window.

4. Launch another session of GeoMapApp. Double click on the GeoMapApp icon on your desktop.

5. Add Sea Ice Extent data layers. Select the menu option Basemaps → Regional Maps (Images) → Antarctica → Sea Ice Extent → January Sea Ice Extent (repeat for all months Feb– Dec).

6. Explore the internet to discover more information about the Sea Ice Extent data layer. Use the information button on the layer manager to launch the website that corresponds to that layer.

7. Add the data layers for every month of the year. Select the menu option Basemaps → Regional Maps (Images) → Antarctica → Sea Ice Extent (1977-2000) → (repeat for February – December).

8. Delete all the layers you have added by clicking the X box in the layer name in the Layer Manger.

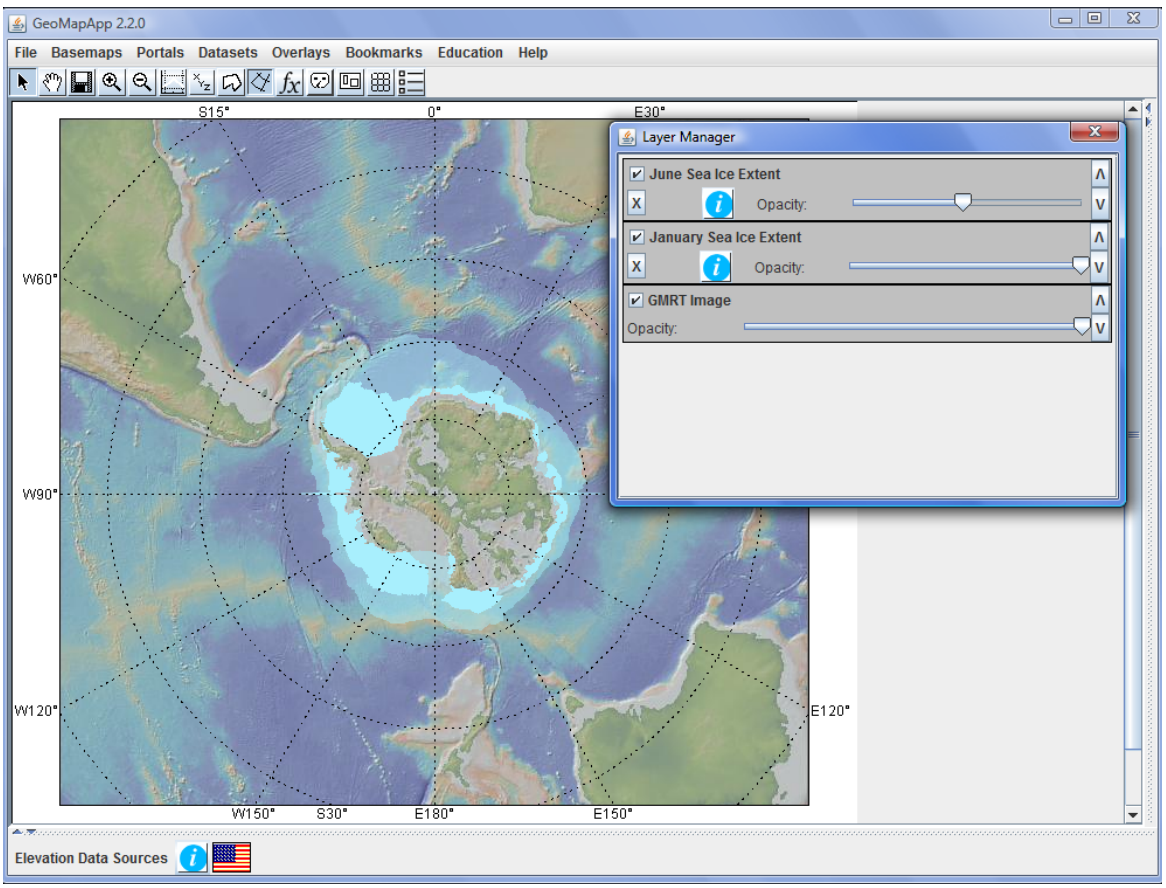
9. Examine the data layers and estimate the % change sea ice coverage (sea ice extent) in the image composites for January and June. This estimate is an example of a qualitative assessment of data.

A. **Add the layer composite for January.** Basemaps → Regional Maps (Images) → Antarctica → Sea Ice Extent (1977-2000) →January Sea Ice Extent.

B. **Add the layer composite for June.** Basemaps → Regional Maps (Images) → Antarctica → Sea Ice Extent → June Sea Ice Extent.

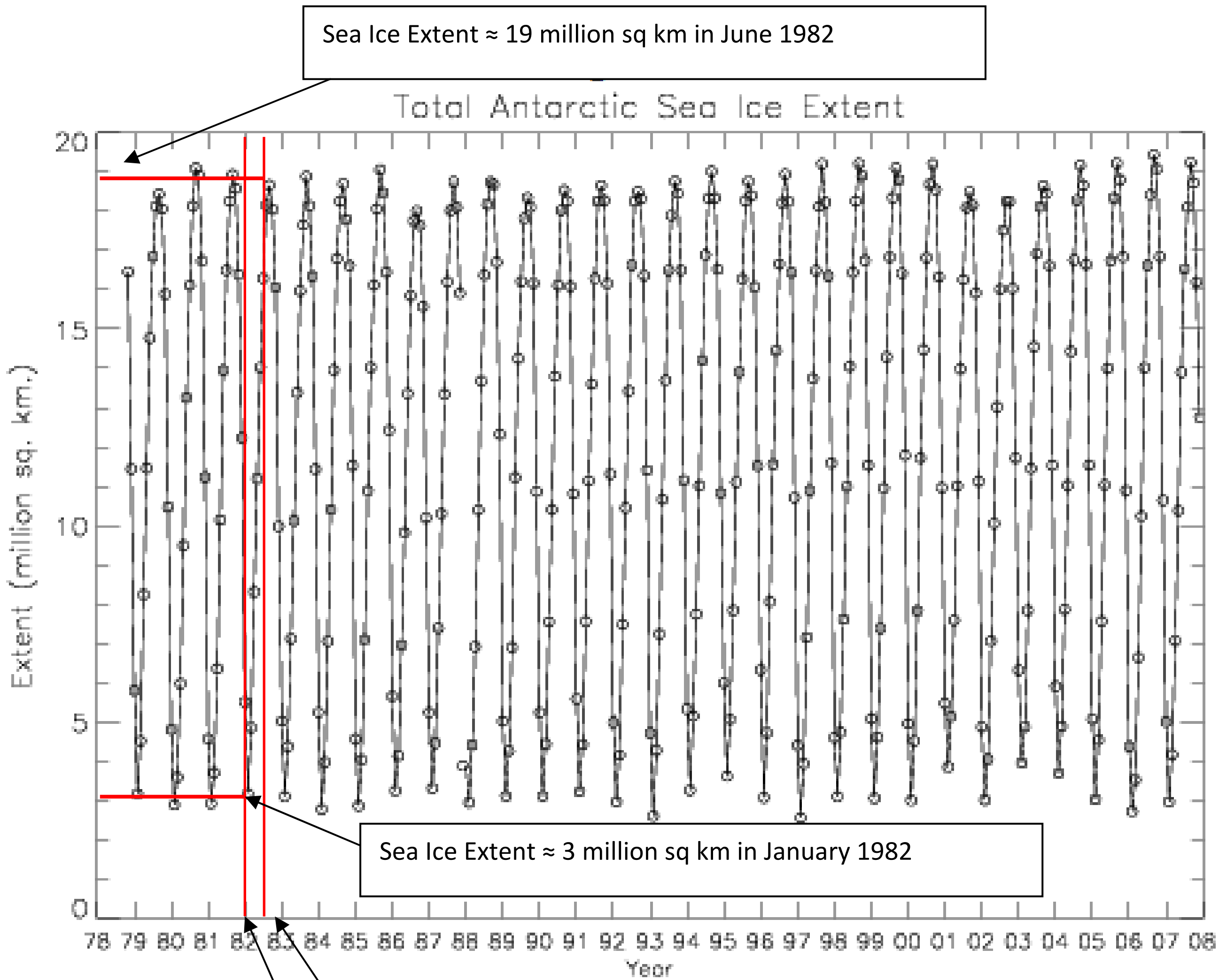
C. **Change the opacity of the June layer**. In the Layer Manager window to approximately 50% of the original image.

D. Compare the images and estimate how much the sea ice changes between January and June.



Question 3. What % change in Antarctic Sea Ice Extent do you observe in the composite images between January and June? Give a 2 sentence justification of your estimate.

9. Measure the total area of sea ice coverage by using the graph below and reading the values on the x-axis and y-axis. This is an example of a quantitative measurement and



assessment of data.

User Tip:Use a ruler to draw grid lines to help you read the data. June is approximately ½ way between the ticks on the x-axis. These 2 red lines are drawn through the months of January and June, 1982.

Question 4. Fill in the table below on Sea Ice Extent Measurements.

Sea Ice Extent in million sq km	1982	1986	1990	1994	1998	2002
Jan	3					
June	19					

Step 3: Examine the data. Eyeball the data you have collected. Compare the results you found with the qualitative and quantitative methods.

Question 5. Why is it important to collect data in the same month every year to assess changes in sea ice extent?

Step 4: Analyze. Reread the question you asked in Step 1 and consider the results you have found. Compare and contrast the results you obtained using the qualitative and quantitative methods of analyzing the data.

Step 5: Act. Create a report describing the ice changes you observed in the Antarctic. Include 2 map images and one paragraph on the variations in sea ice extent related to specific times of year as discovered with GeoMapApp. Include descriptions of the qualitative and quantitative methods you used, how the results differed and when you would use each method in a geographic approach or scientific analysis.

<u>Exploration 3: Follow the Blue Whale along the Pacific Coast.</u>

Step 1: Ask. Which whale species; the blue whale, bowhead whale or right whale is found in the deepest waters?

Step 2: Acquire data.

> **A. Add whale data to your map.** Select File → Import Shapefile → From Local File System… Navigate to the Lesson 3 data folder and select Blue94CA.shp shapefile. Follow these steps and add Blue95CA.shp shapefile.

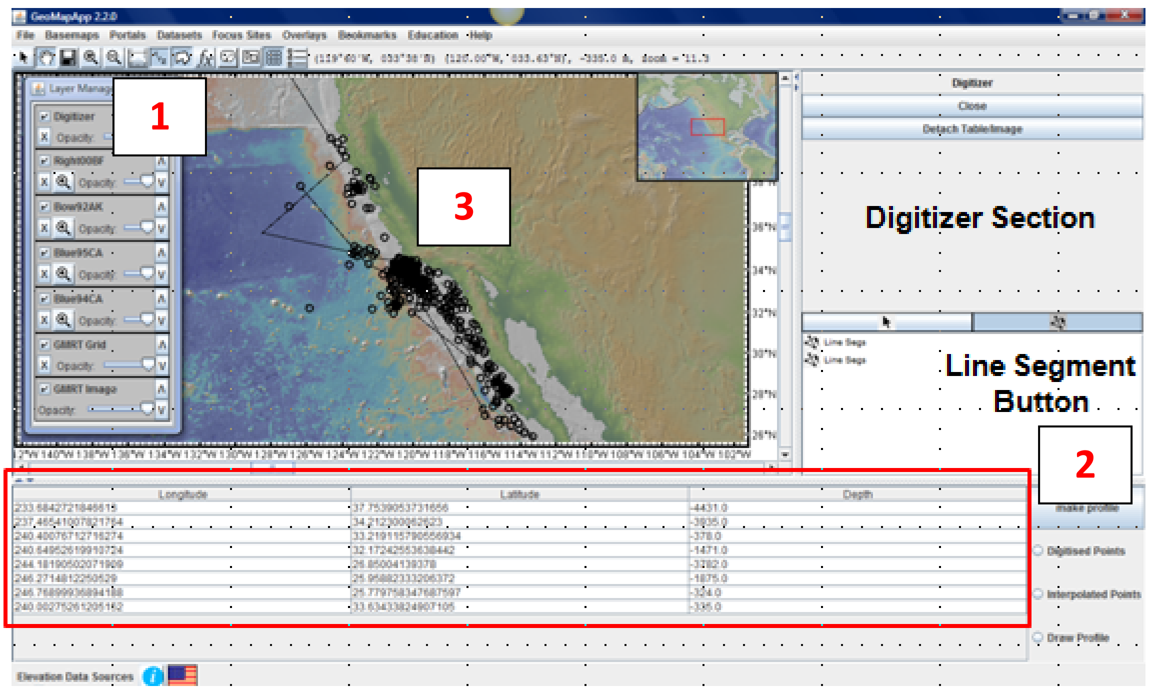
B. Zoom into the blue whale data. Locate the shapefile manager. Zoom into the blue whale data by clicking on the Zoom In Tool located next to the file name, Blue95CA data layer.

C. Determine the depth of the whales' locations.

1. Click on the digitizer tool in the toolbar. A digitizer window opens in the right side of the GeoMapApp window.

2. Click the line segment button in the window that opens.

3. Click on a data point for the blue whale. Notice that a table with longitude, latitude and depth opens at the bottom of the GeoMapApp window.



4. Randomly click on 9 more data points for blue whale locations.

5. Double click on the line segment button after clicking on your last point to close your digitized line.

6. Complete the Table in Question 6 with the data you have collected.

7. Follow the above steps 1-6 for the Atlantic Right Whale and Bowhead whale data.

Question 6: Complete the following table.

Whale Species	Longitude	Latitude	Depth	Average Depth
Blue Whale				
Blue Whale				
Blue Whale				*Add up all of the depth values and divide by the number of values (10) to get the average depth.*
Blue Whale				
Blue Whale				
Blue Whale				
Blue Whale				
Blue Whale				
Blue Whale				
Blue Whale				Average =
Atlantic Right Whale				
Atlantic Right Whale				
Atlantic Right Whale				
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Atlantic Right Whale				
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Atlantic Right Whale				Average =
Bowhead Whale				
Bowhead Whale				
Bowhead Whale				
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Bowhead Whale				
Bowhead Whale				
Bowhead Whale				Average =

Step 3: Examine the data. Eyeball the data you have collected.

Step 4: Analyze. Reread the question you asked in Step 1 and consider the results you have found.

Question 7. How does this relate to the behaviors and characteristics of the different whale species?

Step 5: Act. Create a one page summary of blue whale behavior to post on a webpage about blue whales. Include map screen shots (.jpeg files) exported from GeoMapApp, images of whales from the internet and summarize the data collected in this exercise.

Key words: Map, The Geographic Approach, relative geographic location, absolute geographic location, shield, fissures, seamount, quantitative assessment, qualitative assessment, temporal variation.

Diving in Deeper - Extending the Lesson

1) Extreme locations. Explore GeoMapApp for other extreme locations. You can compare the Mariana Trench and the Grand Canyon, or Monterey Canyon and the Grand Canyon.

2) Research the concept of seasonal variation and study the differences in summer and winter between the Northern and Southern hemispheres.

3) Prepare a debate on climate change and use evidence from GeoMapApp datasets to support or dispute the claim that our Earth's climate is changing at a rapid pace.

4) Create maps of the other whale data (Bowhead or North Atlantic Right Whale) and write reports about their habitats and movements.

References and Web Searches for Students and Teachers Websites

1) Cyberworld of Deepsea Dawn http://dusk.geo.orst.edu/

2) Mount Everest http://www.extremescience.com/MountEverest.htm

3) Mauna Loa http://www.extremescience.com/MaunaLoa.htm

4) Environmental Systems Research Institute http://www.esri.com

5) ArcLessons http://edcommunity.esri.com/arclessons/arclessons.cfm

Explore these lessons created for use with ESRI software products. Note that all shapefiles and excel data tables can be imported and displayed in a GeoMapApp window. Download the ArcLeson of interest into a file you have created on our C/: drive, unzip all your files, then refer to the instructions in Lesson 3 on p.5 for adding data from a folder.

6) GeoMapApp http://www.geomapapp.org/ Explore the many options and capabilities of the GeoMapApp software by browsing the website.