

## Exploring the reefs



### Introduction

Coral reefs surround many of the islands in the Samoan island chain. Many people depend on the reefs for food and economy (fish, shellfish, etc.). Coral reefs thrive in clear, unpolluted water; however, they currently face a number of threats from pollution, sedimentation, destructive fishing methods, and global climate change. Hence, it is important to continually monitor the reefs both up close and at a distance using remote sensing techniques.

Until recently, little was known about the coral reefs surrounding American Samoa below the depths to which humans can SCUBA dive. Therefore, researchers must rely on remotely sensed data to explore these environments. Remote sensing data include satellite images and any other data that are obtained by a hands-off observational approach. SONAR data collection and submersible dives are important remote sensing techniques for the ocean environment surrounding American Samoa. In 2001 and 2002 seven areas around Tutuila, the main island of American Samoa, were surveyed between 2 and 150 meters depth using SONAR multi-beam.

In this lesson, you will explore portions of the reefs around Tutuila using two types of remotely sensed data: 1) IKONOS satellite images that have a visibility of up to 30 m depth, and 2) Multi-beam sonar sound pulse data that are used to construct a view of the sea floor, known as bathymetry.





### Objectives

On completion of this lesson, you should be able to:



- Add data to an ArcMap project.
- Define *metadata* and explain its use.
- Change the *symbolology* for a *layer*.
- Measure objects in an ArcMap project.
- Identify features in an ArcMap project.
- Make a map.
- Explain what factors affect the quality of a satellite image.

## I. IKONOS Data

The IKONOS data used in this lab are four-band (red, green, blue, infra-red), 4-m resolution images. You will be looking at the 3 bands (red, green, blue) that appear in ArcGIS. While the red band does not penetrate water very well, the blue and green bands can penetrate ocean water up to 30 meters. Moisture (clouds) and dust in the atmosphere, as well as pollution and waves in the water can affect the depth of detection by the satellite images.

**Note on Buttons and Tools:** There is a difference between a button and a tool in ArcGIS. When you click on a button, something happens without any other action on your part. For example, when you clicked on the  add data button, a file window appeared. There is also a zoom in button: . The button zooms in on the map when it is clicked. When you click a tool, however, nothing happens until you do something on the map. The zoom in tool  requires you to click on the map and draw a box before it will zoom in closer on the map. **Note:** Use the Full Extent  button to return to the view of the whole island.

### *Adding the data*

1. Open ArcMap. At the “Start using ArcMap with” prompt, click the radio button next to “a new empty map” and click “OK.” Click the  add data button (or go to File -> Add Data). (Note: multiple files may be added by holding the **Shift** key while clicking on file names).
2. Navigate to the directory where the data are stored. To do this you will likely have to click on the connect-to-folder  button. Choose the correct folder and click **Ok**.
3. Choose the file named **Tutuila\_IKONOS.img** and click ok. The file is large and it may take it a few minutes to load...be patient.

### *Exploring the data*


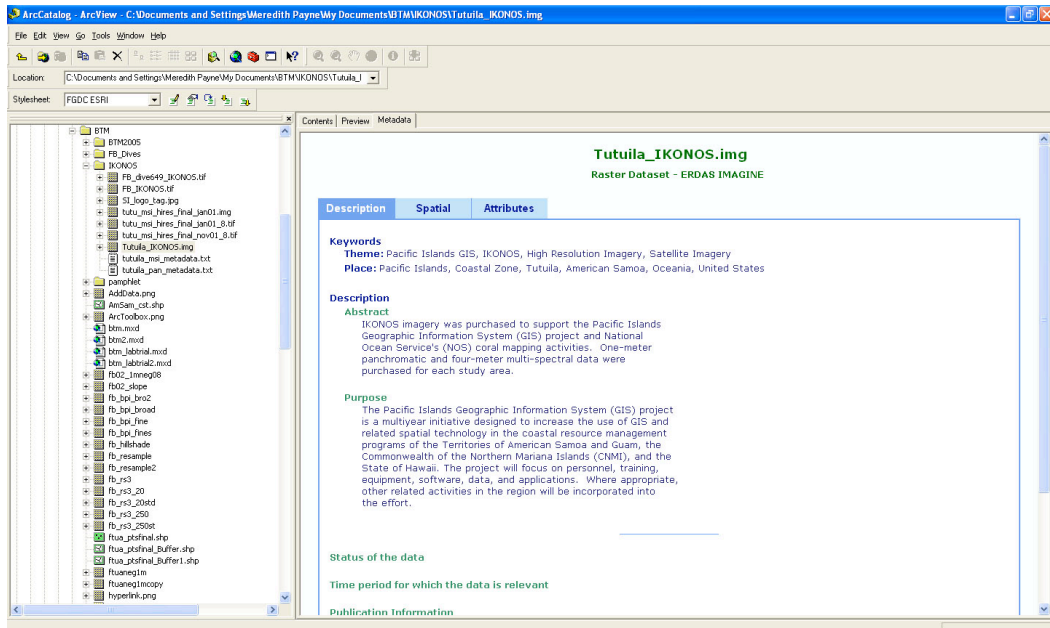
1. **Metadata** is essentially data about data. Metadata contains information such as spatial extent, projection information, date of creation/modification, and the owners and distributors of the data. To find more information about the IKONOS image of Tutuila, you need to look at its metadata. Start ArcCatalog by clicking on Open My Computer and navigate to where the data are stored. Start ArcCatalog from ArcMap by clicking the ArcCatalog button  in the menu bar. Navigate to the **Tutuila\_IKONOS.img** grid in the catalog tree to the left. In the right-hand window, click on the Metadata tab to view the information on this



image. The metadata window has three further tabs and many active links that you can click on to expand and view further information.



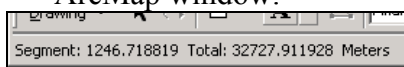
**Figure 1.** The Metadata windows within ArcCatalog.

Explore the metadata for **Tutuila\_IKONOS.img** and answer the following questions:

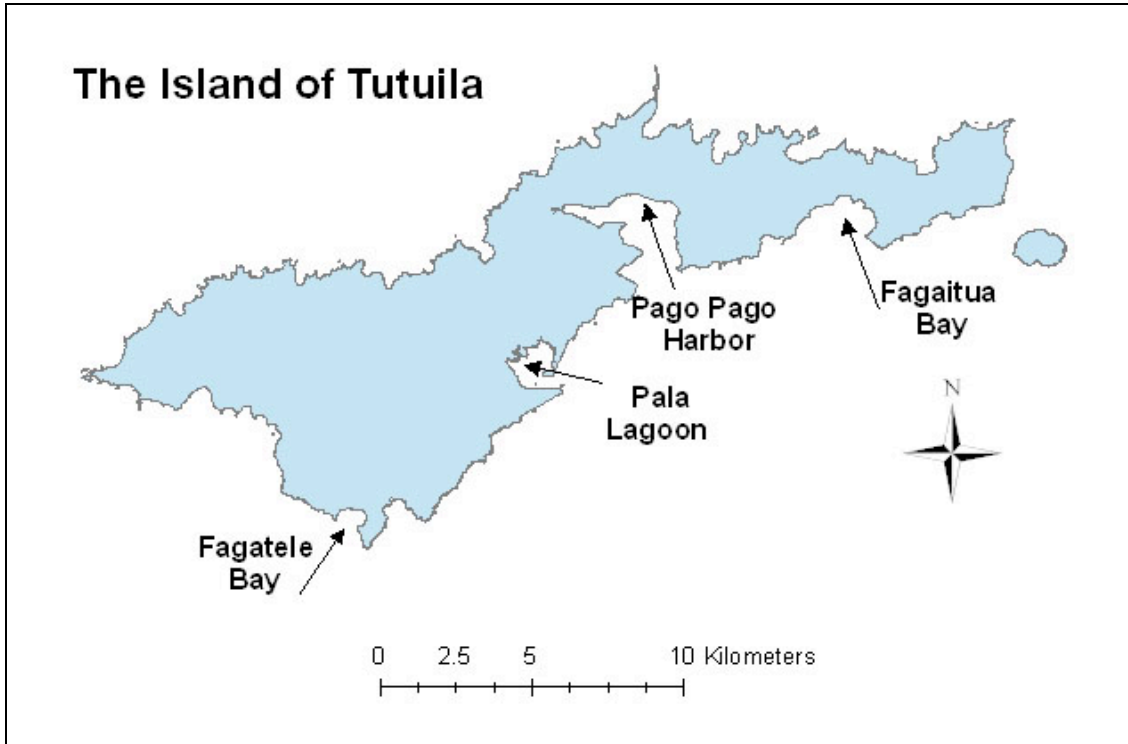
- What is the resolution of the image? (hint: it is a multi-spectral image.)
- How many original images were tiled (pieced together) to produce the image of Tutuila?
- Who created the image?
- When was it created?

2. Return to ArcMap. Zoom in to Pago Pago International Airport (south of Pala Lagoon, Figure 2) using the zoom in tool  (hint: for zooming instructions view the note on buttons and tools in the box above). Using the measure tool  answer the following questions.

- What is the length of the long runway at Pago Pago International Airport in meters? (Click on the measure tool, then click on one end of the runway and double-click on the other end.) The measurement will be shown in the lower left hand corner of the ArcMap window:



- b. What is the length of the long runway at Pago Pago International Airport in feet? To convert units of measure to feet:
- 1) Right Click on **Layers** → **Properties**.
  - 2) Click on the **General** tab and change the **Display** pulldown menu to show feet. Change the display back to meters once you have the answer.



**Figure 2.** Map of Tutuila island showing the locations you will be investigating during this laboratory.

3. IKONOS can penetrate the ocean down to 30 m in clear, smooth water. Zoom in to Fagaitua Bay on the southeast side of Tutuila (see Figure 2). The water in this image appears dark. Notice the dark triangle-shaped area in the shallow part of the reef. This area was dredged at one time and has since been re-colonized by coral.

- a. What are the white blotches around the shallow parts of the reef?
- b. How many channels (‘*ava*) leading from the shallow part of the reef out to sea can be seen in Fagaitua Bay?

Zoom in to Fagatele Bay (see Figure 2) on the southwest end of Tutuila.

- c. Why isn’t this part of the image as useful for looking at the seafloor as the image of Fagaitua Bay?
- d. What is causing the water to be less transparent than the water in Fagaitua Bay?

Zoom in to Pala Lagoon (just north of Pago Pago Airport, see Figure 2).

- e. Why is the water in the lagoon red?
- f. Would you expect to find coral here? Why or why not?

Turn off the IKONOS image of Tutuila by clicking in the check box next to the layer name.

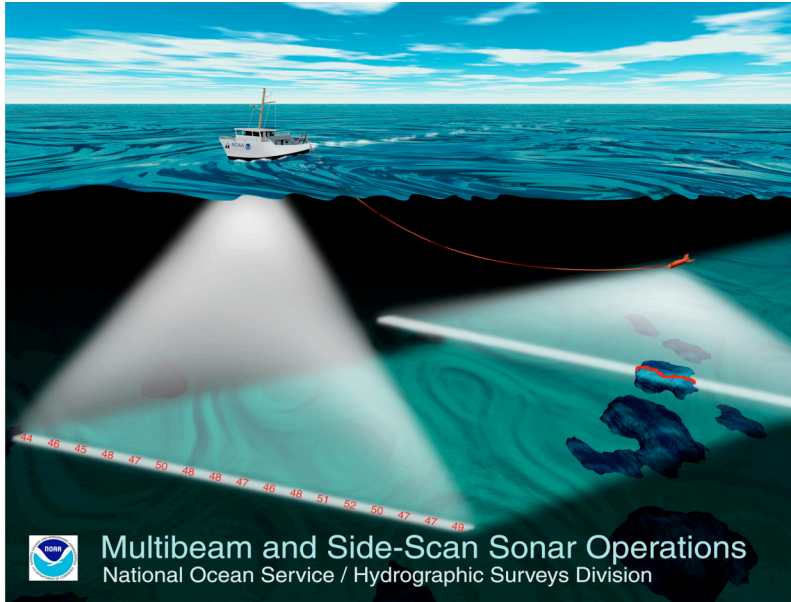
## II. *Multibeam Bathymetry Data*

Bathymetry is the underwater version of **topography**. A bathymetry grid is made up of cells, each with a value equivalent to the depth of the ocean at that point (Figure 3). The real-world distance covered by one side of a cell is the resolution of the grid. For example, the grid you will be working with today has a resolution of 5 m. That means that each side of a square cell in the grid is equivalent to 5 m on the ground. Multibeam bathymetry can be used for depths of a few meters to over 1000 m.

**Figure 3.** An example of a small bathymetry grid composed of depth cells.

1	2	5
2	4	8
4	7	10

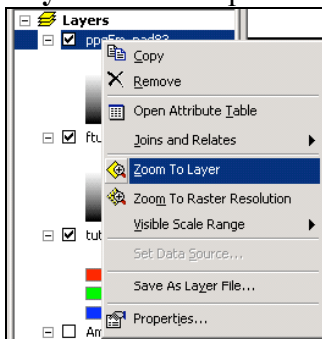
Multibeam surveys works similar to a fish finder. A pulse of sound is bounced off of the ocean floor and the time it takes to return to the ship is measured (Figure 4). In general, the longer it takes for the sound pulse to return, the deeper the ocean is at that point. Unlike satellite images, multibeam sonar is not a picture of the seafloor. It starts out as a collection of return times for the sound pulses and is then processed to produce bathymetry, allowing researchers to get a virtual view of the ocean floor.



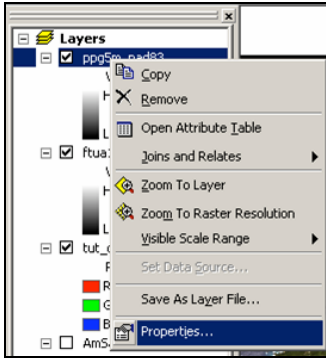
**Figure 4.** The multibeam sonar data collection technique.

*Working with Multibeam Bathymetry data in ArcGIS*

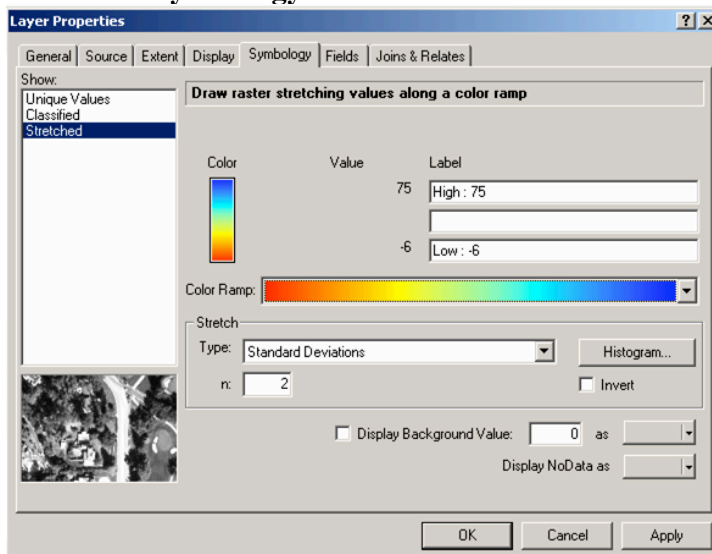
1. Add the **ppg5m84\_neg** grid and the **AmSam\_cst** shapefile to your project (refer to the “*Adding the Data*” instructions for the IKONOS image to remember how to do this). The ppg5m84\_neg grid is multibeam sonar-derived bathymetry for Pago Pago Harbor and the AmSam\_cst shapefile is depicts the outline of the islands of American Samoa. Right click on ppg5m84\_neg in the Table of Contents (Figure 5). Choose **Zoom to Layer** from the options.



2. To modify how the layer is displayed: Right click on ppg5m84\_neg in the layer list again. This time choose **Properties**.




Click on the **Symbology** tab.

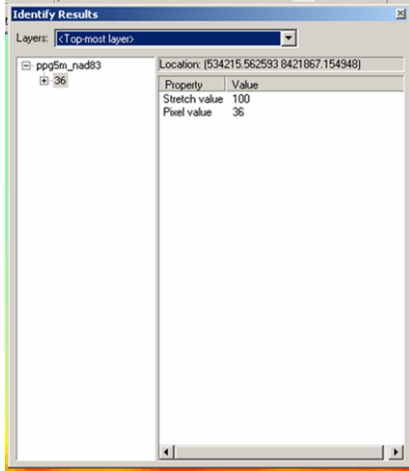


For this layer, the most appropriate way to display the information is **Stretched**, which should already be chosen. The color of the display can be changed in the **Color Ramp** box. Choose the color bar that goes from red to blue. Bathymetry is often shown using


one that starts with red for shallow areas and ends with blue for deep areas. If the color bar is reversed (red for deep values), check the **Invert** box.

### Exploring the multibeam data

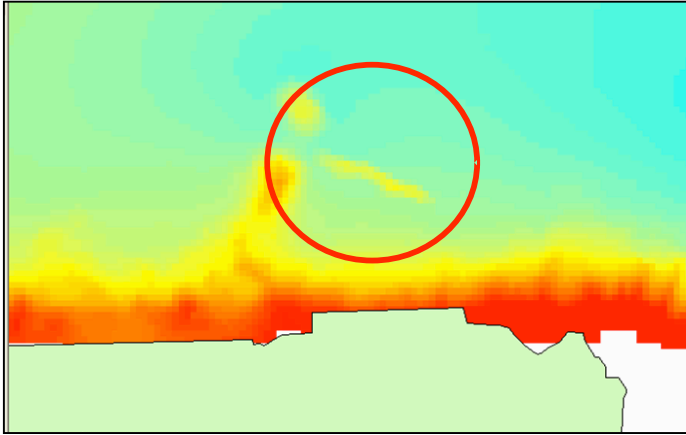
1. The **Identify** tool  can be used to learn more information about an area. First, make sure the ppg5m84\_neg layer is *active*. Do this by clicking on the name of the layer once, so that it is highlighted. Now click on the **Identify** tool and click somewhere on the ppg5m84\_neg grid. The *Identify Results* window will appear with information about where you clicked in it.



The **pixel value** in the Identify Results window shows how deep the place where you clicked is, in meters. Click on different areas to compare depth values in different parts of the harbor.

2. Another way to learn more about a grid is to look at the statistics for it. Right-click on the **ppg5m84\_neg** in the table of contents (left-hand) window and go to **Properties**. Click on the **Symbology** tab if it is not showing. Click on the **Histogram** button . This will bring up the *Histogram* window.
  - a. What is the maximum depth in Pago Pago Harbor? (The units are meters.)
  - b. What is the mean depth in Pago Pago Harbor? (The units are meters.)
3. Zoom in to the northern half of Pago Pago Harbor. The World War II tanker, Chehalis, sunk in Pago Pago Harbor in 1949. This wreck is visible from the multibeam bathymetry. Zoom in to the area circled along the south side of Pago Pago Harbor (Figure 5). Zoom in close enough that you can see all three features. The long straight feature is the wreck of the Chehalis.





**Figure 5.** The wreck of the Chehalis in Pago Pago Harbor.

Visit the following web pages to answer questions c-e:

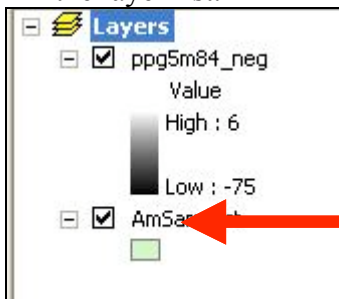
<http://www.history.navy.mil/danfs/c7/chehalis.htm> and <http://dusk.geo.orst.edu/esri02/>

- a. How long is the wreck, in meters?
- b. How deep is the wreck?
- c. How did the Chehalis sink?
- d. What was she carrying?
- e. Is the Chehalis still a concern for pollution in the harbor? Why? (Hint: think about what the ship was carrying).

### *Making a Layout*

Printing maps from ArcMap requires making a layout.

1. Zoom out so the map shows all of Pago Pago Harbor including the **AmSam\_cst** polygon shapefile showing the coast of American Samoa. If you'd like, you can change the fill color of AmSam\_cst by clicking on the color under the layer name in the layer list.



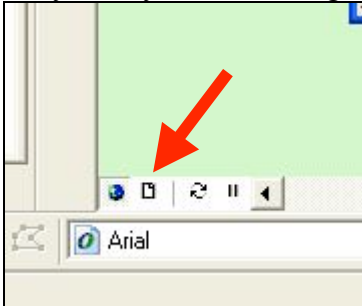
2. Go to **File → Page Setup** and change the page orientation to *Landscape*. Make sure the page size is letter size (11" x 8.5"). **Note:** the faint line around the edge of the page shows where the printable area is. Do not put anything outside of this line or it will be cut off by the printer.

3. Click on the layout button in the lower left hand corner of the map frame. It looks like a sheet of paper (red arrow below). The map frame will change to show a piece of paper and the part of your map that was visible in the map frame.

**Note:** A new toolbar will appear in the layout view: the layout toolbar.



If you want to zoom in or move around on the *layout*, it is important to use this toolbar, rather than the map toolbar. If you use the map toolbar, your layout will change in unexpected ways.



4. It is common to include an inset map to show a more general location of the map. To do this, return to the *Map View*. Do this by clicking the globe icon to the left of the “layout view” icon seen above.

- 1) In the main menu bar, click on **Insert → Data Frame**.

- 2) Add the bathymetry file and the coast file (the ppg5m84\_neg grid and the AmSam\_cst shapefile) to the new data frame. Zoom in to the island of Tutuila. Again, you may change the colors of these files if you wish. **Note:** you may also rename the data frames for your reference if you wish. To do so left-click once on the data frame name (which will currently be named either “layers” or “New Data Frame”) to activate it. Left-click on the name once more to cause the name to be editable. You may now type any name that you wish use for your data frame.

- 3) After you are happy with the colors of your inset map elements and the names of your data frames, return to the *Layout View*. There will be two maps there now, although the frames containing them may overlap. Click on the map of Tutuila and move it to the upper right or left corner of the page.

- 4) Place the map of Pago Pago Harbor where you would like it. You can change the size of the image by clicking on a corner and dragging it larger or smaller.

5. There are a number of important things that should be included on a map:

- Title

- Your Name
- Date
- North Arrow
- Scale Bar
- Neatline
- Legend

***Below you will find detailed instructions on adding these elements to your map.***

**To add a title:** Go to **Insert → Title**. A text box will appear on the map. Type your title in the box. It probably is not a font and size that looks good, so outside of the text box. To edit the style of the text, *double-click on the text* or *right-click* and choose *Properties*. A window will appear with various options. You can edit the text itself in the box under the **Text** tab.

Click on the **Change Symbol** button to change the style of the text. This will bring up the *Symbol Selector* window with various font options. On the right side of the window is a box labeled *Options*. You can change the font, font size and appearance here. When you are done, click **Ok**.

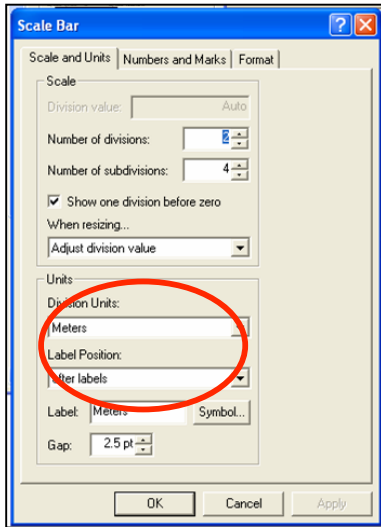
One other thing you may want to change is the *justification* of the text. This is how the text is aligned: left, right or center. This is done in the **Properties** window just under the text box.

To move the Title, once you have finished changing its properties, click once on the text in the layout. Arrows will appear; click and drag the text to where you want it.

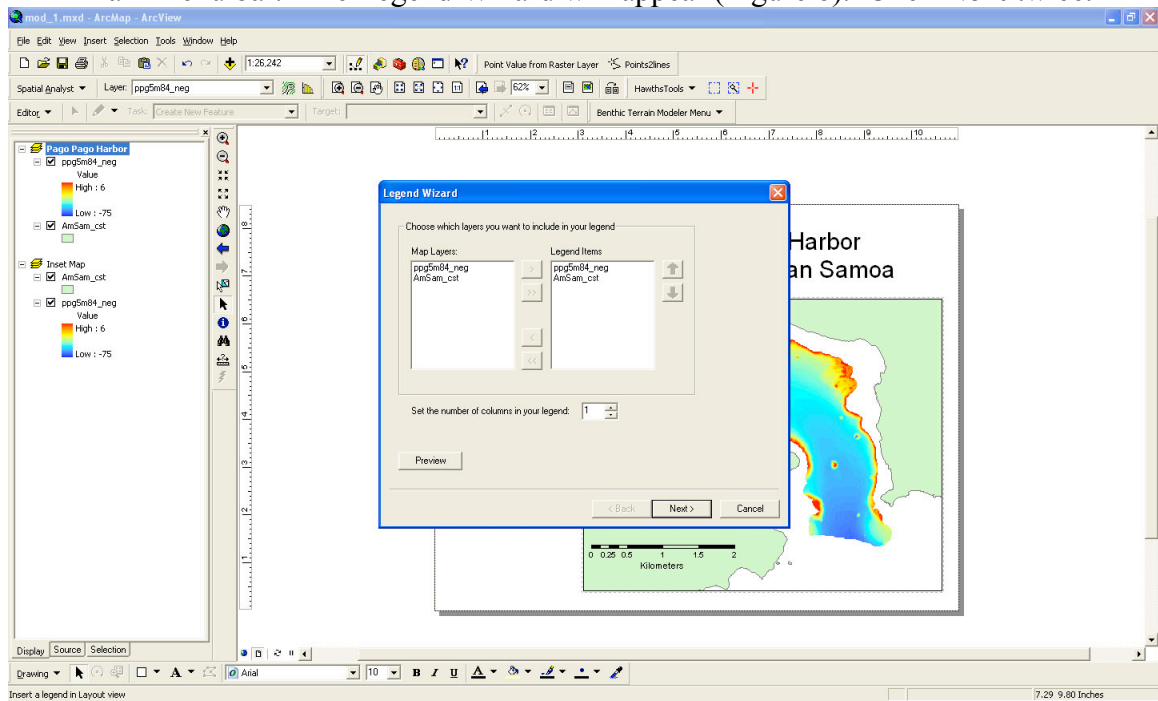
**To add your name and the date:** go to **Insert → Text** while still in layout view. A text box will appear and can be edited and moved in the same way that you made changes to the title.

**To add a North Arrow:** go to **Insert → North Arrow**. The *North Arrow Selector* window will appear. Pick one that suits you and click **Ok**. The North Arrow can be moved in the same way that you moved text. To change the size of the North Arrow, click on one of the corners and drag it to make it bigger or smaller.

**To add a Scale Bar:** go to **Insert → Scale Bar**. The *Scale Bar Selector* window will appear. Choose a scale bar style and click the **Properties** button, making the *Scale Bar* window appear. Make sure the units are in something that makes sense, such as meters, kilometers or miles and click **Ok**. Click **Ok** again to exit out of the dialog boxes. The scale bar can be moved in the same way text is moved. To resize it, click on one of the handles and drag it to a new size.



**Adding a legend:** Make sure your data frame showing your map of Pago Pago Harbor (*not* the inset map of Tutuila) is active. To activate a data frame, right-click on its name in the table of contents and choose **Activate**. Go to **Insert**→**Legend** in the main menu bar. The Legend Wizard will appear (Figure 6). Click **Next** twice.



**Figure 6.** The legend wizard dialog box steps you through making an appropriate legend for your map.

On the *Border Options* screen, choose a border you like from the pulldown menu. Click **Next** twice and then click **Finish**. Just like the other map elements (e.g. the north arrow and the scale bar), the legend can be moved around and resized so that is appropriate for your map. **Note:** you can edit your legend after it appears by right-clicking on it in the *layout view* and choosing **Properties**.

**Adding a neatline:** Go to **Insert**→ **Neatline**. The *Neatline* window will appear. Choose the *Place Inside Margins* option. In the *Borders* pulldown menu, choose a neatline that you like. In the *Background* pulldown menu, choose **Hollow** (meaning “No Fill”). Click **Ok**. Make sure everything on the map lies within the neatline (i.e. nothing touches or falls outside the neatline.)

**Note on Map Text Sizes:** the title should be the largest text in your layout. Your name and date should be smaller and less prominent. The north arrow and scale bars should be large enough to be read easily.

### *National Park of American Samoa Fish Inventory*

Go to the National Park of American Samoa (NPSA) Fish Inventory website: <http://www.nps.gov/npsa/NPSAfish/>. Choose two different species of fish and answer the following questions about them. You may need to search for their scientific, English or Samoan names on a search engine (e.g. Google) and view several other websites to find out more about the fish you chose. Answer the following questions:

1. What are the scientific, English and Samoan names for the two fish you chose?
2. Where do they live? (for example, on the reef? In the deep ocean?)
3. What type of habitat do they prefer? (under rocks? open water?)
4. What do they eat?
5. Are they fish that you have seen in the water, at the market, or is it a fish you have eaten?
6. Are they threatened species? If so, why are they threatened and what is being done about it?

### **Additional Questions**

1. If a satellite image has a resolution of resolution of 5 m, would it be possible to differentiate two cars parked 1.5 m apart from each other?
2. What is the coarsest resolution image that could be used to distinguish features that are 20 m apart?

**Consult your instructor about what parts of this assignment you should turn in.**



Courtesy NPSA