Khaled bin Sultan Living Oceans Foundation

STANDARDS

- **CCSS**: RST.9-10.1, 2, 3, 4, 5, 7, 8, 10; RST.11-12.1, 2, 3, 4, 8, 10; SL.9-10.1, 2, 3, 6; SL.11-12.1, 2, 3, 6
- **NGSS**: HS-ESS2-1, HS-LS2-6
- **OLP**: 5.B.7, 5.B.8, 5.C.33, 7.A.5, 7.C.2, 7.C.3

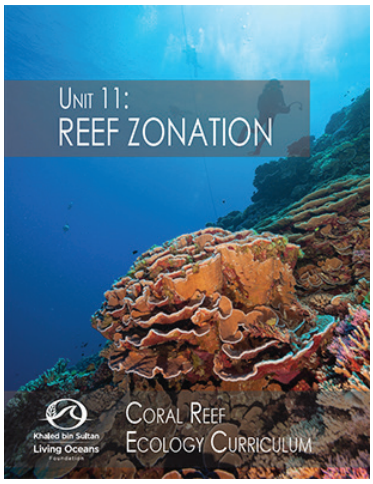
ONLINE CONTENTS

- Reef Zonation Quiz
- *Coral Reef Zones* Video
  Scientists divide coral reefs into zones. They base these divisions on location within the reef and characteristics such as depth, wave action, light intensity, temperature, and water chemistry. Zones of the reef include: lagoon, back reef, reef flat, reef crest, and fore reef.

REEF ZONATION

This lesson is a part of the *Reef Zonation* unit, which explains the characteristics and location of the reef zones. Below is a summary of what is included in the entire unit.

UNIT CONTENTS



A. Background Information
   - Reef Zones
   - Zonation Patterns

B. Lessons

Watch it! Coral Reef Zones
- A worksheet to accompany the *Coral Reef Zones* video

Modeling the Reef
- An art project to research and model a coral reef

GIS Mapping
- An activity exploring interactive GIS mapping tools

Read it! Let's Name the Zones
- A worksheet to accompany the *Let's Name the Zones, the Zones, the Zones of the Reefs… of Raivavae and Tubuai* field blog

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LESSON 2 TEACHER'S NOTES

AUTHORS

- Melinda Campbell, Claire Silva, & Amy Heemsoth Khaled bin Sultan Living Oceans Foundation

LEARNING OBJECTIVE

- Explore the characteristics of reef zones by using GIS maps.

KEYWORDS

- Algal Ridge
- Back Reef
- Drop-off
- Fore Reef
- GISLagoon
- Patch Reef
- Reef Crest
- Reef Flat
- Reef Front
- Spur and Groove Reef
- Topography

MATERIALS

- Computer lab
- Internet
- **Watch It! Coral Reef Zones** student worksheet
- **Lesson 2: GIS Mapping** student worksheet
- *World Web Map* (*http://maps.lof.org/lof*)

INTEGRATING SUBJECTS

- Technology

EXTENSIONS

- Discuss how natural stressors, such as hurricanes, and global climate change impact life in reef zones.
- Research how coral reef ecologists use GIS mapping to monitor the health of coral reefs over time.
- Watch *Mapping the Blue* (*https://youtu.be/1fTzilnT2zU*) and discuss how policy makers use GIS maps of reefs to create strategies for developing marine preservations for conservation.

STANDARDS

- **CCSS:** RST.9-10.2, 3, 4, 5, 7, 10; RST.11-12.2, 3, 4, 10
- **NGSS:** HS-LS2-6
- **OLP:** 7.A.5, 7.C.2, 7.C.3

PROCEDURE

1. Explore *http://maps.lof.org/lof* so you are comfortable with the tools needed for this lesson. NOTE: The *Measure Tool* (procedure #7) is not available on any mobile devices. Additionally, the *Habitat Analysis Tool* (procedure #8) is not available on phones, but is on tablets. To do this entire lesson, a computer is required.
2. Watch *Coral Reef Zones* YouTube video (*https://youtu.be/1wMrB37_GvI*) and answer questions on **Watch It! Coral Reef Zones** student worksheet.
3. Teach *Background Information Unit 11: Reef Zonation*.
4. Hand out **Lesson 2: GIS Mapping** student worksheet.
5. Allow students time to learn how to use the map tools and then have them complete the worksheet.

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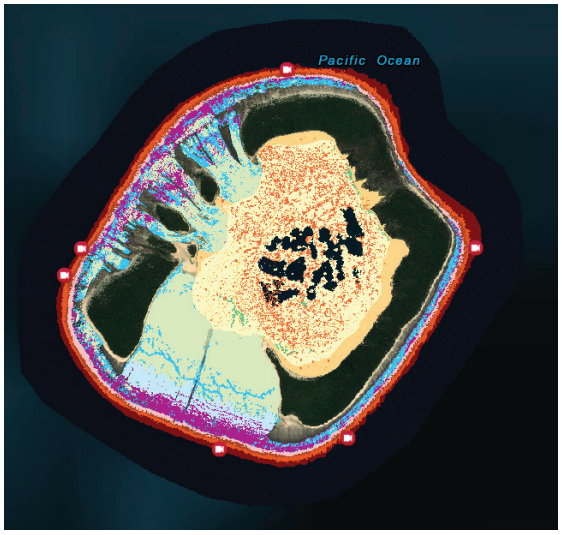
LESSON 2 GIS Mapping

ADDITIONAL BACKGROUND INFORMATION:

GIS stands for Geographic Information System. It is a tool used by scientists and other experts to display and analyze a large data set that is linked to a latitude and longitude. GIS mapping allows visualization of data so that patterns may become more easily visible. The data on a GIS map can often be manipulated and analyzed on the map itself, which allows it to be presented and displayed better than traditional graphs and tables. Often the data is stored in layers. For instance, the Khaled bin Sultan Living Oceans Foundation's World Web Map starts with a map of the world and then you can choose whether to show benthic habitat data, bathymetry, and/or depth contours on top of the map. In addition, our map has videos and photos embedded into it so you can see what the coral reef looks like in specific areas of the world.

PROCEDURES:

1. Go to *http://maps.lof.org/lof*.
2. In the upper-right hand corner is the menu. (If it is not already open, click on the icon.) Click on *Select a Location*, then *French Polynesia*, and then *Bellingshausen*, which looks like the image below. (Be patient, it may take a moment to load.)



3. In the menu, click *View Legend* to see what habitat each color on the map indicates. (You may need to click on *Select a Location* again to close that section of the toolbar.) What three habitats look like they take up the most area on Bellingshausen?

4. Use what you have learned from *Unit 11: Reef Zonation* to define the reef zone in the left-hand column of *Table 1*.

5. Use the legend to list the habitats on the Bellingshausen map that correspond with each reef zone. Fill in the second column in *Table 1*.

6. In the menu, click *Toolbar*, and then click on the  icon for the *Identify Tool*. Now if you click on the different colors on the map, a description of the individual habitats will pop up. (You may need to zoom in to accurately click on a specific habitat. The zoom bar is on the left-hand side of the map.)

7. In *Table 1*, fill in the appropriate columns to compare the topography and depth range of the different habitats in each zone. NOTE: Topography and depth range are the last topics described in the *Habitat Description*.

8. Click on one of the  video icons. (If you see an *Identify Tool* information box, and not the video, click on *Next Feature*  in the top right of the pop-up window until you get to the video.) How does this visual information compare to the written information that you get from the *Identify Tool*?

9. In the menu, click *Toolbar*, and then click on the  icon for the *Measure Tool*. Then click on the  icon and change the unit to meters. Use this tool to measure the widest part of each zone. To measure the width:
   a. Change the zoom until the zone you are measuring takes up as much space on the screen as possible while still being able to see the whole thing.
   b. Click on the edge of the widest part of the zone. A green flag will appear.
   c. Without clicking again, move the mouse until a blue line has been drawn across the widest part of the zone.
   d. Double click to plant a second green flag. (If you only click once, that is ok. Without moving your mouse, double click.)
   e. You can find your *Measurement Result* in the menu.
   f. Record the measurement in the right-hand column of *Table 1*.

10. In the menu, click *Toolbar*, and then click on the  icon for the *Habitat Analysis Tool*. To use the tool:
    a. Zoom out until you can see all of Bellingshausen reef.
    b. In the menu, change the radius to 3 km.
    c. Click on the  icon.
    d. Move your mouse to the map. A box should tell you "*Click to add a point*".
    e. Estimate where the center of Bellingshausen is and click on that spot. A red circle should appear around the entire reef.
    f. Wait a few moments for the report to appear.
    g. Excluding "*Area not mapped*" and "*Terrestrial vegetation*", what three habitats take up the most area on Bellingshausen and how many square meters do they occupy?

TABLE 1:

Reef Zone	Habitats	Topography	Depth Range	Width of Habitat
Lagoon:				
Reef Crest (Algal Ridge):				

Reef Zone	Habitats	Topography	Depth Range	Width of Habitat
Fore Reef:				
Back Reef:				

INSTRUCTIONS: Answer the following questions:

1. Why are the videos a helpful addition to the rest of the data?

2. Follow the procedures for using the tools again, but this time choose a different location. Fill out *Table 2* and use the information in *Tables 1* and *2* to answer the following questions:

   a. What is the name of this reef?

   b. What habitats did both reefs have in common?

   c. What habitats, if any, did the second reef have that Bellingshausen did not?

   d. What habitats, if any, did Bellingshausen have that the second reef did not?

   e. Which zone had the greatest change in number of habitats between the two reefs?

   f. How did the size of each zone in the new location compare to the widths you measured in Bellingshausen?

TABLE 2:

Reef Zone	Habitats	Width of Habitat
Lagoon		
Reef Crest		
Fore Reef		
Back Reef		

3. Why do scientists create GIS maps and how might they be used?

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LESSON 2 GIS Mapping

ADDITIONAL BACKGROUND INFORMATION:

GIS stands for Geographic Information System. It is a tool used by scientists and other experts to display and analyze a large data set that is linked to a latitude and longitude. GIS mapping allows visualization of data so that patterns may become more easily visible. The data on a GIS map can often be manipulated and analyzed on the map itself, which allows it to be presented and displayed better than traditional graphs and tables. Often the data is stored in layers. For instance, the Khaled bin Sultan Living Oceans Foundation's World Web Map starts with a map of the world and then you can choose whether to show benthic habitat data, bathymetry, and/or depth contours on top of the map. In addition, our map has videos and photos embedded into it so you can see what the coral reef looks like in specific areas of the world.

PROCEDURES:

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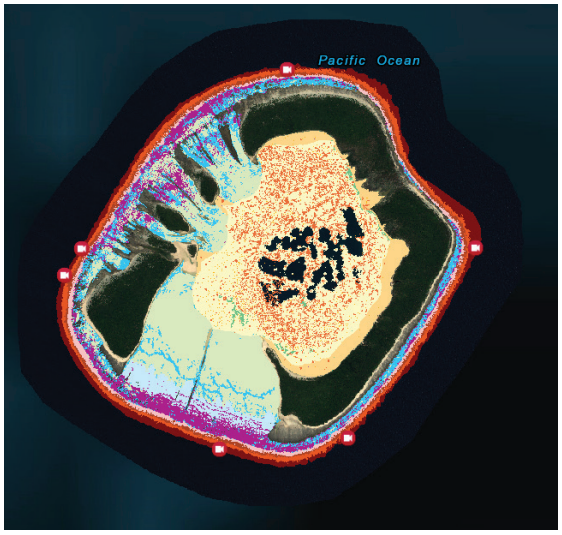
2. In the upper-right hand corner is the menu. (If it is not already open, click on the icon.) Click on *Select a Location*, then *French Polynesia*, and then *Bellingshausen*, which looks like the image below. (Be patient, it may take a moment to load.)



3. In the menu, click *View Legend* to see what habitat each color on the map indicates. (You may need to click on *Select a Location* again to close that section of the toolbar.) What three habitats look like they take up the most area on Bellingshausen?
   The top two habitats by area are clearly lagoonal floor barren and back reef sediment dominated. Third place may be difficult to determine and answers may include deep fore reef slope, back reef sediment dominated, back reef rubble dominated, back reef pavement, shallow fore reef slope, or others.

4. Use what you have learned from *Unit 11: Reef Zonation* to define the reef zone in the left-hand column of *Table 1*.

5. Use the legend to list the habitats on the Bellingshausen map that correspond with each reef zone. Fill in the second column in *Table 1*.

6. In the menu, click *Toolbar*, and then click on the  icon for the *Identify Tool*. Now if you click on the different colors on the map, a description of the individual habitats will pop up. (You may need to zoom in to accurately click on a specific habitat. The zoom bar is on the left-hand side of the map.)

7. In *Table 1*, fill in the appropriate columns to compare the topography and depth range of the different habitats in each zone. NOTE: Topography and depth range are the last topics described in the *Habitat Description*.

8. Click on one of the  video icons. (If you see an *Identify Tool* information box, and not the video, click on *Next Feature*  in the top right of the pop-up window until you get to the video.) How does this visual information compare to the written information that you get from the *Identify Tool*?
Answers may vary.

9. In the menu, click *Toolbar*, and then click on the  icon for the *Measure Tool*. Then click on the  icon and change the unit to meters. Use this tool to measure the widest part of each zone. To measure the width:
   a. Change the zoom until the zone you are measuring takes up as much space on the screen as possible while still being able to see the whole thing.
   b. Click on the edge of the widest part of the zone. A green flag will appear.
   c. Without clicking again, move the mouse until a blue line has been drawn across the widest part of the zone
   d. Double click to plant a second green flag. (If you only click once, that is ok. Without moving your mouse, double click.)
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10. In the menu, click *Toolbar*, and then click on the  icon for the *Habitat Analysis Tool*. To use the tool:
    a. Zoom out until you can see all of Bellingshausen reef.
    b. In the menu, change the radius to 3 km.
    c. Click on the  icon.
    d. Move your mouse to the map. A box should tell you "*Click to add a point*".
    e. Estimate where the center of Bellingshausen is and click on that spot. A red circle should appear around the entire reef.
    f. Wait a few moments for the report to appear.
    g. Excluding "*Area not mapped*" and "*Terrestrial vegetation*", what three habitats actually take up the most area on Bellingshausen and how many square meters do they occupy?
    Lagoonal floor barren (2,344,313.96 m^2), back reef sediment dominated (1,975,659.10 m^2), and back reef pavement (896,767.46 m^2) are the three habitats that take up the most area on Bellingshausen reef.

TABLE 1:

Reef Zone	Habitats	Topography	Depth Range	Width of Habitat
Lagoon: **Technically not a zone, it is a shallow body of water separated from the ocean by a coral reef or by land.**	**1. Lagoonal sediment apron sediment dominated 2. Lagoonal floor barren 3. Lagoonal floor coral bommies 4. Lagoonal floor macroalgae on sediment 5. Lagoonal patch reefs 6. Lagoonal pinnacle reefs branching coral dominated**	**The barren floor, sediment apron, and macroalgae on sediment all have a generally low relief. The lagoon is broken up by isolated pinnacles rising from the lagoon floor, along with patch reefs, usually circular in shape, and coral bommies.**	**Most of the lagoonal habitats are found in shallower water, with the sediment apron only extending to -5 m, bommies to -10 m, and patch reefs -15 m. Macroalgae and pinnacles reach all the way down to -30 m, but the depths from -15 m to -35 m are mostly barren floor.**	**2,642 m**
Reef Crest (Algal Ridge): **The highest point of the reef, which breaks waves and receives the fullest impact of wave energy.**	**1. Coralline algal ridge**	**The reef crest's ocean-face is a cement-like barrier with irregularly spaced ridges and grooves. Ridges are exposed at low-tide and between waves, and grooves allow for seaward transport of water.**	**Depth ranges from +2 m to -1 m.**	**65 m Answers for this column may vary depending on location of measurement.**

Reef Zone	Habitats	Topography	Depth Range	Width of Habitat
Fore Reef: **Found at the furthest distance from shore. Slopes downward and can reach great depths.**	**1. Shallow fore reef terrace 2. Shallow fore reef slope 3. Deep fore reef slope**	**The shallow terrace has highly variable spur tops and grooves, which may continue into the shallow slope area. The shallow slope has a gentle slope, with some mounds building near the bottom and heading into the deep slope which eventually steeply drops off into the ocean depths.**	**The shallow terrace goes from emergent to a depth of -8 m, being taken over by the shallow slope down to -15 m, and finally extending into the deep slope down to -40 m.**	**210 m**
Back Reef: **The area that slopes into a lagoon. It is often shallow and more protected from wave action.**	**1. Back reef rubble dominated 2. Back reef sediment dominated 3. Back reef pavement 4. Back reef coral framework 5. Back reef coral bommies**	**Both coral framework and coral bommies lie on the shoreward side of the back reef. The sediment dominated, pavement, and rubble dominated regions of the back reef have a low-relief, although large boulders may be present.**	**The coral framework and coral bommies are found at depths of 1 m to -2 m, while pavement, sediment dominated, and rubble dominated are found from 0 m to -1 m.**	**1,607 m**

INSTRUCTIONS: Answer the following questions:

1. Why are the videos a helpful addition to the rest of the data?
   The videos give a visual representation of what has been put into writing. This allows scientists to verify that they are discussing the same thing.

2. Follow the procedures for using the tools again, but this time choose a different location. Fill out *Table 2* and use the information in *Tables 1* and *2* to answer the following questions:
   Answers may vary depending on location chosen.
   a. What is the name of this reef?

   b. What habitats did both reefs have in common?

   c. What habitats, if any, did the second reef have that Bellingshausen did not?

   d. What habitats, if any, did Bellingshausen have that the second reef did not?

   e. Which zone had the greatest change in number of habitats between the two reefs?

   f. How did the size of each zone in the new location compare to the widths you measured in Bellingshausen?

TABLE 2: Answers may vary depending on location chosen.

Reef Zone	Habitats	Width of Habitat
Lagoon		
Reef Crest		
Fore Reef		
Back Reef		

1. Why do scientists create GIS maps and how might they be used?
   Answers may vary but might include the study or management of different habitats and helping to establish policies or conservation areas.