Monitoring Coral Reefs
using Remote Sensing and GIS

This activity has two aims:

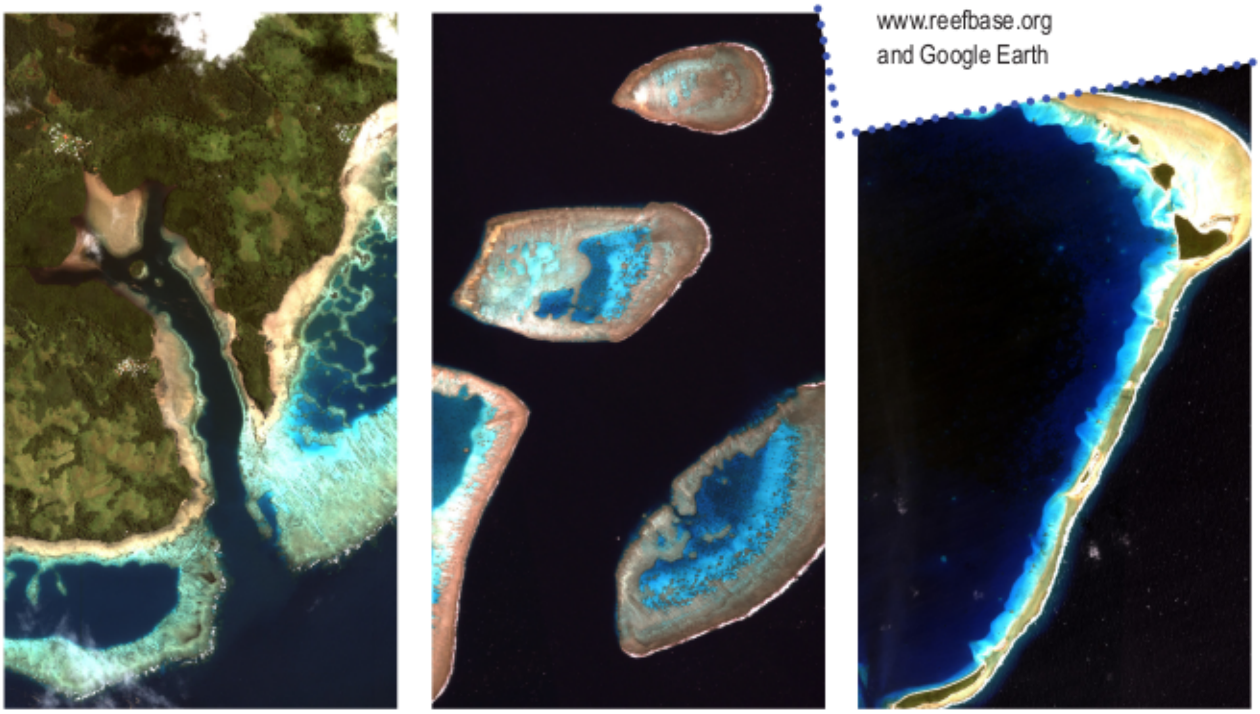
1. Develop an understanding and appreciation of the different types of reefs that occur globally and determine their status.
2. Develop an understanding of the internet tools that use geographical information systems (GIS) and remote sensing imagery to conduct spatial analysis in coral reef environments.

You will first select examples of each of the three reef types: fringing, barrier and atoll reefs, after which you will determine their status *(Figure 1)*.

Tools

- Access to internet www.reefbase.org and Google Earth

Time One hour



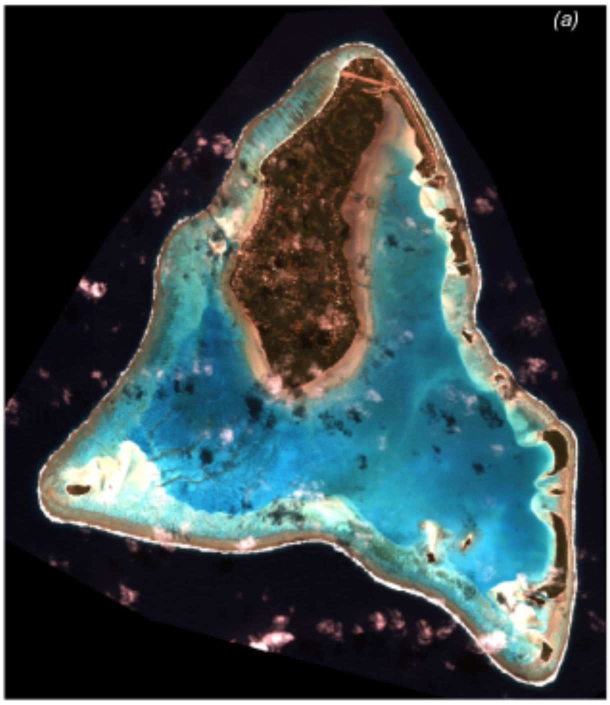
(Figure 1) Examples of a fringing reef in Fiji, barrier reef in Australia and atoll reef in Marshall Islands. All images are high spatial resolution satellite imagery. Source: Centre for Remote Sensing and Spatial Information Science at University of Queensland.

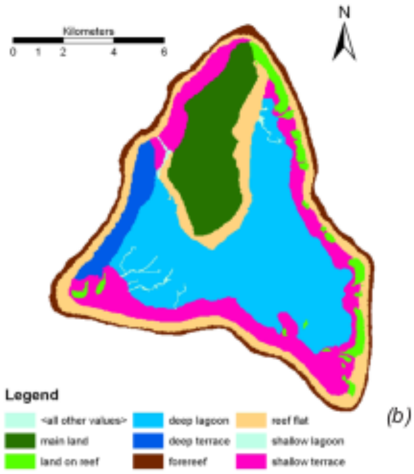
Background

To better understand this activity it is important to read Zones Across the Reef (pages 94-97) in the guide, Coral Reefs and Climate Change. This chapter presents the four major reef types: barrier, fringing, platform and atoll reefs, including examples of each. It further explains reef origins based on geomorphologic processes and changes in sea level.

Coral reefs are located along the coastlines of many nations and are known to be the most biologically productive and diverse ecosystems in the world. Reefs are threatened by a variety of impacts including coral bleaching, coral diseases, sea level rise, coastal development, overfishing, destructive fishing, inland pollution and erosion, and marine pollution. Impacts influence the 'normal' functions of marine habitats and the organisms occupying them, and the surrounding people whose livelihoods depend on healthy reefs. Monitoring and management programs are developed and implemented to better protect the coral reef resources and their biodiversity. Spatial data of biophysical properties (e.g. sea surface temperature, coral reef habitat), often represented by maps, form an integral part of these programs.

As coral reefs are known to cover a large spatial extent, at various depths, varying water clarity and often in remote areas, they are a challenging environment to manage. Satellite or airborne sensors are able to capture imagery of these coral reefs at various temporal (e.g. 1 day, 5 days, 16 days) and spatial scales and are therefore a unique tool used to derive biophysical spatial data that can be used in monitoring programs. The spatial scale has two components: the extent of the area captured by an image (e.g. one reef or several reefs within one image), and the size of the pixels that make up the image and determine the visible detail (e.g. pixel size 2.4m x 2.4m, the size of a small boat lot (Figure 2a), or 25m x 25m, the size of a parking lot). Examples of these programs are the Millennium Coral Reef Habitat Mapping program (Figure 2b), which created maps of coral reefs worldwide showing the geomorphic zones, and NOAA's Coral Reef Watch program, which provide global daily information to predict coral bleaching on coral reefs, or individual reef-based mapping programs (Figure 2c). Water depth, clarity and roughness, however, determine how well biophysical properties can be derived from remote sensing imagery.





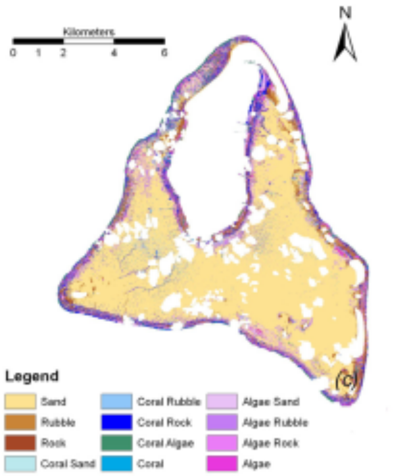


Figure 2: Example for Aitutaki Lagoon Cook Islands of: (a) High Spatial Resolution satellite image Quickbird 2; (b) map of the geomorphic zonation resulting from the Millennium Coral Reef Habitat Mapping Program, and (c) benthic habitat map based on detailed remote sensing processing methods using of the Quickbird 2 image.

Source (a) and (c) South Pacific Applied Geoscience Commission and Centre for Remote Sensing and Spatial Information Science at The University of Queensland.

The strength of spatial data sets derived from satellite imagery is that they have known locations in reference to a coordinate system (e.g. latitude and longitude). As a result, information gathered in the field for which the position is determined with a Global Positioning System (GPS) can be used compared with other spatial data sets. For instance, through reef flat walking, snorkelling or diving, photos or information on the coral cover or from the coral health chart, that have a known GPS position, can be used to create and assess thematic maps of benthic cover (Roelfsema et al 2009) or coral health (Leiper et al 2009). To compare, analyse and/or create maps of spatial data (e.g. map of location of marine parks on top of a habitat map), a Geographic Information Systems (GIS) is used. Examples of GIS are, Google Oceans®, Google Earth®, Microsoft Virtual Earth® and Reef Base GIS (Figure 2). Reef Base host a GIS (http://reefgis.reefbase.org) which specifically provides a spatial information portal of coral reef environments for interested people of the community, scientists and/or managers. The website provides the opportunity to determine what reef types are present in a country and what its threats are.

Classroom activity

Teacher Hint
Explore the Reef Base GIS web site, Google Earth and Marine Remote Sensing Toolkit website before the class room activity.

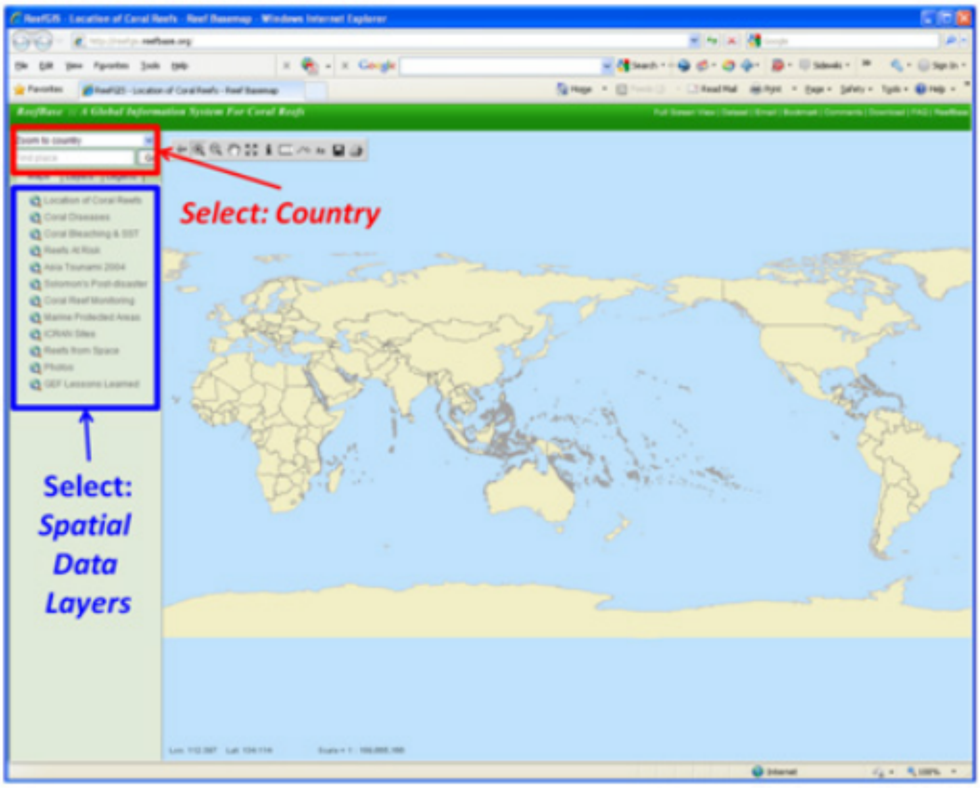


Figure 3: Screenshot of the Reef Base Geographical Information System Website which provides a user interface to assess, question and analyse geographic information related to the reefs of the world by selecting a spatial data layer and a region of interest.

Use http://reefgis.reefbase.org to:

1. Recall where coral reefs are in the world by describing the main regions (e.g. Red Sea).
2. Identify which regions in the world were affected by a severe coral bleaching event during the period January to December 2002 by selecting the spatial data layer: Coral bleaching and SST and then select the dates and refresh the map.
3. Identify the regions which had the largest occurrence of coral disease in the period January to December 2002 by selecting the spatial data layer: Coral diseases, and then select the dates and refresh the map.
4. Locate in South East Asia which countries are mostly threatened in 2002 by: coastal development, overfishing, destructive fishing, or marine pollution by selecting the country and then select the spatial data layer: Reefs at Risk, and refresh the map.
5. Determine areas in South East Asia that are commonly monitored by Reef Check's volunteer monitoring program by selecting the country or zoom into South East Asia and then select the spatial data layer: Coral Reef Monitoring, and refresh the map.
6. For South East Asian countries find out which one's have: atoll reefs, fringing reefs or barrier reefs by selecting the country or zoom into South East Asia and then select the spatial data layer: Location of Coral Reefs, then select the reef and geomorphic type and refresh the map.

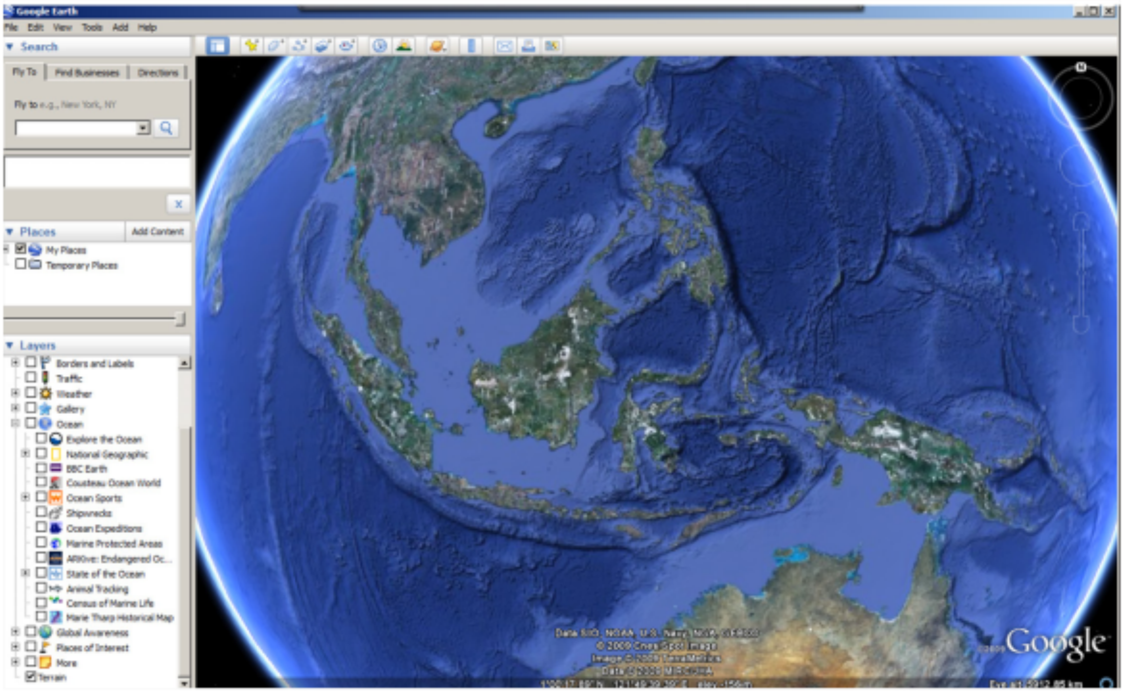


Figure 4: Screen shot of Google Earth zoomed in on the Coral Reef Triangle. Source www.earth.google.com

Use Google Earth *(Figure 4)* **to:**

7. View the satellite imagery of an atoll reef, fringing reef or barrier reef, previously found in Reef Base GIS (task 6) and then describe the location of the reef types in relation to the country by zooming into the area of interest using Google Earth tools and determine the neighbouring countries.
8. For the atoll reef, fringing reef or barrier reef of tasks 6 and 7, describe what you expect are the impacts using a visual assessment of the imagery in location to adjacent countries and oceans. Again, zoom into the area of interest and assess the land adjacent to the reefs on number. Determine the population density by assessing the number of cities or villages or the run of turbid water.

Use Marine Remote Sensing Toolkit *(Figure 5 and 6)* **to:**

Figure 5: Screenshot of Remote Sensing Toolkit, that provides options for managers and scientists planning to use Remote Sensing to map and monitor parameters in terrestrial, marine and atmospheric environments (www.gpem.uq.edu.au/CRSSIS-rstoolkit). Source www.gpem.uq.edu.au/crssis-rstoolkit

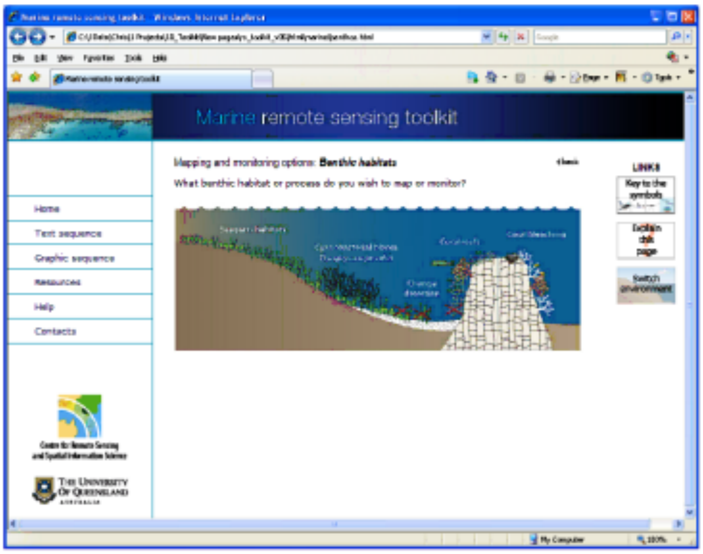


Figure 6: Screenshot of Marine Toolkit where a selection can be made which benthic habitat variable needs to be assessed, such as coral bleaching.
Source www.gpem.uq.edu.au/crssis-rstoolkit

9. Determine what type of remote sensing sensor can be used to derive a map of severe coral bleaching in clear shallow water and maps that predict coral bleaching *(Figure 5)*. Then, go to the marine toolkit user interface and find the suitable monitoring option for a specific environmental variable and use the graphics to determine your remote sensing sensor.
10. Determine what environmental factors influence the capacity of remote sensing to map coral reefs. Read the relevant sections in the marine remote sensing toolkit and interpret the figures.

Questions

1. Explain why management programs need spatial data.
2. Determine the major threats to a reef close to you or of interest to you.
3. Using the images in this activity, describe the difference between a fringing reef, barrier reef and atoll reef.
4. Describe the difference between a satellite or airborne image and a thematic map.
5. Explain the difference between geomorphic zone map and a benthic community map.

Research

1. What reef types will be most influenced by activities on land and why?
2. Use the Marine Remote Sensing Toolkit (www.gpem.uq.edu.au/crssis-rstoolkit) to determine what type of sensor can be used to map a benthic community map in shallow clear water.
3. Discuss the environmental factors that will influence the quality of maps showing benthic habitat in coral reef environments that can be derived from remote sensing imagery.

References

Reid et al. (2009) Coral Reefs and Climate Change: The guide for education and awareness. CoralWatch, The University of Queensland, Brisbane. (See Patterns of Distribution page 86 and Zones across the Reef page 94)

Leiper IA, Siebeck UE, Marshall NJ & Phinn SR (2009) Coral health monitoring: linking coral colour and remote sensing techniques. Canadian Journal of Remote Sensing, 35, 276-286 (supplied on CD)

Roelfsema CM and Phinn SR (2009) A Manual for Conducting Georeferenced Photo Transects Surveys to Assess the Benthos of Coral Reef and Seagrass Habitats, version 3.0. Centre for Remote Sensing and Spatial Information Science, The University of Queensland, Brisbane, Australia (supplied on CD)

Bryant D, Burke L, McManus J and Spalding M (1998) Reefs at Risk: a map-based indicator of threats to the world's coral reefs. World Resources Institute, Washington, D.C.

Google Ocean; www.earth.google.com/ocean

ReefBase; www.reefbase.org

NASA Earth Observatory; www.earthobservatory.nasa.gov

National Oceanic and Atmospheric Administration (NOAA); www.noaa.gov

UQ Centre for Remote Sensing and Spatial Information Science; www.gpem.uq.edu.au/CRSSIS/

Marine Remote Sensing Toolkit; www.gpem.uq.edu.au/crssis-rstoolkit

Millennium Coral Reef Habitat Mapping Program; http://imars.usf.edu/corals/

REMOTE SENSING Handbook for Tropical Coastal Management; www.unesco.org/csi/pub/source/rs.htm