Tools for Management

Marine Remote Sensing Toolkit

A toolkit for technicians, managers and scientists planning to use remote sensing to map and monitor coastal ecosystem health

For effective monitoring, modelling and managing of marine environments such as coral reefs, reliable and cost-effective spatial information is needed. This information can be provided by maps derived from airborne and satellite imaging systems.

As the number of commercial and free airborne and satellite image types is rising, and there is now easier access to public domain and open-source image processing approaches, the choice of which data and processing approach to use is increasingly confusing.

To enable technicians, scientists and managers to make the most appropriate selection of data and a processing approach for a specific environment and application, an interactive, web-based toolkit has been created.

What is the aim of the toolkit?

The Marine Remote Sensing Toolkit aims to show interested parties how images collected from satellites and aircraft can be used to map and monitor changes to commonly used indicators of marine ecosystem health.

Who should use it?

Anyone considering using remote sensing to address a marine science or management question, or trying to understand a map of a coastal or marine ecosystem derived from remote sensing, will find the Marine Remote Sensing Toolkit useful.

The toolkit can be applied to a variety of marine environments including seagrass, coral reefs, mangroves and salt marsh, as well as coastal and oceanic water.

It is also a useful tool for educating interested students or professional marine scientists and technicians.

What should I do first?

Before using the Marine Remote Sensing Toolkit, it is best to assess your particular needs using the mapping needs table, available on the website (see page 2, Table 1). This table forces the user to define their mapping or monitoring needs in the terms that can be used to objectively select suitable image data sets and processing approaches.

Find the Toolkit at: www.gpem.uq.edu.au/cser-rstoolkit/

Technicians, scientists and managers compare a coral reef habitat map with the original satellite image of Aitutaki Lagoon, Cook Island, during a capacity building workshop organised by University of Queensland and South Pacific Applied Geosciences Commission (SOPAC) in Fiji.

The Coral Reef Targeted Research & Capacity Building for Management Program (CRTR) is a leading international coral reef research initiative that provides a coordinated approach to credible, factual and scientifically-proven knowledge for improved coral reef management.

The CRTR Program is a proactive research and capacity building partnership that aims to lay the foundation in filling crucial knowledge gaps in the core research areas of Coral Bleaching, Connectivity, Coral Diseases, Coral Restoration and Remediation, Remote Sensing and Modeling and Decision Support.

Each of these research areas are facilitated by Working Groups underpinned by the skills of many of the world's leading coral reef researchers. The CRTR also supports four Centres of Excellence in priority regions, serving as important regional centres for building confidence and skills in research, training and capacity building.

The CRTR Program is a partnership between the Global Environment Facility, the World Bank, The University of Queensland (Australia), the United States National Oceanic and Atmospheric Administration (NOAA) and approximately 50 research institutes and other third parties around the world.

April 2010

Product code: CRTR 007/2010

Required information to use remotely sensed data for monitoring Coastal ecosystem health indicator(s)	Your mapping or monitoring requirements					
Extent of area to be mapped and monitored	0-50 km^2	50-250 km^2	250-500 km^2	500-5,000 km^2	5,000-50,000 km^2	50,000-km^2
Minimum size of feature to be mapped (i.e. the object you want to see)	extremely fine <5m	fine 5-20m	medium 20-250m	coarse 250-1000m	extremely coarse >1000m	–
Level of *minimum* measurement precision (i.e. smallest measurable change in % coral cover)	0-5%	5-10%	10-25%	25-50%	anything	–
Level of *minimum* measurement accuracy (i.e. required acceptable agreement between estimated and actual value of % coral cover)	anything	Low 10-40%	Medium 40-70%	High 70-90%	Very High 90-100%	–
Time period over which maps are to be updated (e.g. annually)	1-24 hours	1 day	1 week	1 month	3 months	3-5 years
Reason for mapping driven by	Once-off project (e.g. design harbour)	Once-off project, but reccuring for other sites	Event based (e.g. bleaching, vessel grounding)	Continous over time (e.g. 3 yearly seagrass cover)	Retrospective (e.g. mangrove dieback)	–
Access to study site	Easy	Only on demand	Difficult - too remote	Difficult - too many different sites	Dangerous (e.g.crocodiles)	no access
Format information is to be delivered as	Tabular, graphic or numeric summary	Hardcopy map	Digital spatial data	–	–	–

Table 1. Mapping needs table with examples of possible answers.

Marine Remote Sensing Toolkit

How does it work?

The Marine Remote Sensing Toolkit has both a text-based and a graphical version.

Graphical interface

The graphical user interface is suitable for those who prefer a visual model, rather than reading text and tables. It is structured around illustrations of the different monitoring options, marine environments and biophysical variables to be mapped or monitored.

The user has two starting points to choose from depending on what information they seek. They may:

A) Know the specific biophysical variables and environment, and seek to find out which sensor types are suitable for mapping it: or

B) Know the sensor type, and seek to find out which biophysical variables and environment can be mapped with it.

A) From variable to sensor

1. Select the first option of the graphical user interface option – *"From variable to sensor"*
2. Select one of six main groups of biophysical variables (e.g. benthos, water quality, shape of the bottom, coastal features)
3. Select sub-groups of biophysical variables (e.g. for coral in the benthos group)
4. For each subgroup, choose a further biophysical variable (e.g. coral benthic communities)
5. For each biophysical variable, choose a mapping environment. Options include 'in water depth' (exposed, intertidal, shallow or deep); 'water clarity' (clear, clear-turbid or turbid); and water colour (blue, blue/green or brown). The user may therefore end up with 'shallow clear water' as the environment they wish to map.
6. These selections will lead to a final screen which informs the user on the available monitoring options and provides example case studies.

B) From sensor to variable

1. Select the second option of the graphical user interface option – *"From sensor to variable"*
2. Select sensor type or field method
3. Select one of six main groups of biophysical variables (e.g. benthos, water quality, shape of the bottom, coastal features)
4. Select a potential sub-group of a main group (e.g. seagrass)
5. These selections will lead to a final screen that informs the user which biophysical variables can be mapped or monitored for a specific environment.

The toolkit's graphical user interface.

www.gpem.uq.edu.au/cser-rstoolkit/

Example screenshots - the user can choose at which spatial reef scale the benthic variable needs to be mapped (left) followed by a selection of the water depth and water clarity characterising the mapping environment (right).

Text-based interface

The text-based version of the toolkit is suitable for users with preference for reading text and analysing tables. It provides users with similar outcomes to the graphical user interface, however conclusions are based on a series of questions. These questions enable users to find out more about their particular query. Examples of queries may include 'Are mapping and monitoring applicable to my area?' or 'What data dimensions are required?'

What is the toolkit based on?

The toolkit is underpinned by a capability matrix. In simple terms, this matrix cross-tabulates image or field data sets to specific biophysical variables and environment, and indicates the level of capability for these various combinations. The level of capability characterises to what level the data set (e.g. airborne photography) can be used to map the biophysical variable (e.g. seagrass species) under specific environmental conditions (e.g. deep clear water).

The levels of capability assigned to each combination of data set and biophysical variable include:

- not feasible
- feasible but not operational
- feasible but needs further research
- operational
- operational but too cost prohibitive
- operational depending on the size of the feature to be monitored.

The remote sensing data sets are collected mostly from passive or active sensors on satellite or airborne platforms. They also provide options for active sensors deployed from boats, such as echo sounds, or visual observations by snorkelers and divers.

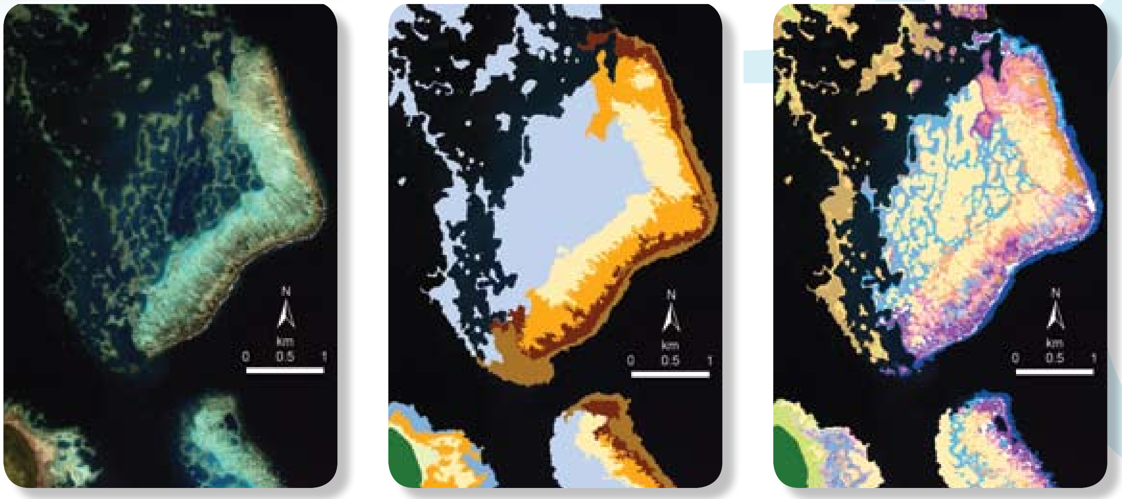
What else does the toolkit provide?

The toolkit provides information on which monitoring option is suitable for change detection and event-based monitoring (e.g. coral bleaching, flood plume mapping, ship grounding, oil spills and the impacts of cyclones).

It contains cases studies for the biophysical variables that provide the required image data required, along with a recommended processing approach and requisite personnel, hardware and software.

The 'help and resources' section provides explanations on the fundamentals of marine remote sensing, image processing, field data collection methods, mapping approaches, accuracy assessment and change detection. It explains the use of the toolkit. The toolkit also provides directions to additional manuals, web sites, scientific publications and reports.

The Marine Remote Sensing Toolkit is part of a bigger web-based remote sensing toolkit that has two other sections - terrestrial and atmospheric. Both have identical functionality to the marine section. The three sections represent the area from deep ocean water to inland mountains, and the atmosphere above it. Together, they present a variety of remote sensing applications and monitoring variables for the three environments which will help users to understand and use optical remote sensing.



Example of how high spatial resolution satellite imagery (left) in combination with field data from a coral reef in Fiji, can result in maps that show information at different spatial scales: geomorphic (middle) and benthic (right). Source: DigitalGlobe and Wildlife Conservation Society

What doesn't the toolkit do?

It does not create maps for users or do any image processing! It does not give one single solution for users' mapping and monitoring needs!

Who supports the toolkit?

A number of organisations have funded development of the Marine Remote Sensing Toolkit, including the CRC for Coastal Zone, Estuaries and Waterways Management; ARC Coral Reef Innovative Mapping; the University of Queensland; CSIRO Land and Water, and the World Bank/GEF Coral Reef Target Research & Capacity Building for Management (CRTR) Program.

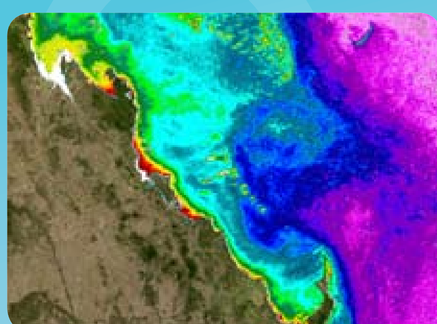
Who created it?

Researchers Chris M. Roelfsema, Stuart R. Phinn, Dieter Tracey from the University of Queensland created the Marine Remote Sensing Toolkit, with support of the students and staff of the Centre for Spatial Environmental Research.

Where can I find it?

The Marine Remote Sensing Toolkit is available online at **www.gpem.uq.edu.au/cser-rstoolkit.**

A student processes a satellite image and field data to create coral reef habitat map.



How are remote sensing images turned into maps of environmental features or processes?

Once an image for a coastal environment is captured, it then undergoes a sequence of image processing operations to allow it to be integrated with other spatial data and to represent a thematic or continuous map of the variable of interest.

Oceanographic patterns are clearly evident from the remote sensing of Chlorophyll a concentrations along the Great Barrier Reef, Australia. Source: NASA

About the CRTR Remote Sensing Working Group

The Remote Sensing Working Group of the Coral Reef Targeted Research & Capacity Building for Management (CRTR) Program investigated the potential and limitations of remote sensing of coral reefs so that the technology can be used to meet realistic and practical management objectives.

In Phase One of the CRTR Program (2004-2009), the Remote Sensing Working Group developed and tested a wide range of remote sensing tools, including satellite, airborne, acoustic and in-field methods.

The Group has achieved its four goals which were to (i) create a decision-support and analysis software for monitoring the health of coral reefs using remote sensing; (ii) develop methods to detect changes in coastal environments; (iii) apply remote sensing to the inventory, monitoring and management of biodiversity; and (iv) create an Ocean Atlas and tools to manage coral bleaching. The Marine Remote Sensing Toolkit contributes to the first goal. For more information on the CRTR Program and the Remote Sensing Working Group, visit www.gefcoral.org.

Participants of a CRTR capacity building workshop learn to use remote sensing as a decision support tool. Photo: Robert Canto

Further Information

Dr. Chris Roelfsema
Biophysical Remote Sensing Group
Centre for Spatial Environmental Research
School of Geography, Planning and Environmental Management
The University of Queensland
Brisbane QLD Australia, 4072

Telephone: +61 7 3365 6977
Email: c.roelfsema@uq.edu.au

Project Executing Agency
Coral Reef Targeted Research & Capacity Building for Management Program
C/- Centre for Marine Studies
The University of Queensland
St Lucia QLD 4072 Australia

Telephone: +61 7 3346 9942
Email: info@gefcoral.org

The CRTR Program is a partnership between the Global Environment Facility, The World Bank, The University of Queensland (Australia), the United States National Oceanic and Atmospheric Administration (NOAA) and approximately 50 research institutes and other third-parties around the world.