Cooperative Research Centre for Coastal Zone, Estuary & Waterway Management

Port Curtis and Fitzroy River Estuary Remote Sensing Tasks

Executive Summary

June 2005

A.G. Dekker and S. Phinn (eds)

The University of Queensland

CSIRO

CRC for Coastal Zone Estuary & Waterway Management

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CRC Phase 1 PC2/FE2 Project

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Executive Summary

Introduction and Structure

From 2000 onwards research teams from CSIRO and the University of Queensland carried out integrated research to establish methods for remote sensing based mapping and monitoring variables of coastal environments that may be used to monitor their condition or health. For the context of this report coastal environments include mangrove wetlands, inter-tidal and sub-tidal sections of a coastal embayment.

The format for this report is based on the four main tasks originally identified by the project team; each of these tasks is outlined below.

Task PC/FE 2.1
Information needs for remote sensing of coastal environments.

Task PC/FE 2.2
Remote sensing products (data and processing techniques) addressing identified specific monitoring and management agency information requirements. This includes an inventory and assessment of availability and accessibility of remotely sensed data for Port Curtis and the Fitzroy Estuary.

Task PC/FE 2.3
Documented techniques for acquiring and processing remotely sensed data in Port Curtis and the Fitzroy Estuary to produce reliable output information. This coastal ecosystem health information consists of relevant aquatic, inter-tidal and terrestrial variables.

Task PC/FE 2.4
Development of remote sensing algorithms for the following environmental zones/variables: aquatic (turbidity, phytoplankton, algal blooms), intertidal, and mangroves.

Task PC/FE 2.5

Calibrated and validated remote sensing data for assimilation into (non-remote sensing) models developed for Port Curtis and the Fitzroy Estuary.

Task PC/FE 2.6
Publications and conferences.

Methods
This projects intended to build on the satellite image processing methods (using commercially available Landsat images) developed in the Moreton Bay project (Phinn & Dekker, 2005) to map the constituents (CDOM – coloured dissolved organic material, tripton – total suspended inorganic material - TSM) controlling the optical properties of a water body, to map the transparency and to map the substratum type and cover. This approach is based on measuring and understanding the underwater light climate characteristics (or properties) controlling the absorption, scattering and transmission of sun and sky light, in different sections of the Fitzroy River Estuary and Port Curtis waters. In simple terms, the approach selects f or each image element (pixel) the appropriate combination of optically active substances. Thresholds based on these specific inherent optical properties are applied using an automated routine that determines how to apply the algorithms for mapping water quality variables (e.g. TSM, CDOM concentration and Secchi disk transparency) and thresholds based on transparency determine where to map the appropriate substrate types.

This project also included a terrestrial mapping and monitoring component. Vegetation index images were calculated for a series of commercially available Landsat images to map changes and trends in vegetation cover in the immediate area of the Fitzroy River Estuary and Port Curtis Harbour. A new form of image analysis was developed to map trends in vegetation cover from a time series of satellite images. The resultant maps serve as a demonstration product for future environmental monitoring programs and can be applied to any image data set or image based products, e.g. this approach could also be applied to the water quality parameter maps developed in the project.

Although preliminary in nature, both the water-based and vegetation-trend processing approaches represent significant improvements for remote sensing of the coastal zone due to: (1) a common international requirement to monitor and manage coastal estuaries around the world to enable sustainable management; (2) the reliable and accurate nature of the results produced; (3) extension and validation of the approaches beyond Moreton Bay and 4) a processing method that is easily adapted to other sensors.

Conclusions
(1) Commercially available, multi-spectral, moderate spatial resolution satellite image data can be used to produce maps of aquatic and terrestrial environmental variables relevant to coastal ecosystem health monitoring in the Fitzroy Estuary and Port Curtis coastal areas.

The project team was able to apply the methods developed in the Moreton Bay project to map the following water quality variables from commercial satellite image data (Landsat 5 Thematic Mapper and Landsat 7 Enhanced Thematic Mapper) collected over Port Curtis and Fitzroy Estuary in 1986, 1990, 1995 and 2002:
- coloured dissolved organic material (CDOM);
- total suspended solids (tripton); and
- Secchi disk transparency.

Distinct optical domains, or zones of water colouration, were evident in the Fitzroy Estuary and Port Curtis water quality maps, and appeared to be controlled by tidal currents and stream flow, along with surface and sub-surface aquatic vegetation.

Due to the predominantly turbid nature of both Port Curtis and Fitzroy Estuary waterways, substrate mapping was not completed using these available Landsat Thematic Mapper (TM)/Enhanced TM (ETM) images, as they were selected for optimal water and land vegetation assessment and not targeted for substratum mapping purposes. Substratum mapping may be possible in Port Curtis under conditions when the tide is low and stream-flow is low, resulting in exposed inter-tidal seagrass beds and visible sub-tidal beds. With the increasing availability of high spatial resolution satellite image data from sensors that can be programmed to image an area at a specific time (currently Quickbird, IKONOS and SPOT) the likelihood of acquiring suitable images for substrate mapping will increase.

Terrestrial environments were also examined as part of this work, focussing on the use of "vegetation indices" to map vegetation cover throughout the immediate coastal areas of Fitzroy Estuary and Port Curtis.

(2) The image processing approach developed for optically complex waters in Moreton Bay can be applied successfully to other coastal environments with different specific inherent optical properties.

The optimised matrix inversion model used to estimate the concentration of organic and inorganic water column constituents was the same model as was developed for Moreton Bay. In this case the model was driven by a set of specific inherent optical properties (SIOP) collected during fieldwork in 2002 in Fitzroy Estuary and Port Curtis areas. Realistic maps of CDOM, TSM and Secchi disk transparency were produced, with the associated error maps clearly indicating areas where substrate was visible or exposed.

(3) Multi-date image analysis techniques can be used to produce maps depicting trends in the state or condition of an environmental parameter over time.

To present the results from multiple dates of vegetation index images in one image that would summarise the change in a pixel's vegetation cover over time, a trend detection approach was developed and applied to a five date series of vegetation index images over the Gladstone area. This approach was applied and validated successfully using multi-date Landsat TM/ETM based normalised difference vegetation index (NDVI) images and aerial photography as a reference source. Areas that showed an increase or decrease in vegetation cover were identified. The approach could also be applied to multi-date substrate cover type and water quality parameter image maps.

(4) Future work can be used to take the demonstration projects presented in this work to operational, accurate and cost-efficient environmental mapping and monitoring programs.

Although the image data used here was the most commonly available commercial product when this project commenced, there are a range of different sensors now operating that could provide at least the same, or probably more information. For water quality monitoring there is a need to enable a high-frequency (e.g. daily) data collection to monitor changes in water quality distribution as its controlling processes act at this temporal scale. Confidence in the model results was assessed, however, more work needs to be completed on the validation of products. Products from the **MOD**erate resolution **I**maging **S**pectrometer (MODIS) and the **ME**dium **R**esolution **I**maging **S**pectrometer (MERIS) sensors should be examined as new data sources, due to their high temporal, spectral and radiometric resolutions, specifically designed for measuring coastal and ocean waters. The same applies to terrestrial vegetation monitoring, where MODIS and MERIS products may also be useful. Potential improvement to seagrass mapping in this region requires assessment of the capabilities of high spatial and radiometric resolution satellite images, along with airborne and satellite hyperspectral imaging sensors. In each case these sensors will improve mapping ability in shallow waters and/or low density seagrass cover.