

eReefs – Transforming the Science and Management of the Great Barrier Reef (eReefs)

eReefs is a collaborative project that contributes to the protection and preservation of the iconic Great Barrier Reef. **eReefs** is built upon an integrated system of data, catchment and marine models, visualisation, reporting and decision support tools that span the entire Great Barrier Reef (GBR) area—from paddock to catchment, estuary, Reef lagoon and ocean. It provides the first comprehensive information platform capable of meeting the many and varied needs of users for access to improved environmental intelligence allowing them to assess past, present, and future conditions and management options to mitigate the risks associated with multiple and sometimes competing uses of the GBR. Importantly, it also forms the first step in building comprehensive coastal information systems for Australia.

eReefs is a public-private collaboration between Australia’s leading research and operational agencies (CSIRO, the Australian Institute of Marine Science, Bureau of Meteorology), endowment funding bodies – including SIEF and the Great Barrier Reef Foundation – representing corporate Australia, the Queensland and Australian governments, and Reef managers and stakeholders.

Innovative science forming the eReefs information platform

Over the past 4 years, the project team funded under the SIEF agreement has delivered highly innovative science that now forms operationally the **eReefs** information platform. This includes:

- Marine Modelling System**
 The centrepiece of the **eReefs** information platform is a whole-of-region, shelf-scale, numerical marine modelling system. The modelling system comprises hydrodynamic models to predict the physical state of the GBR, sediment transport models predicting the fate of suspended fine sediments and a biogeochemical model to predict water column and benthic production, water quality and nutrient cycling. Supporting these components are data assimilation systems, wave models and an offline transport model. Development of these regional models during **eReefs** included: improved bathymetry and methods to account for the presence of reefs; improved representations of open boundary conditions and riverine inputs; improved representation and parameterisation of key biogeochemical and ecological processes such as light availability through the water column, inorganic carbon cycling essential to photosynthesis and respiration, and the dynamic processes determining growth of seagrass, coral and important cyanobacteria. These regional models operate at spatial resolutions of 4km and 1 km and run in near real-time such that current conditions may be estimated, and add to an archive of historic conditions suitable for performing scenario analyses. This provides, for the first time, a comprehensive three-dimensional, time varying, view of the current and historical state of the GBR circulation and water quality.
- RECOM: RElocatable Coastal Model**
 To provide models that can be applied at the scale of individual estuaries, embayments or coral reefs, a highly innovative, web-based modelling environment called RECOM (RElocatable Coastal Model) has been developed. RECOM is designed to be easily accessed by users to quickly establish a model of the area of interest to produce outputs similar to those produced by the regional models. Users can simply and intuitively interact with the models via a graphical interface that includes orthogonal curvilinear grid generation via a ‘point and click’ map interface, selection of parameter sets for sediment transport and biogeochemistry to be applied to the models, and selection of the forcing products and time period for the simulation.

- Automated sensors**

Addressing the need to provide better quantitative and prognostic estimates of river and estuarine discharges and catchment derived loads of nutrients and sediments, **eReefs** has developed and applied sensors that can make automated, near-continuous measurements of water quality and quantity variables. This data has been used to develop empirical models that can be used to better parameterise the marine regional models as well as streamflow forecast models being developed by the BoM as part of **eReefs**.
- BOM Marine Water Quality Dashboard**

Access to satellite-derived synoptic daily maps of water quality for the GBR is now possible through the BoM's [marine water quality dashboard](#). This has been made possible by operationalising CSIRO research products including the development of automated, timely and quality controlled processing of satellite-data from both the ageing MODIS¹ and the more recent (2012) VIIRS² sensors, and with functionality to accommodate many of the new sensors that will become available over the next few years. The accuracy of these products results from the use of algorithms based on the collection of optical data to account for regional variation in atmospheric and in-water conditions of the GBR. Assimilation of water-surface reflectances from these products into the bio-geochemical shelf-scale models has improved the accuracy of these models. New products have been also developed, and are being tested, including particle size, primary production and *Trichodesmium*³.
- Data Brokering Layer**

The backbone of the **eReefs** information platform is an innovative information architecture that enables data from a range of data custodians to contribute to a central Data Brokering Layer (DBL). A set of rules have been developed that help govern how data custodians can contribute to the system. This includes a structured way of adding formal vocabularies to data and establishing data services as part of a Data Provider Node that, once connected to the DBL, provides an interface which can be queried to discover individual data products and services. This information can be discovered dynamically, making it much easier to develop end-user products.
- Visualisation Portal**

Access to these models and datasets has been simplified through the development of a [visualisation portal](#) that allows users to easily find and interact with these **eReefs** products via the web. Users can search for data, discover the available services and metadata and visualise the data in maps and charts. Users can interact with data from multiple data providers within one interface to easily compare different types of data. This interface and the data it holds will continue to expand as the **eReefs** platform moves towards operational maturity.

As demonstrated above, the technical components of the **eReefs** information platform have been built. The models are supported on an ongoing basis by the CSIRO, while the remote sensing components are supported by the BoM and CSIRO. However, much remains to be done to make it a fully operational information system. Over the remaining 5 months of the project, further work will be undertaken to establish operational standards and procedures ranging from data quality standards to service level agreements, establishing verification and validation processes that ensure the integrity and usability of the data and products, and mitigation strategies for dependencies such as access to external data and models.

¹ MODerate resolution Imaging Spectrometer

² Visible Infrared Imager Radiometer Suite

³ a diazotrophic blue/green phytoplankton that forms large blooms across the Great Barrier Reef

Other components of **eReefs** (not funded by SIEF) are due to be completed by **eReefs** partners in late 2017 and include improved catchment flow forecasting as inputs to the real-time models, improvements to catchments model output to better link with the marine receiving model, development of short-term forecasting model and applications, and the development of trend and indicator reporting products.

The demand for **eReefs**

While uptake and adoption of **eReefs** is expected to increase once the project transitions to being fully operational the demand already from a number of users is very strong:

- The BoM operationalised the satellite-derived products of **eReefs** in its [marine water quality dashboard](#). Outputs are used by the GBRMPA in its marine monitoring program for reporting current water quality conditions.
- CSIRO operates the the shelf-scale and RECOM models and a pre-operational remote sensing sensing system and makes these data and visual outputs available through its [eReefs Research Portal](#). This data is particularly used by a number of Reef scientists to assist their research.
- **eReefs** is recognised — and will be relied upon — in many of the new GBR policies and programs currently being designed and implemented by the Australian and Queensland governments. This includes [Reef 2050 Plan](#), and the [Reef Water Quality Protection Plan](#) and supporting programs such as [Reef Integrated Monitoring and Reporting Program](#) (RIMREP) and [Reef Trust](#). For example, the Queensland Government has asked the CSIRO to use the regional models to inform the development of the next generation of water quality targets and guideline values for the GBR.
- The use of the RECOM models has been of direct benefit already in informing the development of an environmental report card for the Mackay Whitsunday River to Reef Partnership. Similarly, the Prawn Aquaculture industry is seeking to apply RECOM to assist in the siting of new facilities that meet stringent environmental regulations.
- Nationally, the *regional* approach taken in **eReefs** is being advocated in the recent [National Marine Science Plan](#).
- Internationally, many of the components of the **eReefs** information platform will built upon in a new project (*AcuaPacífico*) which will be undertaken in Chile to develop an information system for the Salmon Aquaculture industry.

Over the coming years, further adoption is envisaged by other stakeholders including the aquaculture industry (e.g. siting and operation of facilities), tourism (short-term condition forecasts), shipping and port industries (dredging operations, safe navigation) and the insurance and utilities industries (risk assessment and forecasting of flood inundation). Successful adoption by these industries will rely upon close engagement to understand user requirements, and the ability to deliver customised quality assured products at an agreed level of operational service.

eReefs has already — and is expected to continue — to generate significant economic, social and environmental impacts. The principal impact of **eReefs** is in transforming reef management, protecting and assisting in the long-term preservation of the Great Barrier Reef. **eReefs** achieves this by providing environmental intelligence that underpins sound decision-making by government and industry alike. The flow-on effects are many-fold such as acceptability or otherwise by regional communities (social license) or informing decisions from international bodies such as the [UNESCO World Heritage Committee](#). Economically, a recently commissioned impact report⁴ on **eReefs**, estimated on conservative assumptions, the net present value of the **eReefs** project is some \$80 million in 2015-16 dollars, has a benefit-cost ratio (BCR), of 11.4 and should generate \$18.5 million per year by 2018-19.

⁴ ACIL Allen Consulting (2016). eReefs Impact Study.