Tropical Water Quality Hub

National Environmental Science Programme

Reef & Rainforest RESEARCH CENTRE

Final Report

1 January 2015 - 30 June 2021



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The Tropical Water Quality hub is funded by the Australian Government's National Environmental Science Program

National Environmental Science Program
TROPICAL WATER QUALITY HUB
FINAL REPORT
1 January 2015 – 30 June 2021

Hub Name (full activity title): Tropical Water Quality Hub

Host organisation: Reef and Rainforest Research Centre

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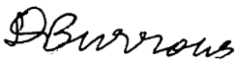
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Other consortium partners/subcontractors/research organisations: Australian Institute of Marine Science; James Cook University; Griffith University; CSIRO; University of Queensland; CQ University

Hub Leader Certification

As Hub Leader, I certify that I have taken adequate steps to reasonably assure myself that:

- each required report component is attached;
- the contents of each component of the report is complete and accurate in all material respects;
- funds have been used for the purpose for which they were provided and all funding conditions have been met, Recipient and Other Contributions have been received, and appropriate oversight has been maintained of Hub projects, their progress, performance and budgets during the reporting period;
- all relevant risks to project delivery have been notified to the Department in this and previous reports and that appropriate steps are being taken to manage those risks;
- the Hub and its sub-contractors have current workers compensation and public liability insurances, as required under the Funding Agreement; and
- any unallocated funds have been identified for refund to the Department.

Signed: 

Hub Leader Name: Prof. Damien Burrows

Date: 12 July 2021

Hub Steering Committee Chair Certification:

As steering committee chair, I certify that any issues of concern or matters raised during Steering Committee meetings where the Final Report was discussed have been adequately resolved, amended or incorporated into the Final Report submitted to the Department.

Signed: 

Hub Steering Committee Chair Name: Ms Leith Boully

Date: 12 July 2021

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Letter from the Hub Leader

NESP research is driven by end-user needs and is thus highly applied, focusing upon delivering tangible on-ground outcomes for environmental management, policy development or social/behaviour change, within the timeframe of the program. As the NESP Tropical Water Quality (TWQ) Hub winds up its operations, we are seeing numerous examples of where, in addition to generating new knowledge, our work has made significant tangible differences to on-ground works, policy, management plans and has greatly influenced other funding schemes. For example, the Great Barrier Reef Foundation (GBRF) has adopted the Crown-of-thorns starfish (COTS) Integrated Pest Management (IPM) approach, pioneered through NESP TWQ Hub research, as the basis for their $58M investment into COTS management.

The TWQ Hub has focused its activities across 4 major thematic areas – achieving control of crown-of-thorns starfish, reduced nutrient and sediment losses to the Great Barrier Reef (GBR), restoration of wetlands and coastal habitats, and management responses to bleaching. All funding has been allocated, including any changes associated with outstanding activity to address the recently identified underspend.

Introducing and successfully implementing an IPM framework to the COTS control program has been the most significant achievement of the Hub. Previous COTS control research efforts were dispersed and had not enabled control to be achieved at any meaningful scale. Implementation of the IPM approach across the 5 boats involved in the field control program has delivered a strategic response to COTS control, greatly reducing the amount of coral that is lost to these predators, creating biodiversity benefits, program cost savings and reducing further spread of COTS. Prior to the introduction of IPM through NESP investments, extensive ecological control of COTS had not been achieved on any reef, but has now been achieved around the entire perimeter on 90% of 103 reefs targeted for control.

The TWQ Hub invested in a range of projects that worked in partnership with a range of stakeholders to reduce sediment and nutrient losses to the GBR in accordance with the goals for the Reef 2050 Water Quality Improvement Plan. Our work on reducing nutrient losses focused, via Project 25, utilising technology advances to enable real-time water quality sampling and project co-design to build trust with farmers in the science that underpins reef water quality targets. The Project 25 approach delivered significant improvements in cooperation between farmer attitudes towards water quality improvements and the need to adopt improved practices. The farmers are using water quality data collected in Project 25 to identify hot-spots within their catchment, and local industry leaders are taking it upon themselves to liaise with fellow farmers whenever poor water quality results are obtained. Under NESP many farmers are now keen to adopt additional forms of water quality and wider catchment management such as drainage control and reinstating local catchment hydrology, which will be further explored under GBRF – Reef Trust Partnership funding. The Project 25 approach has now been adopted by other programs within the GBR catchment.

Our sediment research focused upon gullies, both large and small, the main source of sediment to the GBR. Government agencies have committed more than $65M to gully rehabilitation during the years of NESP. NESP TWQ Hub research has shown that gully rehabilitation can reduce sediment losses by 80-90% and have quantified the costs of rehabilitation across a wide range of scenarios. Prior to NESP research, many considered gully rehabilitation, especially of the larger alluvial gullies, to be cost-prohibitive. However, our research on gully types and prioritisation has shown that a small proportion of gullies, typically 1-3% of the gullies in a catchment, contribute 30-50% of the fine sediment. The high priority gullies were mapped under NESP TWQ Hub across 529,000ha of key catchment areas via development of a new aerial assessment method that is much more efficient,

and up to four orders of magnitude more accurate, than the gully density mapping previously used. By mapping and identifying the priority gullies, trialling various rehabilitation techniques and quantifying the costs and benefits of rehabilitation, the task of meeting reef sediment guidelines becomes more achievable. NESP TWQ Hub research indicates that we can get halfway to the Reef 2050 sediment targets by identifying and treating the most sediment-intensive and cost-effective 2% of gullies. The team's contributions to water quality improvements for the GBR were recognised in 2017 with the awarding of a Eureka Prize.

A key benefit of NESP Hubs is their ability to be flexible and rapidly respond to emerging priorities. Two key examples illustrate this point for the TWQ Hub. Back-to-back mass coral bleaching events were recorded on the GBR in the summers of 2016 and 2017. The Hub, pivoted at short notice their intended research direction, to commission a series of projects that looked at resilience and management options for the GBR in the face of bleaching. Some of this work has formed part of the Great Barrier Reef Marine Park Authority (GBRMPA) Resilience Blueprint and other parts have formed part of the Reef Restoration and Adaptation Program (RRAP), a new >$100M investment for the GBR. In a similar instance, Hub researchers broke the story that the largest mangrove dieback ever recorded in the world had occurred along 2,000 km of the Gulf of Carpentaria shoreline. In response to this event, the TWQ Hub partnered with the NESP Northern Australia Environmental Resources (NAER) Hub to co-fund an investigation into this dieback, which had generated world headlines.

Close collaboration between Traditional Owners and NESP TWQ Hub science has resulted in better co-management of country and improved water quality. Across all research projects and Hub governance, Indigenous engagement and participation has been a priority. The TWQ Hub's design of the three-category approach to Indigenous engagement in research projects was shared with all of the Hubs for their use. Researchers have passed on valuable skills to Indigenous Ranger groups for land and sea monitoring. Together with scientists, Traditional Owners have actioned cultural site clearance and preliminary assessments, gained new skills in wetland rehabilitation, feral pest management, land and sea country mapping, grass seed collection, gully remediation construction, estuary and mangrove management, salinity monitoring, water quality sampling, equipment maintenance, weed management and general site management. Training in jellyfish stinger collection and identification, shoreline video assessment, coral identification and restoration techniques are just some of the skills that have been passed on to maintain healthy country.

Three major symposiums were held throughout the life of the Hub attracting national and international delegates. The inaugural Great Barrier Reef Restoration Symposium held in July 2018 brought together restoration practitioners, scientists, engineers, environmental managers, non-government organisations and industry partners from around the world, to share experiences, insights and ideas for coral restoration. In November 2018, an Innovative Nitrogen Use in Sugarcane Forum was held highlighting the research on nitrogen in sugarcane productivity, profitability and reef water quality. Finally, in 2021, the Impacts and Achievements of the NESP Tropical Water Quality Hub was held. Over two days, scientists and end users presented their research outcomes and perspectives on the practical application of the research and benefit to stakeholders.

The NESP TWQ Hub adheres to the principles of making all data freely available. The NESP TWQ Hub's data repository, eAtlas (www.eatlas.org.au) has received >100 datasets/scripts from TWQ Hub projects for publication. The website provides not only a long-term data archive that will be maintained well beyond NESP, but interactive and visualisation products and receives on average, 6,000 users per month.

Whilst we are immensely proud of our achievements that have demonstrably improved social, economic and environmental outcomes across a number of topical areas, an additional lasting legacy of the TWQ Hub not to be overlooked is our impact on the way that environmental scientific research is conducted. The TWQ Hub has fostered a cultural shift in the GBR research community towards collaborative, integrated, solution-focused research programs, driven by stakeholder needs rather than academic or institutional interest. For many leading researchers, this approach has now become standard practice. In time, I believe this cultural shift will be our most evident enduring legacy.

Research

Achievement of hub outcomes

The NESP Tropical Water Quality (TWQ) Hub focused on innovative research for practical solutions to the water quality challenges facing policymakers, industries and communities from catchment to coast, particularly in the Great Barrier Reef (GBR) region. As stated in the research scope, intended activity outcomes were:

- Coastal management (including rivers and streams) and risk abatement for environmental impacts on tropical water quality from infrastructure, agriculture, extreme events and biosecurity threats;
- Management, monitoring and reporting for coastal species including status, trends and threatening processes; and
- Practical delivery of tropical water quality trials.

Throughout the life of the Hub, research users and research providers have been engaged in a collaborative process to co-develop projects to address current and emerging priorities including:

- crown-of-thorns starfish outbreak mitigation
- wetland and coral restoration
- developing tools for resilience-based management of the GBR
- behavioural and practice change for water quality improvement
- improved water quality targets, monitoring methods and indicators for the RIMRep and the Reef 2050 Plan
- identification, prioritisation and management of sediment and nutrient sources
- Indigenous co-management of species and habitats
- Cumulative coastal impacts including ports and shipping.

During the reporting period of **1 January 2015 – 30 June 2021**, the TWQ Hub funded projects to meet the Minister's research priorities and key end user and stakeholder research needs. At the end of the reporting period, the TWQ Hub had funded 100 projects throughout the life of the Hub including eight synthesis projects in Research Plan v6. These projects met the research priorities of more than 60 end user organisations including Traditional Owners, the Australian and Queensland governments, non-government organisations from grazing, agriculture, tourism and natural resource management bodies. The Australian Government funding of $31.98M to the NESP TWQ Hub leveraged an additional $35.3M in cash and in-kind co-contributions over the six years of the Hub.

The TWQ Hub research outcomes were directed at supporting strategic policy and management directions for the Australian Government agencies, the Queensland Government Office of the GBR and industry stakeholders including the Reef 2050 Plan, RRAP and RIMReP. The synthesis projects approved in Research Plan v6 will contribute to the next Scientific Consensus Statement.

The RPv6 projects have synthesised Hub research outcomes for:

- Innovations in COTS control on the GBR
- Restoring ecosystems from catchment to reef
- Reducing nitrogen runoff without reducing industry productivity
- Reducing end-of-catchment fine sediment loads and ecosystem impacts
- Improving coral condition through better-informed resilience-based management
- Influencing agriculture practice behaviour change and trust frameworks
- Learnings from applied environmental research programs: elements for success

- Integrated environmental assessment to inform environmental decisions (all Hubs).

Research projects

Attachment A lists the projects funded under the Tropical Water Quality Hub and provides information on the project status, information on outputs and links to products for all projects (where available). Exceptions to the NESP Data Management and Accessibility Guidelines are also noted here.

Performance against milestones

Performance against Funding Agreement Milestones

All milestones for the period and to date have been met as per Funding Agreement Milestones 1-30.

Performance against the Research Plan milestones

Information on project progress and performance is provided in Attachment A.

Measuring success

The National Environmental Science Program (NESP) is a long-term commitment to support environmental and climate research. The key objective of the NESP is to improve our understanding of Australia's environment through collaborative research that delivers accessible results and informs decision making. The focus of NESP is on practical and applied research that informs on-ground action and that will yield measurable improvements to the environment.

The Program builds on its predecessors - the National Environmental Research Program and the Australian Climate Change Science Program – in securing for decision makers the best available information to support understanding, managing and conserving Australia's environment.

The NESP is delivered through multi-disciplinary research hubs or consortia, hosted by Australian research institutions.

The NESP seeks to achieve its objective by supporting research that:

- is practical and applied and informs on-ground action
- addresses the needs of the Australian Government and other stakeholders by supporting and informing evidence-based policy and improving management of the Australian environment
- is innovative and internationally recognised
- enhances Australia's environmental research capacity
- is collaborative and builds critical mass by drawing on multiple disciplines, research institutions and organisations to address challenging research questions
- produces meaningful results accessible to government, industry and the community
- includes synthesis and analysis of existing knowledge
- builds relationships between scientists and policy-makers to encourage collaborative problem solving on environmental issues.

NESP end-users are a broad range of stakeholders whose decisions may impact on the environment, and include the Australian Government, state governments, industry, business, community groups and Indigenous land managers (or Indigenous Communities).

The intended outcomes of the NESP are:

- Enhanced understanding of, and capacity to manage and conserve Australia's environment.
- Improved climate and weather information for Australia through a greater understanding of the drivers of Australia's climate.
- Timely research that is used by policy and decision-makers to answer questions and provide solutions to problems.
- Research outcomes that are communicated clearly to end-users and the general public, and stored in a manner that is discoverable and accessible.

Table A: Quantitative performance measures

Key Performance Indicator	Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (numerical only)	Explanation (if any)
1. Percent of projects (active or completed in the reporting period) for which there is a research-user actively engaged in the project.	**100%**	
2. Percent of projects approved under RPV1-6 in which research-users were actively involved in project design.	**100%**	
3. Number of research outputs provided to end users **on time**[1] and as identified in the Research Plans.	**287**	
4. Proportion of research outputs provided to end users **on time** and as identified in the Research Plans.	**75%**	Project approved extensions and external peer-review requirements have delayed delivery of some outputs to end users on time as identified in the Research Plan.
5. Number of instances of where the hub has used NESP-generated information from another NESP hub.	**110**	
6. Number of peer reviewed NESP-funded publications during the reporting period.	**171**	
7. Number of NESP research citations in other researchers' publications during the reporting period.	**1,712**	
8. Number of researchers, including PhD and Post-Doc positions engaged as a result of NESP (total, Full-time equivalent) during the reporting period.	**282 (FTE 44.85)**	Reporting on period 1 Jan 2020 - 30 June 2021.
9. Number of data sets provided to the Hub, or made publicly available, by third parties for the purposes of informing NESP research.	**121**	This KPI began in Annual Report 4.
10. Percentage of data sets made publicly available under open licence by the Hub.	**90%**	Finalisation of eAtlas products and datasets is awaiting reception of all final reports from outstanding projects. Some third party datasets are not approved for upload to the eAtlas.
11. Percentage of NESP research outputs (including publications, data and metadata) that are discoverable and accessible in accordance with NESP data accessibility requirements and the funding agreement.	**95%**	Projects 6.8, 7.3-7.6 are not completed and have adjusted the KPI to reflect this.
12. Number and FTE of Indigenous people employed in a project (separate into full and part time positions).	**42 (FTE 8.5)**	All part-time positions.

[1] On time – delivered on the date the outputs were expected to be delivered

Key Performance Indicator	Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (numerical only)	Explanation (if any)
13. Number of Indigenous researchers/graduates/post-graduate/PhD/Post Doc Positions in projects.	**9**	
14. Number of Indigenous people trained in the use of environmental management tools and techniques.	**373**	
15. The number of management tools for Indigenous waters and land that benefitted from NESP research and outcomes (including but not limited to Plans of Management for IPAs, Co/Joint managed parks, Marine Park Plans of Management, Conservation Agreements).	**33**	
16. Number and type of communication products that have been used to communicate research with Indigenous people.	**111**	Types of products have included emails; letters; presentations; videos; information sheets; workshop; factsheets; training material; face-to-face conversations
17. Number of research, knowledge sharing and communication events held with Indigenous communities.	**212**	In addition, Indigenous peoples attended and presented at the Hub Impacts and Achievements Conference (2021) and the Great Barrier Reef Coral Restoration Symposium (2018).
18. Number of public events, conference presentations, jointly authored/published papers with Indigenous participants/contributors.	**47**	
19. Hub website uploads	**497**	Uploads to 30 June 2021

NESP impact stories

NESP impact stories are provided at Attachment B. These stories showcase the contribution of NESP funded research to the environment, the economy, society, culture, public policy, quality of life, beyond contributions to academia.

Financial Information

Financial reporting

Financial information for the Tropical Water Quality Hub is provided at Attachments C and D.

The Hub notified the department on the 8th June 2021 of an underspend of $189,600 due to returned funds from partner institutions. The department approved four additional short-term projects for knowledge repatriation of NESP TWQ Hub research to end-users, Traditional Owners and industry organisations. These projects are:

- Project 7.3: Extension and awareness of 'Project 25' outcomes to industry and natural resource sectors for improved reef water quality outcomes (NESP $ 50,000; Other $50,000)
- Project 7.4: Technical nitrogen use workshop: for farming leaders, industry and government (NESP $42,000; Other $42,000)
- Project 7.5: Putting the science into Great Barrier Reef Citizen Science (NESP $50,000; Other $50,000)
- Project 7.6: Extension and awareness of NESP TWQ Hub wetland restoration and management impact (NESP $47,600; Other $47,600)

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV6**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs					Outcomes
					NESP Funding* $	Other Cash Contributions - $	Other In-Kind Contributions - $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
1.1	Establishing the future NESP CoTS research framework including an ecologically-based approach to the management of CoTS at multiple scales	This project will lay the foundations for the development of a reliable CoTS surveillance and control program based on detailed understanding of i) CoTS ecology, population dynamics and movement, ii) the CoTS control program's capabilities and constraints, and, iii) IPM principles. In the project's initial phase a COTS Integrated Pest Management (IPM) Workshop will be conducted. This workshop will bring together managers and researchers with purpose of defining a tactical approach to current COTS management and a strategic approach for the management of future outbreaks. This will be achieved through the development of management-focused qualitative models of the CoTS/control system. These models will be used to identify key system components and associated knowledge gaps and will provide the logical structure of a future quantitative simulation model to test and compare alternative management scenarios. These two frameworks, and the data needs identified to operationalise them, will form the basis for the development of a COTS Strategic Research plan. It is envisaged this Project will lead into the COTS IPM Program and provide the direction for COTS research under future NESP investment.	Dr David Westcott	CSIRO	100,000	0	123,374	123,374	223,374	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A			1.1	15.8	No	N/A			N/A	N/A	See Outputs RPV1	The project developed a management-focused qualitative model to determine the optimal trade-off between investment into surveillance versus investment into COTS control activities in the GBR. The outputs derived from the model offer significant potential improvement to the effectiveness of control operations by as much as 70% through appropriate investment in surveillance. The project identified six current and future management contexts: (1) control at sites and local areas; (2) protection of assets; (3) reduction of the spread of the current outbreak; (4) prevention of future primary outbreaks in the initiation box; (5) managing ultimate causes; and (6) the implementation of non-manual controls. For each context the knowledge gaps preventing implementation or limiting effectiveness were identified and classified into four clear areas for research investment: 1. Optimise control at sites and local areas. 2. Optimise control at regional scales. 3. Address outbreak causes. 4. Develop new control technologies. These research areas were integrated into a research strategy that provides a sequence of work to deliver improved operations immediately and deliver improved pest management into the future.
1.2	Developing an approach to evaluate the effectiveness of investments in riparian management in the GBR catchments	The current tools used to estimate the contribution of bank erosion to the Great Barrier Reef (i.e. Source Catchments model), are based on empirical relationships using little or no data from tropical river systems. This project proposes to develop a revised methodology for estimating (a) the natural or benchmark rates of bank erosion in tropical rivers (b) how this information can be coupled with improved data sets on channel morphology, site connectivity and sediment particle size to develop a more robust approach for identifying sites amendable to remediation and (c) where riparian restoration has occurred, evaluate the effectiveness of the remediation.	Rebecca Bartley	CSIRO	99,972	0	68,022	68,022	167,994	RPV1	01/07/2015	30/03/2016	Completed	N/A	N/A		N/A			1.2.1	15.3	No	N/A					See Outputs RPV1	The Fitzroy and Mackay Whitsunday catchments were used as case study sites to test the effectiveness of riparian vegetation for reducing streambank erosion. Using all known data on streambank erosion rates (or channel change) for these GBR catchments, this study specifically tested the hypothesis that sites with more riparian vegetation (>75%) will be more stable and undergo less change in channel width than sites with less riparian vegetation (<50%). Using historical aerial photos (circa 1950 to 2012) for measuring changes in channel width, it was found that remediation approaches implemented by NRM bodies was not directly but rather indirectly influencing riparian zones by removing stock, using fencing or installing off-site stock watering points. Results also showed that: 1. Effects of remediation would take between 2-18 years for water quality improvement; 2. Amount and condition of upstream riparian vegetation was important in reducing run-off; and 3. Using historical aerial photos can provide important insights into how channels have changed over the recent (~50 year) past. Riparian vegetation on its own will, at best, provide a local buffer to erosion and it is recommended that at least 10% of a project budget should be retained to evaluate the effectiveness of on-ground remediation works on water quality using monitoring points.
1.3	A validation of coral geochemical records to reconstruct suspended sediment loads to the Great Barrier Reef lagoon	While coral geochemistry records are widely cited as evidence for increased suspended sediment loads delivered to the Great Barrier Reef since the 1850s, there has been little replication or quantification of the records. Indeed, most records are based on cores collected prior to the year 2000 when limited catchment monitoring data existed to 'validate' the interpretations that certain trace element ratios provided proxies of annual sediment loadings. This project will analyse the geochemistry of coral cores collected in 2012 from sites in the central GBR and compare the ratios to measured sediment and particulate nutrient loads from the Burdekin River	Stephen Lewis	James Cook University	22,500	0	14,686	14,686	37,186	RPV1	01/07/2015	31/01/2016	Completed	N/A	N/A		N/A			1.2.1	14.1	No	N/A					See Outputs RPV1	Previous studies have speculated that the Ba/Ca, Y/Ca and Mn/Ca ratios in coral skeletons are related to land use change and sediment loading from adjacent river catchments to the GBR. A transect of coral cores collected from Magnetic Island, Havannah Island, Pandora Reef and Pelorus Island in August 2012 for the first time, directly examined the link between these trace element ratios in corals and measured sediment and particulate nutrient loads. These sites receive varying influence from the Burdekin River flood plume and provided an opportunity to compare the incorporation of trace elements in the corals from the different locations across single flood events. If a correlation could be established, this novel, independent technique would be able to quantify pre- and post-European suspended sediment loads to the GBR. Results of the analysis are currently withheld from publication.
1.5	Legacy of the Lower Burdekin Water Quality Tender	This project conducts an ex-post evaluation of a water quality tender (auction) project. In 2007-08, a water quality pilot tender was trialled in the Lower Burdekin River area, funded by the Australian Government through the National Market Based Instruments and co-funded and administered by the NQ Dry Tropics. This project will collaborate with NQ Dry Tropics and engage with tender participants to review design, operational, administrative and other matters of the trial. It will evaluate the effectiveness of the tender to achieve long-term change and identify strengths as well as opportunities for improvement. The research will inform economic theory and future tenders.	Romy Greiner	James Cook University	39,795	0	2,984	2,984	42,779	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A			3.5.1	6.6	No	N/A					See Outputs RPV1	This project sought to explore the legacy of the Lower Burdekin Water Quality Tender, in particular its enduring benefits for water quality in the GBR and to summarise any lessons that could inform the design of future tender-based environmental funding programs. The research found a high level of persistence of investments and continuing functionality, meaning that water quality benefits continue to accrue. In particular, the Tender process: • Engaged in an information and communications strategy that generated high levels of participant satisfaction during Tender implementation, but once funding decisions were made the level of transparency and communication became less satisfactory. • Incentivised the participation of many farmers who had not previously addressed water quality or participated in any NRM programs. • Effected learning about the impacts of agriculture on water quality – irrespective of the success of proposals – and thereby generated intrinsic motivation for many Tender participants to want to do more about improving water quality on their land. • Sparked a series of subsequent investments into water quality improvements, many of which were entirely funded by the farmers while others were undertaken with the assistance of other NRM funding programs. • Triggered and/or facilitated farming-systems change to more environmentally benign practices in some instances.
1.6	Multiple and cumulative impacts on the GBR: assessment of current status and development of improved approaches for management	This project will synthesize experimental and field data from NERP, MTSRF and other work for key coral reef organisms and processes to produce a quantitative approach or how multiple pressures lead to cumulative impacts on the GBR. Applying quantitative tools developed for ecotoxicology and water quality guidelines, we will investigate critical interactive effects, environmental thresholds and their uncertainties, and their application in risk assessments. In addition, we will develop a roadmap that clearly articulates the steps towards a management framework to assess and manage the cumulative impacts of multiple local stressors within the context global pressures on the GBR.	Sven Uthicke	Australian Institute of Marine Science (AIMS)	99,944	0	87,569	87,569	187,513	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A			1.4	11.4 14.2	No	N/A	Uthicke, S., K. Fabricius, G. Da'ath, A. Negri, R. Smith, M. Warrne, S. Noonan, C. Johansen, H. Gorrach, and K. Anthony. 2016. Multiple and cumulative impacts on the GBR: assessment of current status and development of improved approaches for management. Final Report Project 1.6. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (144pp.).				See Outputs RPV1	The project outcomes were: (1) summary and synthesis of existing experimental work on cumulative stressors, (2) analysis of field data on stressors and thresholds, (3) testing statistical tools used in toxicology, and (4) investigating a novel tool for risk assessment. The project explored the relative importance of different drivers (e.g. climate change, run-off, sediment resuspension) and activities (e.g. dredging) in causing coral mortality risk under a set of environmental scenarios. Limitations were identified in the current interpretation of interactive effects of multiple stressors on reef components and processes, with the recommendation that a combination of tools from different disciplines – statistical, ecotoxicological, conceptual, semi-quantitative and quantitative mechanistic models, structured decision analyses – are essential to advance understanding of cumulative impacts. The project identified the generation of risk and exposure maps, together with the assessment of pressure and value thresholds, as key approaches to improving understanding of the accumulation of pressures on specific locations or ecological communities. This will better inform management decisions (e.g. for the purpose of assessing permit applications). A prototype is recommended for production of risk maps, by incorporating: (i) spatially explicit data (such as those available via eReefs and eAtlas) on the temporal variability of pressures, and (ii) improved mechanistic understanding of how multiple pressures interact and the ecological consequences. The project developed a roadmap that articulates the steps towards a management framework to assess and manage the cumulative impacts of multiple local stressors within the context of global pressures on the GBR.
1.7	Reducing sediment sources to the Reef: testing the effectiveness of managing alluvial gully erosion	Alluvial gully erosion contributes 20-40% of fine sediment from the three largest sediment contributing catchments to the GBR, yet there has been limited effort to manage this major sediment source. Cost effective reduction of sediment from these alluvial gullies requires data on effective management strategies. We will take advantage of a 'natural experiment' that occurred when Cyclone Ita passed over existing trialk management sites in the Normanby catchment. The project will evaluate the effectiveness of different management strategies to reduce erosion from alluvial gullies. To complement this, we will collect baseline data at additional sites in the Normanby and Burdekin catchments.	Andrew Brooks	Griffith University	100,000	20,000	140,000	160,000	260,000	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A			1.2	15.3	No	N/A					See Outputs RPV1	A series of four moderate scale (2 – 5 ha) cattle exclusion trial sites were established on Kings Plains, Springvale and Crocodile Stations in the Normanby catchment in 2011. A total of 117 vegetation survey plots were established both inside and outside these exclusion plots in 2011, and the sites were all resurveyed in November 2015. Qualitative assessment of the sites suggests that these treatments of sediment yield reduction (75% after 2 years) could be achieved and will withstand the onslaught of multiple cyclones, providing they are maintained as complete stock exclusion zones. This project further tested the hypothesis that surface and sub-surface soils from grazing lands could be highly significant sources of anthropogenically accelerated nutrients to the GBR. At each gully site in the Normanby catchment, samples were collected from the floodplain surface, the gully surface, the gully sub-surface and the material in the bed of the gully. Analyses of nutrient, physical and geochemical parameters on three sediment size fractions (whole soil, <63 um fraction and <10 um fraction) have been completed.
1.8	Sub-catchment scale monitoring, modelling and extension design to support reef water quality improvement	Design of a pilot sub-catchment scale monitoring, modelling and extension program, based on end-user workshop, existing risk assessments, monitoring and modelling programs, for subsequent implementation with farmer's support to identify reef pollutant "spikes/hotspots", their causes and the necessary areas for extension to improve management. Pilot implementation to test the design with the assistance of farmers, extension providers, etc. in a particular local area to underpin future initiatives such as nutrient trading. Subsequently, implementation, monitoring and evaluation of an extension program based on any refinements resulting from the pilot study findings. Use of additional information from implementation as one line of evidence assisting in development and trialing of market based instruments (indicates outcomes of this project that will be subsequently implemented and funded by DEHP, etc. (and hence do not form any directly funded part of this proposal)).	Aaron Davis	James Cook University	100,000	0	130,000	130,000	230,000	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A			1.2.2	12.4 14.1	No	N/A					See Outputs RPV1	Recent GBR and global experiences increasingly recognise that despite its 'diffuse' nature, non-point source pollution still often originates in 'hotspots' or 'critical source areas' from a small portion of the landscape; areas which can be targeted for maximum intervention efficiency. Finer scale water quality monitoring projects integrating farm up to small watershed-scale monitoring-management frameworks (with a key emphasis on stakeholder collaboration and participatory learning processes) are now key mechanisms for achieving water quality improvements. A range of initiatives at the NRM regional level, particularly recently developed Water Quality Improvement Plans (WQIPs), were synthesised to provide spatially explicit data on water quality 'hotspots' at a finer, catchment and sub-catchment scales. A monitoring program design framework presents a range of different 'gold, silver and bronze' standards to accommodate different program objectives, desired levels of integration with other monitoring-modelling initiatives, local capacities and levels available for investment. The range of 'bronze' to 'gold' standard program designs offer some flexibility in the level of investment required to meet different program objectives. These different levels of program design need not be mutually exclusive and even the implementation of an optimal 'gold standard' program will likely have to start modestly (bronze-silver level), which slowly evolves through a carefully staged, adaptive approach. Feedback loops to industry allow farmers to recognise themselves as part of the problem, but also part of the solution. The 'gold standard' of this hierarchy, would entail a stakeholder-guided collaborative approach that uses multiple targeted monitoring sites through a catchment to integrate stakeholder engagement in both the decision-making process and in the implementation of water quality management strategies. The monitoring design framework also provides options for integrating program outcomes into broader, concurrent water quality monitoring modelling programs currently underway in the GBRCA.
1.9	The establishment of a future NESP dredging research investment framework	The project will conduct an inclusive facilitated workshop with key researchers and stakeholders to identify the future knowledge needs for improved management of dredging activities in the GBR. Building upon the recent dredging synthesis and other resources, this workshop will distill a clear, prioritised research framework to inform future NESP investment into dredging research. The framework will: (i) define the scope of work required to develop and apply improved sediment transport models for the GBR lagoon, (ii) identify and quantify the type and extent of ecological impacts, especially of maintenance dredging activities and (iii) identify management options including innovative amelioration approaches.	Britta Schaffelke	Australian Institute of Marine Science (AIMS)	25,000	0	11,197	11,197	36,197	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A			1.4	14.2	No	N/A					See Outputs RPV1	The project synthesised a list of 21 potential research sub-themes for consideration and prioritisation by researchers and stakeholders from industry and government agencies. An initial online survey identified six high priority sub-themes, which were presented and discussed by 30 diverse participants at a facilitated workshop. Distillation into a list of two high and one secondary priority research themes was achieved at the workshop with widespread support. The priority themes will address gaps in understanding of ecological thresholds caused by dredging-related pressures, dredging sediment transport pathways and research to understand the risks associated with disposal of dredge material on land. The resultant priorities to consider in subsequent funding calls were: Priority 1a: Develop critical ecological tolerance thresholds for light reduction, suspended sediments and sediment deposition to predict ecological impacts of dredging operations. Priority 1b: Better quantification of sediment transport pathways over relevant timeframe. Priority 2: Assessment of potential impacts and risks associated with disposal of dredge material on land and in reclamation areas.

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV4?**	Changes from RPV5	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes
					NESP Funding* $	Other Cash Contributions + $	Other In-Kind Contributions + $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
1.10	Identification, impacts, and prioritization of emerging contaminants present in the Great Barrier Reef and Torres Strait marine environments	Increased human activities in the GBR and Torres Strait regions are expected to increase the sources and diversity of contaminants in their marine environments. Here, we will (i) determine the presence and locations of emerging contaminants based on monitoring data and the types of human activities present, and (ii) prioritise the identified emerging contaminants based on their potential risk to these marine environments. Based on the list of priority emerging contaminants, we will develop and recommend key areas of research to inform management and policy decisions that will maintain and improve the condition of the marine environments in the GBR and Torres Strait regions.	Frederieke Kroon	Australian Institute of Marine Science (AIMS)	100,000	9,825	93,397	103,222	203,222	RPV1	01/07/2015	15/03/2016	Completed	N/A	N/A		N/A		2.3.1	12.4 14.1	No	N/A					See Outputs RPV1	The project identified emerging contaminants likely to be present and of potential concern to the GBR and Torres Strait marine environments. These include heavy and trace metals, new (alternative) pesticides, hydrocarbons, coal dust, pharmaceuticals, personal care products, nano particles, antifouling paints, and marine debris (including microplastics). Monitoring information on concentrations of most (but not all) of these emerging contaminants is either rare, not available or absent in the GBR and Torres Strait marine environments. The qualitative risk assessment determined that of the nine emerging contaminants examined, marine plastic pollution poses the highest risk to marine ecosystems, particularly in the Cape York and Torres Strait regions due to exposure to oceanic and local shipping sources. Compared to current pollutants of concern (sediment, nutrients and PSII herbicides), the risk assessment suggests that marine plastic pollution is likely to pose a higher risk to Torres Strait and Cape York marine ecosystems. The next emerging pollutants of concern are chronic contamination of water and sediments with antifouling paints, and exposure to certain personal care products, in regions south of Cape York. The qualitative risks of all other emerging contaminants are relatively low with some minor differences between regions. The project developed water quality guideline values for four alternative pesticides (2,4-D, Metribuzin, Imazapic, Isoxaflutole) commonly found in GBR waters. Recommended research areas include: (1) local, targeted monitoring for priority emerging contaminants where there is little or no recent monitoring data; and (2) examining the ecological impacts of marine plastic pollution, chronic contamination of antifouling paints, and certain personal care products on GBR and Torres Strait marine organisms and ecosystems. Whilst this report has not led to a change in MMP it was considered in the physico-chemical theme group for program design for RIMReP. Independent of the MMP funded work AIMS are understood to be conducting monitoring for microplastics to establish baselines and inform management.
2.1	Assessing the cumulative impacts of climatic disturbances on inshore GBR coral reefs, identifying key refuges and testing the viability of manipulative reef restoration	The Keppel Islands, southern GBR, suffered successive climatic disturbance events (coral bleaching, flood plumes) between 2006 and 2013. Long-term monitoring at 26 sites revealed significant declines in coral cover and fish abundance on both no-take reserve (green zone) and fished reefs. In February 2015, Cyclone Marcia (Category 5) hit the Keppel Islands. We propose to re-survey all 26 monitoring sites to quantify cyclone damage and to identify remaining refuge areas that can support reef recovery and long-term resilience. We also propose to conduct a pilot-scale experiment on degraded reefs in the Keppel Islands to assess the viability of active reef restoration.	Geoff Jones	James Cook University	85,000	0	162,312	162,312	247,312	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A		2.1	13.1 14.2	No	N/A					See Outputs RPV1	Assessment of the current status of coral and fish communities in the Keppel Islands compared to the long-term monitoring dataset collected since 2004 revealed significant declines in live hard coral cover and fish abundances on both no-take (green zone) reserves and fished reefs between 2004 and 2015. Underwater surveys carried out at 20 monitoring sites in October 2015 documented a high degree of spatial patchiness in the condition of coral reefs. 21% of reefs surveyed were highly degraded, with <5% hard coral cover, >50% macroalgae cover, and low fish abundances and diversity. While 13% reefs retained at least 45% coral cover and are postulated to provide a refuge for coral (predominantly Acropora spp.) from cyclone and other damage. Overall in the Keppel Islands, hard coral cover is currently around 30% and coral community recovery is underway at a number of reef sites. The abundance of coral trout (Plectropomus spp.) has fluctuated considerably since 2004 and is highly correlated with the cover of live hard coral cover, habitat structural complexity and prey abundance. No-take (green) zone reefs continue to support higher abundances of larger coral trout than reefs that are open to fishing, however the magnitude of the difference is not as pronounced as it was 2004 and 2006, when reef health and productivity was at its highest. Protection of live coral and reef habitat structural complexity remain a high priority in the Keppel Islands, with reefs that support relatively high levels of live coral evidently the most resilient reefs within the island group. These refuge reefs provide important local stores of coral reef biodiversity, and contribute to the replenishment and recovery of degraded reefs through larval supply.
2.2	A tradable permit scheme for cost effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef	This project will undertake a scoping study to design a pilot nitrogen trading scheme for key cane growing catchments draining into the Great Barrier Reef lagoon. The study will synthesise the current understanding of nitrogen dynamics, local expertise and on-ground practices from the cane industry, with lessons from successful nutrient trading programs elsewhere. Tradable permit simulation will estimate the cost effectiveness of the scheme for reducing nitrogen loads into the GBR, and the financial impact on sugarcane growers. Core enablers will be identified and key steps for implementation will be formulated, including governance structure and monitoring mechanisms.	Jim Smart	Griffith University	99,721	0	181,361	181,361	281,082	RPV1	01/08/2015	29/02/2016	Completed	N/A	N/A		N/A		2.5	14.1	No	N/A					See Outputs RPV1	The key elements of a successful water quality-trading scheme identified are the establishment of a regulatory cap, clear identification of the pollutants to be traded and geographic trading area, development of trading rules and supportive institutional structures. Tradable permit simulation estimated the cost-effectiveness of the scheme for reducing nitrogen loads into the GBR, and the financial impact on sugarcane growers. Core enablers were identified and key steps for implementation were formulated, including governance structure and monitoring mechanisms. A spatially-specific model of a nitrogen-trading market was constructed for the Tully catchment by collating data on sugarcane area, soil class and the Tully drainage network. Nitrogen-trading was simulated using a grid of 4,020 'paddock-scale' 250 m x 250 m cells, each trading as a separate entity in a centralised smart market. Trading of permits in the 'Smart Market' reduces the total cost impact on the cane growing section of the industry to achieve nitrogen reduction targets. As the cap tightens the market price for nitrogen increases and turning marginally productive cane land in key locations to wetlands becomes economically viable. Market simulation results suggest that reducing nitrogen fertiliser applications to 120 kgN/ha may be sufficient to achieve the 50% DIN load reduction target of the Reef 2050 Long Term Sustainability Plan.
3.1	Seagrass mapping synthesis – A resource for marine park and coastal management	Key to understanding the desired state of Queensland seagrasses is reliable data on seagrass distribution, abundance and species composition, and how this changes through time. Also valuable is the ability to reliably "drill" down from large-scale (World Heritage Area) to small-scale estuaries and meadows. TropWATER provides a composite map of seagrass for the GBRWHA available through E-Atlas, GBRMPA and Pangaea. However this layer has not been updated since 2010 and is missing changes from important areas and extensive new data, and provides no meadow-specific information. This project will recompile existing GIS layers, update with 2010-2015 data, and provide meadow-specific information.	Rob Coles	James Cook University	30,000	0	66,257	66,257	102,257	RPV1	01/07/2015	15/02/2016	Completed	N/A	N/A		N/A		3.2	14.2	No	N/A	NESP Science Day Presentation	Yes	43083	http://tiny.cc/2e0cbf	See Outputs RPV1	The project consolidated all available seagrass site and meadow-specific spatial data (approximately 320 separate data sets) for the GBR World Heritage Area (GBRWHA) collected by the TropWATER Seagrass Group and CSIRO into a Geographic Information System (GIS) layers database. The data includes species and meadow distribution and associated metadata. Twelve seagrass species from three families were included from 66,201 sites sampled in the GBR World Heritage Area between 1984 and 2014. Datasets now include multiple surveys for ports and shipping projects that have not been included in previous composite seagrass meadow layers. The study identified areas where much of the data available for management is more than 20 years old or where there are specific habitats unsurveyed. Large areas of central and northern Queensland require updating. Several key habitat types such as reef platform seagrass meadows are poorly represented in the data. The database will be made available on eAtlas.
3.2	Improving historical estimates of abundance and distribution of dugongs and large green turtles in western and central Torres Strait	This project will improve the accuracy of aerial survey estimates of the size and distribution of dugong and green turtle populations in western and central Torres Strait by: (1) collecting and analysing data on their movements and diving behaviour, and (2) estimating the proportion of turtles seen during aerial surveys that are the large female green turtles harvested by indigenous hunters. These data will then be used to (re)estimate the size and distribution of the populations of dugongs and harvestable green turtles in Torres Strait by (re) analysing historical aerial survey data collected in 2001, 2005, 2006, 2011 and 2013.	Helene Marsh	James Cook University	87,674	0	283,547	283,547	381,221	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A		3.2.1	14.2	No	N/A					See Outputs RPV1	The project has calculated improved estimates of dugong and turtle populations in the western and central Torres Strait. The Torres Strait dugong population is substantially higher than previously estimated because most dugongs in Torres Strait occur in water 5-20 m deep where they are out of the sight of aerial observers. The estimate of the foraging green turtle population in Torres Strait is less certain than for dugong. The fisheries independent data is limited, especially given mounting evidence of recruitment failure at Raine Island, the major rookery for the northern Great Barrier Reef green turtle stock. Tracking results have also provided valuable insight into the movement of dugongs and green turtles in the Torres Strait: 1. Dugongs range widely in western Torres Strait, crossing sea country boundaries and jurisdictional borders. One animal travelled twice between its capture site in Badu Sea country to waters around Boigu. 2. Of the nine green turtles that were tagged, most did not range outside the Torres Strait and three travelled from Badu sea country to Raine Island to breed, and then returned. The green turtles that ranged within the Torres Strait are unlikely to have bred in the 2015/16 season.
3.3	Light thresholds for seagrasses of the GBR: a synthesis and guiding document for managing seagrass	Light levels (i.e. water quality/turbidity) can be managed to minimise seagrass losses. Recent attempts to define threshold levels of light required to maintain GBR seagrass state has resulted in a spectrum of recommendations with no single definitive source document to guide regulation. We will compile the available information on light thresholds into a guiding document, which will become a key reference for managers and regulators to use in generating relevant water quality guidelines and conditions for developments such as dredging programs. It will also highlight research information needs and provide interim guidelines for immediate management application.	Catherine Collier	James Cook University	29,755	0	51,746	51,746	81,501	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A		2.3.2	14.2	No	N/A					See Outputs RPV1	The work on benthic light thresholds has been adopted as Authority guidelines and are implemented through Queensland's Environmental Protection (Water) Policy 2009 for the Reef catchment. The MMP implemented light monitoring following a MTSRF report in 2009 that identified light as a key driver in state (also a Collier et al). The MMP considers the threshold work in its reporting.
3.4	Developing and refining biological indicators for seagrass condition assessments in an integrated monitoring program	Refinement of biological indicators for condition assessment is an immediate priority as highlighted in a recent review of the GBR Marine Monitoring Program (MMP). Seagrass carbohydrate content is an early-warning indicator of water quality impacts. Samples collected quarterly since 2008 will be analysed and used to establish baselines and optimize protocols for applying carbohydrates as an indicator for future monitoring. Furthermore, calibration formulae to convert seagrass percent cover, the principal condition indicator, to biomass will be developed allowing integration across programs critical for the Reef-wide Integrated Monitoring and Reporting Program. This project provides excellent value for money because samples have been collected in-kind.	Catherine Collier	James Cook University	68,583	0	195,244	195,244	263,827	RPV1	01/07/2015	31/01/2016	Completed	N/A	N/A		N/A		3.3.1	14.2	No	N/A					See Outputs RPV1	Two indicators were examined: (1) carbohydrate stores in seagrass rhizomes, and (2) calibration formulae for integrating percent cover and biomass data. Carbohydrate results from 2008–2015 provided almost 1,000 samples that represent three seagrass species – Halodule uninervis (586 samples), Thalassia hemprichii (229 samples), and Cymodocea serrulata (177 samples). The sampling period (2008–2015) was affected by extreme weather events (high rainfall and flooding), which influenced seagrass abundance and composition, and resulted in some gaps in the long-term data set. Results show that there are differences among species in predominant carbohydrate storage form. Carbohydrate content was affected by seagrass condition; although further work is required to develop conclusively recommend carbohydrate content as a biological indicator. A preliminary exploration of results has demonstrated a good relationship between seagrass percent cover and biomass, which was improved when canopy height was factored into the calibration and continued refinement of biomass calibrations for other species and habitats will increase the utility of this indicator.
3.5	Assessment of key dugong and turtle seagrass resources in the northern Torres Strait	This project fills a critical information gap for dugong and turtle habitat management in the Torres Strait. It describes seagrasses in a recently identified data deficient region in northern Torres Strait that contains large dugong and turtle populations and is the subject of a proposed extension of the existing Dugong Sanctuary. The baseline assessments will form the foundation for ongoing monitoring, and provide essential information to the TSRA, Australian and Queensland governments for dugong and turtle management plans, complimenting dugong and turtle research studies in the region and building skills and capacity of Traditional Owners and Rangers.	Michael Rasheed	James Cook University	99,696	0	57,654	57,654	157,350	RPV1	01/07/2015	31/01/2016	Completed	N/A	N/A		N/A		3.2.1	14.2	No	N/A					See Outputs RPV1	Over 853 sites were surveyed in intertidal and subtidal areas for seagrass presence/absence, percent cover, above ground biomass, species composition and diversity, as well as seagrass and habitat forming benthic macro-invertebrate communities. Project results from the field surveys have found: 1. Substantial areas of previously undescribed seagrass habitat in the northern Torres Strait, particularly in shallow and intertidal locations (area bounded by Deliverance, Turnagain and Boigu Islands), but sparse elsewhere likely due to strong currents south of Deliverance Island and high suspended sediments close to PNG. 2. Seagrass was present at 43% of sites and 60,263 ha across 34 meadows of seagrass area was mapped. 3. Ten seagrass species from three families were identified. The most dominant species in terms of contribution to mean biomass was T. hemprichii (35%), and H. uninervis was the most commonly occurring species. 4. Evidence that these areas are highly utilised by dugong, with extensive areas of dugong feeding scars present along the PNG coast and around Boigu Island. Subtidal meadow distribution mapped in this study overlaps spatially with very high dugong and turtle density distributions recorded during aerial surveys.

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Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes	
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
3.6	Establishing a research framework for future NESP investment into better understanding of the presence of Box-Jellyfishes (Irukandji) and risks in the Great Barrier Reef	This project intends to conduct a workshop with key researchers and stakeholders to establish the future research framework for NESP investment into better understanding of box-jellyfishes presence and risk in the Great Barrier Reef. This will include defining the scope of work required to: identify how species of Irukandji and stingers respond to changing water quality conditions, predictions of box-jellyfishes presence based on environmental conditions, determine ecological impacts, innovative management options. We will engage with stakeholders to discuss scientific information already available, research gaps to be filled and develop a framework to guide future NESP research to meet end-user needs.	Mike Kingsford	James Cook University	20,000	0	58,747	58,747	88,747	RPV1	01/07/2015	28/02/2016	Completed	N/A	N/A		N/A		3.3.3	14.2	No	N/A					See Outputs RPV1	The project team engaged with stakeholders to discuss scientific information already available, research gaps to be filled and develop a framework to guide future NESP research to meet end-user needs. The workshop focused on defining the scope of research required to: identify how species of Irukandji and other box-jellyfishes respond to changing water quality conditions, predictions of box-jellyfishes presence based on environmental conditions, determine ecological impacts, and innovative management options. The key outcomes from the workshop include: 1. Early warning by forecasting (models), detection (e.g. with jellycams) and accurate identification when jellyfish are collected – the information would in turn be inputted to a revitalised alert system – including developing an 'app.' 2. The development of risk models that are supported by good husbandry of jellyfish (and their benthic polyps) for experiments on the influence of water quality. Continued engagement with stakeholders has developed a series of needs that focus on: (1) building a jellyfish database; (2) developing a forecast model to reduce the risk of stings; (3) test those models – including the use of Rangers; (4) providing on-beach quick ID of jellyfish using digital cameras; (5) delivering more accurate forecast of stings to stakeholders.
3.7	Monitoring the effects of zoning on coral reefs and their associated fish communities in the GBR Marine Park	This project describes the activities of the AIMS long-term program to monitor the effects of zoning on coral reef communities in the period July-October 2015. - In that period there will be one survey trip (out of four made annually) to the southern GBR (Capricorn-Bunker and Swain Reefs) using the RV Cape Ferguson - As well as forming part of the long-term program, these reefs are interesting as they are recovering from the effects of severe storms, notably TC Hamish in 2009. - Initial findings will be reported to stakeholder via a "Survey update", with more comprehensive reporting when surveys of reefs in all regions are complete. (June 2016)	Hugh Sweatman	Australian Institute of Marine Science (AIMS)	100,000	0	195,702	195,702	295,702	RPV1	01/07/2015	30/12/2015	Completed	N/A	N/A		N/A		3.3.1	14.2	No	N/A					See Outputs RPV1	The AIMS monitoring team surveyed the effects of marine park zoning on reef communities – fish and corals – in the Capricorn-Bunker group in October 2015. The four pairs of reefs were chosen to be similar in size, setting, and underwater topography. One reef in each pair is open to fishing while the other was closed to fishing and zoned as a no-take (green) zone. The abundance and biomass of the primary target species of the reef line fishery – coral trout – were higher on no-take reefs in the Capricorn-Bunker group. However there were no consistent differences between open and closed reefs in the numbers of herbivorous fishes, which are considered to be important for reef resilience. These reefs were damaged by storms in 2008 and 2009 but coral cover is recovering rapidly, however, here were no consistent differences in cover of live hard coral or the abundance of juvenile hard corals between open and closed reefs. These results concur with the overall findings of long-term surveys on the GBR since 2006 that protection from fishing has a clear effect on target species, but few indirect effects on other components of the reef community.
3.8	Towards an integrated monitoring program: identifying indicators and existing monitoring programs to cost-effectively evaluate the Long Term Sustainability Plan	This project addresses a series of critical initial steps required to develop a cost-effective integrated monitoring program. First, environmental, social and economic elements and indicators will be identified that could be monitored to enable an integrated evaluation of the Long Term Sustainability Plan (LTSP) targets. Second, existing monitoring programs will be evaluated against the newly developed LTSP targets, to ensure that the relevant aspects of these monitoring programs are considered for inclusion in an integrated monitoring program. Finally, the statistical performance of the AIMS Long Term and Marine Monitoring Programs will be evaluated to illustrate how these programs could cost-effectively contribute to an integrated monitoring program.	Prue Addison	Australian Institute of Marine Science (AIMS)	100,000	0	84,236	84,236	184,236	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A		3.3.1	11.4	No	N/A					See Outputs RPV1	This project addressed a series of critical initial steps required to develop a cost-effective integrated monitoring program: (1) identified a suite of environmental, social and economic elements and indicators that could be monitored to enable an evaluation of the LTSP targets; (2) evaluated existing environmental, social and economic monitoring programs against the newly developed LTSP targets, to ensure that the relevant aspects of these monitoring program are considered for inclusion in an integrated monitoring program; and, (3) evaluated how the AIMS Long Term and Marine Monitoring Programs can cost-effectively contribute to the integrated monitoring program. The project findings provide: 1. Breakdown of the LTSP targets and objectives to assist in the identification and/or development of appropriate and effective indicators to identify the environmental and socio-economic values and attributes that could be monitored to assess progress towards the LTSP targets and objectives. 2. Inventory of existing monitoring programs, and assessment of the relevance of the marine monitoring programs to measure the environmental and socio-economic values and attributes of the LTSP. 3. Assessment of the statistical power of the AIMS Long Term and Marine Monitoring Programs to determine their capacity to detect changes at scales relevant to the LTSP. All project outputs, including a full monitoring program inventory, were delivered to end-users, including the Reef Integrated Monitoring Representative Program (RIMReP) Design working group, to assist in the development of an integrated monitoring and reporting program for the GBR.
3.9	Indigenous capacity building and increased participation in management of Queensland sea country	This project intends to facilitate targeted consultations with key individuals and institutions (i.e. Torres Strait Regional Authority, GBR TO's and Land Councils, etc.) to seek feedback on the implementation of the NESP TWQ Hub Indigenous Engagement and Participation Strategy (IEPS). This will enable the evolution of a strong implementation Strategy for the IEPS. A number of Indigenous community liaison officers (part-time) will be engaged to work at the local level to analyse, scope and prioritise Indigenous specific targets/actions identified within and arising from the 2050 LTSP and to inform future TWQ Hub research priorities (the Research Plan). The project will set the parameters for, and commence development of an Indigenous specific Implementation Strategy and investment framework for the future co-management of sea country.	Melissa George	CSIRO NAILSMA	100,000	0	90,471	90,471	190,471	RPV1	01/07/2015	30/03/2016	Completed	N/A	N/A		N/A		3.6.2	11.4 14.2	No	N/A					See Outputs RPV1	Investigation and analysis of the coordinated framework for increasing Indigenous engagement in sea country management is critical in taking forward co-management with the Australian and Queensland governments and the Great Barrier Reef Marine Park Authority. The key components identified were: (1) strengthen capacity of local Indigenous land and sea management organisations; (2) develop partnership frameworks for the engagement of government and non-government organisations; and (3) support open engagement with information and knowledge generation. At this time, the mechanisms for cohesive and coordinated implementation of the LTSP do not yet fundamentally engage Traditional Owners as real partners in the long-term management of sea country.
3.10	Benchmarking costs of NRM improvements for the GBR	This project aims to provide information on cost benchmarks for key management actions to improve water quality into the GBR. The project involves a review and evaluation of summary data about NRM projects that have been funded recently to address water quality issues. By pooling the data across NRM regions and different activities, it will be possible to identify the distribution of cost/outcome ratios. From this, potential benchmarks can be established (e.g. 75% of sediment reduction actions are less than $xxx/tonne, 95% are less than $XXX per ton). It also provides some identification of the most cost-effective strategies across actions and regions.	John Rolfe	Central Queensland University	29,497	7,372	57,821	65,193	94,680	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A		3.4.2	14.2	No	N/A					See Outputs RPV1	This project summarised and evaluated available data on the cost-effectiveness of improvements in agricultural water quality within GBR catchments to provide benchmarks on cost-effectiveness across the key pollutants to help prioritise future investments in water quality. Cost-effectiveness is the ratio of water quality improvements (such as reductions in sediment or nutrient loads) to the costs of achieving the change. Rigorous modelling indicates the approximate cost-effectiveness thresholds can be set at the average of achieved and predicted costs for end-of-catchment loads as sediment ($259/tonne); nitrogen (DIN) ($150/kg); and pesticide (PSII) ($8,351/kg). These benchmarks should be treated as average thresholds for allocating project funds, both between and within regions. It is likely that lower cost projects can be achieved through more targeted program design and better assessment of cost-effectiveness.
3.11	Monitoring and adaptively reducing system-wide governance risks facing the GBR	Australian governments have addressed water quality issues in the Great Barrier Reef (Reef) over the last decade. While much has improved, more is needed. Reef environmental outcomes, however, depend on the interplay among diverse/fragmented governance "activities" (e.g. water allocation, ports-planning, regional NRM). Despite being recognised in the Reef 2050 Long-Term Sustainability Plan (LTSP), there is no coordinated system for benchmarking/monitoring the health of the overall Reef governance system/ constituent activities. NERP supported a new method for doing so. This project both delivers short term influence over key Commonwealth and State (i.e. GBR Taskforce) decisions regarding management and investment and engages new LTSP implementation/review structures and stakeholders to build commitment to institutionalizing this method over the longer. Outputs will be directly integrated into and inform five-yearly Outlook reporting.	Allan Dale	James Cook University	55,537	0	101,326	101,326	156,863	RPV1	01/07/2015	15/03/2016	Completed	N/A	N/A		N/A		3.4.2	11.4	No	N/A					See Outputs RPV1	Using the GBR World Heritage Area as a case study of international significance, this project applied Governance Systems Analysis (GSA), a novel analytical framework that identifies, benchmarks and enables a more independent and integrated review of the key risks within the overall system of governance. The application of GSA enabled the identification of those governance themes, domains and subdomains most likely to influence environmental and related social and economic outcomes in the GBR. Overall, the implementation of the LTSP water quality improvement targets will remain unachievable if there is not a substantive focus on integrated reform of the key delivery-focused governance subdomains that deliver coordinative and on ground actions within GBR catchments. Three broad-scale dilemmas will affect the capacity of the LTSP in influencing the wider system of governance in mediating GBR outcomes: (1) the LTSP has little mandate or capacity to influence several high risk domains and subdomains not directly related to day-to-day GBR management; (2) the LTSP has significant governance challenges; and (3) the LTSP is not yet substantively guiding and aligning the efforts of other stakeholders, such as NRM bodies, to the effective delivery of effort at the catchment scale in the GBR. Progressing reform in these three areas will require a strong bilateral commitment between the Australian and Queensland governments to jointly monitor and adaptively improve the overarching system of governance effecting GBR outcomes. Engagement on this project has specifically included the following activities: • A major round of structured stakeholder interviews to raise awareness and understanding of the previously published method and to review emerging findings (June to Nov.); • Development of a two draft papers (for intended international publication) concerning findings and recommendations from the first round of the benchmarking-based approach (Sept. to Dec.); and • Structured discussions (sponsored by GBRMPA) with the new Commonwealth and State institutional arrangements established for implementing/reviewing the LTSP, exploring opportunities for institutionalizing the emerging monitoring approach (Nov to Dec.).
3.12	Development of an offset financial contribution calculator for Reef Trust	This project will progress an approach for incorporating environmental offsets into the Reef Trust through development of a prototype calculator to assist potential approval holders and relevant agencies in determining appropriate financial payments as offsets under the Reef Trust. It will extend the methodology currently used to calculate terrestrial offsets to the marine setting. It will delineate clearly the differences in applying such a calculator to the marine–catchment continuum and terrestrial settings. A draft prototype will be tested for its consistency with operational needs and practicality among key stakeholders.	Martine Maron	University of Queensland	80,595	20,149	16,818	36,967	117,562	RPV1	01/07/2015	31/03/2016	Completed	N/A	N/A		N/A		3.5.2	11.4	No	N/A					See Outputs RPV1	'Biodiversity offsets' are a mechanism by which the permitted environmental impacts of development projects are compensated through conservation activities that yield a gain at least equivalent to the impact. Current offsets in Australia, while inclusive of the marine environment, were conceptualised primarily for terrestrial ecosystems and have most often been applied in terrestrial settings. The project team has developed an easy-to-use excel prototype calculator that is based on terrestrial offset calculators used in Australia and international best practice, but adapted for the GBR context. The prototype calculator is an easy-to-use excel tool that considers surrogates; surrogate condition factor; implementation costs; time delay; and administration fees. Results of the analysis are currently withheld from publication.
3.13	eAtlas 2015 - NESP data management, Torres Strait NRM plan delivery platform and Torres Strait reef mapping	This proposal covers the activities of the eAtlas in 2015 (July - December). These are: The eAtlas has approximately 50 datasets that were recently submitted for review that are awaiting preparation, publication and visualisation. This project will complete the publication process for these datasets making them available via the eAtlas and with spatial datasets also being made available via the AODN. (55%) Work with 1st round NESP TWQ projects to capture any new relevant data products for inclusion in the eAtlas and provide training sessions on providing data in the right format. (13%) Support and continue training in the use of the Torres Strait eAtlas with Torres Strait Regional Authority (TSRA) so it can be used as a publishing platform for their new Land and Sea Strategy NRM plans. (14%) Work with TSRA to complete the Torres Strait reef mapping, started under the NERP TE, so that it can be used by GBRMPA to enhance the Torres Strait coral monitoring data (RIMS) (18%6) Note: Figures in brackets indicate percentage of total project cost.	Eric Lawrey	Australian Institute of Marine Science (AIMS)	98,043	0	67,217	67,217	165,258	RPV1	01/07/2015	31/12/2015	Completed	N/A	N/A		N/A		3.5.2	14.2	No	N/A					See Outputs RPV1	Two significant outcomes have been achieved by the eAtlas during this short-term project. Firstly, all of the NERP Tropical Ecosystem Hub program datasets are now published on the eAtlas as high quality metadata records with accompanying downloadable data. The process of documenting and publishing datasets in the eAtlas from NERP was refined and updated providing valuable learnings for the first round of NESP Tropical Water Quality dataset submissions. Secondly, the eAtlas has extended the mapping of the GBR into Torres Strait to allow the creation of a single consistent dataset covering the islands and marine features of the entire GBR. Working with the TSRA, the new Torres Strait Reef and Island Features dataset was mapped at scale of 1:50,000 which is significantly finer mapping than the 1:250,000 scale of the GBR Features mapping of the GBR. This increased level of detail was important to capture the large number of small islands and reefs in Torres Strait. The final result is a highly detailed map dataset of the marine and island features of Torres Strait with permanent IDs that are compatible with the GBR Features dataset, allowing the compilation of a complete and consistent map of the entire GBR. This dataset is now available under a creative commons license from the eAtlas.
2.1.1	Integrated Pest Management of Crown-of-Thorns Starfish	Successful Crown-of-Thorns Starfish (CoTS) management will, for the foreseeable future, depend on manual control at specific sites being effective and efficient. This project will develop an Integrated Pest Management approach to site management, based on a detailed understanding of CoTS ecology and management operations, to protect coral and maximise performance of control activities at economically and ecologically important reefs. It will provide an intelligent, field-deployable decision support tool to guide strategic selection of control activities based on site conditions and management constraints. This approach will be underpinned by new, targeted field work focused on improving management.	David Westcott	CSIRO	604,722	25,000	868,956	893,956	1,498,678	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A		1.1	15.8	No	N/A	• Review paper outlining preliminary ecologically-informed CoTS local-scale control strategy for individual reef sites (December 2016) • Report detailing refined ecologically-informed CoTS local-scale control strategy and rules of thumb for individual reef sites (December 2017) • Phone, tablet or PC-based field-deployable Decision Support Tool (December 2018) • Report and data describing detailed juvenile, sub-adult and adult surveys of key reefs (December 2017 and 2018) • Report and data describing CoTS adult movement data (December 2016 and 2017) • Report detailing the impact of CoTS predators, through a review of Green and Blue Zones, and a review of research into triton (December 2016) • Report outlining results of tests of eDNA for surveillance and recommendations based on these			http://eatlas.org.au/gbr-pressures-terrain		See Outputs RPV2	• The interim CoTS Control Centre has been deployed on all control vessels and is currently guiding their day-to-day decisions and activities. This tool i) automates and standardizes data collection during control operations, ii) guides skippers through the decision steps for selecting reefs and sites during voyage planning and conduct, and, iii) supports program managers in planning and monitoring operations at the fleet/GBR scale. This tool is guiding GBRMPA's program management and integrates CoTS control program data collection into GBRMPA's broader data management system. • Products from this project (surveillance and re-visitation strategies, eDNA research, Triton review) have underpinned the development of future investment strategies for CoTS control by GBRMPA and the Great Barrier Reef Foundation.

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs					Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
2.1.2	Scoping options for low-lying, marginal cane land to reduce DIN in priority wet tropics catchments	This project will explore alternative land use options to reduce nitrogen losses from marginal sugarcane land in priority wet tropics catchments. The Wet Tropics Water Quality Improvement Plan (WQIP) identified that complete adoption of sugarcane best management practices would be insufficient to achieve the nitrogen load reductions needed to meet the Great Barrier Reef (GBR) Water Quality Guidelines. We will map low-lying, marginal cane land with community and industry partners, identify possible alternate uses, quantify the economic costs and benefits of land transition (in terms of alternate income streams), identify constraints and opportunities for alternative land uses to reduce nitrogen.	Nathan Waltham	James Cook University	94,000	0	130,250	130,250	224,250	RPV2	01/01/2016	28/02/2017	Completed	N/A	N/A		N/A			1.2	14.1	No	N/A	• Map showing low-lying, marginal cane land in the priority wet tropics catchments. This will be compatible with other platforms and provided for use by Terrain NRM, local, state and federal Government and other stakeholders. • An-source cost/benefit curves that outline water quality improvement and ecosystem service benefits for alternative land uses. The economic assessment will also quantify potential future income streams such as carbon, water quality credits and rate rebate options. • Report detailing the constraints and opportunities and cost/benefits of alternative land uses in priority wet tropics catchments.				See Outputs RPV2	Research undertaken as part of this project has created an analytical framework capable of identifying areas of land currently used for the production of sugarcane that can be considered high risk from a nitrogen enrichment perspective and potentially suitable for conversion to alternative uses. The framework helps to identify candidate sugarcane land for conversion, and then provide an objective evaluation of the financial impact of converting high DIN risk sugarcane land to alternative land uses. The goal here is to choose land use that would result in DIN reduction at minimum cost to society.
2.1.3	Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project	Working in partnership with staff from the Australian Government's Department of the Environment (DoEE), and the Queensland Government's Departments of Science Information Technology and Innovation (DSITI) and Environment Heritage and Protection (DEHP), this project will use data collected from land managers and elsewhere to critically evaluate the way water quality (WQ) improvement programmes are 'marketed'. It will use insights from those evaluations to inform the reconfiguration of marketing and engagement strategies associated with programmes scheduled for roll-out during 2017, demonstrating methods for monitoring and assessing the extent to which these different Programmes and changed strategies improve adoption and alter behaviours.	Lynne Eagle	James Cook University	480,000	0	983,193	983,193	1,463,193	RPV2	01/01/2016	31/03/2019	Completed	N/A	N/A		N/A			1.2	14.1	No	N/A	Planned outputs include • Three 'factsheets' - one produced relatively early in the life of the project which outlines key objectives and proposed methods (including identification of programmes that will be evaluated as part of the research); one part way through the project, providing an 'update' of insights gleaned; a final one at the end summarising key findings and impacts. • Marketing materials/strategy guidelines and templates, including readability assessment tools and message framing guidelines to support the roll out of Programme X (the programme selected for focused research support and adaption). • A final report • Journal articles and conference papers				See Outputs RPV2	NQ Dry Tropics "The NQ Dry Tropics Connecting Cane Farmers to Their Local Wetlands project has been successfully trialing effective methods to increase sugarcane farmer adoption of farm management practices to achieve reef water quality outcomes and improve the ecological function of wetlands. The project created an engagement strategy based on learnings from a literature review and a social study of barriers and benefits of practice change. This strategy was updated annually based on a social monitoring, evaluation and project adaptation framework. As a result, 13 of the 14 participants are now trialing practice changes on their farms and the project team have a greater understanding of what extension, education, engagement and communication tools work best to increase the benefits and decrease the barriers. The NESP 2.1.3 and 3.1.3 projects played an important role in the successful delivery of this project. The NESP project team reviewed the literature review, social study questions, project fact sheets, information publications, and media releases, providing useful input and insights for improvements. Their support helped us to improve the readability of our communication products to ensure they were appropriate for the target audience. Evaluations of these communication products showed that they were well received and understood by the cane farmers and increased their understanding and awareness of the subject matter (e.g. water quality issues for local wetlands and the Great Barrier Reef)." Laura Dunstan, NQ Dry Tropics, Program Manager, Waterways, Wetlands and Coasts Terrain NRM "Terrain NRM is involved in a number of projects that aim to support farmers in making practice change to improve water quality running off their farms. Given the subject matter, many of the supporting communications products tend to be scientific or technical in nature, which can make their readability challenging. The analysis provided to us by the NESP 2.1.3 and 3.1.3 team gave us reassurance that we were pitching our communications effectively at our target audience. In addition to giving us insights into how previous communications products could have been improved, they also helped inform the development of current materials by evaluating their readability and providing ideas and suggestions on how to refine them further." Elaine Seager, Project Communications Leader, Terrain NRM Behaviour Innovation "Behaviour Innovation (BI) is a company that specialises in the design, delivery and evaluation of population-level behaviour change programs. Project Cane Changer is BI's flagship project and has been successful at increasing sugarcane growers' adoption of Smartcane BMP, a program with strong links to water quality and environmental benefits. BI has implemented behavioural skills training with extension officers and agronomists as part of Cane to Creek and Project Uplift to improve the on-the-ground skillset of extension staff. The NESP 2.1.3 and 3.1.3 projects have provided a useful complement to the body of work BI is currently undertaking. The underlying concepts of the NESP projects are to understand the attitudes, behaviours, and barriers that landholders might have in terms of how they engage with practice change and environmental initiatives (e.g., water quality improvement). Both NESP projects have provided insights which are not only relevant to the approach of Cane Changer but have informed other projects in the region that aim to improve water quality and the health of the Great Barrier Reef" Dr John Pickering, Cane Changer Project Manager, Chief Behavioural Scientist at Behaviour Innovation
2.1.4	Demonstration and evaluation of gully remediation on downstream water quality and agricultural production in GBR rangelands	This project will evaluate the cost, effectiveness and biophysical processes of gully remediation options in the Burdekin Region. Sub-surface soil erosion is the major source of anthropogenic sediment delivered to the Great Barrier Reef and must be addressed to help meet Reef water quality targets. The Reef Trust Gully Erosion Control Programme is the first to focus on gully remediation. This study will evaluate and communicate the impact of gully remediation options to underpin future investor, stakeholder and public confidence in the impact of erosion control programmes on (i) water quality (ii) project cost-effectiveness and (iii) agricultural production.	Rebecca Bartley	CSIRO	600,000	65,000	732,018	797,018	1,397,018	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A			1.2	14.1 15.3	No	N/A	The Planned outputs from this project include: • Reporting on the effectiveness (in terms of cover, erosion and water quality) of various gully remediation approaches in the Burdekin catchment • Reporting on the cost of various gully remediation approaches implemented (which will include site maintenance etc.)				See Outputs RPV2	The work on gully remediation is being used by GBRMPA for informing catchment management to better deliver on improving poor water quality.
2.1.5	What's really damaging the Reef? Tracing the origin and fate of the environmentally detrimental sediment	Recent research has shown that only a portion of the fine sediment fraction delivered from rivers draining into the Great Barrier Reef Lagoon (GBRL) reaches coral reefs and seagrass meadows. The specific sources of this sediment, which affects the health of corals and seagrasses, are as yet unresolved. This project will, for the first time characterise and trace the origin(s) and fate of this environmentally detrimental sediment using samples collected in flood plumes and during resuspension events. This will enable direct spatial targeting of the sources of this material to achieve maximum benefits to GBR health from catchment management actions.	Stephen Lewis	James Cook University	600,000	82,500	746,759	829,259	1,429,259	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A			1.4	14.1	No	N/A	• The project outcomes will be communicated through progress reports, a technical report, conceptual models and peer-reviewed publications. • With the assistance of the Knowledge Transfer component of the TWQ hub, other outputs such as the construction of conceptual diagrams, fact sheets and media releases will be developed as a further communication strategy for the research outputs.				See Outputs RPV2	The work on tracing source sediments in the Burdekin is being used by the GBRMPA for informing catchment management to better deliver on improving poor water quality. Additionally, the project developed novel sampling techniques to characterise and trace the origin(s) and fate of environmentally detrimental sediment within the GBR delivered from the Burdekin, Tully and Johnstone Basins. A novel method of combining organic tracing with trace element data to trace land use sources of the particulate nutrients exported from river basins.
2.1.6	From exposure to risk: novel experimental approaches to analyze cumulative impacts and determine thresholds in the GBRWHA	Understanding cumulative impacts from multiple stressors will be critical for successful management of the GBR under the Reef2050 Plan. The project will produce experimental analyses of concentration-response relationships for selected species under broad, controlled envelopes of sediments, turbidity, nutrients, light, salinity and temperature. Based on new understanding of threshold exposure values, existing and new field data we will produce exposure maps for individual stressors and explore techniques to summarise those into cumulative exposure maps. Results will inform spatial and temporal assessments of ecological risks, and management opportunities for a range of activities in the coastal zones and inshore GBR waters.	Sven Uthicke	Australian Institute of Marine Science (AIMS)	410,165	0	427,997	427,997	838,162	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A			1.4	11.4	No	N/A	This project will produce a number of reports and publications, conference presentations, and material for fact sheets and reviews. It will also produce a range of datasets from the experimental work, and analyses of cumulative impacts for selected field sites. These outputs will be communicated to GBRMPA, the Department of the Environment and to the Queensland Office of the GBR on a six-monthly basis.				See Outputs RPV2	The development of a species sensitivity distribution (SSD) for thermal stress in tropical marine species allows the quantitative prediction of cumulative impacts of chemical pollutants and higher than average temperatures (e.g. for the development of climate-adjusted water quality guidelines). Stress endpoints used in the SSD were: bleaching, inhibition of photosynthesis, respiration, survival/mortality, growth, fertilisation and calcification. The SSD is currently being reviewed by OGBR for finalisation and combination with pollution SSDs to assess cumulative effects of temperature and water quality. The work on cumulative impacts provides an additional line of support for the relevance of the marine park monitoring and also informed the development of policy for the GBRMPA. This project is helping to fill one of the high priority knowledge needs identified in the Reef 2050 Water Quality Research, Development and Innovation Strategy, i.e.: MC.1 Improve our understanding and modelling of the combined impact of pressures on the resilience of Reef and coastal ecosystems. OGBR also anticipate that the outputs will be used in the future to guide the assessments of risk from poor water quality and aid management prioritisation.
2.1.7	Engaging with farmers and demonstrating water quality outcomes to create confidence in on-farm decision-making	Recent global experiences suggest that spatially identifying and prioritising landscape 'hotspots' of pollutant generation for management intervention, and small catchment-scale water quality monitoring in collaboration with landholders linking water quality with specific management practices, are among the most promising strategies for reducing water quality pollution. This project will combine recent hotspot identification in GBR sugarcane catchment of the Russell/Mulgrave with targeted cane farmer interaction activities (related to sub-catchment and localised monitoring activities), focusing on emerging monitoring technologies (real-time water quality monitoring) to link farmer on-farm practices with feedback from sub-catchment water quality measurements. The use of both scientific and citizen science monitoring approaches will deliver robust feedback loops to enable farmers to directly link their activities with water quality conditions. The project will focus on on-farm practice improvements in highest priority catchments to achieve maximum benefits to GBR health from catchment management actions.	Aaron Davis	Australian Institute of Marine Science (AIMS)	600,000	0	490,500	490,500	1,090,500	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A			1.2	14.1	No	N/A	• The project outcomes will be communicated through progress reports, technical reports, conceptual models and peer-reviewed publications • With the assistance of the Knowledge Transfer component of the TWQ hub, other outputs such as the construction of conceptual diagrams, fact sheets and media releases will be developed as a further communication strategy for the research outputs.				See Outputs RPV2	The primary technical-scientific outcomes of the project has been the successful implementation of a sub-catchment water quality monitoring plan developed and driven by the local sugarcane industry. The identified network includes nine sites located throughout the Russell-Mulgrave catchment that differentiate a range of different catchment land-uses (native forest, bananas, sugarcane, urban) to allow discrimination of specific sugarcane contributions to local water quality issues (a key desire of the local cane industry). The sites have also been located to integrate as much a possible with current Great Barrier Reef catchment loads monitoring program (GBRCLMP) to value-add to both programs in coming year's monitoring-modelling efforts. The installation of relatively 'cutting edge' water quality instrumentation has provided almost 'real-time' information on key parameters (such as nitrate) at several key sugarcane catchment sites in the network. This provides the capacity to test whether provision of more local, 'real-time' water quality information will facilitate system understanding and on-ground practice change by local landholders and canegrowers. The outcomes of the sub-catchment monitoring efforts have also been used to begin informing and prioritising local targeting of cane industry extension-engagement efforts to key water quality 'hotspots' in the broader landscape. The collaboration with the CSIRO 'Digiscape' initiative has begun. This provides considerable additional scientific basis to Project 25, including improved data communication and research targeted at maximising user experience and interaction with real-time data at multiple spatial scales. The desire to see monitoring move 'upstream' within catchments has resulted in additional sites being added to the monitoring network and the addition of new membership to the overall Project Steering committee (including a representative from the Banana industry).
2.1.8	Improved water quality outcomes from on-farm nitrogen management	The sugar industry occupies 350,000ha in Reef catchments, applied 58,000t of nitrogen (N) fertiliser in 2014 and is a major contributor of dissolved inorganic nitrogen (DIN) to Great Barrier Reef receiving waters. There are many potential mechanisms for reducing on-farm N-usage. However, the comprehensive review of N use in sugarcane (SRA/DoE 2014) identified widespread over-use of N fertiliser and recommended adopting production unit yield potential (PUYP) combined with enhanced efficiency fertilisers (EEFs) to reduce 'surplus N' (where applied N>crop requirements). This project will combine with existing farm trials at identified N loss 'hot spots' to test PUYP as the basis for determining fertiliser N rates and compare EEFs with standard N fertilisers for minimising N losses, and to examine the water quality benefits that derive from such practice changes. Productivity, economic and environmental indicators will validate these strategies for reducing surplus N and produce recommendations for enhanced BMP's.	Mike Bell	University of Queensland	700,000	378,000	656,503	1,034,503	1,734,503	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A			1.2	14.1	No	N/A	• All datasets produced during the project will be uploaded onto the SSWIR (DSITI) corporate information system and made accessible to all project team members. The final technical report of the project will have, as an attachment, a metadata index indicating where project data are located. • Project data will comprise individual site details and records, and collated datasets for input into the models (APSIM/How Leaky) and decision support tools (SafeGauge for Nutrients). • The project outcomes will be communicated through progress reports, the final technical report and peer-reviewed publications.				See Outputs RPV2	Results from the project are demonstrating that reducing fertiliser N rates will lower runoff losses of fertiliser nitrogen (N). However, lowering N rates below industry best management practice benchmarks (Six Easy Steps) without reducing environmental loss risk increases risks of declining productivity. Enhanced Efficiency Fertilisers deliver improved crop recovery of applied N, with these more expensive fertiliser formulations mitigating risks of productivity loss. Preliminary results of the Reef Trust EEF4D project support these conclusions. Results have been presented to industry and government, and project team members contribute to technical advisory groups revising the industry Six Easy Steps N guidelines and developing the Qld government Sugarcane ERA standards policy.

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Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs					Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
2.1.9	Risk assessing dredging activities	The project will use novel analytical techniques/instrumentation to accurately quantify, for the first time, key proximal stressors associated with dredging/spoil disposal (i.e. sedimentation, light quantity/quality, suspended sediment concentrations) and will determine how these parameters vary with increasing distance from dredging. We will then test the response of corals, sponges, seagrass and algae to environmentally relevant/realistic conditions over appropriate time-frames. Matrices of hard data will be generated to derive water quality thresholds for key habitat forming organisms and for use as input parameters for pressure field-modelling (including cumulative-impact modelling). This will dramatically improve risk assessment processes, provide greater surety for regulators and proponents, allow more informed decision-making and inform future dredging policy.	Ross Jones	Australian Institute of Marine Science (AIMS)	515,806	0	1,419,651	1,419,651	1,935,457	RPV2	01/08/2018	01/08/2019	Completed	N/A	N/A		N/A		1.4	14.2	No	N/A	Planned Outputs include scientific papers, algorithms for spectral light changes, websites including photographs and videos managed with metadata. Technical reports/synthesis Media releases				See Outputs RPV2	The project team have worked very closely with Port of Townsville Limited (POTL) since the project started but especially since the capital dredging project associated with the port expansion was given the go ahead. The team completely re-analysed all POTL's 3.5 years' worth of baseline water quality data collected at multiple sites around Cleveland Bay. From that information they provided descriptions of the natural background turbidity (water cloudiness) and light reduction the local environments are likely to experience, from either natural sediment resuspension events (from storms) or also the regular maintenance dredging that occurs each year. This information can be used during the capital dredging (due to start in 2020) to contextualize what effects the dredging is having on water quality over a range of different periods of time from 1 day to 6 weeks. The team also conducted multiple separate field campaigns sampling very close to the dredging, measuring how light quantity and light quality (i.e. colour) changes because of sediment resuspension. They used both these pieces of information (the baseline data and field campaign) to conduct as series of laboratory-based experiments in the Australian Institute of Marine Science (AIMS). SeaSimulator (a very advanced aquaculture facility). The exposure conditions exactly recreated the suspended sediment concentrations and changes in light quantity and quality that would occur during a range of dredging scenarios and the response of adult corals and sponges and juveniles corals examined over an extended period. Different sublethal stress response parameters were measured and have a set of thresholds (exposure conditions) determined for where effects could occur. This information can be used when dredging is underway (or before-hand for impact prediction), providing the information needed for POTL to use adaptive management techniques (i.e. changing dredging practices) if they are considered necessary. Port Of Townsville has now adopted the recommendations contained in the project team's final report and will reference them in the setting of trigger levels for the Port Of Town Townsville Expansion Project, a major economic development project for Far North Queensland. The Port upgraded existing water quality equipment (i.e. turbidity sensors, light and sediment deposition loggers) to the more sophisticated, state-of-the art equipment used during the NESP project. The Project Leader, Ross Jones, has also been appointed to the Port of Townsville Dredging Steering Group (Independent Advisory Committee) to provide expertise as the project proceeds . It is anticipated that the involvement of AIMS with POTL will extend for many years beyond the project. A range of further recommendations will be incorporated into the development of relevant site specific trigger levels and early warning indicators for this project that will be developed over the next 12 months. Development of these will have input and oversight from the project ITAC (Independent Technical Advisory Committee) and be submitted to regulatory agencies as part of Port of Townsville's approval conditions. Recommendations from this work will be considered and incorporated into future programs and monitoring undertaken by the Port of Townsville and also be incorporated into risk assessments and scheduling for our routine dredging.
2.1.10	The application and adaptation of mine site rehabilitation approaches to alluvial gully rehabilitation in the Bowen Catchment	This project will develop the partnerships and the institutional framework for implementing large scale innovative rehabilitation works which aim to directly reduce sediment supply from the large alluvial gullies on the lower Bowen River. These gullies are the largest single source of suspended sediment loads into the Great Barrier Reef (GBR). The project will work directly with GErncore and Q Coal, who are some of the largest grazing landholders along the section of the Bowen River with the highest concentration of large alluvial gullies. The central premise underpinning the strategy is that alluvial gully rehabilitation is more akin to mine site rehabilitation, and such techniques are more appropriate for tackling this major GBR sediment source than grazing BMPs. The strategy aims to draw upon the mine site rehabilitation experience and expertise within these two major Queensland mining companies, applying and adapting mine rehabilitation approaches to the rehabilitation of alluvial gullies.	Andrew Brooks	Griffith University	100,000	0	130,000	130,000	230,000	RPV2	01/04/2016	30/04/2017	Completed	N/A	N/A		N/A		1.2	15.3	No	N/A	• Communication materials (YouTube videos; media stories; plain English community outreach materials/factsheets) • Concept plans for large scale rehabilitation demonstration projects on at least 2 separate sites within the broader study area • An implementation plan for the demonstration sites, including consideration of commitments for cash and in-kind support from the project partners. • Collation of all existing baseline data for the identified sites – including datasets held by the mining companies • A detailed monitoring strategy for the demonstration project sites.				See Outputs RPV2	This project is seen to be a major catalyst for recasting thinking about "solving" the gully erosion problem, and this change of thinking is now reflected in the Reef Trust gully programme, the BBB Major Integrated Project, the Qld Govt Innovative Gully Project on Strathalbyn Station, as well as in the emerging Reef Credits approach to managing sediment) and nutrient) sources from gully erosion.
2.2.1	Identifying the water quality and ecosystem health threats to the high diversity Torres Strait and Far Northern GBR from runoff from the Fly River	Runoff from the Fly River in Papua New Guinea influences water quality conditions in the Torres Strait (TS) region however the extent and frequency of this influence, and the potential ecological impacts, are not well understood. Further investigation is required to understand the prevalence and frequency of the extension of the Fly River plume into TS, and the characteristics of plume constituents, particularly metals. This project will build on previous efforts to determine the spatial extent, temporal patterns and constituent pollutants of Fly River discharge, and to a lesser extent, assess the vulnerability of ecosystems in the TS exposed to the discharge.	Jane Waterhouse	James Cook University	360,000	0	412,110	412,110	772,110	RPV2	01/01/2016	30/10/2018	Completed	N/A	N/A		N/A		2.3	14.1	No	N/A	Expected outputs based on the project components: Review of existing knowledge: • Synthesis report on Fly River discharge plume behaviors in the Gulf of Papua and northern Torres Strait, and condition of receiving environments. Monitoring and modeling Fly River plumes: • Develop maps of estimated extent of plume intrusions • Visualisation of plume movement • Further development of available modelling tools • Incorporation of data into TS eAtlas Overall: • Final project report detailing the results of the project, including management recommendations and priorities for further investigations. Final Report: Due 30 May 2018				See Outputs RPV2	• The project team worked closely with the TSRA Rangers and the Land and Sea Management Unit to conduct weekly salinity monitoring. We have engaged with TSRA Rangers from Erub, Masig, Warraber, Poruma, Iama, Saibai and Boigu. Six TSRA Rangers were provided direct training, and a further 8-10 are involved and proficient in local salinity monitoring on a weekly basis. • Using multiple lines of evidence the project has provided greater certainty of the extent and frequency of the influence of runoff from the Fly River in PNG on important marine ecosystems in the Torres Strait. It is now feasible to conclude that the influence of the Fly River and associated contaminants is focused in the northern Torres Strait and along the PNG coast, i.e. northern and NW Torres Strait. • This information is important for ensuring the protection of these regions given their importance to Torres Strait communities and turtle and dugong populations, and their connectivity with the Great Barrier Reef Marine Park. • The project results were presented to TSRA staff and the TSSAC in December 2018, and the JAC in March 2019. While all groups showed strong interest in the use of this information in guiding their future management effort, it was agreed that further information, to be progressed through the project extension, was required before any firm management actions were undertaken.
2.2.2	Impacts of mine-derived pollution on Torres Strait environments and communities	This study addresses concerns regarding the impacts of mine-derived pollution on the marine resources of the Torres Strait. Using state of the art procedures, trace metal concentrations in marine waters and sediments will be determined at locations across the Torres Strait. Chemical signatures of mine pollution will be measured in waters and sediments and hotspots of contamination identified. The water quality data generated will allow informed management decisions to be made on how to best address trans-boundary mining related pollution.	Simon Apte	CSIRO	290,000	0	290,000	290,000	580,000	RPV2	01/02/2016	30/10/2018	Completed	N/A	N/A		N/A		2.3	14.1	No	N/A	• A final report will be prepared towards the end of the project and made publically available via web download. • At least three conference presentations at local and international conferences • It is envisaged that there will be at least three peer reviewed journal publications • Regular information sheets (one per year) will be prepared with the assistance of the CSIRO communications team. These will be available for download from the CSIRO, NESP TWQ Hub and eAtlas websites. Hard copies will be provided to the TSRA for distribution to local communities. • Regular contributions to the Tropical Water Quality Hub newsletter • A mid-project and end-of-project workshop will be held at a suitable location in the Torres Strait with a view to updating local stakeholders on project progress.				See Outputs RPV2	Using multiple lines of evidence, the project showed that the influence of the Fly River and associated contaminants is focused on the northern Torres Strait, This information is important for resource management of the region. It also indicates that impacts on the Great Barrier Reef Marine Park are highly unlikely. Technical training was provided to TSRA Rangers based on Erub, Masig, Warraber, Poruma, Iama, Saibai and Boigu resulting in the establishment of a salinity monitoring network. Project results were presented to TSRA, TSSAC and the JAC who are maintaining a watching brief on this topic. Further briefings will be provided throughout the project extension.
2.2.3	Early warning systems to minimize the risk of box jellyfish stings by empowering stakeholders	This project will minimise the risk of box jellyfish stings by empowering stakeholders with an early warning system. We will first develop an openly-accessible database based on information from existing sting datasets, hospital records, and surf lifesaving and research data. We will use this database to develop real-time forecasting models in major stinger hotspots on the GBR, based on environmental conditions and water quality. These forecasts will be tested with our project partners, SLSQ and AMPTO. This project will empower tourism operators, traditional owners and the public to mitigate stinger impacts.	Scott Condie	CSIRO	250,000	0	957,407	957,407	1,207,407	RPV2	01/01/2016	10/12/2018	Completed	N/A	N/A		N/A		2.1	14.2	No	N/A	• Robust early warning system for empowering stakeholders to forecast the risk of jellyfish stings; • The Venomous Jellyfish Database will be (in the public domain) used to build forecasting models and can be used to increase our understanding of jellyfish ecology; • Irukandji and stinger forecast models for sting hotspots at the three focal areas (FNQ beaches, FNQ reefs and islands, and Magnetic Island); • Real-time forecasts of predicted sting events at sting hotspots; • Identified stakeholder management needs, potential actions, and the most effective modes of delivery for our forecasting system based on stakeholder engagement; • Information sessions with stakeholders; • Greater understanding of the influence of water quality and associated factors on stinger/Irukandji occurrences.				See Outputs RPV2	The Australian Venomous Jellyfish Database is now available via eAtlas. The project has improved predictability of box jellyfish stingers presence at beaches, islands and reefs of Cairns, Townsville and the Whitsundays. Wind direction and tidal movement are strong indicators for sting conditions and are now highly valuable to the tourism industry, Surf Lifesaving Queensland and coastal communities of the GBR. Russell Blanchard, lifeguard supervisor for Surf Lifesaving Queensland's North Barrier Branch in Townsville, said the two jellyfish viewing boxes provided by the project "had come in very handy" for volunteer surf lifesavers. "We've used them multiple times already - they are beneficial to volunteer surf lifesavers, who don't necessarily have the same experience identifying jellyfish by eye," he said. "As a whole our involvement in the project has been pretty beneficial, when we gather our own data on jellyfish we are usually dealing with limited areas, the researchers however have been collecting information from a much larger area which gives them a good picture of what the jellies are doing." Discussions with staff from the Bureau of Meteorology indicate that they don't currently have the capacity to implement and maintain operational warning systems for localised applications such as jellyfish swarms (or harmful algal blooms). The strategy is therefore to distribute a factsheet (currently being finalised) through key stakeholders such as AMPTO and SLA. This information sheet provides a comprehensive summary of our findings in relation to the risk of Irukandji stings in a form that can be readily understood and actioned by stakeholders. We will engage again with stakeholders around early spring as they start to plan for the next sting season.
2.3.1	Benthic light as ecologically-validated GBR-wide indicator for water quality: drivers, thresholds and cumulative risks	The project will develop a water quality indicator based on benthic irradiance (the amount of light penetrating to the seafloor). Using experiments and field data we will develop irradiance thresholds for measures of ecosystem health, and develop prototype guideline values. The project will develop a new remote sensing algorithm of benthic irradiance, validated against open-water irradiance data. The project will quantify benthic irradiance throughout the GBR, near-daily over 14 years, and assess region-specific drivers of trends including river discharges. The indicator can directly feed into Reef Plan report cards, irradiance as a limiting factor, and about cumulative risks in the context of coral bleaching.	Barbara Robson	Australian Institute of Marine Science (AIMS)	499,471	0	544,860	544,860	1,044,331	RPV2	01/01/2016	30/03/2019	Completed	N/A	N/A		N/A		2.3	14.2	No	N/A	• A WQI as a reporting metric using benthic light availability, with well-defined drivers and thresholds applicable to coral health, seagrass, and ecological health indicators reported by MMP. • Incorporation of the developed bPAR algorithm into NASA's SeaDAS processing software, as an operational algorithm freely available to the scientific community. • Data on in-situ PAR measurements from the IMOS stations will be made freely available to the scientific community. • Data sets (netCDF format: monthly mean climatologies of benthic irradiance), metadata and maps of benthic irradiance (climatologies and monthly means), and cumulative pressures overlay with temperature, will be distributed through the eAtlas. • Scientific reports and publications on the use of benthic irradiance as a WQI for the GBR; • Scientific reports and publications on light requirements and thresholds for reef organisms and ecosystems.				See Outputs RPV2	The benthic light output is being used by the Marine Monitoring Program to explore the development of a relative annual exposure metric. This is a new and practical guideline and reporting metric that complements existing measures of the Reef Plan report card, and informs the Outlook Report and future regional Water Quality Improvement Plans. • Maps of condition, trends and their drivers, and performance against thresholds in bPAR including the little studied Far Northern GBR and deeper sections of the GBR.
2.3.2	'Human sensors' for monitoring Great Barrier Reef environmental changes and quality of marine waters through harnessing Big Data analysis	This project will take a novel approach to improving monitoring of environmental and aesthetic conditions in real time by capitalising on information provided through micro-blogs from visitors to the Great Barrier Reef. The data mining will integrate human sensing data (e.g. twitter) with existing monitoring data (including the 'eye on the reef'), meteorological data, tourism statistics, and others dispersed data sources and a cost-effective monitoring tool will be made available to stakeholders. All Great Barrier Reef stakeholders will benefit greatly from this innovative monitoring system.	Susanne Becken	Griffith University	227,145	20,000	222,002	242,002	469,147	RPV2	01/01/2016	10/12/2017	Completed	N/A	N/A		N/A		2.2	14.2	No	N/A	The following outputs will be produced and shared: 1. Research publications: at least 3 journal articles in relevant environmental management journals and at least 2 journal articles in Computer Science journals 2. Popular articles on key findings (e.g. The Conversation and other outlets) 3. Development of an infographic to illustrate the use of micro-blog/social media data for environmental monitoring 4. Meta-data information made available to other researchers in this field. 5. Provision to the data as relevant to e-atlas (TWQ Hub)				See Outputs RPV2	Text-based social media itself may appear less suitable for environmental monitoring per se, but are useful for socio-economic monitoring. A preliminary analysis of images (also in conjunction with project 3.2.3), however, has revealed that photos/videos provide a substantial opportunity for environmental monitoring. Again, this insight has been shared with stakeholders and further research on automated image recognition is underway.
2.3.3	Building Indigenous livelihood and co-management opportunities in the Northern GBR--ecosystem services and conservation governance for water quality	This project supports Indigenous co-management and livelihoods by scoping and developing culturally-appropriate ecosystem services (ES) products focused on water quality. Local and regional Indigenous development agencies in CYP will collaborate with researchers with expertise in Indigenous water, co-benefits, ES, wetland ecology, and governance issues. The project will: i) evaluate international examples of nutrient offsets and watershed ES; ii) scope investor demand and develop innovative water quality ES products suitable for Northern GBR geographic, demographic, and market conditions; and iii) improve wetland protection, co-management, business, and governance capability. Key project objectives are to leverage existing ES-based livelihood opportunities and to realize social co-benefits.	Marcus Barber	CSIRO	250,000	0	297,192	297,192	547,192	RPV2	01/01/2016	10/12/2017	Completed	N/A	N/A		N/A		3.6	11.4	No	N/A	The major planned outputs of the project are: • a co-authored Interim Summary Report at the end of year 1 • a co-authored Final Report at the completion of the project • 2 draft research journal papers, each led by a different member of the project team and focused on: o the application of ES products and frameworks to the Eastern Cape and Northern GBR, emphasizing watershed services, nutrient offsets, and/or livelihood co-benefits o regional governance and policy implications of the expansion of ES markets across Cape York Peninsula • supporting datasets encompassing: o literature review of ecosystem services watershed products, metrics and monitoring; o the relationship of ES frameworks to contemporary Indigenous livelihoods and to the co-benefits derived from conservation action; and o the applicability of novel water-quality focused ES products for Eastern Cape and Northern GBR Indigenous communities				See Outputs RPV2	Outcomes from the research directly influenced the CSIRO/CU/AIM consortium approach related to the mid-term review of the Reef 2050 Plan. Through the current Reef 2050 Traditional Owner Aspirations Project Consortium, key outputs from this research are continuing to inform the development of a TO led policy response to end term review associated with the Reef 2050 Plan. Project 2.3.3 has provided substantial additional value to the NESP TWQ Hub through synergies with related projects involving 2.3.3 team members funded through the NESP TWQ and NESP Northern Hubs, through biodiversity funding sources, through additional research partner contributions, and through CSIRO Innovation programs. The project has been successful in undertaking Indigenous community-based evaluation of potential ecosystem services provision on Southern Kaantju territory in eastern Cape York. The need to secure non-government investment support for Indigenous ecosystem services provision represents both the problem and the opportunity for next steps in this research. The outcomes of this project are being relayed through Traditional Owner networks for community contributions to actively working on water quality in coastal regions of the GBR. Programs similar to this contribute to land and sea ranger programs, environmental management and custodianship and community benefits.

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Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Version 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 impact	Comment on project progress	Changes from RPV4?**	Changes from RPV5	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
2.3.4	Working with traditional owners and local citizens to better manage GBR estuarine wetlands	Traditional owner rangers and local citizens of the Port Curtis Coral Coast (PCCC) TUMRA will be engaged in developing a Mangrove Management Plan (MMP) that provides a strategic basis for estuarine repair activity and maximizes water quality outcomes in the southern GBR. Development of this MMP will build capacity within the Gidarjil Development Corporation (GDC) and local community to undertake scientifically-rigorous, ecological monitoring and assessment. These management and rehabilitation strategies will protect sea country resources through partnerships between community, scientists and NRM agencies. The MMP will enable rangers and citizen scientists to conduct scientifically valid surveys of estuarine monitoring, management and rehabilitation within the PCCC TUMRA area.	Norman Duke	James Cook University	450,000	0	476,260	476,260	926,260	RPV2	01/01/2016	28/02/2019	Completed	N/A	N/A		N/A		3.6	11.4 15.1	No	N/A	All reports from this project will be publically available via the TropWATER, JCU website https://research.jcu.edu.au/tropwater/publications and the NESP TWQ Hub website. Stakeholder engagement workshops will provide an opportunity for public feedback on the project outcomes. Results will be published in peer-reviewed journals. We envisage three publications as a result of this research around the following themes: • Traditional Owner engagement and value in estuarine wetland management • Estuarine wetland monitoring and evaluation toolkit to inform estuarine wetland repair • Post-flood recovery of estuarine wetlands				See Outputs RPV2	The Southern Great Barrier Reef Coastal Habitat Archive and Monitoring Program: Mangrove Management Plan has been accepted by the Gidarjil Development Corporation. As operating funds become available, the Gidarjil Rangers continue mangrove monitoring and shoreline assessment on their Country.
2.3.5	eAtlas - Data management for environmental research	Having ready access to the best available information, scientific knowledge and data is vital for evidence based environmental management and for science that builds on the prior work of others. The eAtlas is a web based knowledge and data management system for environmental research data. Its systems ensure that data is discoverable, publicly accessible and preserved for the future. This project will allow the eAtlas team to work with NESP TWQ researchers to: - Assist and support them with data management guidance and training. - Ensure that hub data is well documented, accessible and reusable now and into the future. - Visualise spatial data allowing its use by management without specialised GIS software. This project will also engage stakeholders to establish and implement refinements to the eAtlas systems to remove existing barriers to its broader use.	Eric Lawrey	Australian Institute of Marine Science (AIMS)	450,000	0	474,175	474,175	924,175	RPV2	01/01/2016	31/12/2018	Completed	N/A	N/A		N/A		N/A	14.2	No	N/A	• Planned outputs are that datasets from NESP TWQ hub will be published on the eAtlas.				See Outputs RPV2	The Australian Marine Parks Science (AMPS) Atlas project has proceeded (co-funded by Parks Australia and AIMS) to use an extension of the eAtlas platform and has funded the development of a map based navigation module. This capability will be reincorporated into the eAtlas website as a mechanism for finding content for areas of interest. The AMPS Atlas will be a delivery mechanism for some of the NESP Marine Biodiversity Hub content. The eAtlas is continuing to improve and modernise its infrastructure to integrate with national data portals such as the Australian Ocean Data Network. Traffic on the eAtlas website has increased to up to 9,800 users per month.
3.1.1	Implementation of the crown of thorns starfish research strategy: regional strategies	Crown-of-thorns starfish (COTS) management requires decisions be made about where to invest control effort in order to achieve regional scale objectives, e.g. to modify COTS spread or to facilitate coral recovery. However, no objective basis for choosing sites exists, beyond their economic importance, meaning that achieving these important goals is largely left to chance. This project will leverage past and current research to develop a decision support framework to assist in prioritizing reefs for control and for assessing alternative strategies by integrating the full range of ecological and management information available. Field and desktop research will also be conducted to fill critical knowledge gaps and to assess the prospects of new control technologies.	David Westcott	CSIRO	682,542	175,564	856,063	1,031,627	1,714,169	RPV3	01/01/2017	10/06/2020	Completed	N/A	N/A		N/A		1.1	15.8	No	N/A	• Annual recommendations on priority reefs for control activities. As the DST develops these recommendations will be based on the integration of an increasingly broad range of inputs. • Automated process for developing annual connectivity matrices to underpin DST beyond the life of this project. • Decision support tool to assist in the development and assessment of management objectives and the strategies available to achieve these objectives. This DST is intended to be developed to the point that it can be used and maintained by managers and to operate with data inputs currently being collected in on-going monitoring and management programs. • Reports outlining recommended objectives and strategies identified using the DST. • Report on the prospects for biocontrol and new gene technologies in future control technologies • Report on the distribution and extent of deep reefs in the Cooktown to Townsville region, their use by COTS and the implications of this for the design and success of the control program. • Report on the relationship between zoning and COTS predators and its implications for management • Report on COTS movement at large temporal and spatial scales and its implications for control at local and regional scales. • Report identifying predators of different COTS life history stages. • Regular meetings with stakeholders to ensure information transfer and to provide opportunities for refining products.				See Outputs RPV3	Contributions from project 3.1.1 have been fundamental to the development and implementation of the decision support tools for the CoTS control program. In particular, the CoTS connectivity modelling has been incorporated into the decision process and is now guiding decision making about priority reefs for the control program. Similarly, work on the movement of CoTS has been incorporated into the analyses of control effectiveness to optimise site re-visitation intervals. The decision support tools are now guiding GBRMPA's decisions about how to distribute effort across the GBR and the daily on-water decision making of the control vessels. This project has led to the development of a similar Integrated Pest Management program for the long-spined sea urchin in Tasmania • The GBRMPA run COTS control program strategy is based entirely on the IPM strategy developed by the NESP COTS IPM Projects • GBRF's RTP funded COTS control program (GSBM) will also adopt the NESP COTS IPM Strategy and tools
3.1.2	Improving water quality for the Great Barrier Reef and wetlands by better managing irrigation in the sugarcane farming system	In pursuit of delivering multiple benefits across multiple ecosystems such as freshwater estuaries, wetlands and reefs, this project will work in partnership with industry, extension, NRM, research and government organizations to develop and deploy an irrigation system that is automatically controlled by remotely accessing feedback from the IrrigWeb decision support tool. IrrigWeb provides optimal irrigation schedules on a paddock-by-paddock basis by linking information about climate, soils and management regimes. If new water quality targets as specified in the revised Burdekin Water Quality Improvement Plan are to be met by 2025, it will be critical to establish pathways that enable industry partners to capitalize on new technologies.	Yvette Everingham	James Cook University	458,103	0	426,878	426,878	884,981	RPV3	01/01/2017	01/04/2020	Completed	N/A	N/A		N/A		2.2	14.2 15.1	No	N/A	• Productivity data: - will be stored on industry databases. • Farmer management records - water management records will be stored in either WISA or IrrigWeb or both. • Surveys administered and collected by the project team: - Will be stored on JCU systems. • Press releases by SRA will be stored on SRA systems				See Outputs RPV3	
3.1.3	Harnessing the science of social marketing in communication materials development and behaviour change for improved water quality in the GBR: a desktop review (Project 2.1.3 - Stage 2)	This project extends project 2.1.3 which contains an analysis of communications to land holders for the Reef Trust Tender – Burdekin and The Reef Programme concerning readability, message framing, message tone and visual imagery, factors that significantly impact on message acceptance, engagement and adoption of recommended behaviours. The analysis identified that: 1. Material is written in too complex language; 2. Message tone may be a barrier; and 3. Visual imagery may have unintended effects. These findings have implications across wider programs and there has been considerable interest in extending this analysis to assist in developing and revising foundational material and messages.	Lynne Eagle	James Cook University	19,000	0	21,857	21,857	40,857	RPV3	01/01/2017	10/12/2017	Completed	N/A	N/A		N/A		2.3	14.2	No	N/A	• Planned outputs include: Individual 'factsheets' for each set of material analysed • A final composite factsheet at the end of the analyses, summarising key findings and impacts. • Marketing materials/strategy guidelines and templates, including readability assessment tools and message framing guidelines to support the fine tuning of existing material and the roll out of future communication material. • A final report encompassing the analysis undertaken as part of Project 2.1.3 and the additional analyses proposed in this extension of the project. • Journal articles, seminar presentations and conference papers as appropriate in conjunction with co-investigators.				See Outputs RPV3	
3.1.4	Optimizing the management of riparian zones to improve the health of the Great Barrier Reef	This study uses evaluation of past investments to demonstrate effectiveness, and enable improved targeting, of riparian remediation works for reducing streambank erosion to achieve improved water quality outcomes within the Great Barrier Reef. By re-visiting previous riparian erosion-control investments we will identify what factors result in generating a functional riparian zone, including the conditions under which the investment occurred (rainfall zone, fencing arrangements, soil type, etc.), and the type of remediation revegetation (width of revegetation, connectivity of riparian area, species mix established, etc.). With stakeholder input, we will develop an initial framework to guide future investment in riparian remediation works.	Keryn Paul	CSIRO	178,491	0	177,372	177,372	355,863	RPV3	01/01/2017	30/06/2018	Completed	N/A	N/A		N/A		1.2	15.3	No	N/A	• A report that describes methods and summarises results on what investments conditions and types were most successful; • Compendium or manual with recommendations to guide future investment in riparian erosion-control remediation works, and estimates of the likely co-benefits for carbon and biodiversity, and; • Communication products as per the projects communication strategy, which may include; (i) presentations and audio-visual materials for focus group discussions with service providers (e.g. Greening Australia) to evaluate their response to proposed measures of revegetation; and (ii) presentations for technical workshops with DOHP and DoES programme managers to embed results into Government investment planning (e.g. Regional Body groups, Queensland State Government (Policy and modelling groups) and the Reef Trust Unit).				See Outputs RPV3	As per the project recommendations, the Department of Environment and Energy is currently utilising the datasets from Project 3.1.4 to assess the feasibility of expanding the capability of the FullCAM model to specially account for the relatively high carbon sequestration potential in riparian zones. FullCAM is used in spatial-temporal Land Sector carbon accounting in Australia's National Greenhouse Gas Inventory and used in project-level carbon accounting in key vegetation management projects in the Emissions Reduction Fund. Having carbon sequestration in revegetation/regeneration projects within riparian zones specifically accounted for in future National Greenhouse Gas Inventory will provide the capability required for developing transparent methodologies for supporting carbon payments to land managers undertaking such projects. The project team are also in discussion with the Qld Land Restoration Fund and are seeking opportunities to expand any future carbon credits from riparian restoration projects to include additional payments for water quality benefits and biodiversity benefits, e.g. stacking credits from riparian restoration projects. As per the recommendations from Project 3.1.4, such financial incentives are required to support the widespread land manager uptake of such restoration projects required to have tangible catchment-scale benefits to water quality and Reef health.
3.1.5	Ecotoxicology of pesticides on the Great Barrier Reef for guideline development and risk assessments	Over 50 land-sourced pesticides have been detected in waters of the Great Barrier Reef (GBR) and its catchments. Previous studies on the risks posed by pesticides have focused on five priority PSII herbicides. However, other pesticides are increasingly being used, for which there are few fate, persistence and toxicity data. In order to improve water quality guidelines and assessments of the potential risks posed by these "alternate" pesticides to GBR and its catchments we will quantify their toxicity to freshwater and marine species.	Andrew Negri	Australian Institute of Marine Science (AIMS)	602,839	0	677,556	677,556	1,280,395	RPV3	01/01/2017	10/03/2020	Completed	N/A	N/A		N/A		2.3	12.4 14.1	No	N/A	In addition to key roles in the Research and Development and Extension Sub-groups of the Reef Plan PWG we will:- • Provide data (EC10, EC50 and NOEC) and advice from the research directly to key stakeholders for the development of water quality guidelines (National, State, GBRMPA) and risk assessments (APVMA, Department of the Environment and Energy, LTSP, Reef Plan, RWQPP); • Regularly brief key stakeholders at workshops, conferences and meetings and via reports and journal publications; • Present plans and results at GBRMPA Seminar series, through fact sheets and other NESP communication channels, and the eAtlas • Presentation of data and results to key industry support organisations including SRA, Productivity Services and QDAF. • Present at national and international conferences • Scientific papers.				See Outputs RPV3	The project has quantified the toxicity of priority and alternate pesticides detected in the GBR and its catchments. This work is expected to be used in the MMP with adoption of multi-substance potentially affected fraction assessments preferred as the tool for assessing risk to the freshwater, estuarine and marine ecosystems. Reef 2050 WQIP review conducted in 2018 revised pesticide targets to reflect this adoption. Full implementation is awaiting national review completion.
3.1.6	Exploring trading in water quality credits as a cost-effective approach for managing water quality in the Great Barrier Reef	This project will scope opportunities for water quality credit trading, and develop trading frameworks for managing nitrogen and sediment along the Reef coast. The objective is to determine whether trading in water quality credits can cost-effectively offset emissions increases from future economic expansion, whilst ensuring that end-of-catchment pollution loads stay within designated nitrogen and sediment limits. The project will also estimate how revenues from credit trading could potentially stimulate rural economies and create jobs by incentivising innovative business opportunities.	Jim Smart	Griffith University	316,837	160,000	254,170	414,170	731,007	RPV3	01/01/2017	30/11/2020	Completed	N/A	N/A		N/A		2.5	14.1	No	N/A	For Stakeholders: • Plain-English summary of what would / would not be likely to work in potential credit trading schemes for managing nitrogen and sediment. • Plain-English summary of key features of potential trading frameworks for water quality credits in Reef catchments. • Plain-English summary of potential innovative business opportunities around nitrogen and sediment mitigation in the Reef catchments • Presentations of research findings and project outputs at key locations (e.g. Wet Tropics, Dry Tropics, Brisbane and Canberra), webinar enabled • Summary content, video and slideshow for the NESP TWQ webpage For academia: • At least two peer-reviewed papers detailing research findings				See Outputs RPV3	Increased collaboration with on-ground research in the Wet Tropics MIP and Landholders' Driving Change to quantify the cost-effectiveness of, respectively, constructed treatment systems and gully remediation as interventions to improve water quality outcomes. Final Technical Report will help inform future development of water quality credit trading by the Qld Government – both the OQEB and in other relevant settings by Qld DES.
3.1.7	Reducing sediment loads to the Great Barrier Reef: developing optimal approaches for treating alluvial gully erosion	Alluvial gullies have been shown to be major sources of fine sediment and nutrients to the GBR lagoon, and yet to date there is no accepted practice as to how these major pollution sources can be stabilised and rehabilitated. Working in collaboration with delivery partners implementing gully rehabilitation works through the Reef Trust phases 2 and 4, and various other gully mitigation programs currently being developed by Greening Australia, WWF and GBRF, this project will develop a series of large field trials that will test the effectiveness of different treatments for large active alluvial gully rehabilitation in different soil types in different catchments. These trials will complement similar research effort currently underway through NESP on hillslope gullies.	Andrew Brooks	Griffith University	600,000	150,000	600,000	750,000	1,350,000	RPV3	01/01/2017	10/07/2020	Completed	N/A	N/A		N/A		1.2	14.1	No	N/A	• Project outputs will be published on several websites, including http://www.capeyorkwaterquality.info/, CYNRM, BDT, DSITI, Greening Australia and the NESP TWQ Hub website. • Dedicated policy briefing event • Peer-reviewed publications • Key findings 'brochure' prepared, targeted at the generalist reader • Presentation of results at relevant conferences • Communication of key findings in media releases (coordinated with the NESP)				See Outputs RPV3	The work on gully remediation is being used by GBRMPA for informing catchment management to better deliver on improving poor water quality. Project also developed an informal collaboration with the Laura Rangers to help to maintain the monitoring equipment at Crocodile Gap.
3.1.8	Innovative economic levers: a system for underwriting risk of practice change in cane-farming	This project will enable reduced DIN exports from cane lands by developing and promoting a tested framework for commercial insurance businesses to underwrite risk of nitrogen practice change in sugarcane farming. We will work with insurance, other relevant businesses and, potentially, government to determine the methods and precision for assessing risk. We will then develop, in collaboration with insurance businesses, the sugarcane industry and government stakeholders, a technically sound and robust system where the negative impact of practice change on cane yield is distinguished from the year-to-year yield variability. We will pilot (and improve) this system with collaborating farmers, mills insurance businesses and, potentially, government in the wet tropics so that the framework can be operationalised by insurance businesses.	Peter Thorburn	CSIRO	400,000	0	404,330	404,330	804,330	RPV3	01/01/2017	10/03/2020	Completed	N/A	N/A		N/A		2.5	14.1	No	N/A	• Project outputs will be published on the NESP TWQ Hub website. • Dedicated policy briefing event • Peer-reviewed publications • Project brochure prepared, targeted at farmers/industry • Presentation of results at relevant conferences • Communication of key findings in public releases (coordinated with the NESP)				See Outputs RPV3	Feedback from insurance companies shows that insuring against an adverse outcome from a management practice change (i.e. changed N fertiliser) is both technically and culturally quite different from common agricultural insurance products, i.e. specified risk (e.g. hail) or multi-peril crop insurance. This difference means the insurance businesses do not intuitively have a sense for the risks associated with a management-based product, nor a clear idea of the information (data) needed to quantify the risk. The difference also means there is scepticism about the commercial viability of such a product. Despite this scepticism, some insurance companies are happy to collaborate in the project. Their contributions have been constructive and valuable. However, that is not the case for all companies (or all other stakeholders). Four key Traditional Owner groups have been contacted with regard to this project. • Dawul Wuru – Yirrganydji Traditional Owners • Abriculture – a company set up by a Yidinji Traditional Owner • Djunbunji Land and Sea Program – Mandingalbay Yidinji Traditional Owners. They are keen to be involved with connecting us to cane growers in the East Trinity catchment area. The Djunbunji Land & Sea program manage water quality monitoring in the East Trinity Reserve – with Hills Creek running through the park. They have good relationships with canegrowers in the area. • Girringun Aboriginal Corporation A funding proposal submitted to GBRF forCrystallisation of the potential for sugarcane (and other crops) yield insurance based on the concepts developed in this project.

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV5	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other in-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
3.2.1	Deriving ecologically relevant load targets to meet desired ecosystem condition for the Great Barrier Reef: a case study for seagrass meadows in the Burdekin region	This project will derive ecologically relevant targets (ERTs) for water quality and sediment loads by: 1) defining seagrass desired state targets; 2) calculating water quality guidelines (light); and 3) calculating ERTs for terrestrially sourced sediment loads. Historical and new data collections will be used to derive ERTs via statistical models and eReefs (RECOM), and the seagrass sub-model in eReefs will be used to test ERTs. A framework for setting seagrass desired state will be developed for the entire GBR and water quality guidelines and sediment load ERTs will be quantitatively defined for the Burdekin basin where suspended sediments affect seagrass condition.	Catherine Collier	James Cook University	457,765	31,513	739,177	770,690	1,228,455	RPV3	01/01/2017	30/03/2020	Completed	N/A	N/A		N/A		3.4	14.1	No	N/A	Written outputs: • Plain English summaries of project progress as emails and fact sheets for end-users, including TOs • Manuscripts submitted to peer-reviewed journals • Final report including: o A protocol for establishing seagrass desired state o Desired state for the Burdekin region o ERTs for light and sediment loads in the Burdekin region o Benthic light and Kd at multiple seagrass sites in Cleveland Bay over multiple time periods General outputs: • Presentations that will be delivered to end-users, NESP TWQ annual conferences and at national conferences where appropriate • Press releases, social media postings (tweets, Facebook and website updates) and summary plain English information sheets coinciding with each report/paper release in accordance with NESP media protocols.				See Outputs RPV3	Desired state for seagrass has informed the theme group report for program design for RIMReP noting this is still in development.
3.2.2	The IMS 2050 Human Dimensions Project: cost-effective indicators and metrics for key GBRWHA human dimensions	Building on the work of the work of the GBR RIMReP Program Design Group, this project will develop cost-effective indicators and metrics for human dimension outcomes, objectives and targets in the Reef 2050 Plan, consistent with the Drivers-Pressures-State-Impact-Response (DPSIR) framework. It will add value to and ensure continuity with information collected through the Social and Economic Long-Term Monitoring Program for the Great Barrier Reef (SELTMP). The project will: determine potential and extant indicator sets; evaluate data collection cost-effectiveness; determine thresholds (where appropriate); and provide guidelines for a collaborative approach for developing grading scores, using multiple lines of evidence to rate progress towards Reef 2050 Plan targets, objectives and outcomes.	Allan Dale	James Cook University	150,000	0	187,650	187,650	337,650	RPV3	01/01/2017	28/01/2018	Completed	N/A	N/A		N/A		3.3	14.2	No	N/A	• This project will identify multiple data sets and lines of evidence of value in developing robust indices and indicators associated with benchmarking and monitoring change with respect to the human dimension and indigenous indicators associated with management of the GBR and implementation of the Reef 2050 Plan. • A preliminary benchmark report (human dimensions) and the separately reported integrated framework for Indigenous indicator testing and benchmarking will be key synthesis products.				See Outputs RPV3	The outcomes of the IMS Human Dimensions project have provided a framework to benchmark human dimensions of the Reef 2050 Plan providing indicators and metrics for the themes of governance, heritage, community and economic outcomes. This work has established the framework for which the Human Dimensions of the GBR will be monitored under the Reef 2050 Plan. Traditionally, only biophysical aspects of the GBR have been monitored, ignoring the reality that the GBR is a socio-ecological system. The application of this approach has already significantly informed the Reef 2050 Plan mid-term review, influencing new thinking about the importance of resolving key governance problems associated with the reef, the importance of traditional owner-based interests, and the need to address economic transition in addition to policies focused purely on reducing carbon emissions. With the results of this work fully embedded in the long term RIMReP framework, more informed policy and strategy decisions are likely to emerge in the future.
3.2.3	Monitoring aesthetic value of the Great Barrier Reef by using artificial intelligence to score photos and videos	This project addresses the urgent need to understand and monitor the aesthetic value of the Great Barrier Reef. Focusing on the fast-changing underwater systems of the Reef, this research will use advanced technology (including eye tracking and heart rate measurement) to elicit what environmental and experiential attributes contribute to aesthetic value. A Big Data platform using artificial intelligence will be created to assess large volumes of visitor-supplied imagery and to map aesthetic value across space and time.	Susanne Becken	Griffith University	99,028	30,000	179,275	209,275	308,303	RPV3	01/01/2017	28/01/2018	Completed	N/A	N/A		N/A		3.3	14.2	No	N/A	Stakeholder-focused outputs: • A report on the results from the eye tracking and biophysical measurement experiments to determine key dimensions and attributes of aesthetic value, differentiated by cultural or consumer segment, as appropriate. • An IT proof of concept and architecture with algorithms that can be extended to monitor expert material (e.g. through underwater cameras). • A workshop targeted at Indigenous groups who wish to become more involved in ecotourism opportunities (planned towards the end of the project, e.g. around November 2017). Academic outputs: • Popular articles on key findings (e.g. The Conversation) • At least two articles. • Meta-data information made available to other researchers in this field. • Provision of the data as relevant to e-atlas (TWQ Hub) (see below).				See Outputs RPV3	The establishment of a Big Data platform using artificial intelligence to assess large volumes of visitor-supplied images can map aesthetic value of the GBR across space and time providing the foundations for automated assessment by the GBR Marine Park Authority. The research outcomes have contributed to strengthening the understanding that the aesthetic value of the Great Barrier Reef can be measured, and this is important for the RIMReP development and the method that will eventually be used to report back to UNESCO. GBRMPA has confirmed that the aesthetics monitoring work being undertaken through the NESP TWQ hub by CSIRO (Project 3.2.3) and Griffith University (Project 3.2.4) has been listed a critical program/data source for the whole Great Barrier Reef for Human Dimensions in the RIMReP program design. The CSIRO part of the NESP project is designing indicators for aesthetic monitoring which it is envisaged will be used to describe and measure aesthetics – condition and trends, using the methodologies being developed by the Griffith University team – eye tracking, neural network approaches and AI learning. Aesthetics monitoring using these methods has been rated highly relevant by the Human dimensions expert group and designed to take place annually.
3.2.4	Defining, assessing and monitoring Great Barrier Reef aesthetics	A key criteria for inscription of the Great Barrier Reef as a World Heritage Area is Criteria (vii) – exceptional natural beauty & aesthetic importance. Our project will work across social and ecological disciplines to identify, for the first time, indicators that will enable managers to measure and monitor aesthetic values for the GBRWHA. The outcomes will enable managers to predict and minimize aesthetic impacts below, at and above the water within the World Heritage Area, support implementation of the Reef 2050 Long-Term Sustainability Plan and improve decision processes relating to approvals, impact assessment, strategic planning, incident response and policy development. The indicators will be additionally tested using Artificial Intelligence via project 3.2.3.	Nadine Marshall	CSIRO	105,336	0	116,057	116,057	221,393	RPV3	01/01/2017	10/12/2017	Completed	N/A	N/A		N/A		2b	14.2	No	N/A	• List of factors that contribute to Reef aesthetics that can be used in legal policies and processes and can meet UNESCO reporting requirement. These factors will be accompanied by a list of recommendations about how they can be measured and monitored • Science papers around: o Reef Aesthetics, and its relationship with Wellbeing in the region o The relationship between Reef health and Reef aesthetics o Is the beauty of coral reefs in the eye of the beholder? • Milestone reports as indicated above • Final technical report	Yes			See Outputs RPV3	The research has indicated there are five readily quantifiable indicators of reef aesthetics: coral cover; coral pattern; coral topography; fish abundance; and visibility. Integrating aesthetics into coral reef monitoring and management have the potential to contribute to goals relating to improving wellbeing of communities, while also contributing to objectives around reef health. It is envisaged that the outcomes will be utilised in RIMReP and the 2019 Outlook Report. GBRMPA has confirmed that the aesthetics monitoring work being undertaken through the NESP TWQ hub by CSIRO (Project 3.2.3) and Griffith University (Project 3.2.4) has been listed a critical program/data source for the whole Great Barrier Reef for Human Dimensions in the RIMReP program design. The CSIRO part of the NESP project is designing indicators for aesthetic monitoring which it is envisaged will be used to describe and measure aesthetics – condition and trends, using the methodologies being developed by the Griffith University team – eye tracking, neural network approaches and AI learning. Aesthetics monitoring using these methods has been rated highly relevant by the Human dimensions expert group and designed to take place annually.
3.2.5	Testing and implementation of the water quality metric for the 2017 and 2018 reef report cards	Report cards are used at various levels to summarise and communicate complex information on GBR health. The effectiveness of Reef Plan is communicated through the annual Reef Report card. In the Reef Report Card, marine water quality is reported using a metric, developed in 2009, based on satellite remote sensing of near surface concentrations of chlorophyll and total suspended solids. This provides a wide spatial and temporal coverage of marine water quality. However, the current water quality metric has a number of issues such that the Independent Science Panel has recently expressed a lack of confidence in it and suggested that a new approach was needed. This proposal outlines a research program to deliver elements of this new approach.	Britta Schaffelke	Australian Institute of Marine Science (AIMS)	140,000	163,000	369,374	532,374	672,374	RPV3	01/01/2017	10/12/2017	Completed	N/A	N/A		N/A		3.3	14.2	No	N/A	• A revised marine water quality metric for Reef Report Card which addresses limitations of the existing metric in terms of sensitivity and response to changes; • A biogeochemical model assimilating remote sensing reflectance; • A collection, processing and integration process for marine water quality data collected in situ, via remote sensing and produced by the eReefs biogeochemical model; • Presentations to key stakeholders within the Reef 2050 Plan including RIMReP and Reef Water Quality Protection Plan • Scientific technical report on the outcomes of this research and recommendations on options for operational implementation				See Outputs RPV3	The project outcomes have led the development of a new method to report on marine water quality in the GBR as part of Reef Report Card. Using the eReefs suite of models and integrating information from satellites across the entire GBR domain is used to produce a water quality index. This method supplements discrete water sampling and monitoring activities occurring in the field as part of the Marine Monitoring Program. It gives access to information that was previously unavailable on this scale, helping managers, policy makers and the broader public understand the condition of the GBR lagoon and how such condition changes in response to natural events and human activities
3.3.1	Quantifying the linkages between water quality and the thermal tolerance of GBR coral reefs	This project will deliver two outcomes: (i) understanding of how water quality (WQ) exposure affects the ability of corals to resist and recover from bleaching, (ii) a modelling framework to identify management options that would mitigate the effects of warming on reefs exposed to WQ pressures. Using SeaSim experiments and field data, we examine which WQ parameters (nutrients/light/turbidity) affect corals' thermal tolerance, and assess how temperature and WQ exposure histories affected coral bleaching and recovery during the 2016 bleaching event. We will refine the eReefs model to derive WQ management scenarios expected to maximize coral survival in a warming climate.	Neal Cantin	Australian Institute of Marine Science (AIMS)	590,264	0	590,400	590,400	1,180,664	RPV3	01/01/2017	01/02/2021	Completed	N/A	N/A		N/A		2.1	14.2	No	N/A	• WQ-modulated bleaching thresholds for key coral species that can be used for bleaching forecast monitoring • Scientific reports and publication of new numerical models of the processes of coral bleaching in leading journals. • Scientific reports and publication of the environmental drivers of variation in bleaching sensitivity and recovery on the GBR. • Final technical report				See Outputs RPV3	Developed a new process-based coral-symbiont model applied within the eReefs coupled hydrodynamic-biological model https://portal.ereefs.info/
3.3.2	Science evaluation of coastal wetland systems repair projects across GBR catchments	State and Federal agencies are funding many GBR wetland system repair projects (Mungalla wetlands $1.2M; Reef Trust/Greening Australia $4M; Restoring Burdekin Coastal Ecosystems $837K; Roundhill Creek wetland/FHA $65K, Babinda Swamp Constructed Wetland ~$1.97M). The problem is no scientific data evaluates their success; this project partners with NRMs to fill this R&D gap. Using advanced scientific hydrological and ecological techniques we will generate data to evaluate repair efforts, providing surety to government funding agencies. This project will provide a platform to attract significant private and philanthropic investors, looking to fund large-scale wetland repair projects, via emerging carbon and nutrient trading schemes.	Nathan Waltham	James Cook University	536,932	0	682,867	682,867	1,219,799	RPV3	01/01/2017	01/02/2021	Completed	N/A	N/A		N/A		3.4	14.2	No	N/A	• GIS mapping that captures completed, current and planned wetland system repair projects in the GBR catchment area; • Meta-analysis of available wetland system repair projects collated from the study area for storage in Wetlands Info website and E-atlas; • Access to scientific data collected by the project; • Report detailing the constraints and opportunities to improve coastal wetland restoration and repair for the nominated project sites; and • Scientific publications and presentations at community events. These outputs will include a communication closure plan, to inform end users specifically of the outcomes and success of the project. All end users will be included in this communication, including Indigenous groups involved in the project.	Aug-17		11. https://gbrmpa.gov.au/__data/assets/pdf_file/0007/264222/Reports-Publications-Newsletters-Newsletter-October-2017-Electrofishing-methods-of-evaluating-wetland-rehabilitation.pdf	See Outputs RPV3	The Queensland Government (Queensland Wetlands Program) continues to use data and knowledge generated from Project 3.3.2 to generate conceptual diagrams (e.g. nutrient processing in wetlands), which is disseminated via the GBR Wetlands Program. Research data more broadly is GBR Wetlands Network, which is then used by NRM groups for their own planning, reporting and product material (factsheets, media) for landholders. Additional Outcomes include: • Wetland data used by Jaragun NRM to continue discussions with Australian and Queensland government to progress restoration works in Russell River Catchment, under the Russell River Catchment Sustainability Plan. • Continued assisting with methodology development of a Wetlands Methodology with Green Collar on the Reef Credits for Queensland Government. • Report and outcomes used by Queensland Parks and Wildlife Services to secure internal funding for more feral pig fencing in Round Hill National Park.
3.3.3	Defining the values of the ecological systems that influence the GBR and lie outside the marine park and world heritage area boundaries	The Great Barrier Reef World Heritage Area (GBRWHA), globally recognised for its outstanding universal value, is an integrated and highly connected part of a larger northeast Australia marine bioregion, which includes Torres Strait, the Coral Sea and the Great Sandy Marine Park (Hervey Bay). Understanding the values (ecological, cultural, social and economic) of these adjacent systems, and especially the connections and inter-dependencies between systems, is crucial to effective and efficient protection and management of the globally important natural and cultural values within each system. This project will identify and assess the values of these adjacent systems, and characterise the processes and attributes that influence the values and their connectivity at a regional scale, delivering a resource that can inform cross-jurisdictional planning and management.	Johanna Johnson	James Cook University	256,030	0	344,917	344,917	600,947	RPV3	01/02/2017	28/04/2018	Completed	N/A	N/A		N/A		3.4	14.2	No	N/A	The main project outputs include: • a synthesis of the ecological connectivity between the GBR and Coral Sea, • a synthesis of the physical drivers of ecological connectivity between the GBR and Coral Sea, • a description of important values in the systems adjacent to the GBRWHA, • an analysis of overlaps and synergies in values between systems, and • spatial characterisation of values and the connections and interdependencies across systems for the key values. • If the project identifies additional Biological Important Areas (BIA), the new/ updated BIA will be provided to eAtlas for inclusion on the ERIN Conservation Values Atlas. These outputs will form the basis of a non-technical project report that delivers information that can underpin strategies, plans and programs to improve protection and management of important values, and improve coordination and efficiencies across management jurisdictions. In addition, the project will deliver informal progress reports to key stakeholders and workshop participants, through email and meetings as needed, and at least two project fact sheets (one at the start introducing the project and a final results fact sheets).				See Outputs RPV3	The project outputs have provided the Department of Environment and Energy, Natural Heritage section with a better understanding of the connections between the marine ecosystems, however the research has not yet been used explicitly. The outcomes are most relevant to the National Heritage assessment of the Coral Sea and another area under assessment for National Heritage listing which is adjacent to the Fraser Island World Heritage Area (Cooloola). Both of these assessments have been on hold but the research is relevant and will be used when the assessments continue.
4.1	Crown-of-thorns starfish: surveillance and life history	This project supports the implementation of the NESP Crown-of-Thorns Starfish Integrated Pest Management Project's management and research strategy by i) describing ecological parameters key to parameterizing the tools underpinning the management strategy, ii) analysing existing data sets to assess management performance and describe the interaction between CoTS and bleaching, and, iii) scoping new technologies and surveillance strategies for detecting and monitoring primary and secondary outbreaks. The work will involve a combination of field ecological research, statistical analysis of existing data, technology and strategy development (the latter through workshops) and inform decision making through incorporation into decision support tools and recommendations.	David Westcott	CSIRO	497,500	0	553,770	553,770	1,051,270	RPV4	01/01/2018	15/02/2021	Completed	N/A	N/A		N/A		1.1	14.2	No	N/A	Parameterization of models currently guiding management decisions, decision tree and guidance on future control technologies, design and development of surveillance methods.				See Outputs RPV4	A range of products from the project are now informing or facilitating the decision making process for the expanded CoTS Control Program in the field. This will provide the opportunity for further refinement as required.
4.2	Oceanographic drivers of bleaching in the GBR: from observations to prediction	This project seeks to understand how local, regional and global oceanographic and meteorological processes influence the severity and spatial variability of thermally driven coral bleaching for the Great Barrier Reef (GBR) and Torres Strait. All available relevant environmental observations of the recent bleaching events will be gathered to be more easily discoverable to researchers and managers via a gateway/summary webpage. The data will be used to assess how well the eReefs models are modelling the recent warming during bleaching events and then analyse the reasons behind the variations of bleaching response. 1D versions of remotely sensed bleaching products by NOAA and BoM will be produced and a seasonal prediction capability for marine heatwaves will be developed.	Craig Steinberg	Australian Institute of Marine Science (AIMS)	537,852	0	832,480	832,480	1,370,332	RPV4	01/01/2018	10/12/2020	Completed	N/A			N/A		2	14.2	No		An accessible environmental dataset to be used to validate models and assist bleaching response. Introduce 3D eReefs versions of SST bleaching products to give a vertical component rather than just the sea surface from satellites A review and analysis of forecast and NRT products Seasonal forecast MMW and NRT Bleaching products Review of past thermal events Thermal stress and mixing hazard map identifying regions and reefs persistently at risk of thermal stress or not and the reasons why to assist in identifying the likelihood of repeat bleaching Assist the selection process for regions and reefs suitable for active management intervention Comprehensive environmental observational dataset and maps of past events to feed into projects 4.4 and 4.5. A file specific to the Torres Strait will be made from the outputs described above				See Outputs RPV4	

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
4.3	Best practice coral restoration for the Great Barrier Reef	As coral cover in the Great Barrier Reef (GBR) continues to degrade, pressure is growing for direct interventions to assist the recovery of corals at important sites. A range of coral restoration and assisted recovery techniques have been trialled overseas and in Australia, however there has not been an evaluation of what will work best in GBR conditions. This project will: • Summarise and evaluate the success of coral restoration and assisted recovery techniques worldwide and identify the techniques most likely to help the GBR. • Experimentally test the most promising techniques. • Come up with best practices for post-impact coral reattachment and reorientation. • Explore options for training courses, offset models and Indigenous employment.	Ian McLeod	James Cook University	607,000	6,000	776,000	782,000	1,388,000	RPV4	01/01/2018	10/12/2020	Completed	N/A	N/A		N/A		3	14.2	No	Marine	• Critical scientifically tested information for the development of best-practice guidelines and management strategies. • Photos and video assets to be used to communicate coral restoration opportunities. • Guidelines for best practice coral restoration in the GBR. These may include restoration options that are not appropriate for ecological recovery of coral reefs but do enhance local tourism experiences. • Opportunities for Traditional Owner involvement including employment opportunities • Re-establish local populations of reef corals on damaged reefs areas. • Best practice guidelines for coral restoration in the Great Barrier Reef. • Video 'Coral restoration opportunities in the Great Barrier Reef'. • Training course "Best practice coral restoration in the Great Barrier Reef" for managers, tourism industry, scientists and citizen scientists.				See Outputs RPV4	Restoration review methods have been presented to GBRMPA senior managers and are currently being used to inform their permitting and policy updates in these areas. In addition to these impacts, extensive communication to Tourism Industry bodies has catalysed a number of initiatives including Tropical Cyclone Debbie Reef Restoration/Recovery in the Whitsundays, as well as consultation for a number of underwater Public Art projects. Ian McLeod was asked to provide a review of the GBRMPA draft intervention policy by Belinda Jago, Director, Policy and Planning GBRMPA before it was sent out for general feedback. Coral restoration database and review are used as a resource to gather evidence during the appraisal of permits for restoration projects in the GBR. The Great Barrier Reef Foundation is using our review to inform plans for community grants and a regional hub. As a result of our 2018 GBR Restoration Symposium, Australian researchers, Reef Ecologic and JCU were approached to review coral health and restoration strategies for a large infrastructure development project in Mozambique.
4.4	The traits of corals that survived recent bleaching events	The past two years have seen unprecedented coral bleaching on the GBR but the consequences on biodiversity and genetic diversity are not yet known. This project will address the following questions: 1) Has bleaching resulted in a loss of genetic diversity in three coral species? 2) Do surviving populations contain genetic signatures of adaptation to bleaching temperatures? 3) What is the prevalence of heat tolerant photo-symbionts within surviving corals and in the environmental pool? 4) Are heat tolerant Symbiodinium communities and host genetic variants correlated with ambient environmental and recent bleaching conditions? High throughput genomic sequence variance analysis will identify genes in corals and Symbiodinium types associated with bleaching tolerance. Through correlations with environmental variables we will develop a spatially explicit understanding of the distribution and abundance of stress tolerant coral genes and symbionts (in hospite and free-living) to identify key coral populations for protection, key reefs for resilience management and potential breeding stock for use in reef restoration activities.	Kate Quigley	Australian Institute of Marine Science (AIMS)	582,218	0	713,276	713,276	1,295,494	RPV4	01/01/2018	10/12/2020	Completed	N/A	N/A		N/A		3	14.2	No	N/A	• Estimates of pre and post bleaching genetic diversity of key coral species • Estimates of environmental drivers of the abundance of coral associated and free living reservoirs of temperature tolerant symbionts • Identification of key populations at risk as well as populations with high potential for use as breeding stock for Assisted Gene Flow Estimates on the impact of bleaching on A. hyacinthus genetic diversity • Reports and briefings to incorporate estimates of importance, abundance, and impact of bleaching on key free living reservoirs of temperature tolerant symbionts • Reports and briefings of key populations of Acropora at risk of loses in genetic diversity • A scoping document developed in collaboration with GBRMPA staff (Bronwyn Houlden and others) on how to best operationalise the research findings of this project into management actions. This may include the linked NESP functional reefs project (4.6) led by Prof Mumby on species that underpin reef function or through a targeted workshop in this project or other avenues to be determined. • Scientific papers, including: -Identification of reefs with high genetic value for both the coral host and Symbiodinium populations for targeted management. - Quantification of changes in genetic diversity of A. hyacinthus, A. millepora, and A. tenuis post mass bleaching. • Presentations at conferences, GBRMPA and AIMS • If coral and symbiont genetic diversity can be spatially interpolated then maps will be produced and included in eAtlas • Final project technical report				See Outputs RPV4	The knowledge uncovered by this project feeds directly into the examination of the feasibility and methods for Reef Restoration and Adaptation (RRAP).
4.5	Guidance system for resilience-based management of the Great Barrier Reef	Reefs vary in their risk of damage, recoverability, and responsiveness to management. Deciding where to prioritise action to maximise reef health is complex. This project delivers a guidance system to implement Resilience-Based Management and demonstrates its application in the Whitsunday and Cairns regions. The guidance system will constitute a desktop software that enables users to prioritise which reefs to manage, and potentially restore, in order to maximise ecological and socio-economic outcomes. Outputs will help GBRMPA (1) make tactical and dynamic decisions; (2) provide scenarios of reef futures to support the 2019 Outlook reporting, (3) support RIMReP by identifying target reef recovery rates; and (4) contribute to the Integrated Pest Management system to control COTS.	Peter Mumby	University of Queensland	638,037	140,256	558,579	698,835	1,336,872	RPV4	01/01/2018	10/12/2020	Completed	N/A	N/A		N/A		1,2,3	14.2	No	N/A	RBM guidance software. Agreed though specific format will be developed jointly with users. Recommendations for prioritising action (excel files of coordinates, reef IDs). Online maps of reef state (Google Earth) as open access. Contributions to the CoTS IPM being developed under NESP2, 3 & 4.				See Outputs RPV4	Management and policy outcomes are expected towards the end of this project, when the RBM tool is delivered to stakeholders. The ecosystem models developed for the NESP 4.5 have also been used in a report to the Office of the Great Barrier Reef on climate trajectories and management intervention benefits on the Great Barrier Reef. This report will facilitate development of policy for the Reef 2050 plan revision. Additional Papers Outcome: As a result of the research that has been put into developing the resilience-based management guidance tool, several papers are expected including a study on anchor damage in the GBR, an exploration of heat stress calculation methods for reef areas in climate models, and a publication on water quality.
4.6	Recommendations to maintaining functioning of the Great Barrier Reef	The Great Barrier Reef is experiencing increased environmental stress which threatens its functioning. Yet a subset of species are often disproportionately important in maintaining a functioning ecosystem. This project harnesses Queensland's breadth of reef expertise to deliver timely recommendations on what can be done to strengthen and protect key supportive species. Specifically we ask which species – or functional groups of species – drive processes that maintain a healthy reef. We provide a scientific consensus in support of (1) species' rankings and recommendations for enhanced protection, (2) informed scenarios for what's at stake: the consequences of not taking further action, and (3) make recommendations for targeted R&D. We will also suggest activities that can be undertaken by citizen science organisations to help monitor the status of priority species or identify areas of either outstanding value or threat.	Peter Mumby	University of Queensland	298,583	71,519	315,603	387,122	686,705	RPV4	01/01/2018	10/09/2019	Completed	N/A	N/A		N/A		1,2,3	14.2	No	N/A	Reports recommending species management plans. Agreed – desired and conversation already started for plate corals Workshop discussions with end users to inform recommendations				See Outputs RPV4	Datasets on key species have been tailored for publication within Oceanography and Marine Biology: an Annual Review (OMBAR). This is part of a review on priority species for coral reef ecosystem functioning. Recommendations for including a carbonate budget indicator have been included in the draft revised Reef 2050 Plan.
4.7	Indigenous coral reef tourism	Despite the seemingly abundant opportunities, Indigenous Traditional Owners of the Great Barrier Reef appear to show little interest in participating in the lucrative coral reef tourism industry. This project seeks to understand why this is so, canvas TO attitudes to the industry, map out the opportunities for their participation in both mainstream and Indigenous-initiated ventures, and provide an assessment of current obstacles and what can be done to mitigate them. Research will be undertaken through a combination of surveys (e.g., of tourism industry literature), consultations with TO groups and regulatory authorities, and interviews with mainstream tourism operators (and their representative bodies). The project will result in a report with recommendations relevant to TO groups interested in coral reef tourism, mainstream tourism stakeholders and enterprises, industry bodies and regulatory and management authorities.	Henrietta Marrie	CQU	100,000	0	200,000	200,000	300,000	RPV4	01/01/2018	30/10/2019	Completed	N/A	N/A		N/A		3.6	14.2	No	N/A	• The research report and recommendations will be delivered through the final report and through direct presentations to the Department and to the NESP Steering Committee. • The report will be focused on ways and means to deliver on the Reef 2050 Indigenous Implementation Plan, specifically in relation to Actions EBA1 and EBA2 and related targets focusing on TO economic participation in Reef tourism industries. • It will also address how the outcomes of the research connect to the work of the other NESP Hubs, particularly the Marine Biodiversity, Northern Australia Environmental Resources and Threatened Species Recovery hubs. • Practice change – better inclusion of TO knowledge in GBR tourism, disseminated through TO groups. • Achieve the Reef 2050 Indigenous Implementation Plan Targets EBT1 of increasing the number of TO service providers and viable businesses; and EBT2 increasing the number of employment opportunities for TOs in sea country management and Reef-based industries. Both these targets to be achieved in relation to TO tourism enterprises and employment. • The report will effectively provide GBRMPA with a "SWOT" analysis for TO economic involvement in Reef tourism based on the Reef 2050 Indigenous Implementation Plan.				See Outputs RPV4	Not Yet Reportable
4.8	Project 25' Farmers, water quality and on-farm decision-making	Landholder concerns surrounding the credibility of broad-scale water quality monitoring and modelling initiatives in the GBR catchment area is emerging as one of the key cane industry engagement challenges for promoting significant farming practice change, and delivering water quality improvements. Based around small, sub-catchment scale water quality monitoring in a key cane growing region of the GBR catchment, Project 25 utilises a bottom-up approach to integrated sub-catchment monitoring and intervention to identify 'hot spot' sub-catchments through localised water quality monitoring. The Project emphasises industry ownership and control of monitoring design, and delivery of locally targeted water quality data and extension effort to provide confidence in on-farm decision making and facilitate practice change.	Aaron Davis	James Cook University	600,000	0	600,000	600,000	1,200,000	RPV4	01/01/2018	10/12/2020	Completed	N/A	N/A		N/A		1,3	14.3	No	N/A	Management guidelines for similar program roll-outs and design Specific sub-catchment data on water quality 'hotspots'.				See Outputs RPV4	The work is being used by the GBRMPA for informing catchment management to better deliver on improving poor water quality. Russell-Mulgrave canegrowing industry using water quality data to refine additional water quality monitoring and engagement to identified 'hotspot' catchment areas. TropWATER also approached for submission of similar Project 25 model to lower Herbert region by CANEGROWERS Herbert River.
4.9	Gully characterisation framework to underpin GBR catchment water quality management	In this project we will compile a database of gullies from across Queensland as a tool for communicating the diversity of gullies that exist in the landscape, but also the summon elements from within this diversity, where they exist. Using this database we will develop a gully classification system to ensure that there is a common language used by researchers, land holders, land managers and practioners when identifying gullies for management intervention. This will also form the basis for subsequent automated gully mapping according to gully type. We will also develop a first order decision tool to guide land managers towards the sorts of management options that may be appropriate for the gullies in question. Whilst this will not be a design guideline, it will help to ensure that the range of management options are narrowed down by managers before specialist advice is sought. A checklist of design considerations will also be developed that will ensure that managers undertake the appropriate level of design work for the required intervention. To some extent this project will document and formalise the knowledge and decision making processes that are currently undertaken by the specialist technical advisory team to the Reef Trust Programme.	Andrew Brooks	Griffith University	53,429	0	58,475	58,475	111,904	RPV4	01/01/2018	10/12/2018	Completed	N/A	N/A		N/A		1 2	14.3	No	N/A	Produce a web-based database of Qld gullies Produce a report for wide circulation (subject to further funding from a publisher) – produce a hard copy field guide to Qld Gullies				See Outputs RPV4	Gully Classification System has been adopted by various end users including Greening Australia.
4.10	Evaluating the Costs and Benefits of Agricultural Land Conversion to Wetlands	Government (e.g. Major Integrated Projects, MIPs) and private investors (e.g. Killer Rural Group, WWF, and Greening Australia) are increasingly interested in nitrogen reduction projects, particularly via conversion of land to wetlands. Investing in such projects requires understanding the environmental benefits to be accrued and cost-effectiveness. The best way to provide these data is to evaluate already constructed land-wetland conversion sites that resemble what future projects might look like. This project will collect data from previously completed land-wetland conversion sites, on construction and ongoing maintenance costs, and the water quality and biodiversity benefits. In doing so it will provide explicit data for government and private investors to make informed decisions on future investments of this kind.	Nathan Waltham	James Cook University	482,947	10,000	490,083	500,083	983,030	RPV4	01/01/2018	10/12/2020	Completed	N/A			N/A		1 2	14.3	No	N/A	Data generated during this project will inform Greening Australia project site forward planning, for example, mapping constructed wetlands and drainage works that could be restored, and the ability to estimate economic costings for maintenance will be of direct benefit to Greening Australia, positioning them to further attract private funding investment, in addition to the part funding provided from Reef Trust Data and costing relationships produced during this project will assist to facilitate government-funded and privately-funded investments in potential wetland restoration and wetland conversion sites across reef catchments Review and synthesis of data and case studies in SAP areas. Data and support in rolling out the MIP • Scientific publications in the literature relating to ecosystem values of wetlands, water quality, wetland construction and design, costing and maintenance, and habitat values. • Project articles in Canegrowers to raise profile of this project. • Data generated to be used in catchment source modelling to determine pollution loads reaching the GBR. This could result in a short technical guideline document for government.				See Outputs RPV4	Publications from NESP projects have been distributed among Queensland Government Wetland Network Group (NRM, NGO, Indigenous groups, industry, and government). Other outcomes anticipated for next reporting period.
4.11	Sources, transformations and fate of particulate and dissolved organic carbon – implications for the GBR	Organic carbon has traditionally been poorly studied in marine systems, but recent studies suggest that GBR microalgae can utilise organic matter, and that eroded soil carbon parameters can ameliorate marine algal responses to catchment nutrients. This suggests that organic carbon may play an important role in marine ecosystems than previously thought. Additionally, GBR organic carbon concentrations are increasing, but the mechanisms are unclear. The proposed study would review the literature, develop a conceptual model, and undertake data analysis on organic carbon in the GBR and catchments, and examine links to ecosystem effects. This will improve monitoring and management of water quality in the GBR.	Michele Burford	Griffith University	26,470	8,830	93,239	102,069	128,539	RPV4	01/01/2018	10/12/2018	Completed	N/A	N/A		N/A		1	14.3	No	N/A	Literature review, conceptual model and data analysis with a focus on implications for GBR and the monitoring program. Factsheets and final technical report				See Outputs RPV4	Sources, transformations and fate of dissolved organic carbon – implications for the GBR GBRMPA expects this may inform the narrative in future reporting.

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 impact	Comment on project progress	Changes from RPV4?**	Changes from RPV5	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs				Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other In-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
4.12	Measuring cost-effectiveness and identifying key barriers and enablers of lasting behavioural change in the cane industry	This project will: 1. Develop methodologies for assessing cost-effectiveness and for identifying key drivers of variation in cost-effectiveness in data-challenging situations 2. Use developed methods to evaluate the cost-effectiveness of a range of completed programs for reducing nitrogen runoff from cane production in Reef catchments 3. Within recently-completed and current programs, identify key barriers and enablers of: a. Engagement b. Lasting behavioural change 4. Compare and contrast evaluation methods (targeted individual approach compared and contrasted with a within project stakeholder approach) to deliver an adaptive management evaluation tool for measuring engagement whilst programs are on-going. 5. Inform future investment decisions by helping to identify key characteristics of cost-effective projects that will successfully engage stakeholders to deliver lasting behaviour change.	Sharyn Rundle-Thiele	Griffith University	404,985	28,800	446,671	475,471	880,456	RPV4	01/01/2018	30/08/2021	Completed	N/A	N/A	Additional comments from the Queensland Government OGBR after the report was sent to the DAWE for approval to upload are being addressed by the project leader.	N/A		1.1 2.3	14.3	No	N/A	Literature review, conceptual model and data analysis with a focus on implications for GBR and the monitoring program. Factsheets and final technical report • Final technical report				See Outputs RPV4	Measuring cost-effectiveness and identifying key barriers and enablers of lasting practice change in the cane industry is being used by GBRMPA for informing catchment management to better deliver on improving poor water quality. Pesticide runoff and nitrogen application rate reductions are evident in projects we have evaluated. These collectively mean less chemicals are entering waterways in projects observed by the NESP 4.12 project team. Additional Outcomes: One Griffith University Blog article was published on 20th November 2019. See https://tinyurl.com/vnlv2p9 A video illustrating the CCS process was published on the Social Marketing @ Griffith You Tube channel on May 28th 2019. See https://www.youtube.com/watch?v=ZOksULqcmtk The NESP 4.12 project team delivered a workshop at the World Social Marketing Conference, Edinburgh, Scotland in May 2019 outlining the CCS process employed in NESP 4.12. The NESP 4.12 project team delivered a workshop at Agents of Change, San Diego, USA in February 2020 titled "Herding the Cats". This workshop introduced the CCS methods that has been developed in NESP 4.12.
4.13	Assessing the Gulf of Carpentaria mangrove dieback	In early 2016, extensive dieback of mangrove forests was recorded along the southern and western Gulf of Carpentaria coastline. Landsat analysis suggests that 7,400 hectares of mangrove forest suffered dieback over a relatively short and synchronous time period around November 2015, along a >1,000km wide front from Karumba in the east to Limmen River in the west. Recent field visits to a limited range of affected sites suggest that a relatively low percentage of trees have recovered and most are dying/dead. This is the largest event of natural dieback of mangroves ever recorded in the world. This project will provide a survey, description and analysis of the extent of the dieback across its range, as well as examining patterns of dieback. The assessment will include training and participation of local Indigenous ranger groups in mangrove assessment and monitoring methods, as well as providing recommendations for recovery, potential intervention, future monitoring and further studies. A synthesis workshop will also be held to present the findings of the assessment to a wide audience.	Norm Duke	James Cook University	200,000	50,000	200,000	250,000	450,000	RPV4	01/06/2017	10/03/2020	Completed	N/A	N/A		N/A		1.1 1.2 2.1 4.1 5.1	14.2	Yes	NAER Hub	Identification of factors relating to the implementation location, implementing farm business and implementing landowner that influence the cost-effectiveness of the program in terms of reducing nitrogen loads to the Reef lagoon. Where data permit, cost-effectiveness assessment will encompass key risks/assumptions e.g. risk of reversion to old practices and potential impacts from external drivers such as cane and and fertiliser prices, and information from sources other than government extension. Practice change – landowners and project stakeholders. • Social survey reports for the suite of programs evaluated. • MAA assessments for the suite of programs. • Cost-effectiveness assessments for the suite of programs. • A set of recommendations for identifying cost effective programs that deliver lasting practice change. • Subject to approval, research outcomes include journal publications, conference presentations and one or more student theses. • Seminars and workshops will be conducted within the Reef network. • A final report that delivers a set of recommendations for identifying cost-effective programs that can engage land owners to deliver lasting practice change. This project will assist current and future Reef investment decisions.				See Outputs RPV4	The complete re-survey of the dieback as part of this project enabled a direct comparison of associated factors like the presence of ghost nets. This enabled to additional outcomes – as a measure of the effectiveness of land & sea ranger collecting of nets from beaches and shorelines; and current deposition rates of abandoned fishing gear in the region for evaluation of State and National regulatory changes on the approved use of fishing equipment by international and local industry operators.
5.1	Matching the CoTS IPM to the scale of the new control program	The CoTS IPM program is designing an ecologically informed control program that integrates knowledge of the spatial and temporal dynamics of CoTS outbreaks and the operations of on-water control to provide i) the most efficient strategies for investing management effort at all scales of management, ii) an operational framework for the control program, and, iii) to identify and fill key research gaps. This project will support the expansion of the IPM's tools to match the expansion of the control program, finalize scenario testing to assess appropriate control objectives, and, assess the social benefits of the CoTS training program.	David Westcott	CSIRO	494,360	13,600	505,460	519,060	1,013,420	RPV5	01/01/2019	15/02/2021	Completed	N/A	N/A		N/A		1	15.8	No	N/A					See Outputs RPV5	
5.2	From exposure to risk: novel experimental approaches to analyse cumulative impacts and determine thresholds in the GBRWHA	Understanding cumulative impacts from multiple stressors will be critical for successful management of the GBR under the Reef2050 Plan. We will produce experimental analyses of concentration–response relationships for selected species under broad, controlled envelopes of local stressors at different climate scenarios. Results will inform assessments of ecological risks, and management opportunities for a range of activities in the coastal zone and on the GBR. In a project-extension we will use exposure maps and ecological models, based on our developed and existing databases and experimental results, to advance our understanding of the contribution of individual disturbances in a cumulative framework (including both acute and chronic disturbances) to the current status of the reef. In turn, this new knowledge will inform management on setting future water quality thresholds, identifying catchments and regions as priorities for management action aimed at ameliorating impacts to reef health and building resilience for large-scale cumulative disturbances.	Sven Uthicke	AIMS	120,000	0	193,052	193,052	313,052	RPV5	01/01/2019	30/06/2020	Completed	N/A	N/A		N/A		2	14.1	No	N/A					See Outputs RPV5	In addition to delivering research in peer-reviewed international journals and at stakeholder-focussed workshops the project has delivered an interactive on-line tool using the eAtlas platform and derived exposure maps that reflects the key model results.
5.3	Benthic light as ecologically-validated GBR-wide indicator for water quality drivers, thresholds and cumulative risks	The project is developing a water quality indicator based on benthic PAR (light penetrating to the seafloor). We have experimentally estimated irradiance thresholds for ecosystem health for the Great Barrier Reef and have developed a new remote sensing algorithm to estimate and map benthic irradiance throughout the GBR. This will feed into Reef Plan report cards, RIMReP monitoring, and assessments of drivers of cumulative risks. This proposed extension will allow us to: work with stakeholders to embed the products into their workflows; improve the remote sensing algorithm with seasonal and regional cloud corrections; and evaluate an additional benthic light product based on the eReefs models to complement the remote sensing product.	Barbara Robson	AIMS	137,350	0	164,461	164,461	301,811	RPV5	01/01/2019	10/12/2020	Completed	N/A	N/A		N/A		2	14.2	No	N/A					See Outputs RPV5	Working with Stephen Sagar (NESP Marine Biodiversity Hub Project C3) has provided an opportunity to leverage the Australian Geoscience Data Cube as a mechanism for wider distribution and availability of our remote sensing data products. • It is anticipated that GBRMPA will use the final bPAR Water Quality Index as part of their GBR reporting toolbox. We are working towards this end with GBRMPA staff to ensure that the product meets their needs. • It is anticipated that regional NRM groups including the Fitzroy Partnership for River Health will be able to use local implementations of our bPAR WQI as a component of their regional water quality report cards. • We will work with Queensland DES and CSIRO to make the WQI available for use in evaluation of the impact of land management scenarios on marine ecosystem health. • Raw bPAR products are being used by Neal Cantin as an input to NESP TWQ Project 5.7 • Raw bPAR products have been used by Sven Uthicke as an input to NESP TWQ Project 5.2 • Findings from this project will be fed into NESP 6.4 and 6.5 communication products. • Paul Muir at the Museum of Tropical Queensland will be using our spectral Kd data products in an analysis of factors affecting reef health.
5.4	Deriving ecologically relevant targets to meet desired ecosystem condition for the Great Barrier Reef: a case study for seagrass meadows in the Burdekin region	This project will derive ecologically relevant targets (ERTs) for sediment loads for the Burdekin basin and provide the seagrass desired state across the GBR by: 1) defining seagrass desired state for the GBR; 2) calculating light requirements; and 3) calculating ERTs for terrestrially sourced sediment loads, using Cleveland Bay as a case study. Historical and new data collections will be compiled and used to derive ERTs via statistical models and eReefs (RECOM), and the seagrass sub-model in eReefs will be used to test ERTs.	Catherine Collier	JCU	200,886	0	235,245	235,245	436,131	RPV5	01/01/2019	10/12/2020	Completed	N/A	N/A		N/A		2	14.1	No	N/A					See Outputs RPV5	
5.5	Measuring aesthetic and experience values using Big Data approaches	This proposed research responds to the urgent need of understanding how ecological changes affect the aesthetic value and the user experience of the Great Barrier Reef, and how these could be measured and monitored in a cost-effective way. The research capitalises on two major trends, namely peoples' ability and willingness to share large amounts of information through various online platforms, and rapid development in computing technology to store, process and interpret these data.	Susanne Becken	GU	237,216	20,000	263,991	283,991	521,207	RPV5	01/01/2019	30/09/2020	Completed	N/A	N/A		N/A		2	14.2	No	N/A					See Outputs RPV5	
5.6	Designing the Aesthetics Long Term Monitoring Program (ALTMP)	Aesthetic condition and trend of the Great Barrier Reef (GBR) are critical to monitor for the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP), and World Heritage Area reporting. The purpose of this proposed project is to design and implement an aesthetics long term monitoring program (ALTMP) for the GBR. It will include a strong research component that identifies how to convert a subjective measurement into an objective one. Baseline data will also be provided that represents a snapshot of aesthetic condition at a large number of below-water and above-water sites within the GBR, and for a range of stakeholders.	Nadine Marshall	CSIRO	149,743	0	150,631	150,631	300,374	RPV5	01/01/2019	30/06/2020	Completed	N/A	N/A		N/A		2	14.2	No	N/A					See Outputs RPV5	Outcomes anticipated after project completion, via RIMReP
5.7	Assessment and communication of the spatial variability in bleaching severity throughout the Great Barrier Reef following back-to-back bleaching events in 2016 & 2017 (FAST TRACK PROJECT)	This desktop analysis of existing bleaching observations and data will deliver three key outcomes: (i) a quantitative assessment of the spatial variability of severe coral bleaching and mortality throughout the Great Barrier Reef (GBR) on regional and within individual reef scales, (ii) a quantitative comparison of bleaching observations from a range of observers AIMS, GBRMPA, JCU Centre of Excellence and the GBRMPA CDTS control team (implemented by AMPTO) which used a variety of methods and spatial assessments (iii) clear science communication and engagement with key stakeholder groups (tourist operators, reef managers and media outlets) in an effort to improve the communication and understanding of the variability and the spatial impacts of coral bleaching throughout the GBR.	Neil Cantin	AIMS	65,000	0	68,088	68,088	133,088	RPV5	31/09/2018	20/01/2020	Completed	N/A	N/A		N/A		2	15.8	No	N/A					See Outputs RPV5	Not Yet Reportable
5.8	What's really damaging the Reef? Tracing the origin and fate of the environmentally detrimental sediment and associated bioavailable nutrients	Recent research has shown that only a portion of the fine sediment fraction delivered from rivers draining into the Great Barrier Reef Lagoon (GBRL) reaches coral reefs and seagrass meadows. The specific sources of this sediment, which affects the health of corals and seagrasses, are as yet unresolved. This project will, for the first time characterise and trace the origin(s), fate and nutrient bioavailability of this environmentally detrimental sediment using samples collected in flood plumes and during resuspension events. This will enable direct spatial targeting of the sources of this material to achieve maximum benefits to GBR health from catchment management actions.	Stephen Lewis	JCU	682,746	155,870	810,184	966,054	1,648,800	RPV5	01/01/2019	10/12/2020	Completed	N/A	N/A		N/A		3	14.1	No	N/A					See Outputs RPV5	The Landholders Driving Change project led by the NQ Dry Tropics NRM is one of our key end users as our results allow for better prioritisation of remediation sites in the Bowen-Broken-Bogie catchment. The Townsville Port Authority have full access to our results which will help with their baseline monitoring prior to their capital dredging operations. Our water quality data have been included in the Catchment Loads Monitoring Program to calculate the most reliable loads from the Burdekin, Tully and Johnstone Rivers. The Office of the Great Barrier Reef uses project outcomes to better prioritise funding in the Great Barrier Reef catchments. Results from the flood plume component of our project have been incorporated into the Great Barrier Reef Marine Park Authority's Marine Monitoring Program (MMP) and included in their annual reports. Innovations from this project are planned to be incorporated into MMP reporting into the future. Our logger data and flood plume composition data will be used to help calibrate/validate the eReefs model. Importantly our research is highlighting the spatial variability of the influence of new sediment delivered to the GBR and we also hope to provide insights on the additional influence/impact on the anthropogenic component of this newly delivered sediment.

Tropical Water Quality Hub 2021 - Final Report - Attachment A

Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 impact	Comment on project progress	Changes from RPV4/5**	Changes from RPV6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs					Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other in-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
5.9	Gully remediation effectiveness	There is significant Government investment in water quality improvement focused on reducing gully erosion (~550 ml), however, there is limited measured data to demonstrate the effectiveness of the remediation approaches. This project is collecting land condition, terrain and water quality data from five gully remediation trial sites in the Burdekin catchment. These data will demonstrate if the on-ground investment programs are actually improving measured water quality, and quantify the cost-effectiveness of the various approaches. The measured field data will be extrapolated using Lidar, which will support the prioritisation and evaluation of future remediation sites over larger (whole of property) scales. Communication products developed will provide the evidence needed to increase landholder engagement in remediation programs that are focused on improving water quality runoff to the GBR.	Rebecca Bartley	CSIRO	472,000	0	526,600	526,600	998,600	RPV5	01/01/2019	31/10/2020	Completed	N/A	N/A		N/A		3	14.1 15.3	No	N/A					See Outputs RPV5	Queensland Government has focused its MIPs projects on the Bowen, Broken and Bogie (BBB) area of the Burdekin region due to CSIRO funded work on fallout radionuclide and cosmogenic isotope studies in conjunction with sediment load measurements and modelling. This work was conducted over a 10-year period. The Landholders Driving Change project in the Burdekin is now using the NESP project as a template for their rehabilitation evaluation. Reef Credits wanting quantitative data on the effectiveness of rehabilitation to provide an economic market value
5.10	Development and application of automated tools for high resolution gully mapping and classification from LiDAR data	Accurately mapping gullies at high resolution and quantifying their key attributes is the critical first step in the process of prioritising and designing rehabilitation solutions. At least 40% of the accelerated erosion that is contributing to poor water quality in the GBR Lagoon is sourced from gully erosion, demanding effective management and rehabilitation of these features. Current gully maps across the GBR are low resolution and overly simple, providing no differentiation between gully type. Airborne LiDAR is now widely recognised as being the best way to accurately map gullies at a landscape scale at a suitable resolution for management planning. Given the large volume of LiDAR data now becoming available, this project will develop and apply automated tools to enable the location of gullies to be extracted from LiDAR DEMs, along with key attributes of the gullies enabling them to be grouped into classes of similar gully types to aid prioritisation, management and catchment modelling.	Andrew Brooks	GU	357,297	88,324	275,148	364,472	721,769	RPV5	01/01/2019	10/12/2020	Completed	N/A	N/A		N/A		3	14.1 15.3	No	N/A					See Outputs RPV5	Not Yet Reportable
5.11	Improved Water Quality Outcomes from On-Farm Nitrogen Management	The sugar industry occupies 350,000ha in Reef catchments, applied >55,000t of nitrogen (N) fertiliser annually and is a major contributor of dissolved inorganic nitrogen (DIN) to Great Barrier Reef receiving waters. There are many potential mechanisms for reducing on-farm N-usage. However, the comprehensive review of N use in sugarcane (SRA/DoE 2014) identified widespread over-use of N fertiliser and recommended adopting production unit yield potential (PUYP) combined with enhanced efficiency fertilisers (EEFs) to reduce 'surplus N' (where applied N>crop requirements). This project is utilizing existing farm trials at identified N loss 'hot spots' to test PUYP as the basis for determining fertiliser N rates and for comparing EEFs with standard N fertilisers for minimizing N losses. Water quality benefits that derive from such practice changes are being evaluated. Productivity, economic and environmental indicators will validate these strategies for reducing surplus N and produce recommendations for enhanced BMPs.	Michael Bell	UQ	418,000	200,000	585,200	785,200	1,203,200	RPV5	01/01/2019	10/12/2020	Completed	N/A	N/A		N/A		3	14.1	No	N/A					See Outputs RPV5	Project outcomes and methodology have been used as a guide to a large Reef Trust 4 investment The potential role for EEF products in best practice N fertiliser strategies is recognized in the development of nutrient management plans and the 6ES nutrient management package endorsed as industry best practice The Reef Trust 4/EEF60 project has modelled their entire research program on the treatments, fertiliser products and monitoring approaches developed in our NESP project. Agronomists and sugar industry advisors also have a greater awareness of the benefits of using EEF technology in sugarcane cropping systems. Project has generated considerable interest from the commercial fertiliser manufacturers and distributors, who are seeking guidance on the best application and use strategies for EEF products. This includes the broader grains and cotton industries, in addition to sugar.
5.12	Scoping land use conversion options for high DIN risk, low-lying sugarcane areas in Burdekin and Mackay Whitsunday regions	The Reef 2050 Long-Term Sustainability Plan and Reef 2050 Water Quality Improvement Plan 2017-2022 have set ambitious targets for Great Barrier Reef (GBR) water quality improvement. Indeed Water Quality Improvement Plans (WQIP) for most NRMs in the Great Barrier Reef catchments recognise that complete adoption of sugar cane best management practices will still not be sufficient to achieve the nitrogen load reductions required to meet the Great Barrier Reef (GBR) Water Quality Guidelines. Here we capitalise on existing evaluation frameworks developed in NESP TWQ Project 2.1.2, as we aim to (1) identify possible alternate land uses in coastal low-lying cane land, that has a high DIN loss, cane land; ii) quantify the economic costs of changing land use and market mechanisms to incentivise this transition (e.g. Reef Credits); and iii) explore benefits (e.g. farm profitability) of land transition. Funding this project will provide land use change options across two NRMs that have different climatic conditions, industry groups, water boards and potentially different land use transitions – opportunities that Project 2.1.2 identified in the Wet Tropics might not be the best approaches in other NRM regions.	Nathan Waltham	JCU	185,850	0	250,345	250,345	436,195	RPV5	01/01/2019	10/11/2020	Completed	N/A	N/A	The Final report is being finalised for publication.	N/A		3	14.1	No	N/A					See Outputs RPV5	Not Yet Reportable
5.13	Coastal wetland systems repair across GBR catchments – Values Based Causal Framework validation	Conservation and repair of the coastal wetland ecosystems' in the Great Barrier Reef catchments have come into focus following media converging on the point that the reef health and land use in catchments has been compromised. While on-ground wetland repair investment activities are underway, data to demonstrate water quality and biodiversity return for the investment is not available. Here we continue working with project partners, further contributing to change management practices, consolidate new project partnerships, and road test the Queensland Wetlands Values Based Causal Framework using existing and new data.	Nathan Waltham	JCU	146,000	0	211,145	211,145	357,145	RPV5	01/09/2019	10/12/2020	Completed	N/A	N/A		N/A		3	14.2	No	N/A					See Outputs RPV5	• Project team have been engaged by QWP to complete a review of waterbird populations and altered hydrology project (submitted June 2020). • Project team engaged by Reef Catchments to prepare data review for Baker Creek constructed wetland (submitted June 2020)
5.14	Identifying the water quality and ecosystem health threats to the high diversity Torres Strait from the Fly River runoff	Runoff from the Fly River in Papua New Guinea influences water quality conditions in the Torres Strait region. Recent work (NESP Project 2.2.1 and 2.2.2) has clearly demonstrated that this influence is largely constrained to the northern Torres Strait, as far east as Bramble Cay and at least as far west as Boigu Island. The southern extent of influence is considered to be limited to within 40-50km of the Papua New Guinea (PNG) coast in the western areas, and around 80km in the eastern areas. The intensity of this influence, and the potential ecological impacts, are still not well understood. Trace metal concentrations are higher in the northern Torres Strait around Boigu and Saibai, however it is not clear whether this enrichment is natural or the result of mine derived inputs of trace metals. Further investigation is required to understand the prevalence and frequency of the extension of the Fly River plume into the northern Torres Strait, and further characterisation of plume constituents, particularly sediment and trace metals in comparison to previous results including the Torres Strait Baseline Study.	Jane Waterhouse	JCU	445,445	0	452,883	452,883	898,328	RPV5	01/01/2019	29/01/2021	Completed	N/A			N/A		3	14.1	No	N/A					See Outputs RPV5	As a result of the engagement between the TSRA and the research agencies a joint project between AIMS and the TSRA is to kick off in July 2019 to investigate diver-less methods of coral reef monitoring. The sediment modelling has been progressed in collaboration with scientists from the University of Kerala (India), the Palau International Coral Reef Research Center (Palau), the European Union Council Union Presidency (Romania), and the Environmental Management of Enclosed Seas (Japan). CSIRO conducted a survey of water quality in the Fly River estuary, Gulf of Papua and NE Torres Strait on behalf of OK Tedi mining Ltd. This project was commissioned in direct response to the outcomes of the two NESP projects (2.2.1 and 2.2.2). Results will be publicly available in late 2020.
5.15	eAtlas extension: Data management for environmental research	The eAtlas is a web-based knowledge and data management system for environmental research data. Its systems ensure that data is discoverable, publicly accessible and preserved for the future. The eAtlas is the primary data repository for the NESP TWQ hub and in this project we will continue working with all NESP TWQ projects to ensure their research data outputs are preserved, documented and made publically accessible via the eAtlas. This project will also work closely with the GBRMPA- Reef knowledge team on the development of a prototype information delivery system for the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP).	Eric Lawrey	AIMS	217,000	0	333,947	333,947	550,947	RPV5	01/01/2019	01/01/2021	Completed	N/A	N/A	The final report is being finalised for publication.	N/A		N/A	14.2	No	N/A					See Outputs RPV5	23 datasets/scripts from NESP TWQ projects have been published on the eAtlas in the last 6 months. The website receives on average 6,000 users per month. The NESP TWQ 4.2 project has developed three Degree Heating Week products based on the eReefs hydrodynamic model. The eAtlas team has started developing visualisation products for this data service, leveraging eReefs infrastructure developed in a separate project. Visualising the NESP TWQ 4.2 data does however requires some additional development to handle merging the hindcast of data with the near real time data into a single coherent visualisation product. The eAtlas team is starting work on modernising the eAtlas systems as part of an AIMS internally funded project. This work will help ensure that the eAtlas systems remain relevant for key stakeholders into the future.
6.1	Innovations in COTS control on the GBR	For decades, crown-of-thorns starfish (COTS) research effort has been fragmented and failed to inform improvements in the effectiveness of the control program. However, under the NESP Tropical Water Quality Hub's Integrated Pest Management (IPM) research program, a more collaborative and targeted approach has harnessed research effort and enabled delivery of significant improvements in effectiveness and efficiency of control, while also looking to develop methods for the future. Wholescale adoption of this IPM approach by the Great Barrier Reef Marine Park Authority (GBRMPA) and operators is already demonstrably saving live coral cover on the Great Barrier Reef (GBR).	Suzanne Long	RRRC	150,000	0	150,000	150,000	300,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		1	15.8	No							
6.2	Restoring ecosystems from catchment to reef	A range of NESP TWQ Hub-funded projects have delivered insights into improved ways of restoring and evaluating ecosystem restoration efforts, from upper catchments through to the reef focused on sediments, nutrients and wetland restoration. Synthesis of the outcomes will provide practical recommendations for land and sea managers.	Suzanne Long	RRRC	250,000	0	250,000	250,000	500,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		3	14.1 15.3	No							
6.3	Reducing nitrogen runoff without reducing productivity	Many NESP TWQ Hub projects have contributed to an improved understanding of nitrogen (N) management in sugarcane farming leading to reduced dissolved inorganic nitrogen (DIN) losses via improved management advice and practical solutions. The synthesis project will bring together a range of approaches that are addressing mechanisms for reducing N-losses, with a particular focus on real-time water quality monitoring, detection of N- loss hot-spots, on-farm nitrogen management, reef credit trading and other economic levers that incentivise improved farm management practices.	Johanna Johnson	RRRC	200,000	0	200,000	200,000	400,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		3	14.1	No							
6.4	Reducing end-of-catchment fine sediment loads and ecosystem impacts	A wide range of NESP TWQ Hub projects have focused on the source, transport, fate and impact of sediments on estuarine and reef ecosystems. These projects have responded to the Reef 2050 Plan targets and Water Quality Improvement Plan. Synthesis of this new knowledge will provide advice on practical on-ground actions for land and sea managers, policy implications and identify remaining gaps for future research and management investments.	Johanna Johnson	RRRC	150,000	0	150,000	150,000	300,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		3	14.1	No							
6.5	Improving coral condition through better-informed resilience-based management	Resilience-based management and integrated monitoring and reporting through the Reef Integrated Monitoring and Reporting (RIMRep) program are key templates for managing the GBR. A wide range of NESP TWQ Hub projects have focused on resilience-based management and decision making for maintaining and improving coral condition in the GBR. These projects directly contribute to the goals outlined in the 2016 Blueprint for the Reef and support the development of RIMRep. Many of these research investments are in direct response to the 2016-17 mass bleaching events. There have been many research projects and initiatives driven by the same goals and there is a need to bring the learnings together into a succinct coherent story.	Johanna Johnson	RRRC	200,000	0	200,000	200,000	400,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		1,2,3	14.2	No							

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Project Number/ID	Project Name/Title	Project Summary	Project Leader	Lead Organisation	Approved Funding Research Plan Versions 1-6					First Approved	Start Date	Completion Date	Status	Tracking	COVID-19 Impact	Comment on project progress	Changes from RPVI6**	Changes from RPVI6	NESP Research Priorities	Sustainable Development Goals (SDG's)	Cross-Hub Collaboration	List Hubs included in Collaboration	Outputs					Outcomes
					NESP Funding* $	Other Cash Contributions * $	Other in-Kind Contributions * $	Total Other Contributions* $	Total Budget* $														Outputs	Is the output publicly available?	Date of publication or expected publication	Link to output	Comments on outputs	Project Outcomes
6.6	Influencing agriculture practice behaviour change and trust frameworks	The ecologically-determined water quality improvement targets for the Great Barrier Reef can only be met with significant improvement in farm management practices. Numerous programs over many years, utilising a variety of approaches, have worked with land managers and representative farmer groups, seeking to achieve high levels of uptake of recommended farming practices. However, these have only met with low-moderate success. There has been significant work encouraging and facilitating behaviour and practice change in recent years, including through, but certainly not limited to, the NESP TWQ Hub. Programs encouraging behaviour and practice change are set to remain a feature of contemporary reef funding programs. Thus it is timely to coordinate a synthesis of learnings in this domain. Increasing understanding of, and improving trust frameworks and behaviour change of land managers will lead to improved water quality to the Great Barrier Reef. Understanding the impetus, benefits and barriers of behaviour change for agricultural practice is a large step in improving water quality to the Great Barrier Reef.	Suzanne Long	RRRC	150,000	0	150,000	150,000	300,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		1,3	14.3	No							
6.7	Learnings from applied environmental research programs: Elements for success	The structure, governance and administration of large multidisciplinary applied environmental research hubs is critical to their ability to deliver new knowledge that funders and stakeholders need. While the MTSRF, NESP TE and NESP TWQ have differed in model and delivery since 2006, they have operated in the same region and delivered to similar stakeholders over that period of time. This is a unique opportunity to review and report on what has been learned about effective and efficient delivery of new knowledge for impact, for the benefit of future Commonwealth-funded applied environmental science programs.	Suzanne Long	RRRC	80,000	0	80,000	80,000	160,000	RPV6	01/01/2020	31/07/2021	Ongoing	N/A	N/A	All outputs have been peer reviewed and are being finalised for publication.	N/A		N/A	N/A	No							
6.8	Integrated environmental assessment to inform environmental decisions	This project is a cross-hub research collaboration that draws on the considerable experience, regional knowledge, data and networks in the NESP Hubs to explore the potential application, and benefits, of integrated environmental assessments (IEA), focusing on Northern Australia. The project will develop a process framework to guide IEA, identifying available information and critical knowledge gaps, methods for synthesis and analysis, and participatory approaches and governance settings. The project will review the existing tools and systems to support IEA and identify opportunities and potential location/s to test implementation in Northern Australia. The project will provide decision-makers in the Department (and State and Territory regulatory and planning agencies) with pathways for undertaking IEA approaches in Northern Australia, to underpin sustainable regional development and, avoid environmental harm to internationally important biodiversity assets and cultural heritage values.	Brendan Wintle/ Michael Douglas/Nic Bax/Damien Burrows/David Kerdy/ Kirsten Parris	TSR	39,593	0	40,000	40,000	79,593	RPV6	01/10/2019	30/08/2021	Ongoing	Delayed	N/A	A draft final report is due by 30 June for review, workshops with DAWE and Indigenous stakeholders will take place in July 2021, and a Final report will be submitted in August 2021.	Minor	The project leader, Bendan Wintle has an extension to June 2021 approved by the DAWE.			Yes	Threatened Species Recovery, Marine Biodiversity, Northern Australia, Tropical Water Quality, Earth Systems and Climate Change, Clean Air and Urban Landscapes Hubs						
7.1	Continuity proposal for 'Project 25' - farmers, water quality and on-farm decision-making				50,000	0	50,000	50,000	100,000		01/02/2021	30/06/2021	Completed	On Track	N/A	The Draft final Report has been received by the Hub. It is currently in review.	N/A		1,3	14.3	No							
7.2	Assessing the Benefits of Using Existing Drainage Infrastructure to Meet Reef Water Quality Targets				50,000	0	50,000	50,000	100,000		01/02/2021	31/07/2021	Completed	N/A		The Draft final Report has been received by the Hub. It is currently in review.	N/A		1,3	14.3	No							
7.3	Extension and awareness of 'Project 25' outcomes to industry and natural resource sectors for improved water quality outcomes				50,000	0	50,000	50,000	100,000		24/01/2021	31/07/2021	Ongoing	Delayed		The Hub is organising knowledge repatriation activities with end users, traditional Owners and stakeholders at locations along the GBR.	N/A		1,3	14.3	No							
7.4	Technical nitrogen use workshop: For farming leaders, industry and government				42,000	0	42,000	42,000	84,000		24/01/2021	31/07/2021	Ongoing	Delayed		The Hub is organising knowledge repatriation activities with end users, traditional Owners and stakeholders at locations along the GBR.	N/A		3	14.1								
7.5	Putting the science into Great Barrier Reef Citizen Science				50,000	0	50,000	50,000	100,000		24/01/2021	31/07/2021	Ongoing	Delayed		The Hub is organising knowledge repatriation activities with end users, traditional Owners and stakeholders at locations along the GBR.	N/A		3	14.2								
7.6	Extension and awareness of NESP TWQ Hub Wetland restoration and management impact				47,600	0	47,600	47,600	95,200		24/01/2021	31/07/2021	Ongoing	Delayed		The Hub is organising knowledge repatriation activities with end users, traditional Owners and stakeholders at locations along the GBR.	N/A		3.4	14.2								
Total Project Costs					**25,779,883**	**2,131,922**	**31,603,620**	**33,735,542**	**59,515,425**																			

* On Track: The timeframes and milestones for the project are being met.
Delayed: The timeframes and milestones for the project are not being met.

* If you are collaborating with another Hub please only include your Hubs portion.

** Significant: includes changes ≥10% of total project costs, changes in scope that impact on the outputs, milestones delayed by more than 3 months, changes to final delivery dates, and changes to the Project Leader or Lead Organisation.
Minor: includes changes <10% of total project costs, delays in milestones of less than 3 months, and changes to project team (other than project leader).

Theme title

Responding to Coral Bleaching on the Great Barrier Reef

Theme description

There is concern that bleaching on the Great Barrier Reef (GBR) has increased its relative contribution to coral decline and mortality. 2016 and 2017 saw bleaching events saw significant mass bleaching across the Reef with additional bleaching taking place in 2020. Understanding the relative contribution of bleaching to coral loss was an important step in developing appropriate strategies for ongoing protection coral on the GBR as heat wave bleaching conditions present an existential threat to the Reef's future.

The TWQ Hub was deliberately structured to be flexible and responsive to changes in end-user needs during the Hub's lifetime and was able to rapidly pivot, brokering and funding ~$2.7 million of new projects to address the threat of climate change during 2017-18, involving significant collaborations between lead researchers from partnership institutions. This research laid the foundation for an applied research response into both bleaching recovery, and potential opportunities for intervention under the subsequent $100m Reef Restoration and Adaptation Program (RRAP).

Impact snap shots

Understanding links between water quality and coral bleaching

Results from Quantifying the linkages between water quality and the thermal tolerance of GBR coral reefs suggest that heat stress was found to be the primary significant diver for bleaching across recent events, with inshore corals showing greater recovery following bleaching compared to those in the mid-shelf. Contrary to some expectations, the bleaching response across inshore and mid-shore corals was not exacerbated by higher levels of nitrate and phosphate, the land-based nutrients that runoff from coastal river catchments. While it is now suggested that improvements to water quality alone are unlikely to mitigate the severe bleaching that occurs as a result of heat stress, those improvements are crucial to assisting in Reef recovery.

What makes a coral species more tolerant to heat?

Some corals are more resilient than others when exposed to heat stress. The traits of corals that survived recent bleaching events, looked at the distribution of three coral species populations across the GBR and how they respond to these stressors. This involved assessing both the genes and respective coral symbionts' response to heat stress. By knowing the distribution and abundance of stress tolerant coral genes and their symbionts, key coral populations are now being identified for protection, key reefs for resilience management, and potential breeding stock for use in the subsequent $100m Reef Restoration Adaptation Program. *Acropora millepora* was found to be both homogenous across the Reef ecosystem, as well as being the most resilient to heat stress, suggesting increased emphasis should be placed on protection or restoration of this species, potentially after mass bleaching events.

Resilience-based management tool begins to illuminate pathways for Reef recovery

Guidance system for resilience-based management of the Great Barrier Reef developed and applied an algorithm that uses present-day coral cover and a GBR-scale connectivity model to identify important larval source reefs for supporting recovery of the GBR from its present-day state. This work led to the creation of a resilience-based management (RBM) tool which has now laid the groundwork for further decision support software development under the Reef Restoration and Adaptation

Program. The tool has since provided a structured method to explore strategy options for restoring and protecting the Great Barrier Reef with its decision support software for planning of interventions to support reefs recently recognised in a report from the National Academies of Science, Engineering and Medicine (USA).

Improved predictive modelling to shift messaging and management

Crown-of-thorns starfish: surveillance and life history, applied its data-driven modelling approach to improve the scale of modelling for predicting both coral bleaching and subsequent mortality, following widespread heat stress events on the Great Barrier Reef. *Coral Bleaching and Mortality on the Great Barrier Reef* suggested that initial reports on mortality following the 2016-17 bleaching events made alarming estimations and that mortality across multiple bleaching events was varied and influenced by several factors. Data from surveys undertaken under the crown of thorns starfish control program allowed for finer-scale estimation for mortality, putting Reef Mangers and Reef Users in a better position to respond to these events by assisting in Reef recovery efforts.

Research outputs and attributions

Relevant Projects

Project 4.1: Crown-of-thorns starfish: surveillance and life history

Project 3.3.1: Quantifying the linkages between water quality and the thermal tolerance of GBR coral reefs

Project 4.4: The traits of corals that survived recent bleaching events

Project 4.5: Guidance system for resilience-based management of the Great Barrier Reef

Outputs

Report - Coral Bleaching and Mortality on the Great Barrier Reef: A Data Driven Modelling Approach

Report - Assessing the linkages between water quality and coral bleaching on the Great Barrier Reef

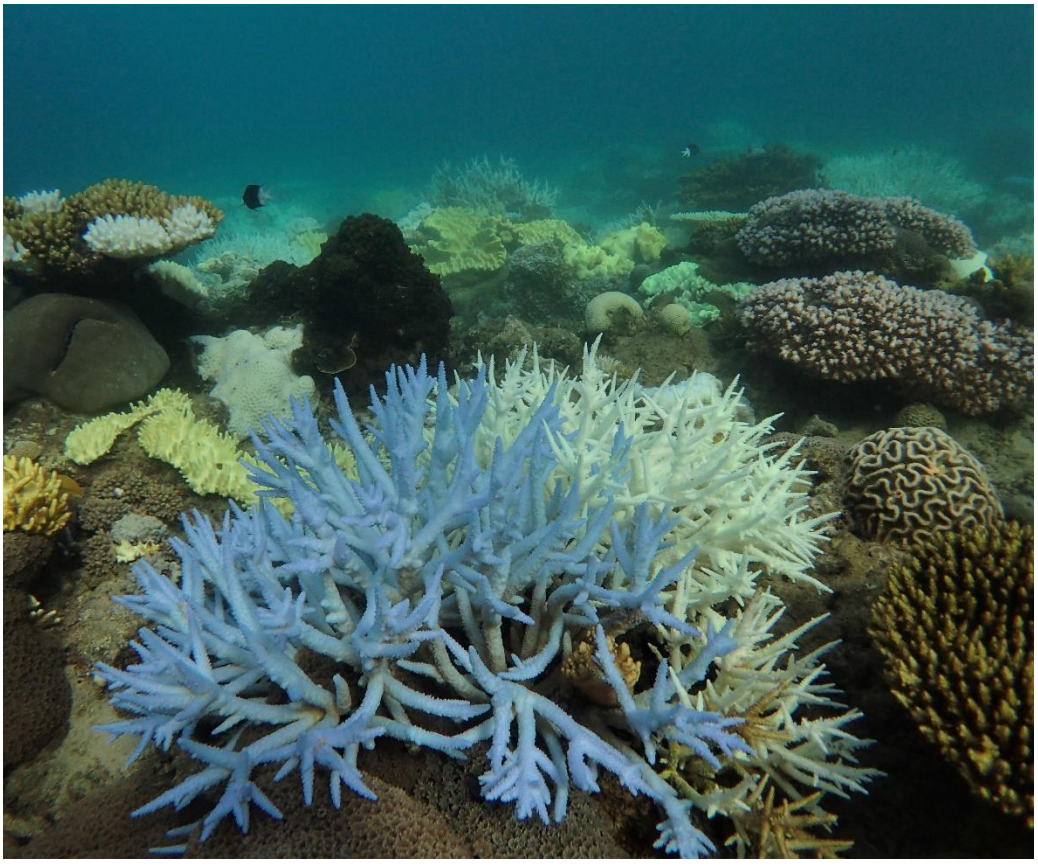
Report - Resilience-Based Management Tools for the Great Barrier Reef

Report - The genetic traits of corals that survived recent bleaching events

Images and video



Caption: Coral reefscape. Image: Robert B. Mason, University of Queensland



Caption: Reef at Russell Island, north Queensland. Image: Neal Cantin, AIMS.

Theme title

Ecosystem Restoration is key to improved water quality

Theme description

Healthy coastal ecosystems are critical for the long-term health of the Great Barrier Reef (GBR). Protecting, maintaining and restoring coastal ecosystems is critical to supporting Reef recovery. An integrated whole-of catchment approach is needed to protect and restore the ecological functioning of coastal ecosystems and improve the quality of water flowing to the GBR. From ridge to reef, TWQ Hub research focused on ecosystem restoration including gully restoration, coastal wetland restoration and innovative coral restoration techniques. A resilience-based management approach was subsequently developed to assist reef managers in decision-making. Fine sediment reduction is now a priority under the Queensland Government's Reef 2050 Water Quality Improvement Plan.

Impact snap shots

Gully remediation to reduce sediment and nutrient loss

It is now understood that gully erosion contributes ~40-50% of the fine sediment load to the GBR from less than 1% of the total catchment area. This knowledge led to an investment of over $65M in gully rehabilitation from various government agencies. However, the methods and approaches for reducing this erosion source were not well understood until NESP-funded research began addressing the gap. With such significant investments in play, and a huge area and thousands of gullies to consider for treatment, NESP research developed a new method to identify different types of gullies in the landscape, and to prioritise management effort and resources such that the appropriate treatments are applied to different gullies in the most cost-effective manner.

TWQ Hub research also trialled various rehabilitation options across small and large alluvial gullies finding that the applied treatments reduced fine sediment losses by 80-90% and provided detailed costs estimates for various forms of treatment. This research constitutes some of the first control/treatment field experiments to measure actual changes in water quality on the ground as a result of gully rehabilitation efforts, with results critical in constraining scenario analysis in future Paddock to Reef modelling.

Hub research has also developed a method for identifying priority gullies for rehabilitation, one which is vastly more accurate and efficient compared to previously used mapping. These results not only demonstrate the gull rehabilitation techniques are effective, but also when, where and how to best apply them for maximum effect. NESP research indicates that we can get halfway to the Reef 2050 sediment targets by identifying and treating just the most sediment-intensive and cost-effective 2% of gullies. The team's contributions to water quality improvements for the GBR were recognised in 2017 with the awarding of a Eureka Prize.

Wetland restoration across various GBR catchments

Through a series of research projects and working with land managers, TWQ Hub research used advanced scientific hydrological and ecological techniques to generate data to evaluate wetland repair efforts, providing surety to government funding agencies. A whole-of-catchment approach through various wetland sites along the Queensland coast has documented the benefits of restoring coastal wetlands through applied practical solutions and monitoring. Various methods were trialled and monitored including the removal of historical tidal bund walls which supported fish movement between freshwater and saltwater; constructed wetlands on agricultural properties; feral pig exclusion fencing; and the identification and removal of aquatic weeds in wetlands. Methods have proven to

benefit native species, reduce nitrogen on farms entering waterways and improved water quality entering the Great Barrier Reef.

Coral restoration for reef resilience

The Great Barrier Reef is suffering from the combined effects of many threats and disturbances, including mass coral bleaching, pollution, storm damage, and outbreaks of crown-of-thorns starfish. While some of these threats are caused or exacerbated by global issues such as climate change, others may be amenable to local- or regional-scale intervention, restoration and management. Focused on innovative coral restoration techniques, collaboration with tourism operators and reef managers allowed techniques to be trialled and evaluated. A coral restoration database created under the TWQ Hub is now informing the Reef Restoration and Adaptation Program (RRAP) and informing the upcoming Great Barrier Reef Marine Park Authority's (GBRMPA) Coral Restoration and Adaptation Policy. These policies are being used to better assess and guide future restoration project applications for the Great Barrier Reef.

Research outputs and attributions

Relevant TWQ Hub Projects:

Project 2.1.4: Demonstration and evaluation of gully remediation on downstream water quality and agricultural production in GBR rangelands

Project 2.1.10: The application and adaption of mine site rehabilitation approaches to alluvial gully rehabilitation in the Bowen Catchment

Project 3.1.7: Reducing sediment loads to the Great Barrier Reef: developing optimal approaches for treating alluvial gully erosion

Project 3.3.2: Science evaluation of coastal wetland systems repair projects across GBR catchments

Project 4.3: Best practice coral restoration for the Great Barrier Reef

Project 4.9: Gully Characterisation Framework to underpin GBR Catchment Water Quality Management

Project 5.9: Gully remediation effectiveness

Project 5.13: Coastal wetland systems repair across GBR catchments – values based causal framework validation

Images and video

Webinar on coral gardening

Video: The value of constructed wetlands in Great Barrier Reef catchments



Caption: Griffith University researchers undertaking a high-resolution terrain survey to ground truth alluvial gully mapping in the Bowen catchment (Photo Justin Stout)



Caption: Assessing an alluvial gully in the Bowen catchment (Photo Justin Stout)



Image: An ephemeral hillslope channel (left) before and (right) after highly successful rehabilitation. This site has now increased the local habitat value of the site as a refuge for birds, reptiles and other fauna (Photos: NQ Dry Tropics)



Caption: Feral pig fencing at Roundhill Reserve. Image: Nathan Waltham.



Caption: Fish species monitoring in restored wetlands. Image: Nathan Waltham.

Theme title

Indigenous engagement for improved water quality

Theme description

Close collaboration between Traditional Owners and NESP TWQ science has resulted in better co-management of country and improved water quality. The NESP TWQ Hub led the way in the foundational development of a meaningful engagement strategy with Aboriginal and Torres Strait Islander peoples in the sustainable cultural and environmental management of the Great Barrier Reef and its catchments. In addressing targets of the Reef 2050 Plan, the aspirations of Traditional Owners and building capacity has been fundamental to land and sea country management and governance.

Working with Indigenous Ranger groups throughout the life of the Hub, researchers have passed on valuable skills that can be carried forward in land and sea monitoring for healthy country. Together with scientists, Traditional Owners have actioned cultural site clearance and preliminary assessments, gained new skills in wetland rehabilitation, feral pest management, land and sea country mapping, grass seed collection, gully remediation construction, estuary and mangrove management, salinity monitoring, water quality sampling, equipment maintenance, weed management and general site management. Training in jellyfish stinger collection and identification, shoreline video assessment, coral identification and restoration techniques are additional skills that have been passed on for future management.

Impact snap shots

Tracking Aesthetic values provides new engagement for Traditional Owners along GBR

Measuring Aesthetic Values Using Big Data Approaches has provided an insightful example of how social sciences research is complementary in designing, interpreting and improving the AI system for monitoring the aesthetic value for the Great Barrier Reef (GBR). Throughout the project, these results were communicated to over 30 Indigenous communities along the GBR Coastline. Dewayne Mundraby, IPA Tourism & Infrastructure Manager found the exchange of knowledge both useful and empowering:

> *There is a very strong sense of responsibility and continuity of connection, we can appreciate how industry can not only impact the environment but also on first nations identity and therefore, blurs the aesthetic importance, focusing on the immediate visible issue;*
>
> *What's important is preservation and rehabilitation to ensure the cultural story lines continue, transmission of knowledge, mixing culture and science in the interest of generations to come.*

This impactful cross-cultural exchange was achieved by incorporating the exchange of knowledge into the project's Indigenous engagement strategy, a key element of every TWQ Hub project design.

Reef Monitoring and Restoration skills passed onto Sea Country Traditional Owners through Innovative Workshop

The skills and knowledge gained by Sea Country Traditional Owners supported by the Hub to attend the 2019 & 2020 Reef Leadership and Restoration Workshops at Orpheus Island have since commenced or begun planning activities on their country, engaging in Indigenous tourism and inshore coral monitoring. Sarah Giudice, who leads the Gidarjil Sea Rangers has thoroughly appreciated the upskilling within her team:

"The Gidarjil Sea Rangers who attended the Workshop found it beneficial in a number of ways. The workshop definitely contributed to the Sea Ranger's coral species, fish and macroinvertebrate identification skills and also their experience and confidence in the water. The planning and restoration techniques they learnt has set us in good stead to identify any of our inshore reefs that could benefit from restoration."

The workshop also focused on developing leadership skills and emphasising the role everyone must play in preserving precious and unique natural ecosystems.

Indigenous Partnerships lead to ongoing capacity for Cape York Traditional Owners

A partnership between Hub scientists, Cape York Natural Resource Management staff and Indigenous graziers has reduced sediment run-off from one of the Indigenous Land and Sea Corporation's (ILSC) Crocodile-Welcome Station gullies by 85%. This success has spurred on the expansion of gully remediation activities. With the support of the Australian Government's Reef Trust, the ILSC have now purchased an excavator and employed a crew of local Traditional Owners to continue the works, providing ongoing social and ecological outcomes.

New skills and greater capacity for Ranger groups thanks to Hub engagement.

Since 2006, Mangrove Watch, co-developed by Tropical Water Quality Hub Researcher Prof. Norm Duke has been used to make mangrove monitoring more accessible to groups and communities. Hub research assessing the recent dieback of mangroves across the Gulf of Carpentaria led to several Indigenous Ranger Groups being upskilled in these monitoring techniques following engagement across the span of the project. Various Northern Territory and Queensland Gulf Rangers as well as Sea Rangers from Gidarjil Aboriginal Corporation are now trained in the Shoreline Video Assessment Methodology, which allows local rangers to efficiently monitor mangrove health from boat or shore.

Relevant projects

Project 2.3.4: Working with Traditional Owners and local citizens to better manage GBR estuarine wetlands

Project 5.5: Measuring aesthetic and experience values using Big Data approaches

Project 3.1.7: Reducing sediment loads to the Great Barrier Reef: developing optimal approaches for treating alluvial gully erosion

Project 4.13: Assessing the Gulf of Carpentaria mangrove dieback

Project 2.1.3: Early warning systems to minimize the risk of box jellyfish stings by empowering stakeholders

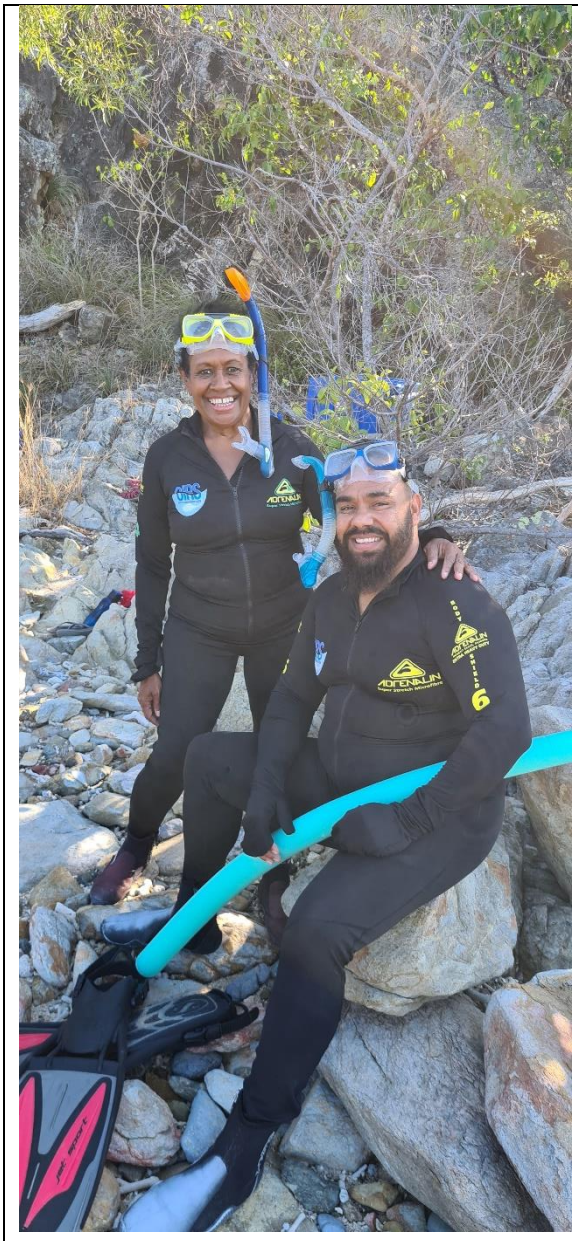
Images and video

Video - Orpheus Island Reef Restoration and Leadership Workshop 2020

Video – Crocodile Gully rehabilitation



Caption: Carpentaria Land Council Aboriginal Corporation Rangers talk about mangroves with Dr Norm Duke. Credit: Jock McKenzie, JCU



Manbarra Traditional Owners Vicki Saylor and Richard Parsgaard at the Reef Restoration and Leadership Workshop, 2020. Credit: Hulton King, RRRC.

Theme title

Blueprint for Crown-of-thorns starfish control on the Great Barrier Reef

Theme description

Crown-of-Thorns Starfish (COTS; Acanthaster spp.) are voracious coral predators and the cause of significant coral loss on Australia's Great Barrier Reef (GBR). For reasons that are unclear, COTS populations go through periodic cycles of abundance and can reach densities of hundreds of individuals per hectare. During these periods of high density, COTS can consume most of the hard coral cover at a site.

COTS outbreaks are one of the few threats amenable to direct intervention, emphasising the importance of ensuring that control efforts are as effective as possible at defending live hard coral cover. Although there is a long history of research into COTS biology, ecology and causes of outbreaks on the GBR, there were few significant advances in how control activities are implemented and how to maximise effectiveness.

The Tropical Water Quality Hub's adaptation of a world-first Integrated Pest Management (IPM) approach to the marine environment has delivered a strategic response to COTS control on the GBR and is effectively reducing outbreak incidents and ecosystem impacts. The applied COTS IPM approach has filled critical ecological knowledge gaps, developed and delivered new tools and methods for surveillance and control, and has demonstrably improved the capacity for manual COTS control to defend coral cover on the GBR.

Impact snap shots

Advancing understanding of Crown-of-thorns starfish ecological processes

NESP TWQ Hub researchers and industry partners used a systems understanding of COTS outbreaks and of control logistics to develop an IPM control strategy that demonstrably protected more hard coral than any other action. Collaborative and strategically-targeted research projects were conducted to address gaps in knowledge. A continuous assessment of control performance and operations in situ enabled continuous improvement in the COTS IPM Program ensured the Program effectively achieved the protection of coral at a local, reef and regional scale. These approaches are now being expanded to meet the program's new potential under the COTS Control Innovation Program, including the future development of new tools and technologies not reliant on manual control, such as eDNA detection, predation and chemical cues.

Protecting hard coral cover on the Great Barrier Reef

COTS predation has been identified as a major cause of coral loss at the scale of the GBR contributing as much as 42% of coral loss between 1985 and 2012. This poses long-term risks to overall reef health and resilience. The IPM COTS Control Program is now successfully ensuring that COTS densities are kept below the critical densities that allow coral growth to outpace COTS predation. It is now twice as likely that a COTS infested site will have COTS numbers reduced to below the ecological threshold where net coral loss occurs. Under the previous approach it took 60% longer to achieve this outcome at site, meaning that more coral was lost before control was successful, and was successful at just 53% of sites and 0% of reefs. The IPM COTS control program now achieves these outcomes at 88% of sites and 92% of the reefs where implemented. Ultimately the program greatly reduced the number of reefs consider to be in active outbreak mode and there are even some indications it has also reduced the starfish's overall geographic spread.

Improved efficiency and effectiveness in COTS control through development of a decision support tool app

The COTS Control Centre Decision Support System (CCC-DSS) developed by CSIRO under the TWQ Hub is used daily on the COTS Control vessels. The CCC-DSS is installed on 32 ruggedised Android Tablets along with a suite of three data collection apps developed for the Great Barrier Reef Marine Park Authority (GBRMPA) and three decision support components developed under the Hub's COTS IPM research program. The tablets have also been managed remotely, including locating hardware and updating software. Data is then shared between the apps that make up the CCC-DSS within a tablet, between tablets on a vessel independent of cellular connectivity, and with GBRMPA's Eye on the Reef Database when cellular networking is available. The CCC-DSS is now used by GBRMPA for control operations identifying priority reefs for control and maintenance, and thus boosting the program's impact in protecting hard coral cover.

Training and employment of Indigenous and non-Indigenous to control Crown-of-thorns starfish

The COTS Control youth training program funded by the Queensland Government's Skilling Queenslanders for Work Program has operated since 2010 and produced several hundred graduates. The training program has had a substantial and significant positive impact on the self-reported life satisfaction of the COTS program graduates, with many reported having greater confidence in their skills and vastly improved employment opportunities. With an average age of 22, over 80% of graduates found employment following the program maintaining a strong personal connection with, and motivation to protect the GBR. With youth graduates nearly 27 times more likely than other local youth to be fully employed, it is no exaggeration to say that this program has changed lives for the better in far north Queensland, especially in Indigenous communities.

Research outputs and attributions

Relevant TWQ Hub Projects:

Project 2.1.1: Integrated pest management of Crown-of-thorns starfish

Project 3.1.1: Implementation of the Crown-of-thorns research strategy: regional strategies

Project 4.1: Crown-of-thorns starfish: surveillance and life history

Project 5.1: Matching the Crown-of-thorns starfish Integrated pest management to the scale of the new Control Program

Relevant Outputs:

Report - Integrated Pest Management Crown-of-Thorns Starfish Control Program on the Great Barrier Reef: Current Performance and Future Potential

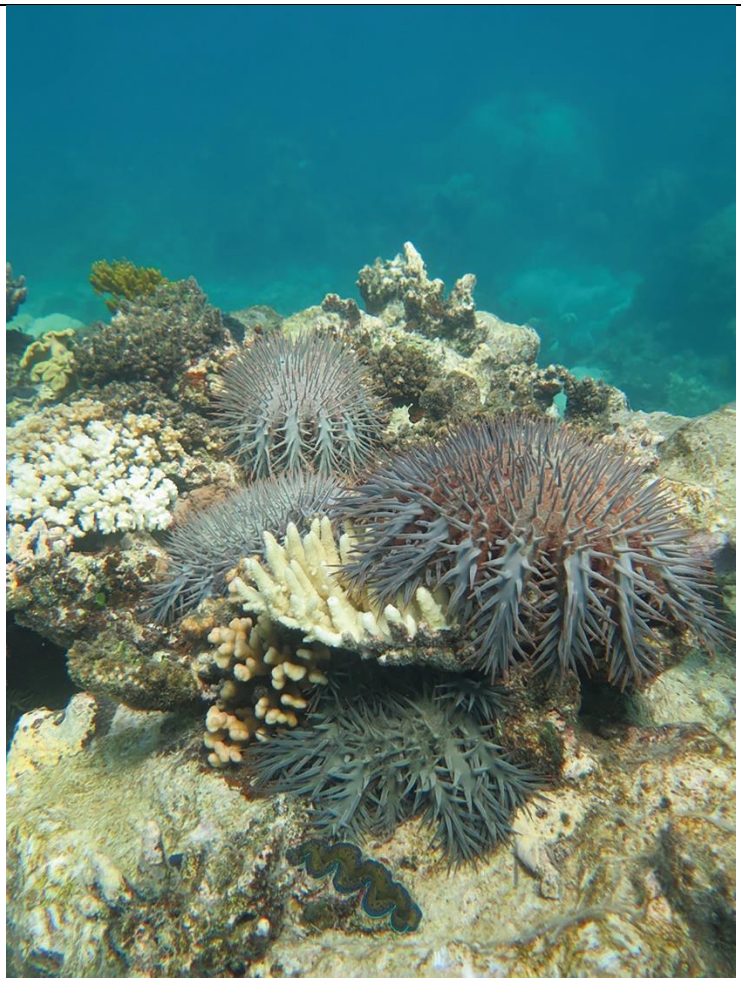
Report - The COTS Control Centre: Supporting ecologically-informed decision making when and where decisions need to be made

Report - Social and Economic Outcomes of the COTS Control Youth Training Program

Case Study - How a significant improvement in defending live coral cover from COTS outbreaks on the GBR was achieved using science

Images and video

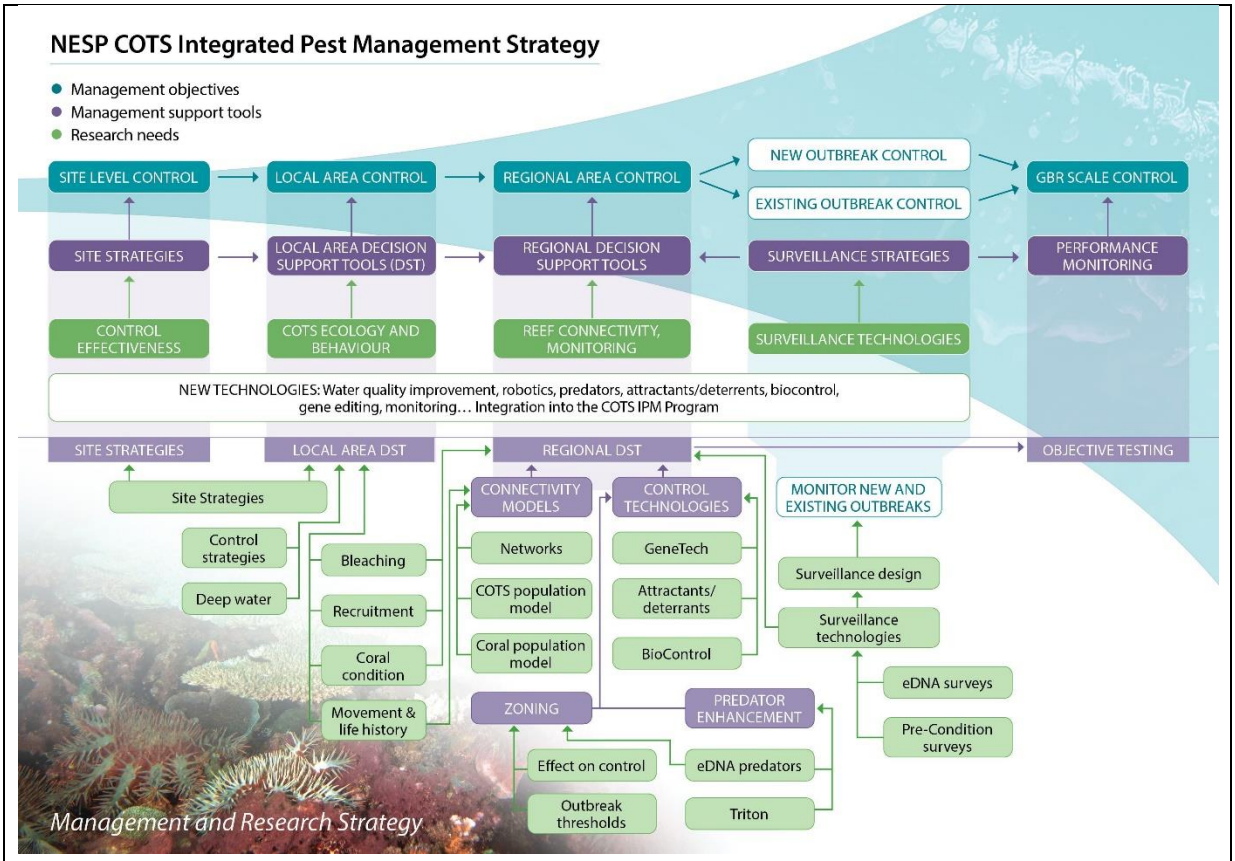
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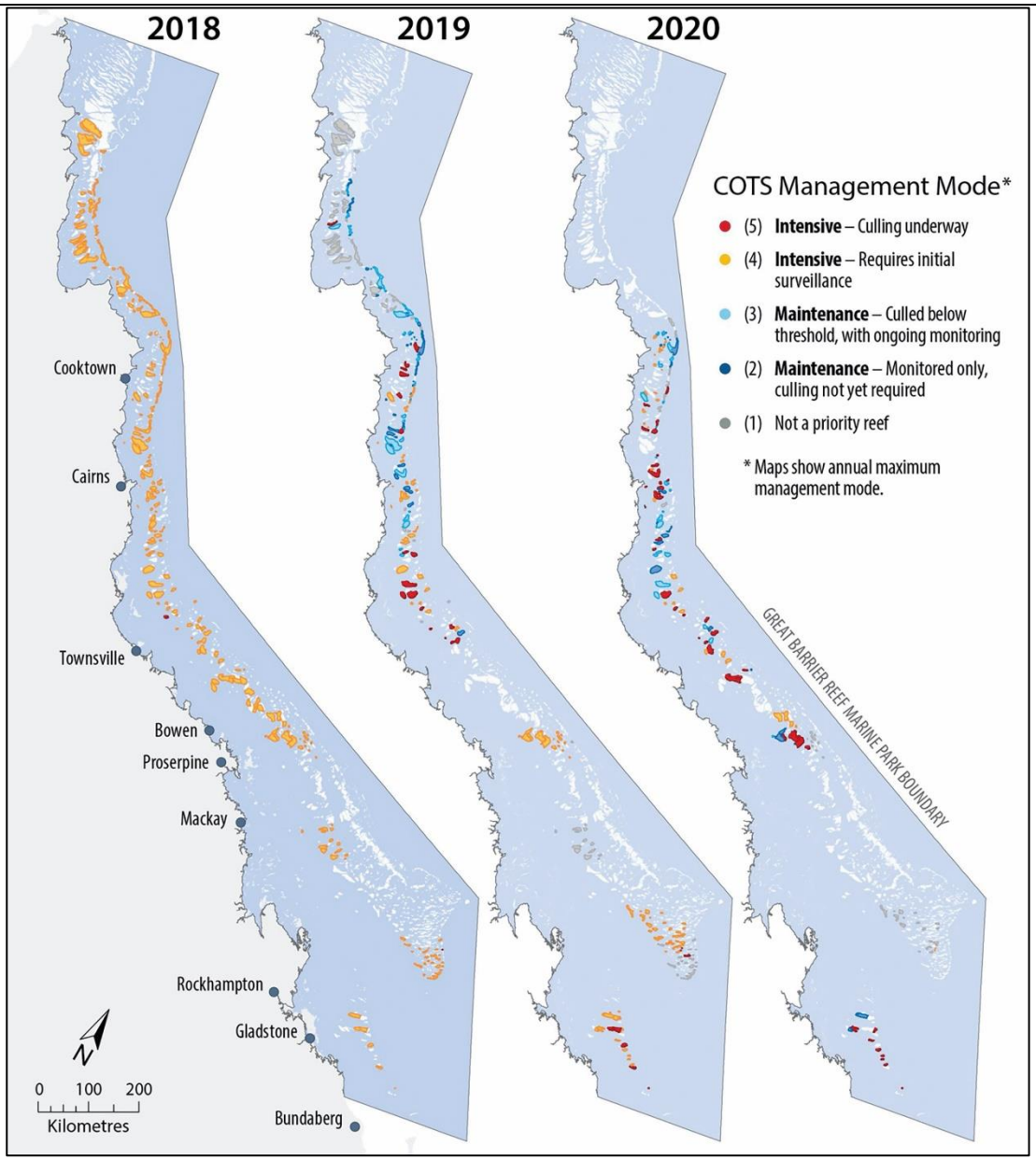
Caption: COTS outbreak at Rib reef, GBR. Image: Morgan Pratchett, ARC Centre for Excellence in Coral Reef Studies.



Caption: COTS Control diver in action. Image: Dan Beard.



Caption: Management objectives, management support tools, and research needs for the NESP IPM research strategy, established by Westcott et al. (2016).



Caption: Changes in reef management modes across the GBR from 2018 to 2020 when the innovative Integrated Pest Management approach was applied.

Theme title

Achieving change in farming practices

Theme description

One of the biggest challenges in meeting the water quality targets set under the Reef 2050 Plan – and restoring trust - has been the ability to determine with confidence the sources and amounts of dissolved inorganic nitrogen, sediment and other pollutants in river systems that flow onto the Great Barrier Reef. The Russell-Mulgrave catchment in the Wet Tropics just south of Cairns was facing many of the challenges for farmer engagement and uptake of improved farming practices for water quality. These challenges, including a lack of credible data to overcome pre-existing mistrust in the science, technology to provide real-time runoff sensing, and the ability to identify nutrient hot spots. In meeting these challenges, the Hub also engaged water quality scientists with established experience and rapport with the sugar industry were involved, as it was acknowledged that the provision of complex messages is best done by trusted, highly credible sources.

"We are sometimes told that we are the worst polluting catchment and at other times that title goes to [another catchment]. We are told that the information comes from the 'end of catchment' water quality modelling. I can tell you that very few farmers believe that modelling." Barry Stubbs, second-generation cane grower in the Russell-Mulgrave catchment

Impact snap shots

Real-time water quality monitoring builds trust

Technological advances have allowed accurate and real-time measurements of nitrate concentrations in local waterways throughout the year to be gathered and immediately fed back to local canegrowers via CSIRO's specially developed mobile phone app. Analyses of wet season data from the study showed that the first big flushes of rain were responsible for approximately 40% of the contaminants that end up flowing onto the Reef from that catchment. The integration of relatively traditional monitoring approaches (discrete sample collection for subsequent laboratory analysis), with the emerging technology enabling real-time high-frequency, sensor-based monitoring allowed the data to be available to the farmer in real-time. Through a series of "shed workshops", a safe learning environment was also created in which farmer committee members could better interpret the real-time data and understand its context.

"The project allows us to monitor the catchment in real-time… we can now see where the problems are and where they are not", Steve Calcagno, second-generation cane grower in the Russell-Mulgrave catchment

This research has led to ongoing investments under the Reef Trust Partnerships to further practise change in the Russel-Mulgrave catchments using these approaches.

Internet of Things improves cane farming practice

NESP TWQ Hub researchers developed an Internet of Things (IOT) platform that has vastly improved the efficiency of automated irrigation systems on a cane farm in the Burdekin catchment. The platform combines information from weather forecasts and the grower's own watering system to create a suggested model for irrigation for the day, saving the grower huge amounts of time and effort, also minimising wasted water and sediment runoff to the Great Barrier Reef. As a pilot

demonstration this Hub project has created a foundation around the IOT platform that can now adopt other automated functions in the cane farming space and continue to improve the water quality outcomes for catchments using them.

Research outputs and attributions

Relevant Projects

Project 2.1.7: Engaging with farmers and demonstrating water quality outcomes to create confidence in on-farm decision-making "Project 25"

Project 4.8: 'Project 25' – farmers, water quality and on-farm decision-making

Project 3.1.2: Improving water quality for the Great Barrier Reef and wetlands by better managing irrigation in the sugarcane farming system

Project 2.1.3: Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project

Outputs:

Internet-of-Things Uplink-Downlink Summary Brochure

Report - Improving water quality for the Great Barrier Reef and wetlands by better managing irrigation in the sugarcane farming system

Report - Engaging with farmers and demonstrating water quality outcomes to create confidence in on-farm decision-making ("Project 25")

Report - Findings from a longitudinal study of farmer decision influencers for Best Management Practices, Queensland, Australia

Images and video

Video – Canegrowers and scientists

Video – Improving the efficiency of automated irrigation



Caption: Dr Aaron Davis, James Cook University and local canegrower in the field assessing prospective water quality monitoring site locations. Image: Boyd Robertson, RRRC.



Caption: Sugarcane field near Giru. Image: Lynne Eagle, James Cook University.



JCU/TropWater Researcher Aaron Davis demonstrating nitrate sampling on farmland to local farmers and extension officers. Credit: Boyd Roberston, RRRC.