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Final Report

Reef Trust Offsets Calculator

A prototype calculation approach for determining financial liability for marine biodiversity offsets voluntarily delivered through the Australian Government Department of the Environment (Reef Trust)

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The University of Queensland
AUSTRALIA

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ACRONYMS

DMA.............. Distinct Matter Areas
DOE .... Department of the Environment
EEI .... Ecological Evaluation Index
EPBC .... Environmental Protection and Biodiversity Conservation
GBR .... Great Barrier Reef
GBRMP......... Great Barrier Reef Marine Park
GBRMPA ...... Great Barrier Reef Marine Park Authority
GBRWHA...... Great Barrier Reef World Heritage Area
HEA .... Habitat Equivalency Analysis
MNES............ Matters of National Environmental Significance
N .... Nitrogen
NESP .... National Environmental Science Programme
NNL............... No Net Loss
NRM.............. Natural Resource Management
PCA .... Principal Components Analysis
REA .... Resource Equivalency Analysis
TN .... Total Nitrogen
TP .... Total Phosphorous
TWQ.............. Tropical Water Quality

ABBREVIATIONS

Ha .... Hectare
kg.................. kilogram

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EXECUTIVE SUMMARY

The purpose of this project is to design a draft calculation approach to determine the amount of money that a proponent would pay when voluntarily using the Reef Trust as an offset provider. This project is funded by the National Environmental Science Programme's Tropical Water Quality Hub. The researchers worked in close collaboration with the Reef Trust team at the Department of the Environment to develop an approach that is consistent with relevant policy principles, such as the EPBC Act Environmental Offsets Policy, and end-user needs.

Biodiversity offsetting is 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 offset approaches in Australia, while inclusive of the marine environment, were conceptualised primarily for terrestrial ecosystems and have most often been applied in terrestrial settings. However, the marine and terrestrial environments are fundamentally different mediums for offset application. The Australian Government's Reef Trust includes a mechanism that allows proponents to enter voluntarily into agreement with the Reef Trust to meet offset obligations. This arrangement could significantly increase the likelihood that marine biodiversity offsets are successful, but for that to be the case, a robust method is required for calculating the financial liability of a proponent who partners with Reef Trust in order to implement an offset.

The project team developed a prototype calculator that is based on terrestrial offset calculators used in Australia and international best practice, but adapted for the Great Barrier Reef context. The prototype calculator is a transparent and easy-to-use spreadsheet-style tool that considers:

- Surrogates: proxies for groups of Matters of National Environmental Significance (MNES) that are likely to be negatively impacted by proposed projects
- Surrogate Condition Factor: factor that accounts for the ability of a habitat or species to respond to conservation action, based on scientific evidence of condition and trend of the MNES
- Implementation Costs: estimates of cost to implement offset activities, including implementation risk factors, in order to achieve a benefit for the MNES
- Time Delay: factor that accounts for the time difference between impact and the benefit being generated by the offset activity
- Administration Fees: charge to recover the costs of administering, monitoring, reporting, and adapting offsets

The prototype calculator outlines a framework for estimating liabilities, and it requires data to quantify the components of the calculation before it is fully functional. Further synthesis of existing data and expert elicitation are recommended to progress the development of the approach to implementation stage.

1.0 INTRODUCTION

1.1 Project Purpose

The draft calculator is intended for marine biodiversity offsets that are voluntarily delivered through the Reef Trust

The purpose of this project is to design a draft calculation approach that could be used—with appropriate data inputs—by proponents and relevant environmental assessors to determine the amount of money that a proponent would pay when voluntarily using the Reef Trust as an offset provider. The calculator would be used after impact assessment is complete. The calculation approach is to be applicable to impacts on matters of national environmental significance which comprise the GBRWHA, as well as the World Heritage Area itself.

This project is funded by the National Environmental Science Program's Tropical Water Quality Hub. The researchers have worked in close collaboration with the Reef Trust team at the Department of the Environment to develop an approach that is consistent with relevant policy principles, such as the EPBC Act Environmental Offsets Policy and end-user needs. It is anticipated that the final output of this contracted research project - the draft calculation approach - will need pilot testing and may need revision before finalisation, and ongoing refinement and adaptive management thereafter. Its successful use will also require the collation of data on the cost and effectiveness of alternative management interventions. Once populated with these data, the calculator is designed to allow the cost of offsetting particular impacts to be transparently derived for individual projects using only the information collected in standard impact assessments.

1.2 Biodiversity Offsets Defined

'Biodiversity offsetting' is a mechanism whereby the permitted environmental impacts of development projects are compensated through conservation activities that yield a gain at least equivalent to the impact. Biodiversity offsets are increasingly being used globally in both marine and terrestrial environments, though the policy principles, design and technical approaches used for these offsets vary among jurisdictions and schemes.

Biodiversity offsets are a mechanism to compensate for residual impacts on Matters of National Environmental Significance

International best practice in biodiversity offsets calls for quantifiable conservation gains to counteract any significant biodiversity loss, based on adherence to the 'mitigation hierarchy.' The mitigation hierarchy requires that all impacts to biodiversity must first be avoided or minimised, then damage done restored. Any residual damage to biodiversity can then be offset as a last resort, to achieve the primary objective of 'no net loss' (NNL) of biodiversity (Ten Kate et al. 2004). Biodiversity offsets can only achieve the goal of NNL by adherence to stringent conditions (Dutson et al. 2015).

Biodiversity offsets are not appropriate for all development impacts as there are limits to what can feasibly be offset. This concept of 'offsetability' is important in instances where NNL is unable to be achieved as a result of the irreplaceability or vulnerability of the biodiversity value, or is ecologically or practically infeasible (BBOP 2012a, b; Pilgrim et al. 2013).

1.3 Offsets in Australia

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. However, the marine and terrestrial environments are fundamentally different mediums for offset application. Two primary examples of these differences are ownership and connectivity (Bos et al. 2014), which can make offsets in the marine environment more difficult. Unlike land, marine and coastal resources are public commodities, making sustained legal protection difficult to maintain without consistent public support (Bell et al. 2014; Dutson et al. 2015). Marine environments also have greater spatial and hydrological connectivity, enabling many impacts to flow further and affect a greater range of species and ecosystems (Carr et al. 2003; Bell et al. 2014; Bos et al. 2014).

The Great Barrier Reef World Heritage Area (GBRWHA) encompasses the Great Barrier Reef Marine Park (GBRMP) and some island and nearshore areas (Dutson *et al.* 2015). The GBRWHA is jointly managed by the Australian and Queensland governments via intergovernmental agreement (1978) and various laws and regulations, while the Great Barrier Reef Marine Park Authority (GBRMPA) is the independent agency with the primary responsibility for the management of the park (GBRMPA 2014). Biodiversity offsets within the Great Barrier Reef are covered under both state and national legislation.

The EPBC Act Environmental Offset Policy guides the governments' approach to offsets in the Great Barrier Reef World Heritage Area

In Queensland, offsets are regulated by the Environmental Offsets Policy, including the Environmental Offsets Act 2014, which seeks to counterbalance any significant residual impacts on matters of national, local or 'State Environmental Significance.' This includes any species listed under that Nature Conservation Act 1992, areas classified as highly protected zones under the Marine Parks Act 2004, referable wetlands and watercourses in protection areas or in high ecological value waters, fish habitat areas and marine plants under the Fisheries Act 1994 and legally secured offset areas (Queensland Government 2014). In addition, many biodiversity offsets in Australia are governed by the Commonwealth government EPBC Act Environmental Offset Policy, which sets out the Government's approach to offsetting significant residual impacts on Matters of National Environmental Significance (MNES). In the marine environment, this includes Ramsar-listed wetlands, all EPBC-listed threatened species and ecological communities, internationally-listed migratory species, all World Heritage areas, and the GBRMP.

To date, offsets in the GBRWHA have been assessed and implemented by proponents of development ('proponents') on a per-project basis, leading to fragmentation and inefficiencies (Bos et al 2014). In 2014, the Australian Government created the 'Reef Trust', a program focused on the restoration of the Great Barrier Reef, including the ability to improve and consolidate marine biodiversity offsets in the region. The Reef Trust includes a mechanism that allows proponents to enter voluntarily into agreement with the Reef Trust to meet offset obligations. This arrangement could significantly increase the likelihood that marine biodiversity offsets achieve NNL or net benefits, but there are several technical and policy elements that require research and careful design to avoid suboptimal outcomes. One of those elements, addressed by this report, is a method for calculating the financial liability of a proponent who partners with Reef Trust in order to implement an offset.

1.4 Offset Liability Examples

While there are several existing approaches for calculating the ecological requirements for adequately offsetting a given impact, there are relatively few frameworks which then allow for the conversion of these to monetary values. Fewer still attempt to do this in a way that reflects the full replacement cost of the lost biodiversity, which is essential for ensuring the monies collected are adequate to achieve a 'no net loss' or 'improve or maintain' outcome.

In the United States, wetland mitigation offsets are determined by 'The Five-Step Wetland Mitigation Ratio Calculator', based on the 'net present value' approach to valuation, which considers both the existing and resulting level of wetland function, the length of time until full mitigation success, the risk of unsuccessful mitigation, and the capacity and opportunity to produce value and services of both the lost and the mitigated wetland (King & Price 2004).

In New South Wales, a biobanking approach is used, which identifies the biodiversity values of the impact and offset site, determines the biodiversity impacts, and quantifies the biodiversity credits lost at the impact site and gained at the biobank site (State of NSW 2014). The offset provider market then determines the range of prices at which a given type of credit can be purchased. This methodology does not discuss marine habitats, and specifically states that it does not apply to marine mammals, migratory shore birds or Lord Howe Island.

Biodiversity offsets in Queensland are currently developed using the Queensland offset calculator, which uses the 'Distinct Matter Areas' (DMA) to be impacted and a matter dependent area-based 'multiplier' (for example a threatened regional ecosystem has a multiplier of 4). The current system quantifies an offset requirement based on the areal extent of impact. An option is available via which proponents pay a set price per credit required into a trust fund which in turn invests to achieve the required offset benefits. The price of credits is fixed per credit type and is based primarily on land values (or in some regions foregone income from land use) and administration costs. However, this method assumes that both the impact and the offset are quantifiable based on the area affected (Bos et al. 2014), which is often not the case (and is even more challenging in the marine environment).

1.5 Project Approach

The project team was tasked with developing a draft calculation approach that is 1) based on and consistent with existing Australian terrestrial biodiversity offsets calculators (particularly the EPBC Act offsets assessment guide) but adapted to the marine context, 2) developed in consultation with key stakeholders including relevant government agencies, industry representatives, and non-governmental representatives, and 3) consistent with the Reef Trust and the current regulatory context for marine biodiversity offsets in the GBRWHA particularly the EPBC Act. The scope of this project is to create a calculation approach that accounts for impacts to biodiversity; impacts to other aspects of Outstanding Universal Value – including heritage values, cultural values, and other values that cannot be scientifically quantified AND exchanged – are outside the scope of this project.

This project also built upon two recent publications in which the project team was involved:

The calculator will be consistent with the EPBC Act and terrestrial offsets calculators in Australia, yet adapted to the marine context

Bos, M., Pressey, R.L. & Stoeckl, N. (2014). Effective marine offsets for the GBRWHA. *Environmental Science & Policy*, 42, 1-15.

Dutson, G., Bennun, L., Maron, M., Brodie, J., Bos, M. & Waterhouse, J. (2015). Determination of suitable financial contributions as offsets within the Reef Trust. Report to the Department of the Environment, Commonwealth of Australia.

Together these publications provide recommendations for how to systematically improve the assessment, implementation, and evaluation of marine biodiversity offsets in the GBRWHA. Improving how proponent financial liability is calculated – the subject of this project – is one of those recommendations.

The project has been conducted with the frequent engagement of key stakeholders. Three stakeholder workshops have been conducted:

- August 2015, Townsville, attended by representatives of industry, government, and non-governmental organisations
- February 2016, Canberra, attended by representatives of the Department of the Environment
- April 2016, Brisbane, attended by representatives of industry, government, and non-governmental organisations

Detailed information on stakeholder workshops – including invitation lists, objectives, outputs, and presentation slides – are included in Appendix 1.

2. BACKGROUND

Although end-users of the calculation approach will be able to simply input basic information about impacts to the calculator and identify a cost of a voluntary payment to the Reef Trust, the development of the calculator itself still required the detailed consideration of what comprises a sound offset, in order that the Department of the Environment can accurately cost the provision of offsets of different types. In this section, we outline the necessary considerations that the Department of the Environment must make when identifying the types of actions that will need to be invested in to acquit a given offset liability.

Bos et al. (2014) analysed potential methods for determining financial liability for marine offsets in the GBRWHA and concluded that financial liability should be calculated based on the following six considerations:

1) the **cost** of the offset, rather than the economic value of the MNES,
2) the magnitude of the impacts and gains relative to the **counterfactual** baseline,
3) the contribution to the achievement of at least no net loss or a **net benefit**,
4) consideration of offsetability and implementation **risks**,
5) **time** delays between impact and offset, and
6) the **total** cost including implementation, evaluation, and adaptation of the offset.

In addition, a seventh consideration is necessary when offsets are delivered through a calculator: **surrogates** of biodiversity. As a background to the development of the calculator, each of these concepts is explained and discussed below. Incorporation of each consideration into the calculator is detailed in Section 3.

2.1 Cost versus value

Previous marine biodiversity offsets in the GBRWHA have been calculated based on the estimated economic value of the impacted MNES. The methods to estimate the economic value of an MNES are debated in the literature, which reflects both methodological and philosophical concerns. Even if consensus could be reached on the right method to estimate economic value, this value is not necessarily correlated with the cost to maintain or restore a MNES. For example, it is possible to have a fishery that generates a large economic value but which is relatively cheap to manage, or by contrast, it is possible to have a species of low economic value but for which damage is very expensive to offset. There is thus no theoretical correlation between value and cost. Using economic value as the basis for offset liability calculations introduces large risks that the funds will not be sufficient to implement the offset (or possibly overpriced for the offset). Table 1 summarises alternative approaches for converting offset requirements to a financial liability, including economic value, cost, and other approaches.

Table 1: Potential methods for liability calculation (from Bos et al. 2014)

Option	Name	Financial Liability Calculation	Strengths	Weaknesses
1	Spatial equivalence	Size of impact area x multiplier x cost to restore area	Established methods from terrestrial offset policies	Spatial extent of impact and offset are often difficult to quantify in the marine environment
2	Partial economic value per ha lost	Based on the Deloitte Access Economics economic valuation of the Great Barrier Reef, calculate the average value per ha	Easy, cheap, and fast to calculate; no additional valuations necessary beyond biannual update of Deloitte calculation for whole of region	Only accounts for market values of certain industries and does not account for values associated with many ecosystem services (ecological, social, and cultural) Average value for large region does not capture spatially variable values and ignores unique habitats and species Does not account for costs to manage impacts and/or restore values; these costs are not necessarily correlated with the economic value of lost or damaged areas Impacts to the marine environment extend beyond site boundaries due to flows of water and movements of species so calculations focused only on a 'site' can underestimate impacts
3	Valuation study done for each and every offset	Context specific	Theoretically possible to estimate the correct value	Final estimates contentious because they are highly sensitive to valuation method and other research choices
4	Scaled flat fee or percentage based on development footprint	Fee based on size of development / investment	Easy and transparent to calculate	Neither cost nor size of development is necessarily correlated with cost to offset impacts
5	**Cost of offset activities**	**Full costs to administer and implement offset**	**More likely that budget will be sufficient to cover costs of offset implementation since**	**Does not account for social equity and issues related to distribution of costs and benefits between stakeholders**

Option	Name	Financial Liability Calculation	Strengths	Weaknesses
		activities	**this option also requires, appropriately, that required and low-risk offset activities have been identified before the development is approved**	**Time-consuming and difficult to cost out each offset activity**

Based on this analysis, cost will be used as the basis for the calculation approach. Cost is also the only approach that is likely to yield outcomes consistent with the EPBC Act Environmental Offsets Policy and terrestrial offset calculators in Australia.

2.2 Counterfactuals

An offset exchange comprises a loss due to an impact and a gain due to an offset action. The two must be of the same magnitude to achieve a no net loss outcome. However, while the idea is simple, calculating the losses and gains correctly is not always intuitive. This calculator is concerned only with calculating the size of a gain from an offset action (in order to derive a cost per unit of gain or benefit), while the size of the loss from an impact is determined separately, through the impact assessment process.

The conceptual basis of offsetting relies on estimates of both 1) predicted outcome for biodiversity as a function of an action, such as an impact or an offset, or both combined, and 2) predicted changes to biodiversity *in the absence of the action*. The latter is called the “counterfactual” (Ferraro 2009). The difference between the two estimates is how the loss and the gain in a biodiversity offset trade are calculated.

Existing impact assessment approaches tend to set the counterfactual at the offset site as the current status, implying that in the absence of the project in consideration, the biodiversity values of the site would remain unchanged through time. This approximation is inaccurate. Biodiversity values in the Great Barrier Reef Region are expected to change through time due to a complex suite of human impacts and human interventions. To more accurately quantify the portion of change that is directly relevant to the project in consideration, the calculation approach must use a counterfactual that takes into account both regional scale trends (e.g., Outlook Report), targets, and funded interventions (e.g., government commitments to achieve water quality improvements).

“Counterfactual” refers to the likely situation in the absence of the project under assessment, including both regional trends in conditions and other planned interventions

The magnitude of an estimated impact to a MNES from a development project can be conceptualised as in Figure 1a. The horizontal axis represents time, where t=0 is defined as the start of an impact. The vertical axis represents the value of the MNES of concern, where value is measured in units that are relevant to the type of MNES (for example, extent and quality of seagrass; see Section 3 below). The blue line represents the counterfactual scenario for the value of the MNES over time, i.e., how the value would have changed over time in the absence of the development, but accounting for any background threats that would themselves trigger offset requirements. Where investment in conservation or improved condition of the values is intended, then the counterfactual (blue line) must also reflect this intention (Maron et al. 2015b; Maron et al. In press). In this example, the value of the MNES is anticipated to decline slightly initially, even without any specific offsettable impacts occurring, but then improve and stabilise over time. The red line in Figure 1a represents the predicted change in value of the MNES over time due to the development project, and the red hatched area – the difference between the two – is the impact.

The same reasoning applies to the magnitude of the estimated benefit achieved at an offset site (Figure 1b). In Figure 1b, the blue line is the counterfactual – what would have happened without any offsettable impacts or the offset action itself, but including any potential conservation investment not linked to the offset that may have occurred. The green line represents the magnitude of the predicted benefit from the offset action, measured in the same units that the impact was measured in. The green hatched area is the benefit, and when combined with the impact, the overall net outcome is shown in Figure 1. The intended net outcome for the system in a ‘no net loss’ offset exchange is maintenance of the counterfactual trajectory for the system.

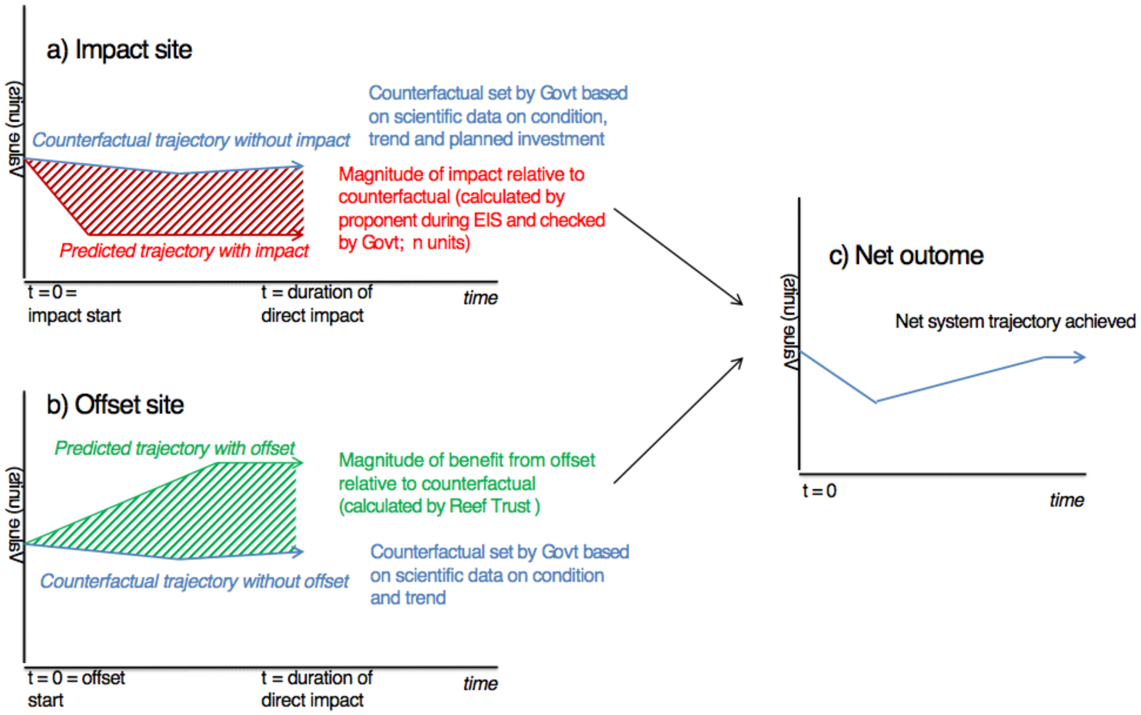

Figure 1: Conceptualisation of the magnitude of a predicted impact and offset benefit, relative to a counterfactual scenario, over the duration of the impact of a development project. The horizontal axis represents time where t=0 is defined as the start of an impact. The vertical axis represents the value of the MNES of concern, where value is measured in units that are relevant to the type of MNES (see Section 3 below). The blue line represents the counterfactual scenario for the value of the MNES over time, i.e., how the value would have changed over time in the absence of the development, but accounting for any background threats that would themselves trigger offset requirements.

2.3 Net Benefits

Under the EPBC Act, offsets must result in at least maintenance of the impacted MNES. This is conceptually equivalent to a 'no net loss' outcome. However, a key principle in decision making under the Reef 2050 Plan is that of delivering a net benefit to the ecosystem. The scope of the net benefit approach encompasses all components and processes of each ecosystem as well as the social, cultural and economic values of the area. The achievement of a net benefit to the GBRWHA is a collective responsibility. The purpose of net benefit is to enhance the condition of matters of national environmental significance, including the Reef's Outstanding Universal Value. As such, the Department of the Environment may consider encouraging, but not requiring, offsets that achieve a net benefit. In relation to offsets, this is a step beyond the more common goal of at least 'no net loss', and reflects the 'improve' option from the 'improve or maintain' goal of the EPBC Act Environmental Offsets Policy. There has been recent debate regarding how fundamentally the concept of net gain must differ from that of no net loss (Bull & Brownlie In press). The calculation approach we propose allows the

Global best practice offsets achieve "net benefits" or gains larger than maintenance of MNES user to determine whether a financial contribution beyond that required to achieve a no net loss effect is to be increased to achieve a net benefit effect, and if so, to what extent.

2.4 Risks

Offset risk – the likelihood and consequence of an offset failing to deliver no net loss to a MNES – must be carefully considered and accounted for in determining an offset approach. Two specific components of risk are most relevant for the consideration of offsets: 1) offsetability risk, and 2) implementation risk. Offsetability risk refers to the risk that an impact cannot be offset due to characteristics of the MNES (e.g., condition, vulnerability, and resilience). Implementation risk refers to the risk that an offset activity is done adequately and considers factors such as the implementation methods, stakeholder support, etc. Each component of risk will be discussed in turn.

Offset risks include both MNES risk factors and implementation risk factors

Offsetability risk is first considered during the environmental assessment process. In the first instance, offsetability risk is binary; either the impacts of the proposed project are determined by the government to be acceptable or not. After the primary assessment of offsetability risk, a second and more nuanced assessment of offsetability is needed during the consideration of offsets. Some impacts are easier to offset than others due to the nature and condition of the relevant MNES. Table 2 below, which is based on the offsetability risk assessment process recommended by the global standard – the Business and Biodiversity Offsets Programme – and adapted for the Great Barrier Reef region by Bos et al 2014, provides detail on high, medium, and low risks for each MNES risk factor.

Table 2: MNES risk factors: ability of MNES to respond to offsets (adapted from Bos et al 2014)

	Low Risk	**Medium Risk**	**High Risk**
Condition of MNES	Good to pristine condition	Moderate condition	Poor condition
Counterfactual trend of MNES	Improving	Maintaining	Declining
Resilience of MNES	High	Unknown or Variable	Low

The second component of risk is the implementation risk. Table 3 below, which is based on the global standard – the Business and Biodiversity Offsets Programme guidance – and adapted for the Great Barrier Reef region by Bos et al 2014, provides detail on high, medium, and low risks for each implementation risk factor.

Table 3: Implementation risk factors (adapted from Bos et al 2014)

	Low Risk	Medium Risk	High Risk
Methods	Methods are peer-reviewed and/or proven to be feasible and effective	Methods are peer-reviewed and likely to be feasible and effective	Methods are not robustly tested and effectiveness unknown or known to be ineffective in other contexts
Measurement	Offset gains are easily measured	Offset gains are difficult to measure and/or difficult to assign causality to offset activity	Offset gains are not measurable in the appropriate geographic and temporal scales
Stakeholder support	Stakeholders support the project	Some stakeholder concerns	Stakeholders are divided or unsupportive

2.5 Time Delays

When considering the liability for impacts, the time between impact and the achievement of no net loss (or net benefit) has a large contribution to the loss of biodiversity. This time delay can be broken into two components: 1) the time between the start of the impact and the start of the offset, and 2) the time between the start of the offset and the achievement of the goals of the offset.

Currently, neither of these components is adequately considered in the approval of marine offsets in the GBRWHA. Recent approval conditions have not required offset implementation to start until works commence, which can be years after permit approvals, losing valuable time for ecosystem restoration. Moreover, even an offset project that commences prior to an impact can experience delays of many years before the benefits from the offset project are realised (Gibbons et al. in press).

The Department of the Environment released an Advanced Offset Policy which encourages proponents to consider implementing offset activities and achieving no net loss or net benefits *before* project impacts start. In the case of advanced offsets, there is zero time delay, and the costs to achieve no net loss and net benefits are significantly reduced.

When advanced offsets are not used, the time delay needs to be considered in the calculation approach (see Section 3).

2.6 Total costs

The cost must reflect the lifecycle of the offset including the coordination, management, implementation, evaluation, and adaptation (if necessary). If the cost is underestimated, then the burden of paying the difference (or a degraded environmental asset) is passed to the public. To account for all of these factors, the Queensland terrestrial offsets calculator uses an "administration" fee of 25% on top of the estimated cost of implementing the offset. We recommend the same approach be used for Reef Trust administration costs as a starting point, but that as real administration costs become clearer, the value is updated appropriately.

2.7 Surrogates

The biodiversity values of the GBRWHA are complex, multidimensional, and impossible to quantify and measure holistically. In order for an offsets calculator to quantifiably exchange impacts for benefits, the calculator must use 'metrics,' which are systems of measurement in which losses and gains are quantified. No one metric can adequately characterise all biodiversity values. Thus, any metric or even a set of metrics will be a fundamentally imprecise and incomplete 'surrogate' of the biodiversity values within the system (Salzman & Ruhl 2000; Dutson et al. 2015). A biodiversity surrogate is a relatively easily-measured metric that works as a proxy for other components of biodiversity that are harder to measure.

Surrogates allow measurement of biodiversity because holistic biodiversity values are not quantifiable

A single surrogate for all biota of interest in the GBR is highly unlikely to be acceptable or adequate. The greater the number of surrogates used, the more precisely the full range of impacted biota can be quantified, leading to improved ecological equivalence (Quétier & Lavorel 2011). The EPBC Environmental Offsets policy allows for the use of the most ecologically applicable metric(s) for the particular circumstances. Choosing a system of surrogates and appropriate metrics for their measurement was a key component of this project.

3. PROTOTYPE CALCULATOR

Based on the considerations described above, financial liability can be estimated with the summarised formula:

> Liability = sum for all surrogates of
>
> (surrogate condition factor x
>
> surrogate cost per unit x
>
> # impacted units x
>
> time factor)
>
> + administration fee

A prototype spreadsheet-style calculator is included below as Table 4, and each column is explained thereafter.

Table 4: Draft Calculator in spreadsheet form. Grey shading indicates information that is provided in the calculator (columns A, B, and G). Orange shading indicates values that are accessed in attached appendices (columns C, D, and F). Yellow shading indicates values that are entered by the user based on environmental assessment data (column E). Green shading indicates values calculated by the tool (no data entry; column H).

A	B	C	D	E	F	G	H
Surrogates				**Impacts**	**Costs**		**Liability**
Name	Unit	Surrogate Condition Factor	Surrogate Cost per unit ($AUD)	# Units Impacted*	Time Factor	Admin. fee	Offset liability (AUD $)
Water quality surrogates							
Suspended fine sediment	Total Suspended Sediment					25%	
Nitrogen	Dissolved Inorganic Nitrogen					25%	
Habitat surrogates							
Intertidal beach/mudflats and associated shorebird species	Ha x condition metric **					25%	
Mangrove forest habitats and mangrove species	Ha x condition metric **					25%	
Seagrass meadow habitats and seagrass species	Ha x condition metric **					25%	
Shallow coral reefs and associated benthic species	Ha x condition metric **					25%	
Deep reefs and associated benthic species	Ha x condition metric **					25%	
Lagoon floor and associated benthic species	Ha x condition metric **					25%	
Shoals and associated benthic species	Ha x condition metric **					25%	

A	B	C	D	E	F	G	H
Surrogates				**Impacts**	**Costs**		**Liability**
Name	Unit	Surrogate Condition Factor	Surrogate Cost per unit ($AUD)	# Units Impacted*	Time Factor	Admin. fee	Offset liability (AUD $)
Island terrestrial vegetation	Ha x condition metric **						
Halimeda bank habitat and Halimeda species	Ha x condition metric **					25%	
Species surrogates							
Bony fish	Kg Biomass					25%	-
Sharks and rays	Number of Individuals					25%	-
Sea snakes	Number of individuals					25%	-
Marine turtles	Number of individuals					25%	-
Estuarine crocodiles	Number of individuals					25%	-
Seabirds	Number of individuals					25%	-
Shorebirds	Number of individuals					25%	-
Whales	Number of individuals					25%	-
Dolphins	Number of individuals					25%	-
Dugongs	Number of individuals					25%	-

* Significant residual impact to be offset; ** See Appendix 3 for metric options

Column A: Surrogates

To create a calculation approach that balances pragmatism and accuracy, we recommend adopting the use of a set of surrogates that are

- representative of biodiversity MNES,
- able to be measured and quantified,
- inclusive of MNES that have to be considered individually because of regulation (e.g., threatened species),
- coordinated with monitoring programs in the Great Barrier Reef region to enhance reporting, and
- simple to use but comprehensive enough to account for biodiversity values.

We developed a set of tiered surrogates for use in the calculator. These surrogates may be considered to account adequately for many of the 62 Outstanding Universal Values of the GBRWHA. However, some of the values are not able to be included in an offset calculator, because they are not exchangeable (for example, historic shipwrecks). Figure 2 describes the tiered approach to surrogates, and the development of the surrogates is detailed in Appendix 2.

We envisage a drop-down list from which surrogates relevant to any given offset transaction can be selected form within each of the three tiers.

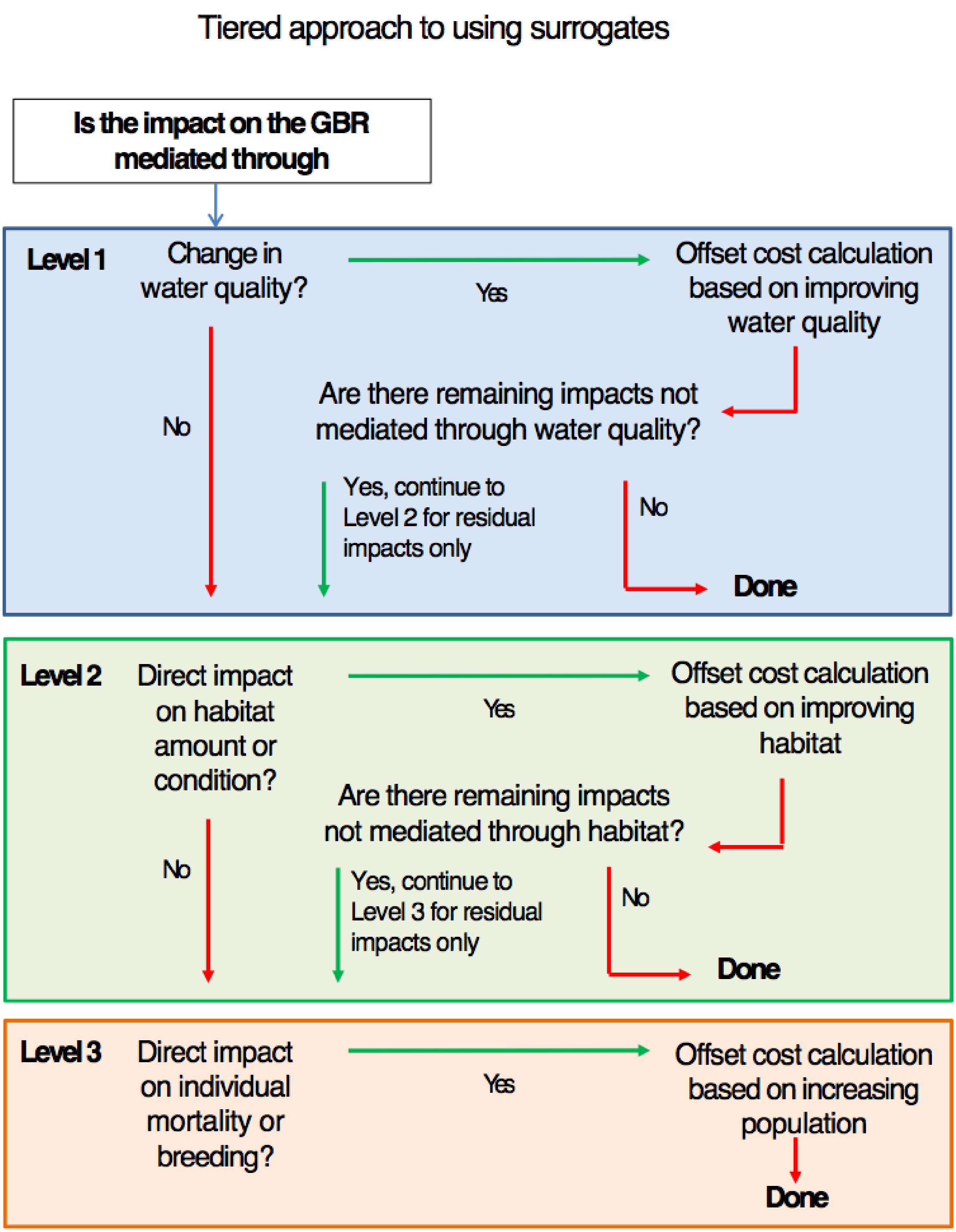

Figure 2: Tiered approach to surrogates

Column B: Units

Column B is the units (e.g., number of individuals) in which each surrogate is measured. This would be autopopulated once the surrogate was selected. For proposed habitat surrogate metrics, please see options in Appendix 3.

Column C: Surrogate Condition Factor

The Surrogate Condition Factor accounts for the ability of MNES to respond to an intervention. This factor considers the condition, trend, and resilience of the group of MNES underlying each surrogate (Table 2). MNES that are not able to respond well and quickly may require more work to be done to achieve a gain, which in turn implies a greater cost. The factor needs to be estimated for each surrogate (and, potentially, for a range of implementation zones, if there is spatial variation in the condition of the MNES), and updated periodically over time because characteristics of MNES such as condition and trend are not static. We recommend that the Department of the Environment fund an expert elicitation process to estimate default surrogate condition factors for the surrogates in each implementation zone (with guidance to align these with particular impact and offset types), and determine a review cycle for these estimates of approximately 3-6 years (perhaps aligning with the process of developing the Outlook Report for the Great Barrier Reef by GBRMPA). Estimates could be based on the risk tool in Table 2 above and available data for the MNES underlying each surrogate (e.g., Outlook Reports). The output of the expert elicitation would populate a table to be embedded in the calculator tool.

For example, surrogates whose underlying MNES are in excellent condition, are known to have high resilience, and are predicted to be improving in condition, the factor might be set to “1” which would not increase the financial liability of the offset. As a counter example, for surrogates whose underlying MNES are in poor and deteriorating condition, the factor premium might be set to a value >1, which would increase the financial liability of the offset and thus the amount of work that would be done in order to benefit the MNES. Inclusion of this multiplier, with periodic updates of the default numbers, allows the calculator to adapt to changing contexts and improves the likelihood (and decreases the consequence) that an offset achieves the regulatory requirements of maintaining or enhancing MNES.

It is further recommended that surrogate condition factors are estimated separately for different offset implementation zones. The condition, trend, and resilience of MNES varies widely geographically within the GBRWHA. To improve accuracy, we recommend the delineation of 3-5 “offset implementation zones” along the length of the GBRWHA, and the estimates of surrogate condition factors to be considered for each zone. Zones should be delineated based on a combination of ecological and anthropogenic factors, so that Zones reflect similarity in terms of the surrogate’s condition and the pressures it faces.

Column D: Surrogate Cost per unit

Column D is the offset implementation cost for each unit of gain. The value that appears in this column is auto-populated. The appropriate value, given the surrogate and the implementation zone, is calculated in a background table that is curated by the Department of the Environment (Reef Trust). The background calculation is done once (but should be updated as better information becomes available), and the calculated value then applies to any offset for that surrogate in that implementation zone. Calculating this cost is complex because several key factors must be transparently accounted for including:

- how much a given offset action costs to implement,

- what the outcome of the offset action is expected to be in terms of each surrogate, and
- the counterfactual scenario – what the outcome for each surrogate would have been without the offset action, but with any other intended interventions.

Details about the recommended calculation of cost per unit and recommended approaches for estimating counterfactuals are included in Appendix 3. We recommend that the Department of the Environment (Reef Trust) fund further research and expert elicitation to develop standardised cost per unit for each surrogate and include these as a reference table to the calculator. These values should reflect the full cost to the Department of the Environment (Reef Trust) of purchasing an offset benefit, and it is in the interest of the Department of the Environment (Reef Trust) to identify the most cost-effective options for offset delivery that are likely to be widely available in each implementation zone.

Column E: Impacted Units

The first information input into the calculator by the user is the number of impacted units of each surrogate for which offsets are required. These values are estimated during the environmental impact assessment process. The term ‘impacted’ should be formally defined by the Department of the Environment for use in the calculator, in alignment with the EPBC Act and other relevant legislation. We recommend a definition along the lines of “damaged, degraded, displaced, destroyed, or lost” or similar. Further work is needed to guide users of the calculator to transparently and uniformly calculate the number of impacted units from the details available in the environmental assessment and approvals process.

Column F: Time factor

The time delay between impacts and offset gains results in losses to ecosystem services and increases risks that offsets will achieve net benefits. To mitigate time delays, we recommend the use of a ‘time factor’ that disincentivises such delays and reflects time preference – that is, the fact that a benefit received today is of greater value than the same benefit received in ten years, for example. This is done by applying a discount rate. Table 5 (below) could be used as the basis for the calculation of the time delay factor and built into the back-end of the calculator tool so that the proponent (or the Department of the Environment) enters simply expected number of years delay between impact and offset. Typical discount rates tend to fall in the range 2-10%, with 5% being common. Without direct information on time preference for environmental benefits, 5% is a reasonable starting point as a discount rate. The values in table 5 show how a 5% discount rate converts to a multiplier on a quantity, for example, an offset benefit or a cost. For example, a one-year delay between the loss and the gain incurs a 5% penalty to reflect the disbenefit of the time lag. As such, the benefit required to achieve no net loss in present value terms is 1.05 x the benefit required if there was no time delay.

Table 5: Time delay factor calculation

Time delay between impact and benefit (# years or partial years)	Discount rate	Time Delay Factor
0	0.05	1.00
1	0.05	1.05
2	0.05	1.10
3	0.05	1.16
4	0.05	1.22
5	0.05	1.28
6	0.05	1.34
7	0.05	1.41
8	0.05	1.48
9	0.05	1.55
10	0.05	1.63
11	0.05	1.71
12	0.05	1.80
13	0.05	1.89
14	0.05	1.98
15	0.05	2.08
16	0.05	2.18
17	0.05	2.29
18	0.05	2.41
19	0.05	2.53
20	0.05	2.65

Column G: Administration fee

The administration fee is necessary to account for the administration of the offsets component of the Reef Trust and the management, monitoring and (if necessary) adaptation of the offset. The Queensland terrestrial offsets calculator uses the rate of 25% for the administration fee and this could be taken as a precedent for the marine biodiversity offsets calculator. However, as the true administration costs become apparent, the administration fee should be adjusted appropriately. The Queensland terrestrial offsets calculator includes a sliding scale which reduces the administration fee for large projects due to efficiencies, and this could be considered for the marine calculator in future versions of the tool. Administration costs derived through the calculator are separate to the funding directly invested by the Reef Trust to purchase a benefit the impacted matter/s. Part of the administration costs could be passed on to Reef Trust delivery agents for use in administering the project and to assist with the monitoring and reporting requirements where needed.

Column H: Liability

This column is the financial liability that is the result of the risk and time adjusted cost plus the administration fee. It is calculated for each surrogate, and then summed across surrogates.

4. EXAMPLE CALCULATION

To illustrate how the prototype calculator could be used, we provide an example calculation based on a hypothetical situation of a proposed new port development. The numbers used in this example are not intended to be realistic; rather, the intention is to show how the calculator uses inputted numbers to return a liability estimate. **In this example, we used defaults for: surrogate condition factors, surrogate costs per unit, and time factors. We created a false hypothetical scenario of a selection of surrogates and numbers for the number of units impacted. The calculator was then used to estimate the financial liability.**

A	B	C	D	E	F	G	H
Surrogates				**Impacts**	**Costs**		**Liability**
Name	**Unit**	**Surrogate Condition Factor**	**Surrogate Cost per unit ($AUD)**	**# Units Impacted**	**Time Factor**	**Admin. fee**	**Offset liability ($AUD)**
Water quality surrogates							
Suspended fine sediment	Tonnes total suspended sediment	1	$1,000.00	20	1	25%	25,000.00
Nitrogen	Kg dissolved inorganic	1	$1,000.00	10	1	25%	12,500.00
Habitat surrogates							
Intertidal beach/mudflats and associated shorebird species	Ha * condition metric **	1	$1,000.00	5	1	25%	6,250.00
Mangrove forest habitats and mangrove species	Ha * condition metric **	1	$1,000.00			25%	
Seagrass meadow habitats and seagrass species	Ha * condition metric **	1	$1,000.00	25	1	25%	31,250.00
Shallow coral reefs and	Ha * condition metric **	1	$1,000.00	20	1	25%	25,000.00

associated benthic species							
Deep reefs and associated benthic species	Ha * condition metric **	1	$1,000.00			25%	
Lagoon floor and associated benthic species	Ha * condition metric **	1	$1,000.00	2	1	25%	2,500.00
Shoals and associated benthic species	Ha * condition metric **	1	$1,000.00			25%	
Island terrestrial vegetation	Ha * condition metric **	1	$1,000.00				
Halimeda bank habitat and Halimeda species	Ha * condition metric **	1	$1,000.00	6	1	25%	7,500.00
Species surrogates							
Bony fish	Kg Biomass	1	$1,000.00			25%	-
Sharks and rays	Number of Individuals	1	$1,000.00			25%	-
Sea snakes	Number of individuals	1	$1,000.00			25%	-
Marine turtles	Number of individuals	1	$1,000.00	20	1	25%	25,000.00
Estuarine crocodiles	Number of individuals	1	$1,000.00			25%	-
Seabirds	Number of individuals	1	$1,000.00			25%	-
Shorebirds	Number of individuals	1	$1,000.00			25%	-
Whales	Number of individuals	1	$1,000.00			25%	-
Dolphins	Number of individuals	1	$1,000.00			25%	-
Dugongs	Number of individuals	1	$1,000.00	5	1	25%	6,250.00
Total financial contribution							**$141,250.00**

5. LIMITATIONS AND DATA REQUIREMENTS

The liability calculation approach and prototype calculator developed during this project have been designed for the purpose of voluntary marine biodiversity offsets delivered through the Reef Trust. It is important to emphasize that the output of this project is a **draft calculation approach** that needs further research, development, and refinement. It also has substantial upfront **data requirements**, because it effectively needs to consider the full range of potential offsets and alternative delivery approaches in order to determine which options are likely to be most cost-effective in a given circumstance, and what they would cost.

The calculator is not intended to be used in the following situations:

- to evaluate impacts and offsets for non-biodiversity values such as heritage and culture
- to estimate financial liability for non-permitted actions (e.g., ship grounding, toxic pollutant spill)
- to estimate financial liability for regional and global scale issues (e.g., climate change impacts to the Great Barrier Reef)

With modification or considered adaptation, the calculator might be able to be used for the following situations, but it is currently not designed to fit:

- proponent-implemented offsets
- impacts to the terrestrial environment, except where quantifiably linked to marine outcomes
- voluntary contributions to the Reef Trust for purposes other than marine biodiversity offsets (e.g., philanthropic donations or private investment)

In addition, for the calculator to be fully functional and finalised, the following items need to be addressed:

- <u>Review of mapping of MNES to Surrogates</u>: clear and precise mapping of all MNES to the list of surrogates to ensure that no MNES are inadvertently missed or inadequately accounted for by the surrogates.
- <u>Surrogate Metrics</u>: for some of the recommended surrogates, further research is required to determine the most suitable unit of measurement that will allow for quantifiable estimates of impacts and gains.
- <u>Surrogate Condition Factors</u>: for each surrogate, further research and expert elicitation are required to set default surrogate condition factors, based on the condition, trend, resilience, and other factors of the underlying MNES. These may vary among implementation zones. Risk premiums will need to be updated periodically in alignment with Reef 2050 timeframes.
- <u>Surrogate Cost per Unit</u>: for each surrogate, further research and expert elicitation are required to develop robust estimates to use as default implementation costs per unit surrogate. These estimates can be based on known and predicted costs and effectiveness of conservation, restoration, and management activities for underlying MNES, and updated periodically in alignment with Reef 2050 timeframes. Expert elicitation and review of existing work, as well as the outcomes of projects funded through the NESP Tropical Water Quality Hub, may provide more data to support these recommendations.

- Number of units impacted: an approach is needed to define and guide proponents and assessors in measuring the number of units of a surrogate which will be impacted by a proposed action and which require offsets. This connects directly to the estimated impacts measured through the Environmental Impact Assessment process.
- Data availability in referrals: recommendations may need to be made regarding the environmental assessment process to ensure that appropriate and adequate information is gathered in the referral stage to make the calculator usable and accurate should it end up being used post-approval. The information required is basic (e.g., what matters are expected to be impacted, how much, and through what process), and collecting it is likely to be standard in impact assessments, but ensuring it is expressed explicitly in impact assessment reports will help ensure ease of use of the calculator.
- Counterfactuals: the Department of the Environment, in coordination with other government agencies, will need to consider the linking of Reef 2050 targets to counterfactual scenarios of practice change and investment for each surrogate (see Appendix 5 for full details). These counterfactuals will need to consider both condition and trend data, as well as planned and funded interventions.

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APPENDIX 1: STAKEHOLDER WORKSHOPS

Workshop #1

The project began with a stakeholder workshop in August 2015 to solicit stakeholder and end-user input on project approach and outputs. The workshop was facilitated by Melissa Walsh and attended by 16 representatives of the project team, Australian Government, Queensland Government, Industry, Natural Resource Management (NRM), environmental non-governmental organisations, and environmental consultants (see Table 2; note that additional industry representatives were invited but were not available).

Table 1.1: Invited participants at the first stakeholder workshop, August 2015, Townsville Queensland

Invitee	Affiliation	Sector
Melissa Walsh	Marine Conservation Finance Consulting	Project team
Jon Brodie	JCU	Project team
Ami McGrath	Reef Trust - Department of the Environment	Aust. Gov.
Georgina Newton	Reef Trust - Department of the Environment	Aust. Gov.
Chris Murphy	Queensland Major Projects, ESD - Department of the Environment	Aust. Gov.
Nicola Garland	Queensland Resources Council, Advisor Environmental Policy	Industry
Jason Vains	Reef 2050 Area - Great Barrier Reef Marine Park Authority	Aust. Gov.
Josh Gibson	Reef 2050 Area - Great Barrier Reef Marine Park Authority	Aust. Gov.
Amanda Bridgedale	GBRMPA	Aust. Gov.
Carole Sweatman	Terrain	NRM
Paul Doyle (APOLOGY)	North Queensland Bulk Ports Corporation	Industry
Rochelle Tomkins (APOLOGY)	Department of Environment	Aust. Gov
Sean Hoobin	WWF	Env. NGO
Craig Hempel	Department of Environment and Heritage Protection - Offset area	QLD gov
Ailsa Kerswell	EcoLogical Queensland Manager	Env. NGO
Tyrie Starrs	Policy Implementation - Environment Protection, ESD - Department of the Environment	Aust. Gov.
Marjorie Cutting	AECOM environmental consultant	Environmental consultant

The workshop objectives and outputs are summarised below in Table 3.

Table 1.2: Objectives and outputs of stakeholder workshop #1

	Workshop Objectives	**Workshop Outputs**
1.	Solicit input on approach to develop prototype calculator	Finalised project approach
2.	Discuss marine MNES, potential surrogates and indicators, and currencies of measurement	Draft surrogates / indicators and currency(ies)
3.	Discuss the range of offset activities that the prototype calculator needs to account for, including cost estimates and/or methodologies	Summary of types of offset activities and cost methodology
4.	Identify potential case studies to illustrate the operation of the prototype calculator, including combinations of impact type, target type, and offset action	List of potential case studies
5.	Discuss the Reef Trust Guidance document	Input for the development of the guidance document

Workshop #2

A second workshop was held in February 2016 in Canberra involving representatives of the Department of the Environment (see Table 4 for invitees). The purpose of the second workshop was to present an early draft of the calculation approach and provide an opportunity for the Department of the Environment ask questions and provide feedback.

Table 1.3: Invited participants at the second stakeholder workshop, February 2016, Canberra

Name	Organisation
Melissa Walsh	NESP Calculator team
Roland Trease (apology)	Environment Protection - Strategic Policy, ESD
Hal Rowe (apology)	Environment Protection - Strategic Policy, ESD
Tyrie Starrs	Policy Implementation - Environment Protection, ESD
Niki Ward (apology)	Policy Implementation - Environment Protection, ESD
Vivek Vrjayraghavan	Policy Implementation - Environment Protection, ESD
Panna Patel	Post Approvals, ESD
Rochelle Tomkins (apology)	Post Approvals, ESD
Ami McGrath	Reef Trust, BCD
Ingrid Cripps	Reef Trust, BCD
Kirsty Johnson	Reef Trust, BCD
Georgina Newton	Reef Trust, BCD
Terri-Ann English	Qld Major Project Assessment, ESD
Karina Richards	Qld Major Project Assessment, ESD
Stephen Bates	International Heritage, WHAM
Susan McErlain	International Heritage, WHAM
Liz McMillan (apology)	Qld Major Project Assessment, ESD
Kat Miller	Assurance and Reform, ESD
Cynthia Piscitelli (apology)	Assurance and Reform, ESD
Renee Allen-Narker	Assurance and Reform, ESD

Workshop #3

A third workshop was held in April 2016 in Brisbane involving representatives from industry, government, and non-profit sectors (see Table 5 for invitees). This workshop provided an opportunity for stakeholders to learn about the methods and progress of the project, and to provide feedback on the draft calculation approach (see Table 6 for objectives and outputs).

Table 1.4: Invited participants at the third stakeholder workshop, April 2016, Brisbane

Name	Organisation	Sector
Martine Maron	NESP - Team leader	Project team
Melissa Walsh	NESP - Team member	Project team
Jon Brodie	NESP - Team member	Project team
Policy Implementation	Department of the Environment - Policy Implementation - Environment Protection, ESD	Aust. Gov.
Post Approvals	Department of the Environment - Post Approvals, ESD	Aust. Gov.
Queensland Major Projects	Department of the Environment - Queensland Major Projects, ESD	Aust. Gov.
Rachel Parry	Department of the Environment - Reef Branch	Aust. Gov.
Ami McGrath	Department of the Environment - Reef Trust	Aust. Gov.
Ingrid Cripps	Department of the Environment - Reef Trust	Aust. Gov.
Trish Randell	Department of the Environment - Reef Trust	Aust. Gov.
Damian Wrigley	Department of the Environment, NESP team	Aust. Gov.
Josh Gibson	Great Barrier Reef Marine Park Authority - Reef 2050 Area	Aust. Gov.
Mel Cowlishaw	Great Barrier Reef Marine Park Authority - Reef 2050 Area	Aust. Gov.
Amanda Bridgdale	Great Barrier Reef Marine Park Authority - Reef 2050 Area	Aust. Gov.
Kirstin Dobbs	Great Barrier Reef Marine Park Authority – Approvals	Aust. Gov.
Andrew Duncan	Department of Environment and Heritage Protection - Offset area	Qld Gov.
Claire Andersen	Department of Environment and Heritage Protection - GBR Taskforce	Qld Gov.
Vanessa Coverdale	Department of Environment and Heritage Protection - Offset area	Qld Gov.
Craig Hempel	Department of Environment and Heritage Protection - Offset area	Qld Gov.
Karen Oakley	Office of Coordinator-General	Qld Gov.
Steven Tarte	Office of Coordinator-General	Qld Gov.

Name	Organisation	Sector
Michael Robinson	Department of Environment and Heritage Protection - Environmental Services & Regulation division	Qld Gov.
Marjorie Cutting	AECOM - Environmental consultant	Environment
Miles Yeates	Eco Logical Australia - Senior Environmental Consultant	Environment
Ailsa Kerswell	Eco Logical Australia (Queensland) - Manager	Environment
Michael Berkman	Environmental Defenders Office (Queensland)	Environment
Sean Hoobin	WWF	Environment
Paul Marshall	Reef Ecologic	Environment/research NGO
Tom Kaveney	Adaptive Strategies (Consultant) - Industry contact suggested by QRC	Industry
Sally Wilson	Consultant	Industry
Paul Doyle	North Queensland Bulk Ports Corporation/Queensland Ports Association	Industry
Frances Hayter	Queensland Resources Council	Industry
Nicola Garland	Queensland Resources Council	Industry
Chelsea Kavanagh	Queensland Resources Council	Industry
Mike Berwick	Queensland Regional Groups Collective	Regional
Natalie Stoeckl	Economics researcher, involved in offsets research with Melissa Bos and Bob Pressey	Research

Table 1.5: Objectives and outputs of stakeholder workshop #3

	Workshop Objectives	Workshop Outputs
1.	Describe and explain the rationale behind the proposed calculation approach developed during the project	Draft final research report describing potential calculation approach
2.	Seek feedback from potential end-users on transparency and ability of calculation approach to handle the likely range of impact types	Feedback for consideration ahead of finalisation of the research report; decision on timeline for feedback
3.	Outline the data needs should such an approach be employed	List of data needs and potential data sources
4.	Provide opportunity for the Department of the Environment to discuss next steps for the process of developing a financial contribution calculation approach under the Reef Trust	Process for further stakeholder engagement with Reef Trust

APPENDIX 2: SELECTION OF SURROGATES

Conceptualisation of surrogates

One of the outcomes of the first stakeholder workshop was the identification of the approach to select the surrogates for the draft calculator. Melissa Walsh presented to the workshop participants a theoretical approach to find a balance between the most accurate list of surrogates (number of surrogates = hundreds to thousands) and the most pragmatic (number of surrogates = 1), and this was well-supported by participants. Participants workshopped the use of a triangle diagram to conceptualise how all or some values of the Great Barrier Reef could be "rolled up" into a workable number of surrogates (See Figure 2.1).

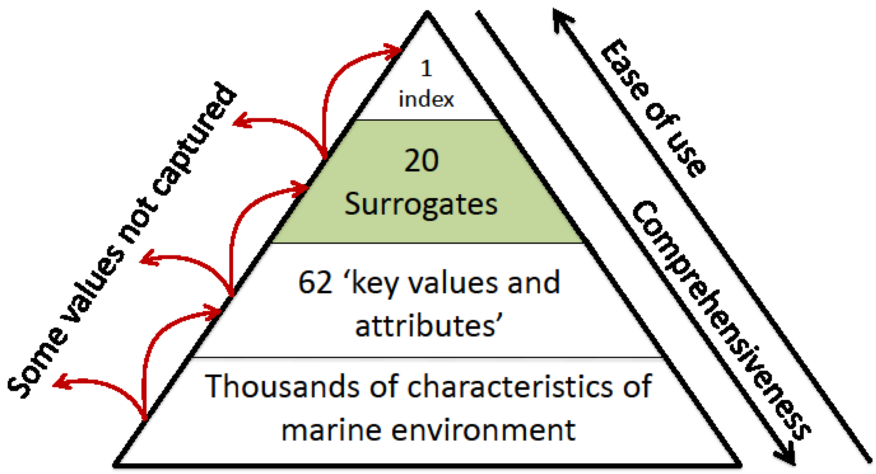

Figure 2.1: Conceptualization of the selection of surrogates to represent the Matters of National Environmental Significance of the GBRWHA for use in the marine biodiversity offsets calculator for the Reef Trust. We sought to strike a balance between capturing comprehensively all GBRWHA values, and an easy to use but oversimplified single index.

Strategic Assessment surrogates

Workshop participants discussed the importance of connecting the surrogates used for the offset calculator to the Great Barrier Reef Strategic Assessment ("Strategic Assessment"; GBRMPA 2013) and the Reef 2050 Long Term Sustainability Plan (“Reef 2050 Plan”; Department of the Environment 2015). The Strategic Assessment and Reef 2050 Plan provide context for 1) the Reef Trust and 2) the use of marine biodiversity offsets within the GBRWHA. These documents identify a list of “key values and attributes relevant to Matters of National Environmental Significance” that was developed through rigorous, peer-reviewed scientific process over the span of four years (see Table 4.8; GBRMPA 2013). There appeared to be consensus among participants that the list of 62 values and attributes was a “good place to start” for identification of surrogates for the calculator, but that 62 was likely too many surrogates and further criteria would be needed to narrow down the list (i.e., “roll-up the values”) into a smaller number of surrogates.

Workshop participants also noted the need to avoid “double counting” of impacts to values that are considered through other legislation. For example, terrestrial biodiversity offsets policies consider impacts to the terrestrial habitats of the GBRWHA, and therefore the following values and attributes were eliminated from the possible list of surrogates (see Table 2.1). Where impacts from a particular proposal affect both marine and freshwater or terrestrial environments, both this calculator and complementary ones, such as the Offsets Assessment Guide, may need to be used. Here, we focus only on marine impacts.

Table 2.1: Strategic Assessment Key Values and Attributes evaluated for coverage by surrogates for the calculator

From Strategic Assessment Table 4.8 - Key Values and Attributes Relevant to MNES	Out of scope for a biodiversity calculator	Out of scope for marine biodiversity offsets (covered by terrestrial calculators)	Can be grouped with other co-located matters as a distinct matter group	Remove because not enough information currently available to count as separate surrogate	Proposed Surrogates
Biodiversity - GBR Habitats					
Islands					Island terrestrial vegetation
Beaches and Coastlines			With affected species and habitats		Intertidal beach/mudflats and associated shorebird species; various affected species (e.g. marine turtles)
Mangrove forests			With mangrove species		Mangrove forest habitats and mangrove species
Seagrass meadows			With seagrass species		Seagrass meadow habitats and seagrass species
Coral reefs (<30m)			with associated species		Shallow coral reefs and associated benthic species
Deeper reefs (>30m)			with associated species		Deep reefs and associated benthic species
Lagoon floor					Lagoon floor and associated benthic species
Shoals					Shoals and associated benthic species
Halimeda banks					Halimeda bank habitat and Halimeda species
Continental slope				X	

Open waters				X	
Saltmarshes		X			
Freshwater wetlands		X			
Forested floodplains		X			
Heath and shrublands		X			
Grass and sedgelands		X			
Woodlands		X			
Forests		X			
Rainforests		X			
Connecting waterbodies		X			
Mangroves			With mangrove habitat		Mangrove forest habitats and mangrove species
Seagrasses			With seagrass habitat		Seagrass meadow habitats and seagrass species
Macroalgae			With other marine habitats		Coral reef habitat surrogates (deep and shallow)
Benthic microalgae			With other marine habitats		Coral reef habitat surrogates (deep and shallow)
Corals			With coral reefs		Coral reef habitat surrogates (deep and shallow)
Other invertebrates			With other marine habitats		Various marine habitats
Plankton and microbes				X	
Bony fish					Bony fish

Sharks and rays					Sharks and rays
Sea snakes					Sea snakes
Marine turtles					Marine turtles
Estuarine crocodiles					Estuarine crocodiles
Seabirds					Seabirds
Shorebirds					Shorebirds
Whales					Whales
Dolphins					Dolphins
Dugongs					Dugongs
Geomorphological features					
Coral reefs	X				
Islands and shorelines	X				
Channels and canyons	X				
River deltas	X				
Halimeda banks	X				
Seagrass meadows	X				
Indigenous heritage					
Places of historic significance — historic shipwrecks	X				
Places of historic significance — World War II features and sites	X				

Places of historic significance — lightstations	X				
Places of historic significance — other	X				
Places of scientific significance (research stations, expedition sites)	X				
Places of social significance — iconic sites	X				
Community benefits of the environment					
Income	X				
Employment	X				
Understanding	X				
Appreciation	X				
Enjoyment	X				
Access to Reef resources	X				
Personal connection	X				
Health benefits	X				
Aesthetics	X				

Distinct matter areas and co-location

To continue the process of rolling-up values into a smaller number of surrogates, we next used the principle of "distinct matter areas" (DMA) which is used in the Queensland terrestrial offsets policy (Queensland Government 2014) and is akin to the economic principle of 'separability'. The Queensland policy guidelines for determining a "distinct matter areas" are:

> "*The financial settlement calculation starts with the assumption that all prescribed environmental matters on the impact site can be co-located if treated as a single DMA, and only one offset site should be needed in most cases.*
>
> *However, separate DMAs must be based on the following principles:*
>
> • *there should be one only Regional Ecosystem per DMA;*
>
> • *wetlands must be in separate DMAs to non-wetland areas;*
>
> • *impacts to protected areas are treated as a separate DMA to the other matters impacted;*
>
> • *species that have very specific habitat requirements (such as rocks for rock wallabies or caves for certain bat species) must be in separate DMAs;*
>
> • *each separate species functional group must be in a separate DMA; and*
>
> • *matters imposed by Queensland Government agencies must be in separate DMAs from matters imposed by local governments*"

The intent behind these guidelines is to assess the separability of values. To apply this concept to marine biodiversity surrogate roll-up, we assessed which values and attributes were separable, and which would always require co-location of offset implementation (see Table 2.2).

Table 2.2: Surrogates that can be co-located

Values and attributes from the Strategic Assessment that require co-location	Proposed surrogate
Mangrove forests (habitat)	Mangroves forests and mangrove species
Mangrove species	
Seagrass meadows (habitat)	Seagrass habitats and species
Seagrasses (species	
Deeper reefs (>30m; habitat)	Deeper reefs (>30m and associated corals, microalgae, macroalgae, and other invertabrates)

Shallow reefs (<30m; habitat)	Shallow reefs (<30m and associated corals, microalgae, macroalgae, and other invertebrates)
Macroalgae	Deeper reefs or shallow reefs as described above
Benthic microalgae	Deeper reefs or shallow reefs as described above
Corals	Deeper reefs or shallow reefs as described above
Other invertebrates	Deeper reefs or shallow reefs as described above

Infeasible surrogates

Next, to be consistent with the agreed approach to make the calculator pragmatic, we eliminated from the list of possible surrogates those values and attributes that currently do not have enough data to make them measurable against a counterfactual, which are not manipulable through offset actions (e.g., geomorphological features), or which are not a component of biodiversity per se (Table 2.3).

Table 2.3: Potential surrogates with inadequate data or which are otherwise unsuitable

- Continental slope (data deficient)
- Open waters (data deficient)
- Plankton and microbes (data deficient)
- Coral reefs (geomorphological feature)
- Islands and shorelines (geomorphological feature)
- Channels and canyons (geomorphological feature)
- River deltas (geomorphological feature)
- Halimeda banks (geomorphological feature)
- Seagrass meadows (geomorphological feature)
- Understanding (community benefit)
- Appreciation (community benefit)
- Personal connection (community benefit)
- Health benefits (community benefit)
- Aesthetics (community benefit)
- Enjoyment (community benefit)

Island area and length of coastline are not parameters that realistically can be manipulated. On the other hand, the quality of these features, described by habitat condition, can be measured, described and manipulated. Using various habitat measures to capture the values associated with islands, beaches and coastlines means that some of the values intrinsic to the existence of islands and coastlines may be concealed in an offset trade, and this risks them being lost (see Figure 2.1). However, the intangibility and place-based nature of these values means that offsetting is not a realistic prospect for them. Habitat-related proxies, as we have included within the list of surrogates, are likely to capture most other, more measurable, values associated with islands, beaches and coastlines. Other values are crucial, but are not biodiversity values in and of themselves (although they may be reliant on biodiversity values), such as personal connection and health. Similarly, biodiversity offsetting does not directly handle compensation for lost income, employment, or access.

Water quality surrogates

After the steps detailed above (5.1-5.4), a list of potential surrogates remained that included both species and habitat surrogates; however, two key surrogates that have historically been used in marine offsets were missing: water quality surrogates. In many development projects, impacts on both species and habitats may be mediated through changes in water quality. This opens up an opportunity to simplify the process of accounting for losses and gains across many surrogates, by targeting the process through which impacts are mediated, where appropriate. Where such impacts occur, offset exchanges are proposed to use the water quality surrogates 'suspended fine sediment' and 'dissolved inorganic nitrogen' (Dutson et al. 2015.).

Surrogate Metrics

The metrics for each surrogate were investigated by reviewing both the scientific and grey literatures. A number of metrics were available for certain ecosystem types (Intertidal, Reef, Seagrass, Mangrove), and less available for others, such as Deep Reefs and Halimeda banks. Herein we propose units of measure for each potential surrogate (Table 10). Units of measurement for water quality surrogates are taken from Dutson et al. 2015.

Habitat surrogates are those for which impacts or offset benefits can be measured in units of area x condition. The way in which condition is described will vary among the surrogates, and will be drawn from the existing literature on condition/quality assessments for similar ecosystem types. Where this is not possible, a condition score will need to be developed, and we recommend this be standardised against a benchmark, and comprise measures of the values that are the most important components of the habitat in question. Additional details will be investigated through the latter half of this project.

Species surrogates can be measured by the number of individuals or the biomass within a population or a site. In particular, for species that are separately listed under the EPBC Act, residual impacts on each species will need to be addressed individually, but for other species, treating them as species groups may be acceptable.

Table 2.4: Draft units of measurement for proposed surrogates

<table>
<tr><th>Proposed Surrogates</th><th>Metric (Unit of Measurement)</th></tr>
<tr><td colspan="2">Water quality surrogates</td></tr>
<tr><td>Suspended fine sediment</td><td>Total suspended sediment</td></tr>
<tr><td>Nitrogen</td><td>Dissolved inorganic nitrogen</td></tr>
<tr><td colspan="2">Habitat surrogates</td></tr>
<tr><td>Intertidal beach/mudflats and associated shorebird species</td><td rowspan="9">Ha * proportion of benchmark density of keystone species (OR another composite metric of condition)</td></tr>
<tr><td>Mangrove forest habitats and mangrove species</td></tr>
<tr><td>Island terrestrial vegetation</td></tr>
<tr><td>Seagrass meadow habitats and seagrass species</td></tr>
<tr><td>Shallow coral reefs and associated benthic species</td></tr>
<tr><td>Deep reefs and associated benthic species</td></tr>
<tr><td>Lagoon floor and associated benthic species</td></tr>
<tr><td>Shoals and associated benthic species</td></tr>
<tr><td>Halimeda bank habitat and Halimeda species</td></tr>
<tr><td colspan="2">Species surrogates*</td></tr>
<tr><td>Bony fish</td><td>Biomass</td></tr>
<tr><td>Sharks and rays</td><td>Biomass/no. individuals of key species</td></tr>
<tr><td>Sea snakes</td><td rowspan="8">Number of individuals</td></tr>
<tr><td>Marine turtles</td></tr>
<tr><td>Estuarine crocodiles</td></tr>
<tr><td>Seabirds</td></tr>
<tr><td>Shorebirds</td></tr>
<tr><td>Whales</td></tr>
<tr><td>Dolphins</td></tr>
<tr><td>Dugongs</td></tr>
</table>

** Some species surrogates may be calculated across a group of species. However, for species which are listed separately as an MNES in their own right, separate accounting within each species will be required to ensure NNL is achieved.*

Tiered approach to surrogates

Because many of the impacts on a large range of the surrogates retained are mediated through a small number of particular pathways of impact, there may often be opportunities for efficiencies in the number of separate surrogates a proponent must consider. For example, where an impact comprises solely of decreased water quality due to increased sediment suspension, this impact may have flow-on effects to many other MNES and surrogates of concern. However, if a proposed offset action involved action to proportionately improve water quality through reducing sediment runoff from other sources, then the same suite of MNES impacted ought also to be benefited by the offset action (assuming basic rules of equivalence are followed). Therefore, accounting separately for losses and gains of each MNES may be redundant.

In other cases, of course, there will be multiple pathways of impact to a range of MNES, and in those cases, each would need to be considered separately. We therefore recommend a tiered, hierarchical approach to the use of the proposed surrogates in accounting for losses and gains (see Figure 2.2).

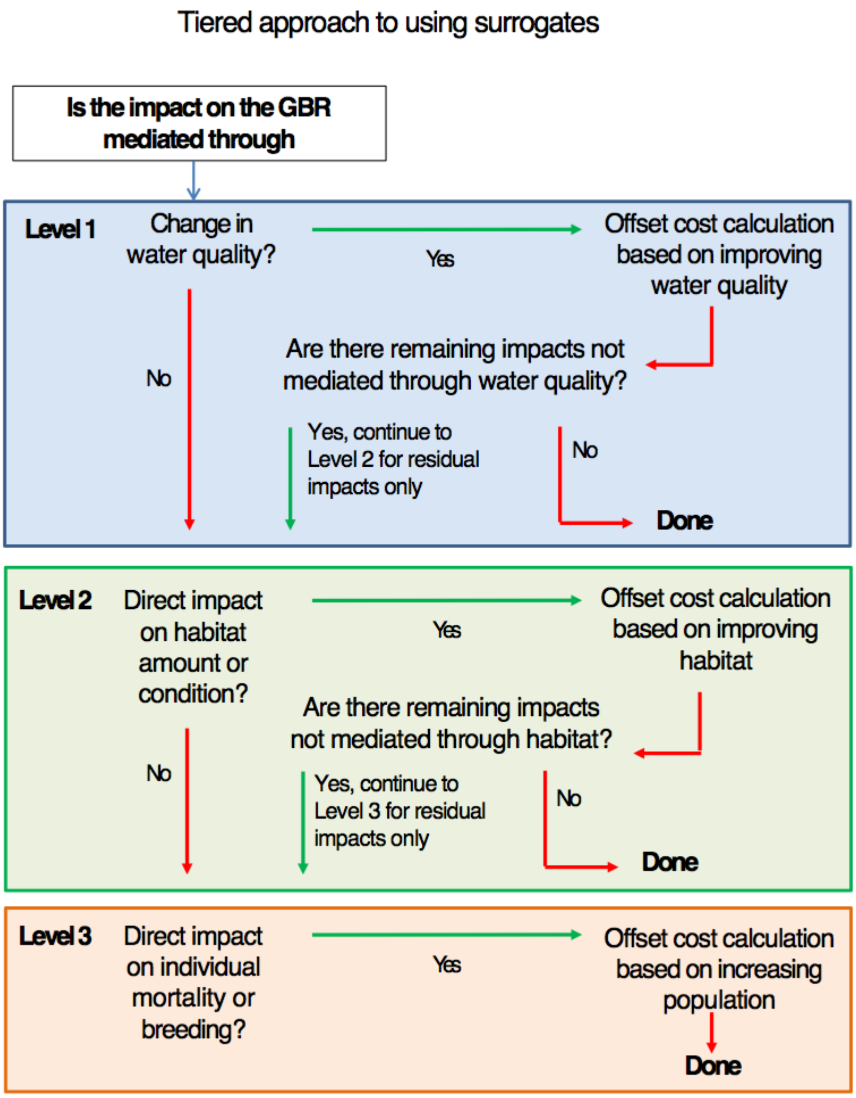

Figure 2.2: Tiered Approach to Surrogates

The surrogates retained fall into three broad categories.

First, in many cases, impacts on both species and some habitats may be mediated through changes in water quality. Where such impacts occur, offset exchanges can be done considering only the first level of the hierarchy of surrogates: water quality surrogates. In this situation, offset actions that improve water quality may be the only actions required to achieve no net loss for all affected matters, and so calculations relate only to the costs of doing those actions. However, water quality surrogates are unlikely to capture the full range of impacts on habitats or on species that are MNES. Where impacts on habitats and/or species are mediated through impacts other than changes in water quality, calculations must be done using appropriate habitat surrogates and species surrogates.

Habitat surrogates the second level of the hierarchy of surrogates. Habitat surrogates are those for which impacts or offset benefits can be measured in units of area x condition. The way in which condition is described will vary among the surrogates, and will be drawn from the existing literature on condition/quality assessments for similar ecosystem types. Where this is not possible, a condition score will need to be developed, and we recommend this be standardised against a benchmark, and comprise measures of the values that are the most important components of the habitat in question.

Habitat surrogates are to be used for offset exchanges when the impact is on the habitat itself, such as through removal of vegetation. For some actions, impacts on water quality and habitat, taken together, may adequately capture the pathways through which all significant impacts on other MNES are expected to occur. In these cases, offset actions that involve restoring or improving water quality and habitat may be all that is required to achieve a no net loss offset outcome, and so the costs of these actions only are calculated. However, there are also many species-specific impacts that are not mediated through either impacts on habitat or water quality. In these cases, species surrogates must be used directly to calculate any impacts, and required offset benefits, which are additional to those captured using habitat and water quality surrogates.

For most species, the metric we propose be measured is simply the number of individuals. Therefore, an expected impact resulting in the loss of X individuals would require an offset of a gain in X individuals, in present value terms. Offset actions that are expected to increase the number of individuals may be actions that increase survival rates – for example, reducing boat strike risk in an offset implementation area – or that increase breeding success, such as managing impacts of predators at nests or increasing availability of key breeding habitats; in these cases, the calculation needs to reflect the costs of doing these actions. The appropriate action will depend on the ecology of each species.

To summarise, where impacts on a particular MNES include impacts from water quality, and additional impacts on habitat, and/or additional impacts on species, then the surrogate table should be used sequentially. All impacts mediated through water quality change should first be acquitted through the purchase of appropriate water quality credits, and any remaining impacts not yet offset must be accounted for in the appropriate surrogate – habitat credits for impacts mediated through habitat change, and species credits for any remaining, species-specific impacts not already offset by the water quality and habitat credits.

APPENDIX 3: HABITAT SURROGATE METRIC OPTIONS

Proposed Surrogates	**Potential Metric Examples**	**Metrics used in the Integrated Monitoring Program**	**Proposed Metrics for this Calculator**
Intertidal beach/mudflats and associated shorebird species	**<u>BENTIX</u>** (Mediterranean) - (Simboura and Zenetos 2002).: development of a biotic index that uses soft bottom macrobenthic indicator species and related habitat types to determine ecological quality in the Mediterranean. (lagoons also). Index categorizes species into three groups G1) species sensitive to disturbance in general (k strategy species); GII) species tolerant to stress and disturbance and second order opportunistic species; and GIII) first order opportunistic species, pioneers, colonisers, hypoxia tolerant. BENTIX= (6x %G1 + 2x(%GII + %GIII))/100. Score then used to categorize ecological status of soft bottom habitat where a score of 0 is Azoic, 2-2.5 is heavily polluted, 2.5-3.5 is moderately polluted, 3.5-4.5 is slightly polluted, and a score of 4.5-6 is normal/pristine (Simboura and Zenetos 2002). **<u>Benthic Quality Index</u> (BQI) - (Rosenberg et al 2004)** (Mediterranean): the Hurlbert (1971) diversity index was calculated to classify the benthic species according o tolerance and sensitivity of disturbance. The index values were then used in combination with the species abundance distribution pattern along a gradient of disturbance, and the total number of species at a particular station, to calculate a new benthic quality index (BQI) for that site. Replicate samples from one station or occasion binned and averaged for abundance and species number. Assessments based on tolerant and sensitive species and taxa (available at www.marine-monitoring.se). **Biotic Index (CYMOX)**: 10 metrics (out of the 54 tested) encompassing from the physiological (d15N, d34S, % N, % P content of rhizomes), through the individual (shoot size) and the population (root weight ratio), to the community (epiphytes load) organisation levels, and some metallic pollution descriptors (Cd, Cu and Zn content of rhizomes) were retained and integrated into a single index (CYMOX) using the scores of the sites on the first axis of a PCA. These scores were reduced to a 0-1 (Ecological Quality Ratio) scale by referring the values to the optimal (reference) and worst (most degraded) conditions. The ecological status of sites obtained applying CYMOX	<u>Beaches and Coastlines:</u> Remote mapping of coastal habitats, mangroves, saltpans and saline, quantity and source of marine debris <u>Shorebirds/Seabird:</u> Census of breeding sites for seabirds and shorebirds	Ha * condition metric aligned with the Integrated Monitoring Program

	correlated significantly with the environmental gradient, validating its adequacy to reflect ecosystem health. Our results confirm the suitability of C. nodosa (and associated organisms) as an adequate system from which to obtain reliable bioindicators. Moreover CYMOX, a new biotic, multivariate index obtained from some of these bioindicators, properly reflects ecosystem status, and complies with WFD requirements. The reliability of CYMOX is based, firstly, on the well-known response of the metrics used (i. e. N, P, d15N, d34S, Cd, Cu, and Zn rhizomes content; shoot size; root weight ratio; and epiphyte load) to anthropic impacts, as documented in the literature (Romero, Martínez-Crego, Alcoverro, & Pérez, 2007) and experimentally (and specifically) confirmed in this study (Oliva et al 2012). **Coastal ecosystem bioindicators:** (Romero et al. 2007) - Principal component analysis (PCA) used to combine 14 metrics into single scale. Physiological level: Nitrogen and phosphorus content in rhizomes (%DW) Soluble carbohydrate reserves in rhizomes (%DW); Nitrogen isotopic ratio (d15N) in rhizomes (o/oo), Sulfur isotopic ratio (d34S) in rhizomes (o/oo). Individual level: Shoot surface (cm2/shoot); Percent of leaves with necrosis (%) Population level: Shoot density (shoots/m2); meadow cover (%); Plagiotropic rhizomes (%). Community level: Nitrogen content in epiphytes (%DW) Pollution: Trace metals (copper, lead and zinc concentrations) in plant tissues (rhizomes) (mg/gDW) Ecological Evaluation Index (EEI) – see Lagoon section, used in lagoon habitat (mud with submerged angiosperms (MA), mud with macroalgae (MM) (Orfandis et al. 2003, 2008).		
Mangrove forest habitats and mangrove species	**An integrated conceptual ecological model (ICEM**) for the southwest coastal wetlands of Florida was developed that illustrates the linkages between drivers, pressures, ecological process, and ecosystem services. Five ecological indicators are presented: (1) mangrove community structure and spatial extent; (2) waterbirds; (3) prey-base fish and macroinvertebrates; (4) crocodilians; and (5) periphyton. (Wingard and Lorenz 2014).	Mangrove diversity: Extent of mangrove area	Ha * condition metric aligned with the Integrated Monitoring Program

	standing biomass of the mangroves (Simard et al., 2006). Species composition (including exotics), Hydrology and Water Quality:. Typically measured water quality parameters include monthly measurement of salinity, temperature, dissolved oxygen, pH, total phosphorous (TP), total nitrogen (TN), total organic carbon, nitrate, nitrite, ammonium, soluble reactive phosphorus, and chlorophyll a (Boyer, 2006). **2. Waterbirds:** Waterbird metrics include population size, nesting production and success, and species composition. **3. Prey-base fish and macroinvertebrates**: Prey-base fish are residents of the coastal wetlands and provide support to the higher level consumers. Their density and distribution are linked to salinity, nutrient availability, productivity, and hydroperiods (Davis et al., 2005; Lorenz, 2000; Lorenz et al.,2009), which makes them good indicators of physical components of the system. Macroinvertebrates (primarily mollusks and crustaceans) can be found in freshwater, terrestrial, estuarine and marine environments. Like the prey-base fish, they function as prey to higher consumers (Trexler and Goss, 2009), but they are also heterotrophic consumers (grazers, deposit feeders, suspension feeders and carnivores) and can play an important role in nutrient cycling (Wingard and Hudley, 2012). Select species of macroinvertebrates can be very sensitive to subtle changes in salinity and water depth (Brewster-Wingard et al., 2001; Wingard and Hudley, 2012). **4. Crocodilians:**Crocodilian indicator metrics as reported in Mazzotti et al. (2009) would include, relative density, body condition, and occupancy rates of alligator holes; and for crocodiles juvenile growth and hatchling survival. **5. Periphyton:** The microalgal species contribute to soil production, and play an important role in ecosystem metabolism and nutrient cycling (Wingard and Lorenz 2014). The composition of the algal species is strongly influenced by the microenvironments of the region, nutrient availability, water quaity, water availability, and salinity; and therefore can serve as indicators of changes to these components of the system. In addition, because of the short-lived nature of many periphyton species, they respond rapidly to changes in the system, especially hydrology and water quality (Gaiser et al. 2005).		

Seagrass meadow habitats and seagrass species	**Estimation of seagrass coverag**e; expressed as a percentage of area covered by plants with respect to the area not covered is an important part of the structural description of a seagrass meadow (Buia et al 2004) - Mediterranean Bed density - the number of lead roots per surface area unit (usually 1m2). This variable represents one of the most important descriptors for assessing the state of a meadow (Buia et al. 2004). Covering - A further variable that integrates the estimation of density in the structural description of a bed is covering, expressed as a percentage of the bottom covered by plants with respect to that not covered and made up of sand, rocks, dead matter,etc. (can be seasonably dynamic) **Seagrass Biomass:** For example, in the Florida Keys National Marine Sanctuary, seagrass habitat equivalency analysis (HEAs) use aboveground seagrass biomass as the common metric since this measure is highly correlated with services provided by the habitat [45]. However, the assumption of a representative metric is challenging in complex ecosystems [47], and the successful application of a metric in seagrass ecosystems required extensive supporting research to allow selection of a simple representative (Viehman et al. 2009). **Total seagrass cover:** Total area of seagrass (ha) - NOAA technical report (Karnauskas et al 2013). **Physiological level:** Nitrogen and phosphorus content in rhizomes (%DW) Soluble carbohydrate reserves in rhizomes (%DW); Nitrogen isotopic ratio (d15N) in rhizomes (o/oo), Sulfur isotopic ratio (d34S) in rhizomes (o/oo). **Individual level:** Shoot surface (cm2/shoot); Percent of leaves with necrosis (%) **Population level**: Shoot density (shoots/m2); meadow cover (%); Plagiotropic rhizomes (%). **Community level:** Nitrogen content in epiphytes (%DW) **Pollution**: Trace metals (copper, lead and zinc concentrations) in plant tissues (rhizomes) (mg/gDW)	Condition and extent: Extent of coverage, species composition, seed banks, epiphytes & macro-algae, meadow edge mapping (late dry season, late monsoon season), reproductive health, seagrass tissue elements (C:N:P) (late dry season), rhizosphere sediment herbicides, in-situ within canopy temperature, in-situ canopy light, dugong trails (Hedge et al. 2013). Water Quality: Particulate and dissolved nutrient species (N & P), Chlorophyll, **Sediments,** Suspended sediments Turbidity, Pesticide concentrations ambient and in flood waters. Dredging and Ports: Sedimentation, Light, Turbidity - same as above for condition and extent (Hedge et al. 2013).	Ha * condition metric aligned with the Integrated Monitoring Program
Shallow coral reefs and	**Coral Cover:** (Viehman et al 2009) - USA - Coral cover has been used as an indicator metric to represent lost services in habitat equivalency analyses for determination of	Coral condition/resilience: % cover of hard & soft	Ha * condition metric aligned with

associated benthic species	compensatory restoration. Single, total coral cover metric: For coral reef grounding injuries in the U.S., NRDAs have traditionally used a two-dimensional measurement of all biological coral tissue cover measure as **either area or percent cover (17).** A coral cover metric is easily translatable to compensatory restoration projects such as transplantation, coral nurseries, and recruitment seeding that are designed to increase coral cover. Therefore, ecological service conversion factors for compensatory restoration options are not required to account for a compensatory restoration that differs from the injury metric. From an ecological perspective; however, a coral cover metric may be an overly simplistic representative of ecosystem services. A two-dimensional, total coral cover metric would be best used on reefs dominated by scleractinian corals of similar species or functional groups providing similar ecosystem services. Composite metrics using percent cover: Composite metrics have been suggested as an alternative to a two-dimensional, total coral cover metric in order to more comprehensively account for coral reef community diversity [55]. When composite metrics are used within an HEA to assess habitat injury, either individual metrics could be aggregated and weighted prior to the HEA (Habitat equivalency analysis), or separate HEA equations could be calculated for each individual metric and weighted afterwards. For either approach, options for weighting include relative cover [55] or expert opinion of the relative contribution of each to the local ecosystem's total services. Composite metrics used in environments other than coral reefs have historically been weighted and aggregated into a single HEA equation to represent the total percentage of service loss caused by the injury [42]. Size-frequency distribution: Size frequency distributions at the species or functional group level can reflect the life history strategies of different corals [56,57], have predictive power for population development [58], and allow representation of the (typically non-linear) relationship between services and colony size, thus providing insights into ecological function. Determining size-frequency distributions of habitat forming organisms (in this case, corals) is conceptually straight-forward. Each colony present is measured and assigned to a size class and species or functional group. The number of classes and the size range within each class should be appropriate for the services provided by different life history stages for the species of interest. For example, a 5 cm coral might be a juvenile for one species but a fully mature,	corals; coral size classes; larval settlement; taxonomic composition; % coral cover; COTS; counts of juvenile corals; coral disease; Drupella; surveys of sessile benthic organisms (~70 categories) using still images visual counts of reef fishes (7 families), Density of crown of thorn starfish (Hedge et al. 2013). Water quality for reefs: Particulate and dissolved nutrient species (N & P) Chlorophyll, suspended sediments, turbidity; Direct use of region: Sedimentation, Light, Turbidity, Research project work done on anchor damage but no long-term monitoring (Hedge et al. 2013). Invertebrates: Reefs: surveys & observations of COTS and sessile benthic organisms (~70 categories including corals)	the Integrated Monitoring Program

	reproductive adult for another species. Coral size-frequency distributions have been used to examine the effects of bleaching [59], disease [60], lesions [61,62], marine protected area creation [63], hurricanes [64,65], and water quality degradation [56,66]. The size-frequency method is also beginning to be applied to coral recovery monitoring from vessel groundings [5,67,68], and species-specific recovery modeling [67]. <ins>Topographic complexity:</ins> **Habitat Equivalency Analysis (HEA):** (Thur et al. 2007): Habitat equivalency analysis entails three steps: (1) quantifying the present value of natural resource service losses due to injury, (2) quantifying the present value of service gains provided by the compensatory restoration project(s) per unit, and (3) calculating the quantity of compensatory restoration required to equate the losses and gains. **STEP 1**:To quantify service losses, it is necessary to know eight parameters concerning the injury and affected resources: 1. When the injury began, 2. Baseline service level over time, 3. Service decline function, 4. Extent of injury (area for habitats or counts for individual organisms), 5. Degree of injury (percent service level decrease), 6. When the injury begins to recover, 7. Service recovery function (time path of service restoration), 8. Maximum percent service provision following restoration. **STEP 2:**Analogous information is required to quantify the benefits provided by a compensatory project, whether such projects involve creation of new habitat, enhancement of existing habitat, or prevention of future degradation of resources. These parameters include the following: 1. Initial service level of the compensatory project, 2. Time that provision of additional services begins, 3. Compensatory project maturity function (time path of service provision), 4. Maximum service provision following restoration action, 5. Compensatory project duration, 6. Relative value of the compensatory resource compared to the injured resource. **STEP 3:** The timing of the interimand perpetual service losses and the gains from a compensatory project must be considered to derive the present value of each (Lyon 1996). It is common practice to use a constant discount rate of 3% in natural resource damage assessments (NOAA 1999), although this convention has been questioned (Cline 1999; Weitzman 1998, 1999; Dunford and others 2004). Once the service losses and gains have been appropriately discounted, restoration is scaled by dividing the present value of the losses by the present value of the gains per unit of compensatory restoration. The dividend is the number of restoration units necessary to compensate the public for the lost natural resource		

services. (See Thur et al. 2007 for deterministic formula used in NOAA HEA calculations). * use with caution as the accuracy of the restoration requirement is directly correlated to the quality of the data inputs*

Amphistegina (Foraminiferida) Densities - Crosby, Gibson, and Potts (1995): conference proceeding: Algal symbiont-bearing foraminifera, Amphistegina spp., can provide a practical, reliable, low-cost indicator of coral-reef vitality. These protists are relatively large (1-3 mm adult diameter), reef-dwellers found nearly circumtropically. In their dependence upon algal endosymbionts for growth and calcification, their adaptation to nutrient-poor, warm, shallow-water environments is similar to that of reef-building corals. They live on reefrubble and on closely-cropped coralline and filamentous algae on reef substrate. When environmental conditions change to favor organisms using autotrophic and heterotrophic nutritional modes over organisms using mixotrophic (algal symbiotic) modes, Amphistegina populations decline. Under "healthy" reef conditions, Amphistegina population densities should exceed 50 living individuals per 100 cm2 bottom area of rubble. Population densities of 10-50/100 cm2 indicate cause for concern. Under environmental conditions marginal for reef growth, Amphistegina may be present but uncommon (<10/100 cm2 of rubble). Living specimens are usually not found in areas where rapid reef degredation is occurring . Amphistegina spp. are among the most common reef-dwelling organisms worldwide. Two species, A. lobifera and A. lessonii, are abundant on reefs and associated hard substrate environments throughout the Indo-Pacific except for the eastern tropical Pacific.1 A. lobifera lives most abundantly at depths less than 10 m; A. lessonii is most common at depths from 5-40 m2.

Butterfly fish: the coral feeding chaetodontids make ideal indicators because they feed directly on the corals. Many species are obligate corallivores and do not feed on anything else. Furthermore, they show strong preferences for certain species of corals which provides a further dimension of sensitivity to the system. Our conclusions are that butterflyfish can help predict coral changes such as slow chronic perturbations, but our study cannot be used to compare between reefs. It must be site specific. A key point is that changes over time at the same site is the indicator not just how many species are present.

	Resource Equivalency Analysis (REA): Resource equivalency analysis (REA) has become the dominant method for calculating natural resource damages for biological injuries from pollution incidents. This methodology compares resources lost as a result of an incident to benefits that can be gained from a habitat or wildlife restoration project. Compensation is evaluated in terms of resource services instead of market currency. Trustee agencies are required to spend damage recoveries “restoring, rehabilitating, replacing or acquiring the equivalent” of the injured resources. REA is a tool that is intended to evaluate the amount of restoration needed to compensate from incident-related losses. It involves two steps. The first is to quantify the natural resource injury in terms of the loss of ecological services. This utilizes information on the degree of injury (e.g., the impact per unit area), the duration of injury (e.g., time for the resource to recover), and spatial extent of the injury (e.g., the number of acres, miles of stream, or number of birds affected). The second step is to identify an appropriate restoration project (usually offsite) and evaluate it in terms of the degree and duration of ecological benefits that it is likely to provide. The project is then “scaled” in size so that the total value of ecological service benefits from a compensatory restoration project offsets the value of ecological service losses that resulted from the injury (Jones and Pease, 1997). In its simplest single-period formulation, the above resource equivalency problem solves the following equation for the scale, or spatial extent, of the required compensatory restoration project (denoted AR). Rosenberg et al. (2004): See explanation above (Intertidal/beach)		
Deep reefs and associated benthic species	*so far none specific to deep reefs, all studies discuss 'reef' ecosystems and deep reefs are not distinguished from shallow reefs. Therefore use of same indicators as above recommended.		Ha * condition metric aligned with the Integrated Monitoring Program
Lagoon floor and associated benthic species	**Ecological Evaluation Index (EEI)**: Orfandis 2003, 2008).Marine benthic macrophytes (macroalgae, angiosperms) are key structural and functional components of many coastal lagoons, and are sensitive to anthropogenic stress.Use of functional metrics to measure macrophyte growth and abundance in lagoons (Mediterranean) to determine. Nutrients, especially nitrogen excess, shifts the coastal lagoon habitat from late-successsional angiosperms to domination by macroalgae. This switch is better	<u>Invertebrates:</u> Lagoon floor: No ongoing monitoring but comprehensive survey of the seabed biodiversity conducted	

	indicated by functional metrics and the biotic index EEI. Therefore lagoon water quality monitoring programs should use macrophyte monitoring programs using replication and EEI.	2003–2006 (Hedge et al. 2013).	
Shoals and associated benthic species			Ha * condition metric aligned with the Integrated Monitoring Program
Halimeda bank habitat and Halimeda species			

APPENDIX 4: CALCULATION OF COST PER UNIT

This appendix details the methods behind calculation the "surrogate cost per unit" which reflects the core principles of calculating offset benefit as captured in the Offsets Assessment Guide (other key principles such as accounting for uncertainty and time lag are captured in subsequent steps the in the main calculator).

The Department of the Environment (Reef Trust) will need to develop these costings based on data for a range of relatively cost-effective conservation interventions. It is highly likely that in different parts of the GBR, or different 'implementation zones', different types of interventions will be appropriate and cost-effective. Therefore, populating this table should be done separately for different implementation zones. Appropriate zoning for the purposes of offset implementation can be done with reference to expert opinion.

The calculation of cost per unit benefit requires information about:

1. A standard type and amount of offset action (for example, streambank stabilisation using method *X* over 100 m of stream order *Y* in implementation zone *Z*);
2. the cost of that unit of action;
3. the expected benefit (in units of relevant surrogates) from that action compared to if it were not done;
4. the estimated proportion of the catchment in which similar investment would be required to occur anyway in that implementation zone to achieve existing targets for reef health, if no more development impacts or offsetting were to occur .

The additional benefit of the action is then taken as the expected benefit per standard adjusted for the probability that it would have occurred anyway, and the amount of offset action and cost are then rescaled to illustrate the total amount of offset investment required to achieve a standard unit of benefit (for example, reduction of one tonne of sediment; recreation of one hectare of seagrass habitat):

Cost per unit benefit = implementation cost per unit action / benefit per unit action × (1 - probability of action occurring without offset)

This value is then imported to the relevant cells in column D of the calculator. The embedded table will also return information on the required amount of offset action in which the Trust must invest in order to be likely to achieve one standard unit of benefit for the MNES.

Table 4.1: Estimation of implementation cost per unit of benefit

Blue shading = final values to be input to relevant cell in column D of calculator. Orange shading indicates values to be provided by the Department of the Environment. Green shading indicates values that are calculated. The example values used herein are for illustrative purposes only, and are not intended to be realistic.

Surrogates		**Action Type**			**Benefit**	**Correction for additionality**		**Cost per unit benefit**
Relevant surrogate	Standard unit of benefit	Details of action	Standard unit of offset action	Implementation cost per standard unit action	Benefit per unit offset action in units of surrogate	Probability of investment action to achieve targets in absence of offset	Corrected benefit per standard unit offset action	Total adjusted cost per standard unit offset benefit
Seagrass	One quality hectare	Replanting of seagrass	1 Ha	$7,500	0.2 Quality Hectares	0.1	0.18	$41,667 *(per quality hectare)*
Sediment	One tonne suspended	2nd order streambank stabilisation in Wet Tropics catchment	100 m	$1,000	0.4 tonnes	0.2	0.32	$3,100 *(per tonne fine sediment avoided)*

Surrogates
In this section, each surrogate for which offset costs are to be calculated is identified and the units in which the surrogate is measured is noted. This information matches that in the main calculator and is fixed by the Department of the Environment. The cost per unit of benefit calculated using this table is then autopopulated into the relevant column in the main calculator (Column D).

Column 1. Relevant surrogate (autopopulated)
There is at least one row for each surrogate for which offset costs are to be calculated. Where there are multiple possible offset actions that are similarly cost-effective (see column 3, below), the Department of the Environment may wish to have multiple rows for each surrogate and for the final calculation to reflect an average across these rows for each surrogate. It is recommended that the Department of the Environment have multiple tables, one for each implementation zone, such that the main calculator looks up the appropriate table when the implementation zone is set.

Column 2. Standard unit of benefit (autopopulated)
The standard units in which benefits will be measured for that surrogate are stated here. For example, for offset benefits for seagrass, one unit of benefit would be one ‘quality hectare’ of seagrass, consistent with the area x condition units described in the table of surrogates in Table 10.

Action type
In this section, the type of offset action which the Department of the Environment would fund in order to achieve a benefit for each surrogate is described. We recommend that the Department of the Environment determine suitable offset implementation activities for each surrogate and then estimate a realistic cost to implement those activities per unit. Expert elicitation may be necessary due to many unknown and uncertain aspects of cost estimation.

Column 3. Details of action (input by the Department of the Environment)
This column describes the specific type of offset action that seeks to achieve a benefit for the surrogate. There may be more than one option for each surrogate; for example, an offset action to achieve a benefit for seagrass might be replanting of seagrass, or installation of seagrass-friendly moorings. One type of offset action should be indicated per row.

Column 4. Standard unit of offset action (input by the Department of the Environment)
Based on the surrogate being considered, a standard unit of offset action in specified. For example, replanting of key habitats or change in tillage practice may be described on a per hectare basis, and a standard unit of action might therefore be a hectare of replanting; other actions (such as streambank stabilisation) may be measured in linear units; still others (such as installation of seagrass-friendly moorings) may be a count. This standard unit is required so that the cost of each action can be estimated in standard, per-unit terms.

Column 5. Implementation cost per standard unit action (input by the Department of the Environment)
The estimated direct cost of delivering one unit of the offset action is entered here, excluding any costs of administration. This cost may be drawn from experience with investment in

similar actions through existing programs such as Reef Programme, estimates from restoration practitioners or engineers, or published estimates (e.g. (Bayraktarov et al. 2015)).

Benefit

The raw benefit from an offset action depends not just on how much of an action is done (e.g., replanting one hectare of seagrass) but how effective that action is. For example, revegetation or replanting of vegetation generally results in a regenerated habitat that is of lower quality than the original, pre-disturbance habitat (Maron et al. 2012). There is also a high failure rate for certain types of restoration work (Bayraktarov et al. 2015). This part of the calculator described the average benefit for the surrogate from a given unit of offset action, as described in columns 3-5.

Column 6: Benefit per unit offset action in units of surrogate (entered by the Department of the Environment)

In this column, the user inputs the estimated average benefit from a standard unit of offset action in units of the relevant surrogate. For example, how many quality hectares is on averaged achieved by replanting of one hectare of seagrass meadow?

This part of the calculation requires the user to consider the *implementation risk* (see Table 3 in Section 2.4). An alternative to considering the risk as part of the estimation of benefit is to structure the calculation so that an explicit and separate estimation of implementation risk is provided as an adjustment to the benefit expected if implementation was done perfectly. This would align with the implementation risk approach used in the EPBC Act Offsets Assessment Guide, commonly used to estimate benefit for terrestrial offsets.

Correction for additionality

The gain from an offset action is the difference between what is expected to occur at the offset site if the offset action is done, and what is expected to occur if the offset action is not done. This is the concept of *additionality*, which is core to offsetting, and illustrated in Figure 2.1.

Because of the need to take into account the chance that there may have been chance at the offset site even without the offset being done, the cost per unit of benefit is usually very different to the cost per unit area of doing an action, for example. Because there are considerable existing programs and commitments to the maintenance and improvement of the GBR, these must be taken into account to ensure that offsets help, rather than hinder (such as through failing to achieve no net loss), the goals of maintenance and improvement of the reef. Existing commitments to investing in improvements in Reef health means that it is highly unrealistic to assume that the particular investments funded through offsets via the Reef Trust are the only ways in which land management practices would change in reef-draining catchments in the future, or are the only mechanism through which investment in improving the condition of the reef would occur.

This means that at any given offset site, there is a non-zero probability of investment in the same actions that the offsets will target, such as restoration or practice change to reduce negative impacts from terrestrial runoff. This probability must be taken into account when the additional benefit of the offset works is calculated. As outlined in (Dutson et al. 2015) p. 23:

"*Only actions that are expected to achieve more than the target-linked counterfactual level of water quality improvement can be considered to generate some additional benefit that can be used to offset an impact. This could be calculated by assuming the probability of a given change in land management occurring without the offset payment was proportional to the area of that change modelled to occur in that catchment in order to achieve the counterfactual*."

The specific recommendations of (Dutson et al. 2015) are to:

- *"Establish an explicit baseline, consistent with agreed biodiversity or reef water quality targets, against which the 'improve or maintain' standard is to be achieved.*
- *Ensure that property-level baselines used for calculating offset benefits are consistent with this whole-of-reef baseline*."

Therefore, a calculation of offset implementation cost per unit benefit must be done carefully in accordance with these principles in order to underpin all subsequent calculations. Implausible assumptions made at this stage undermine subsequent calculations and could result in errors in estimated costs of several orders of magnitude (Maron et al. 2015a).

Column 7: Probability of action in absence of offsets (input by Department of the Environment)
This value represents the chance that at any given similar site, the beneficial action or practice change would occur anyway at some point in the future due to other existing or likely future government programmes, or through changes in industry practices. For example, land use practices in reef-draining catchments are not static. Increasingly, industry is moving toward more efficient use of fertilisers, programs such as Reef Programme are funding soil conservation measures, and government pledges to increase investment in improving reef water quality even in the absence of increased coastal development and associated offsets are captured in key documents, such as the Reef 2050 Plan. Achieving the existing targets means that there is on average some chance that beneficial actions will be done at any given site even if the offset action did not occur. This probability will be higher for certain types of actions than for others. We recommend that the department develop these probabilities based on intended investment in the GBR through sources other than offsets. In Appendix 2, we provide a discussion of the existing targets for the surrogates and how they could be translated into values to enter into this column of the calculator.

If, when made, offset payments into the Reef Trust are not tied to offset actions at particular sites, rather the sites where the offset actions are done will be determined at a later date, we suggest that the value entered into this column is a flat value per action representing an average across all potential offset sites within a given implementation zone.

Column 8: Corrected benefit per standard unit offset action (automatically calculated)
The benefit per unit of offset action in units of the surrogate are corrected for additionality by accounting for the non-zero chance that a given action may have occurred at a site even without the offset investment.

Cost per unit benefit

Column 9: Total adjusted cost per standard unit offset benefit (automatically calculated, and auto-populated to calculator column 4.2)

In this column, the corrected benefit per standard unit of offset action is then used to calculate how much offset action would be required to generate one full standard unit of offset benefit (for example, one quality hectare of seagrass meadow, or one tonne of fine sediment reduction). The cost of that amount of offset action then appears in this column.

APPENDIX 5: DETERMINATION OF COUNTERFACTUAL SCENARIOS

Offsets must complement and support broader conservation efforts, not counter them. Accounting for the context in which offsets occur is crucial to their effectiveness and the effectiveness of other actions taken to achieve conservation goals (Brownlie & Botha 2009; Gordon et al. 2011; (BBOP) 2012; Githiru et al. 2015; Gordon et al. 2015; Maron et al. 2015a; Maron et al. In press).

The section of the proposed calculator in which the conservation context of offsets is accounted for is in the calculation of the magnitude of benefit from the offset action *relative to the counterfactual*. The counterfactual is the trajectory we expect to occur at a site if the offset was not done. If we assume that there is no chance that any beneficial change would occur at a site if the offset was not done, then the offset benefit is entirely additional. On the other hand, if there are broader conservation targets set for the region in question, then there is some chance that the beneficial action would have been done anyway, as part of efforts to achieve those conservation targets (Maron et al. In press).

In the calculator, there is a step that requires an estimate of the chance that a beneficial conservation action would have occurred anyway. The effect of this estimate is to increase the amount of the financial contribution, and in turn, the amount of offset benefit it can purchase, in order to ensure that the offset achieves maintenance of the matter to be offset *relative to what would have occurred in the absence of the impact and the offset* – that is, the counterfactual scenario (Commonwealth of Australia 2012).

This Appendix discusses the ways in which this estimate of the chance that a beneficial conservation action would have occurred anyway can be developed.

Counterfactual scenarios against which offset outcomes can be compared to assess additionality and no net loss can be conceptualised at two different scales. First, there is the system-level counterfactual, which describes what is expected to happen to an entire system (for example, the GBR as a whole) if neither offsets nor the development that triggers them occur. The goal of a no net loss offset strategy is to *maintain this system-level outcome*, but *with the development and offsets* occurring.

Second, there is the site-level counterfactual, which describes what is expected to happen at an individual offset site if the particular offset was not done. The difference between the site-level counterfactual and the scenario expected with the offset is the *additional benefit attributable to the offset*, and in a no-net-loss offset scenario, it must at least equal the loss at the development site.

These two counterfactuals – the system-level counterfactual and the site-level counterfactual – are related. The net outcome of impact-offset exchanges must be consistent with the system-level counterfactual, or else the overall outcomes of the offset approach will work against achieving the system-level counterfactual scenario (Table 5.1).

Therefore, the first step in deriving a site-level counterfactual is to determine the system-level counterfactual for each surrogate of biodiversity under consideration. The second step is to derive plausible site-level counterfactuals that are consistent with achievement of the system-level counterfactual.

Here, we propose the use of targets described in the Reef 2050 Plan as the basis for system-level counterfactuals. These targets are presented not as merely aspirational, but as genuinely intended to be met through investment in conservation action and practice change in industries that affect runoff to the GBR lagoon.

Table 5.1: Consequences of alterative assumptions about site-level counterfactuals when calculating financial cost of offsets delivered through the Reef Trust

Type of site-level counterfactual trajectory	Net outcome of offset exchange	Consequences for cost-sharing
No change to site condition without offset investment	Maintenance of current condition or trajectory	Additional cost borne by other parties (e.g. government) to make up shortfall from offsets in achieving no net loss relative to Reef 2050 Plan targets borne by third parties
Probability of change to site condition without offset investment proportional to amount of change required to achieve Reef 2050 Plan targets	Maintenance of trajectory toward Reef 2050 Plan targets	Offset payments by proponent cover full cost of achieving no net loss relative to Reef 2050 Plan trajectory

It is important that offsets through the Reef Trust contribute to, rather than work counter to, the achievement of these goals. To do this, site-level counterfactuals need to be consistent with the context of the Reef 2050 Plan targets. In Table 5.2 below, we outline for each surrogate the target described in the Reef 2050 Plan. In some cases, targets are specific, measurable, and relate directly to the names surrogates. In other cases, targets are inferred from more general targets. Achieving the targets often requires an improvement in the current trajectory of the surrogate. For example, meeting the target for reducing dissolved inorganic nitrogen by 2018 (Table 5.2) will require greater annual reductions than are currently being achieved. The system-level counterfactual trajectory for dissolved inorganic nitrogen reduction, therefore, is one of steep reduction.

Investment at the site-level to reduce nitrogen runoff might involve change to agricultural practices, for example, or works in riparian zones to improve nutrient capture. To derive the site-level probability of such investment occurring, we need to know: How much of such action is required across the GBR catchments to achieve the Reef 2050 Plan target, setting aside any impacts from specific development that requires offsetting? If achieving the Reef 2050 Plan target would require practice change across an estimated 10% of properties in a given GBR catchment area, then this reflects the chance that any given site will undergo practice change, even without the specific offset investment.

In reality, site-level probability of beneficial change in the absence of offset investment will vary among sites. However, the Reef Trust will receive funds without first having particular sites for investment identified. Therefore, we recommend that an average site-level probability of beneficial change given the intention to meet the Reef 2050 Targets, taken across the catchment, is the appropriate value to use.

Alternatively, the counterfactual baselines can be modelled from the Outlook of the Great Barrier Reef data reports that are published every five years. This condition and trend data could be used to extrapolate trajectories for each surrogate, updated every five years or more frequently as necessary.

Table 5.2: Proposed surrogates and associated targets under Reef 2050 Plan

Proposed Surrogate	Unit of Measurement (metric)	Target in Reef 2050 LTSP	Condition & trend in Reef 2050 LTSP
1. Water quality surrogates			
Suspended fine sediment	Tonnes total sediment	>20% reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas (no mention of particle size) (WQT1)	12% reduction in 2014
Nitrogen	Kg dissolved inorganic	>50% reduction in anthropogenic end-of-catchment loads of dissolved inorganic nitrogen in priority areas by 2018 (WQT1)	17% reduction in 2014
2. Habitat (condition x area) surrogates			
Intertidal beach/mudflats and associated shorebird species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)	Condition and resilience indicators for coral reefs, seagrass, island, estuaries, shoals and inter-reefal shelf habitats are on a trajectory towards achieving at least good condition at region and Reef-wide scales (EHT1)	Not mentioned
Mangrove forest habitats and mangrove species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)		Good and stable
Seagrass meadow habitats and seagrass species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)		Poor and declining
Shallow coral reefs and associated benthic species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)		Poor and declining
Deep reefs and associated benthic species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)		Very good, trend not known
Lagoon floor and associated benthic species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)		Not mentioned

Shoals and associated benthic species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)	Condition and resilience indicators for coral reefs, seagrass, island, estuaries, shoals and inter-reefal shelf habitats are on a trajectory towards achieving at least good condition at region and Reef-wide scales (EHT1)	Not mentioned
Halimeda bank habitat and Halimeda species	Ha * propn of benchmark density of keystone species (OR another composite metric of condition)	Halimeda bank not specifically mentioned (EHT1)	Very good and stable (although not studied)
3. Species surrogates			
Bony fish	Biomass	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1). Specific for coral trout – stocks managed at 60% of the unfished population (BT3)	Very good and stable
Sharks and rays	Biomass/number of individuals of key species?	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Not mentioned
Sea snakes	Number of individuals	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Not mentioned
Marine turtles	Number of individuals	The populations of loggerhead, green and flatback turtles are stable or increasing at Reef-wide and regionally relevant scales (BT2)	Poor and declining or stable
Estuarine crocodiles	Number of individuals	Not specifically mentioned but could be as with other species e.g. the trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Not mentioned
Seabirds	Number of individuals	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Poor and declining on cays and generally
Shorebirds	Number of individuals	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Not mentioned

Whales	Number of individuals	The trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Good and no trend known, humpbacks very good and increasing
Dolphins	Number of individuals	The populations of Indo-Pacific humpback and snubfin dolphins are stable or increasing at Reef-wide and regionally relevant scales (BT2). For other dolphins may be as with other species e.g. the trends in key indicator species populations and habitat condition are improving at Reef-wide and regionally relevant scales (BT1)	Good and no trend known (except IP humpback and snubfins)
Dugongs	Number of individuals	The populations of dugongs are stable or increasing at Reef-wide and regionally relevant scales (BT2)	Poor and declining in south, robust in north

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APPENDIX 6: STAKEHOLDER FEEDBACK ON DRAFT REPORT

A draft version of this report was provided to a large group of stakeholders including all attendees as Workshop 3. We are most grateful for the extensive feedback received and for the very constructive discussions had at workshops. The report was revised in the light of the feedback received, mainly to better-explain more complex aspects of our proposed approach, with some minor restructuring of the way in which some components of the calculation approach were embedded within the calculator itself.

Many of the issues raised by some stakeholders in the feedback are also relevant to the further development of policy beyond the scope of this research project, which aimed to develop a transparent prototype approach for costing environmental offsets for the Great Barrier Reef. However, considerable work remains to be done before an approach to offsets in the context of the Great Barrier Reef is formalized and implemented. In order to inform this future work, the comments and feedback provided by some stakeholders on the draft final report are appended here in accordance with their preference. The two sets of feedback we append are from:

1. Queensland Resources Council (see below)
2. Queensland Ports Association (appended as PDF)

1. FEEDBACK ON DRAFT FINAL REPORT: QUEENSLAND PORTS ASSOCIATION (PREPARED BY MR PAUL DOYLE)

Thank you for providing us with the opportunity to review and comment on the Reef Trust Offsets Calculator Report. We really appreciate the work undertaken and the consultative approach adopted through multiple workshops and the willingness to share information along the way. The report, and more specifically through the development of the prototype calculator, has identified a number of issues and approaches to marine environment offsetting that require careful consideration and resolution. Our overall view is that while the prototype has advanced the thinking, there is still a deal of work required to establish both a calculator and an effective framework for financial offset contributions into the Reef Trust. Some of this work relates more to the overall policy framework and implementation arrangements than to the technical aspects of a financial calculator.

The Queensland Ports Association (QPA) has previously made clear its view that the policy framework and implementation arrangements will need to be properly established before a financial calculator can be fully developed and finalised. Without these policy and implementation settings it is difficult to establish the absolute parameters for a calculator of this type. It is evident that through your NESP project it has been necessary to make certain assumptions on many aspects of the offset arrangements, such as: what attributes and surrogates should be used/offset; how additionality or counter factual baselines get measured; and whether the intent of offsets is ’no net loss’ or ’net benefit’.

Many of our thoughts relate to the broader policy framework and accordingly we will be providing our policy related thoughts to DotE directly as part of our comments on the Reef Trust Offsets Guide.

Specific to the calculator we provide the following key points for your consideration:

Scope of Calculator (impact assessment v's financial calculation)
The report states that the calculator only applies "*after the environmental impact assessment has been completed*". However a number of components included in the calculator contain impact assessment elements, such as: offsetability, MNES risk factors, surrogate determination. These factors also need to be determined (quantitatively or qualitatively) if a proponent delivered offset is selected.

While it is understandable that the Reef Trust calculator has had to include these factors in the absence of them being established as part of an ecological evaluation or calculator, ideally it would be better if a common and standardised method (calculator) was developed to determine the offset liability (e.g. ecological equivalency) irrespective of the offsets delivery method. The Reef Trust calculator could then focus on converting the ecological offset liability into a financial amount. Ensuring that the offset liability and financial contribution steps are split has the benefit of ensuring that proponent delivered offsets and Reef Trust offsets are being established from the same basis and impact evaluation. Reef Trust offset contributions and proponent delivered offsets will then be comparable in terms of costs and environmental benefit, enabling an informed selection and improved legal rigour.

<u>*Surrogates*</u>
QPA supports the use of surrogates and understands the technical and pragmatic need for such an approach. We are however of the view that all efforts should be made to ensure that all attributes (MNES/WH values etc) that will require regulatory offsetting should be incorporated into a single offset approach and calculator. Multiple offsetting requirements, conditions and calculation methods will only add further costs to both proponents and the regulatory and compliance load of government. In line with broader government policies a single streamlined approach must be sought. As such the attributes covered, the surrogates selected and the calculator function should incorporate all GBR related values for which offsets may be required. While the QPA acknowledges that not all attributes can be offset, we do believe that a broader approach is possible to the one chosen in the prototype.

<u>*Risks factors*</u>
As was raised at the latest workshop, QPA questions the need or appropriateness of the MNES and implementation risk factors in the calculator. In line with our comments above on more delineation between determining offset liability and financial calculations, the consideration of offsetability and MNES risk (or other values) should occur during the impact assessment process (and approval condition setting) where the appropriateness, need, and quantum of offsets is determined. It is inappropriate to add this to a financial conversion calculator particularly as the size of the funding amount does not moderate or remove the risk or alter the appropriateness of an offset condition.

Similarly, implementation risks can and should be dealt with by ensuring the selection of funded offset projects considers the risks of failure. To this end it is worth noting that in the case of the GBR, where substantial change improvement is needed, it may be necessary or desirable to fund innovative or unproven activities that have the promise of delivering substantial change. This will increase their risk profile but may still be seen as acceptable given the potential benefits. Within this there should be an acknowledgement that some activities may fail or not fully deliver on projected outcomes – a certain level of failure should be accepted. These matters need to be considered in the offset project selection process and cannot be simply converted into a numerical factor or addressed by altering a funding amount. In the case of Reef Trust funded projects this risk evaluation can be embedded into the governance and project selection process.

Counterfactual baselines

The concept of counterfactual baselines is understood as is the need to provide additionality in the offsetting process. QPA however does not agree with the proposed method for establishing the counterfactual baselines as we believe it will simply add another subjective process/factor to an already overly complicated mechanism. We believe that a simpler and more accurate process can be developed through the use of the GBR attribute condition and trend data already available from the GBR Strategic Assessment and updated in Outlook. This condition and trend information is scientifically based and is updated every 5 years, noting that in some cases the scientific data is not yet optimal. Further unnecessary complication of trying to predict the success or otherwise of other human interventions through expert elicitation will simply add further cost and opinion to a process that needs to be effective, rigorous and transparent.

The Outlook reporting which will be enhanced through RIMRep will provide a 5 yearly update on the trajectory of key attributes that can be used as the baseline. As interventions are rolled out this trajectory may alter over time. A five yearly interval is a reasonable period of time to adapt and update trajectories and also to ensure temporary or seasonal changes (blips) are accounted for without having to revisit forecasts every time a new set of data becomes available. It would also mean that baselines are based on best available actual data rather than subjective predictions. We acknowledge that there may be a need to refine the condition and trend information to a regional scale, however, in many instances this information is already available or will be as part of other GBR research and monitoring activities.

The use of existing data and documented trends should be better incorporated into the calculator process, especially where it avoids the need to invent new processes.

We hope these are useful comments, however it is also acknowledged that they may not fall within your current scope of work. We would however hope that they are considered in the next steps of developing a Reef Trust calculator. We would be more than happy to discuss and explore these concepts with you and/or the Department at any time in the future.

QUEENSLAND
resources
COUNCIL

Working together for a shared future

6 May 2015

NESP Tropical Water Quality Hub Project 3.12
C/- Martine Maron
ARC Future Fellow & Associated Professor Environmental Management
School of Geography, Planning & Environmental Management
The University of Queensland
Brisbane, QLD 4072

To Martine and team,

Thank you for providing the Queensland Resources Council (QRC) the opportunity to comment on the National Environmental Science Programme (NESP) Tropical Water Quality Hub Project 3.12 **Reef Trust Offsets Calculator Final Report**. We also appreciated the opportunity to participate in workshops at the various stages of project development.

QRC is the peak representative organisation of the Queensland minerals and energy sector. QRC's membership encompasses minerals and energy exploration, production, and processing companies and associated service companies. The promotion of leading environmental management practices is a key goal of QRC, and is vital to ensuring the Queensland resources sector remains environmentally responsible and continues to meet community expectations.

As evidenced by its World Heritage listing and recognition of its Outstanding Universal Value, the Great Barrier Reef (GBR) is unquestionably one of the most important features of Australia's environmental heritage and biodiversity landscape. The resources sector has a very strong interest in preserving the biodiversity of the iconic GBR, and QRC recognises that the health of both the Reef and the resources sector are intertwined.

QRC's fundamental position in relation to the Reef and industry co-existence is the need for continuing focus on risk management and addressing the significant scientifically documented environmental threats i.e. agricultural land uses as the main source of nitrogen, sediment and pesticides into the Reef, as well as Crown of Thorns starfish. The fulfilment of legal and ethical obligations and transparent presentation of factual scientific information by industry, governments and the community is essential if this is to occur. It goes without saying that any policy or program that fails to adequately consider the major contributors to the key threats (to the long-term health of the GBR), will ultimately fail to halt the decline in the Reef's condition. In this regard, QRC is supportive of a proportionate, combined effort by industry (resources, ports, agriculture, tourism, fishing etc.) as well as government, communities, and other private enterprise working together to protect and conserve the Reef.

QRC supports the Reef 2050 Long Term Sustainability Plan (Reef 2050 Plan) as the centrepiece for ongoing protection and management of the GBR and understands it was the basis for the World Heritage Committee's (WHC) decision not to place the GBR on the World Heritage 'in danger' list in July 2015. The Commonwealth and Queensland Governments have placed much emphasis on meeting actions set out in the Plan as a means of demonstrating clear and significant progress on management of the GBR to the WHC.

Maximising the resilience of the GBR to the pressures of climate change, by proactively addressing other pressures identified in the Strategic Assessments and through the Reef 2050 Plan will be a key consideration going forward. Commitment is required from government, industry and the community at large to address the impacts of climate change far beyond the resources industry.

Linkages to the Reef 2050 Plan
Whilst the development of the Reef Trust Offsets Calculator Prototype (RT calculator) is not in direct response to a specific Reef 2050 Plan action, it is related to a number of Reef 2050 Plan actions and has broader policy linkages and implications. We are of the view that these related actions include:

- **EHA 8** - Develop a net benefit policy to restore ecosystem health, improve the condition of values and manage financial contributions to that recovery;
- **EHA 14** - Implement ecosystem health initiatives through the Reef Trust Investment Strategy;
- **EHA18** - Avoid, mitigate or offset impacts on marine and coastal ecosystems to achieve a net benefit for Reef resilience and ecosystem health;
- **EBA 11** - Continue to refine and improve guidance and procedural requirements for avoiding, mitigating and offsetting impacts to the Reef from industry activities using standardised policies, procedures and guidelines;
- **WQA 4** - Implement innovative management approaches through the Reef Trust for improving water quality; and
- **GA14** - Develop, implement and maintain mechanisms and policies to enhance investment in delivering on-ground activities based on good science and evidence that support the Plan's outcomes and targets, and which contribute to a net benefit policy to ensure the outstanding universal value and integrity of the Reef is maintained or enhanced.

So whilst the development of the RT calculator is in and of itself a discrete NESP research project, it has links with Reef Trust, the EPBC assessment process and associated offsets policy.

Assessment of offset quantum
The RT calculator is to be a tool which provides proponents with the option of using the Reef Trust to deliver offset activities for significant residual impacts (that cannot be avoided or mitigated) identified through the Commonwealth EPBC Act and Queensland environmental assessment processes. Getting the RT calculator framework and approach right from the onset, such that it is sensible, practical and user-friendly, as well as complimentary to/with existing offset policy, is of high importance to QRC.

QRC would strongly recommend that the assessment of financial offset contributions to the Reef Trust commence only once the impact and offset liability have been determined. **The Reef Trust should <u>not</u> concern itself with impact assessment or offset quantum determinations**. Once the regulatory bodies have completed their assessment and determined that an offset is required, the proponent should be able to voluntarily decide whether to deliver the offset themselves or invest in the Reef Trust in order to discharge their offset liability. In the event the proponent chooses to invest in the Reef Trust, only then will the RT calculator apply.

The RT calculator is required to convert a proponent's ecological offset liability into a monetary value. **QRC is on the whole supportive of and recognises the need for a marine offsets calculator**.

However, a key feature of voluntary offset delivery schemes is making them market competitive and attractive to proponents. Other monetised offset schemes in Australia, including the Queensland financial settlements, the NSW biobanking scheme and the third party offset approach in Victoria, have been met with a mix level of adoption as the cost structures did not fit with proponent and market expectations. In a number of these schemes, the original formulas and values have been revised and reviewed in order to make or keep it market competitive.

To ensure the Reef Trust financial offsets scheme is successful, proponents will need to be able to clearly identify the benefits in comparison to self-delivered offsets. Issues to consider include: affordability, corporate reputation, legal risk and liability, environmental gains, and the ease and effectiveness of entering into a Reef Trust offset agreement.

Within this context, QRC suggests that there appears to be a major oversight in the development of the RT calculator. There needs to be a mechanism (e.g. another calculator), driven by the the Department of the Environment (DotE) assessment branch, that firstly allows for conversion of a GBR (and related) Matters of National Environmental Significance (MNES) significant residual impact into an offset quantum, which in turn provides the necessary input into either a proponent-driven offset or voluntary financial offset via the Reef Trust (where the current RT calculator will then apply).

While for land based offsets, the EPBC Act has a very detailed and comprehensive calculator, there is no equivalent for marine offset types e.g. restoration of sediment causing landscapes, rehabilitation (such as re-planting or habitat protection) of significant species. This has led to a fundamental overstep in the development of the RT calculator where it is attempting to do both i.e. assess impacts and determine the equivalent quantum of offsets. The RT calculator should only be focused on converting a pre-determined ecological offset liability into a monetary value. The determination of the ecological offset liability should be undertaken during the impact assessment process and based on adaption of existing approaches combined with Reef related policy instruments.

The Final Report (page 30) flags that the RT calculator could be adapted to fit proponent-implemented offsets; i.e. a mechanism for the conversion of a known ecological impact into an offset quantum. QRC strongly recommends that in fact this should be the opposite direction and the development of a marine equivalency calculator (noting that this would be broader than the GBR) be the next body of work by DotE through the Environmental Standards Division, prior to the finalisation of the RT financial calculator.

Lack of a marine offset policy
A key cause of the above-mentioned oversight is the lack of an EPBC Act (or Queensland Government) tailored marine offsets policy.

In 2015, QRC developed a set of marine offsets principles, in collaboration with its members, and shared these with DotE. We understand the many differences in composition, processes and functions between terrestrial and marine environments, creating challenges in translating impact assessment and offset design approaches from land to sea. Primarily there are two key aspects that differ between terrestrial environments and marine that make a simple translation of policies created for land based assessments and offsets inappropriate in the marine context:

- **Ecosystem process** – in most cases, marine ecosystems are much more dynamic, ephemeral and seasonally variable than terrestrial ecosystems. Marine environments will vary on a seasonal basis, within years and also over multiple years and decades. The dynamic nature of these systems means that they are able to recover quickly and have significant differences in terms of sensitivity and resilience (i.e. a marine system is more likely to be highly sensitive but has the capacity to recover quickly when stresses are removed).
- **Jurisdictional and tenure arrangements** – the jurisdictional arrangements in the marine environment are very complex, and often involve overlapping responsibilities. Land-based tenure arrangements are generally much simpler, with all acreage vested in the Crown. Leasehold and freehold concepts do not apply in the marine environment. International access and rights of passage add an additional layer.

Accordingly, these differences mean that offset approaches such as purchase, protection, revegetation / rehabilitation, ratios, maintain, improve and net benefit, all need to be considered differently. In the GBR region these issues are particularly complex given the jurisdictional context, World Heritage status, tropical (cyclonic) climate and environments (including land based inputs).

The current Commonwealth and State offset policies do not recognise the differences between land and marine offset realities. The EBPC Act Environmental Offsets Policy for example was designed for terrestrial ecosystems, so it is not always appropriate or possible to apply it directly to the marine environment without some consideration of how offsets are actually able to be delivered. To add to the complexity, the GBR is a multifaceted MNES – it is both a World Heritage Area and a Marine Park, and is also home to an abundance of individual species and ecological communities (threatened and migratory). Therefore, there needs to be further definition provided (through policies, procedures and guidance) on what constitutes a residual significant impact in the marine environment and therefore the required level of offset for this MNES. Concepts such as Outstanding Universal Value and integrity should allow more flexibility in providing offsets that address the big ticket impacts to the reef – i.e. equivalence for improving integrity which is de-coupled from specific impacts.

Note that QRC is not suggesting the Government develop a marine offsets policy from scratch, but rather the policies are revised to have a degree of reference to marine aspects which enables an offsets liability equivalency to be calculated.

Counterfactuals

One of the biggest challenges, and a major QRC concern with the RT calculator, is the variability in marine systems and the report's assumptions around counterfactuals or base cases in the absence of offsets.

The recent bleaching event in the pristine north is one good example of how predictions of the base condition going forward in the absence of a project are close to impossible (compared with terrestrial habitats). Even now we know there is a bleaching event, the condition of affected reefs in a few years' time is unpredictable. Such predictions will be a big challenge.

The counterfactual theory uses logic that we believe, could be challenged. For example, an upward counterfactual trend, as assumed in the Final Report and at the workshops, is based on successful implementation of all Reef 2050 Plan actions in the absence of project impacts and offsets (Reef 2050 counterfactual). This is only one of many scenarios for a potential counterfactual and while we want to believe in this optimistic case it may not be realistic. There are a range of factors that should be considered in developing a counterfactual, including the risk of failure in implementing actions and in turn not being able to achieve the targets of the Reef 2050 Plan or unpredictable changes to the baseline condition (e.g. coral bleaching).

As was suggested at the workshop on 6 April 2016, a simpler more reliable approach would be to use Outlook based condition and trend reporting that is updated every five years (a short time period ecologically and in development terms) as a guide to developing and maintaining a more realistic and dynamic alternative counterfactual than that assumed in the Final Report and at the workshops (i.e. Reef 2050 counterfactual). Adopting the Outlook trends would over time show how the actions of the Reef 2050 Plan are progressing whilst also providing data inputs for ongoing revision of the counterfactual projections. Whilst the alternative counterfactual could result in a divergence to that of the Reef 2050 Plan, offsets could contribute, in part, towards bridging the gap and achieving the outcomes of the Reef 2050 counterfactual. This approach could be viewed as achieving a net benefit; however, QRC understands that for this alternative to be considered it would require further consultation with stakeholders and a possible change in Government approach on GBR policy.

Going forward, ultimately there will need to be some simplification or assumptions about counterfactuals, which should be reasonable and make the RT calculator useable. Given the RT calculator application is meant to be voluntary, there will ultimately be a balancing act. The RT calculator won't be used by proponents until the assumptions are reasonable enough.

Limitations and data requirements

QRC supports that the majority of the items listed in the 'Limitations and data requirements' section of the Final Report as needing further work to be addressed. Most of them are in fact integral to achieving the equivalency calculator, which we have emphasised in some detail above. The first three points listed on page 30 of the Final Report are in fact all relative to the concept of the proponent-based calculator (i.e. converting a known impact into an equivalent offset quantum).

Further, the point on page 31 of the Final Report, which speaks to data availability in referrals, should be removed as it is well beyond the scope of the RT calculator. The assessment process and the sufficiency or otherwise of material provided by companies is for the Environmental Standards Division.

Again we question the application of the concept of counterfactuals as it relates to the last point on page 31. What is being suggested would seem to be almost unachievable within any sort of reasonable timeframe. The danger of investing in one fundamental premise is that there isn't an opportunity to validate how this will operate in practice. It is important that research projects challenge our way of thinking in regards to trends and offsets, but this is an example of where the Report has not run a rule of reality over its own findings.

Key concepts and assumptions

The RT calculator has been developed on a number of apparent key concepts and assumptions, as made evident in the Final Report and at recent workshops. Firstly, the Reef 2050 Plan targets have been adopted as the preferred counterfactual for which all actions should be measured against. However, as provided above, the Reef 2050 counterfactual offers a single, best case scenario and does not consider other factors, such as external influences impacting baseline conditions or implementation risk, which could alter the trajectory. The Reef 2050 counterfactual is one of only many hypothetical counterfactuals, which could be considered and should be validated in line with existing data collection and trends.

Further, offsets appear to be assumed and relied upon as a means for achieving the Reef 2050 counterfactual; however, the extent to which proponents will be liable for fulfilling this obligation is unquantified. Without a clear understanding what portion of the environmental benefit is to be delivered by proponents through offsets, it is unknown if the Reef 2050 counterfactual can be achieved.

Similarly, offsets appear to be relied upon as one of the key mechanisms to achieving the concept of net benefit, which is yet to be quantified. This does not provide proponents confidence as to how much an offset is required to provide beyond no net loss. The Great Barrier Reef Marine Park Authority (GBRMPA) has made it clear that the target for offsets will only be 'no net loss', and that 'net benefit' applies to all parties with an interest in the Reef. As discussed above, this concern is further exacerbated because there isn't a mechanism for converting the known significant residual project impact (as determined by an environmental impact statement) into a quantum of offset. QRC suggests that not unlike the Queensland terrestrial offset calculator, there should be a cap on offsets to provide some level of expectation, and which allows for the consideration of aspects such as time factors, particularly given there is no upper limit set for net benefit.

The concept of additionality is embedded in the RT calculator as a means for the offset to provide an additional benefit beyond that linked to the counterfactual. However, it appears that this concept should be applied at the time whereby the known impact is converted into a quantum of offset. In the Commonwealth and State terrestrial offset calculators, a multiplier accounts for a greater portion of land to be offset than that impacted to allow for a matter to be maintained (no net loss) and improved. This is already a substantially conservative approach. Therefore it should be no different when developing another mechanism for determining the equivalent offset required to provide an additional benefit in the marine environment.

Submission structure
Given this background and context, QRC provides the NESP Tropical Water Quality Hub Project 3.12 Team with the following comments in relation to their Final Report. We note that this Final Report represents the key outputs from Phase 1 of NESP Project 3.12 – development of the RT calculator – and a second phase is anticipated by DotE to further develop and test the RT calculator.

Our comments have been separated into two parts – general comments, which are additional to those above, and specific comments. General comments are provided below. Specific comments are included at **Attachment A**.

<u>General comments</u>

- We commend the NESP team for developing a 'first of its kind' prototype calculation approach for determining financial liability for marine biodiversity offsets voluntarily delivered through the Reef Trust. This presents many challenges, for the reasons outlined above, and is by no means an easy task.
- <u>We agree that the RT calculator will need pilot testing and revision before finalisation and ongoing refinement and adaptive management.</u> This represents Phase 2 of RT calculator development works.
- We agree that the place for the RT calculator is **AFTER** an impact assessment is completed and the equivalent quantum of offset determined.
- We believe the most difficult body of work is still ahead i.e. the development of surrogate metrics and unit costs. Until these are developed and endorsed, the RT calculator should not be implemented. We look forward to providing input into this body of work.
- As discussed at the workshop on 6 April 2016, we are unconvinced that there is a need to include the MNES and implementation risk factors in the RT calculator. More money does not automatically equate to reduced risk and the risks cited can be dealt with through good program management, the impact assessment process and determination of the equivalent quantum of offset to be provided.
- The RT calculator does not seem to be sufficiently grounded or linked to existing or developing policy approaches and appears to mix impact assessment elements with monetary conversion aims.
- There needs to be some mechanism, driven by the DotE assessment branch that allows for conversion of an impact into an offset quantum which in turn provides the necessary input into either a proponent-driven offset or voluntary offset via the Reef Trust.
- Additionality should not be built into the RT calculator. Rather it should be considered in the conversion of a known ecological impact into a quantum of offset, which is to be determined using another mechanism and associated multiplier.
- There appears to be confusion around the concept of net benefit. The NESP project seems to rely on offsets as a means to achieve net benefit, yet elsewhere in the report it is said that the Reef 2050 Plan is to deliver on net benefits from a more holistic point of view, extending beyond offsets. We would suggest there is another term used to describe the benefit an offset provides beyond no net loss (as per the views of the GBRMPA who are responsible for developing the Reef 2050 net benefit policy) to contribute towards the overarching goal (i.e. everyone's responsibility) of net benefit without the implied dependency on offsets to achieve this benefit.
- In Table 2 it is suggested that within 'good to pristine' habitats there is an 'improving' counterfactual trend; yet pristine areas are already likely to be as good as they are going to get, therefore 'maintaining' might be more appropriate.
- There appears to be risk within risk and offset required on top of offset built into the RT calculator. This raises specific concerns of duplication/double-counting. Refer **Attachment A** for examples.

We look forward to a having an ongoing role in the development of the RT calculator given it will potentially impact many of our members as end users of the final endorsed product.

Once again, thank you for the opportunity to provide feedback on the NESP Tropical Water Quality Hub Project 3.12 Final Report. Should you have any further comments or queries, please do not hesitate to contact me via telephone number 0417 782 884 or e-mail Francesh@qrc.org.au.

Yours sincerely

Frances Hayter
Director, Environment Policy

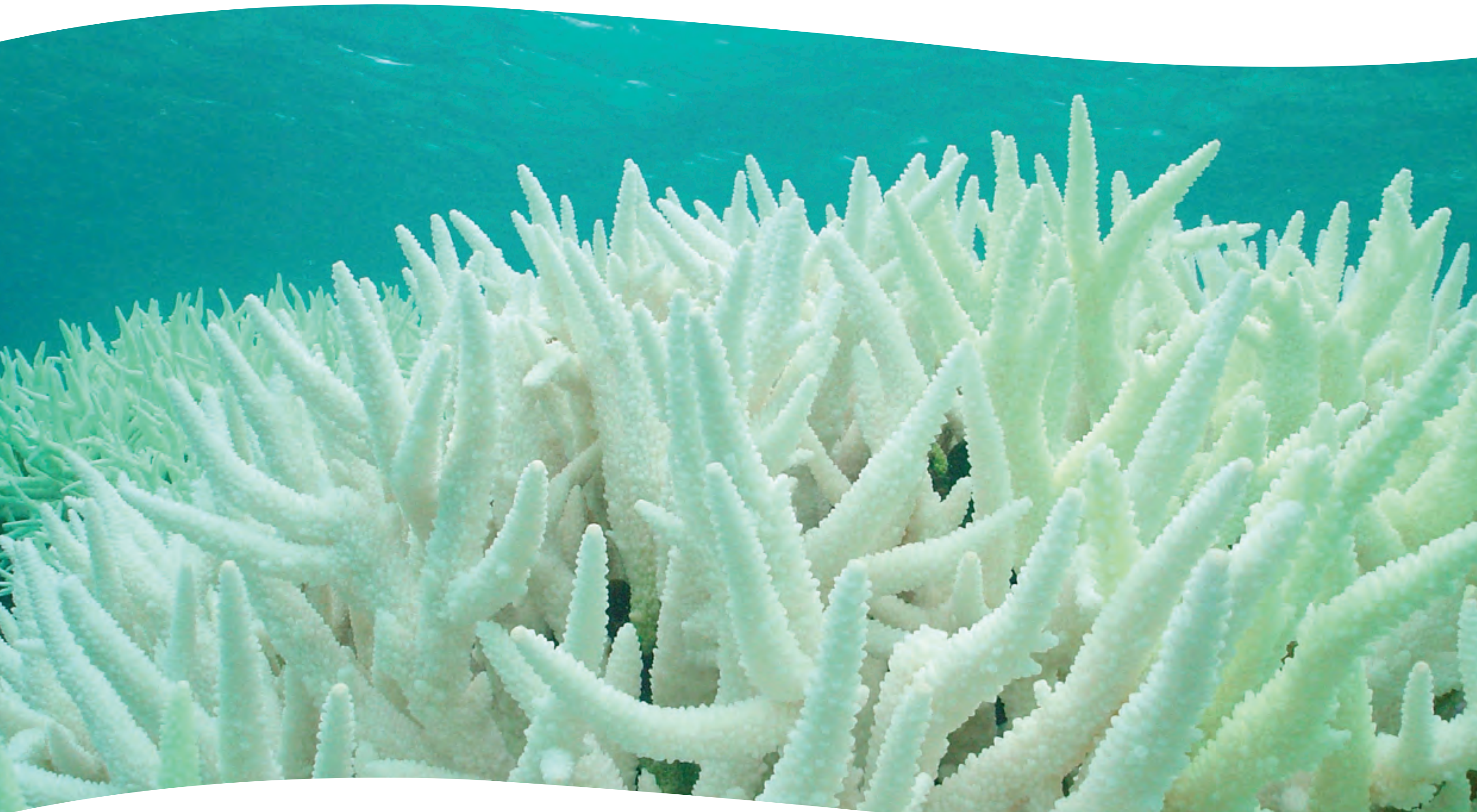
Attachment A – QRC Specific Comments on NESP Tropical Water Quality Hub Project 3.12

Section	Page No.	Comment
Cover page	Page 1	Suggest the word 'prototype' or 'draft' be inserted into the bold title.
Project Approach	Page 4	To make it clear that the calculator only applies **after the environmental impact assessment has been completed**, suggest the last sentence of the first paragraph 'an operational calculator could be used to derive indicative costings for offsets at any stage after an impact assessment is completed' be moved to the top of the section.
Project Approach	Page 7	States the project team attempted to make the output consistent with both the current regulatory and policy context and the recommended future regulatory and policy context – how? It would be good to see this spelt out. The NESP view does not seem to be consistent with existing GBRMPA policy (e.g. in the context of "offsetability" and net benefit).
Project Approach	Page 7	The publications listed have not been peer reviewed by an independent party and as such the outputs are reliant on the assumption that the key principles of the calculator are correct and robust.
Project Approach	Page 7	The key principles provided in the April 2016 workshop (e.g. improving counterfactual based on the Reef 2050 trajectory) clearly demonstrates a disconnect with the position of GBRMPA who recently set the target for offsets at no net loss (refer April 2016 RAC meeting).
Cost vs Value	Page 10	Table 1, Option 2 mentions site based calculations can underestimate impacts – on what basis is this statement made? The assessment determines impact for the purposes of calculating an offset, including consideration of flows of water and movements of species. The assessment takes into consideration potentially years of baseline data (as per the Abbot Point Capital Dredging PER).
Counterfactuals	Page 11	States the calculator is concerned only with calculating the size of a gain from an offset action while the size of the loss from an impact is determined separately through the impact assessment process. Agree but need to acknowledge the two go hand-in-hand; need to have assessed the impacts first in order to be able to calculate the offsets. Further, the calculator should only be concerned with converting a known offset quantum into a monetary value as opposed to determining the magnitude of gain required.
Counterfactuals	Page 11	States the existing impact assessment approaches tend to set the counterfactual at the offset site as static, implying that in the absence of the project in consideration the biodiversity values of the site would remain unchanged through time. Not true – take the Abbot Point Capital Dredging PER as an example; eight years of seagrass monitoring was used to inform the baseline and assessment and therefore accounted for annual and seasonal variations.
Counterfactuals	Page 11	The improving counterfactual trend (as adopted in the report) assumes the best case scenario with regards to actions undertaken to improve reef health. However, while this report / calculator prototype builds in a factor of implementation failure, the same should be done for the improving trajectory to provide a more realistic counterfactual.

Counterfactuals	Page 11	How is the counterfactual predicted? What inputs are informing this prediction? There would need to be a consistent approach /method for determining these counterfactuals for proponents. Also there needs to be a better understanding as to when (i.e. what stage of the approvals pathway) these counterfactuals should be determined – both impact and offset? It is important to note that this report deals with the conversion of the determined offset amount into a monetary value. What this section discusses is how to determine the impact (loss) and offset (gain) which should have already been determined before arriving at the need to use the calculator to convert this into a monetary value. This report needs to avoid going back and commenting on the impact assessment process and the method by which the offset should be quantified.
Net Benefits	Page 13	This project appears to rely on offsets to achieve net benefit when previously it is said that the Reef 2050 Plan is to deliver on net benefits from a more holistic approach extending beyond offsets – particularly given offsets are voluntary through the Reef Trust. We would suggest there is another term used (whether it's additionality or something else) to describe the benefit an offset provides beyond no net loss to contribute towards the overarching goal (i.e. everyone's responsibility) of net benefit without the implied dependency on offsets to achieve this benefit.
Net Benefits	Page 13	States the calculator approach allows the user to determine whether a financial contribution beyond that required to achieve a no net loss effect is to be increased to achieve a net benefit effect; we would re-iterate that offset calculators already include a multiplier to account for no net loss and improvement.
Risks	Page 13	States that after the primary assessment of "offsetability risk" a second more nuanced assessment of "offsetability" is needed during the consideration of offsets and then refers the reader to MNES and implementation risk factors. This seems to be assessing risk within risk and introducing more value-judgement. Stakeholder support is included as one of the implementation risk factors; how is this relevant and how will it be measured?
Risks	Page 13	Remain unconvinced that there is a need to include the MNES and implementation risk factors in the calculator. More money does not allay the risk and the risks cited can be dealt with through good program management, the impact assessment process and determination of the equivalent quantum of offset to be provided.
Time Delays	Page 15	States recent approval conditions have not required offset implementation to start until works commence, which can be many years after permit approvals. Yes, there are business and economic realities here; proponents should not be penalised for project delays. Instead the report should suggest the offering of incentives for proponents willing to implement advanced offsets.
Time Delays	Page 15	Given that the risk and time delay factors are already built into the calculator, shouldn't this in part account for any uncertainty in terms of what is suggested by the administration fee? In light of this, we would question a blanket 25% administration fee on top of the estimated cost of implementing the offset. What is the origin of the 25%? The reasons behind its magnitude needs to be provided in the report. Furthermore, we understand that the Reef Trust also factors uncertainty into its costings (including the risk of implementation failure from their end when determining unit costs of individual projects).
Prototype Calculator	Table 4, Page 18	The unit used for suspended fine sediment is tonnes sediment comprised of particles <16*u*m – what is this intended to capture? If the assumption is that it is fine silt and clay sediment fractions; from the Abbot Point PER, the average particle size for fine silt was 8*u*m and 2*u*m for clays. Please provide background as to the origin of this value.
Column A: Surrogates	Page 22	Need to see another example worked through the tiered approach; the example provided in the workshop was not realistic. Also note, reference to impact

		should be 'significant residual impact'.
Column C: Surrogate Condition Factor	Page 23	What does it mean that the Reef Trust should fund an expert elicitation process to estimate default surrogate condition factors? Default in terms of the condition being aimed for, default at the time of the offset calculation? By whom and how would this be determined? Will local data be considered in the calculation for offsets e.g. if your surrogate is seagrass and you know from 8 years of seagrass data the condition of seagrass in the area of impact, how will this be factored if at all, into an offset for seagrass? We would suggest that default condition factors would need to be developed by an independent body with key stakeholder input and demonstrated scientific data. A one-size-fits-all approach will not work. The condition of surrogates may change substantially between sections of the reef, therefore the idea of regional condition factors and offset implementation zones is appropriate.
Column C: Surrogate Condition Factor	Page 23	How will offset implementation zones be defined - based on habitat, type of offset or location e.g. inshore vs offshore?
Limitations & Data Requirements	Page 31	States that appropriate and adequate information needs to be gathered in the referral stage to make the calculator usable and accurate; what does this mean? How much extra data is proposed?
Water Quality Surrogates	Page 51	New term 'residual net impacts'. Needs to be defined and align with existing offset policy,
Appendix 3: Habitat Surrogate Metric Options	Page 57	Question the relevance of many of the metric examples provided; in the absence of local/ GBR/ Australian examples, should we realistically be using/referencing Mediterranean examples? How would the relative density and body condition of crocodiles be known?
Appendix 4: Calculation of Cost Per Unit	Page 79	Suggests the calculation of cost per unit benefit requires information about the estimated proportion of the catchment in which similar investment would be required to occur anyway in that implementation zone to achieve existing targets for reef health if no more development impacts or offsetting were to occur – How would this realistically be known? This need to be a broader discussion with DotE which should be recognized in the report.
Appendix 4: Calculation of Cost Per Unit	Page 82	Why would an offset hinder the reef? What is a non-zero probability of investment? Needs further definition/explanation.
Appendix 4: Calculation of Cost Per Unit	Page 83	States that because payments into the Reef Trust are not tied to offset actions at particular sites, but rather the sites where offset actions are done and will be determined at a later date, it is suggested the value entered into the 'probability of action in absence of offsets' column is a flat value representing an average across all potential sites within a given bioregion – is this equitable? If you have eight years of seagrass data for your project and know the seagrass in the impact area is resilient, low density and patchy, would your offset even consider this?

Appendix 5: Determination of Counterfactual Scenarios	Page 85	State that in the calculator, there is a step that requires an estimate of the chance that a beneficial conservation action would have occurred anyway. The effect of this estimate is to increase the amount of financial contribution and in turn, the amount of offset benefit it can purchase in order to ensure the offset achieves maintenance of the matter to be offset relative to what would have occurred in the absence of the impact and offset – this does not seems equitable; talks to the positive counterfactual trajectory that was discussed at the workshop; it would appear proponents are to be further penalised by having to provide further offsets on top of those beneficial actions being undertaken to reach Reef 2050 targets?
Appendix 5: Determination of Counterfactual Scenarios	Page 85	Now there are 2 counterfactuals – site level and system level; at the system-level, is it being suggested that all stewardship, Reef 2050 Integrated Monitoring and Reporting Program, philanthropic measures will be known and understood to inform the counterfactual trajectory? Offsets need to be put in perspective.



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