Noosa Oyster Ecosystem Restoration Project

Restoration and conservation of shellfish ecosystems in the Noosa River estuary

Monitoring, Evaluation and Reporting Plan 2020-2023

Updated November 2021

This monitoring plan is reviewed and updated as new information specific to the Noosa project becomes available.

Rock oyster reef. Courtesy of Ben Diggles.

This project was made possible by The Nature Conservancy, Noosa Shire Council, The Thomas Foundation, Australian Marine Conservation and Australian Government

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1. Purpose

The purpose of this Plan is to outline the Monitoring, Evaluation and Reporting (MER) approach, methods of data collection and analysis, deliverables and anticipated timelines for the Noosa Oyster Ecosystem Restoration Project (the 'Project"). The Project commenced on 25th July 2019 and is scheduled to be completed by 30th September 2022.

The primary intent of the Project is to restore oyster-dominated shellfish ecosystems, created predominantly by the oyster species, *Saccostrea glomerata,* a rock oyster, as well as other molluscs (oysters, mussels, worms) and algae, which occur naturally in the Noosa River estuary. This ecosystem type is functionally extinct in the Noosa River estuary and listed as a critically endangered by the International Union for the Conservation of Nature (IUCN).

This MER Plan details a set of environmental, social and economic objectives, targets and goals, which are set across TNC Australia's shellfish restoration projects. The monitoring system includes establishing and using a reference ecosystem, or reference model, as a predefined ecological target for the shellfish ecosystem being restored.

Reporting on progress with the restoration work includes both reporting of trends towards an ecological trajectory and standard project inputs and outputs (e.g. oysters deployed, m^2 of habitat provided). The MER Plan includes information on performance metrics, monitoring methods, analyses, reporting, timeframes, and roles and responsibilities for collecting and analysing data.

The MER Plan follows a standard 'best practice' approach to monitoring, evaluation and reporting, which is applied across all TNC Australia's shellfish restoration projects. TNC has adopted the MER principles of the international Society for Ecological Restoration (SER), the Open Standards for the Practice of Conservation (OSPC) and best practice methods for shellfish ecosystem restoration. By monitoring a common set of ecological indicators, we will also be able to compare these results with other restoration projects in Australia and globally.

The goals, objectives and indicators of the Noosa MER Plan are therefore distinct from a wider set of Project objectives and measurable outcomes, which are presented in Schedule 1 to the Noosa Alliance and Funding Agreement (July 2019). The two frameworks, however, are intrinsically linked. Annex 1 to this plan specifies the linkages between the goals, objective and indicators of the MER Plan and the objectives and measurable outcomes of Noosa Alliance and Funding Agreement (July 2019).

The execution of this Plan enables project partners and funding bodies to determine whether the project is successful in achieving predefined environmental, social and economic targets.

2. Geographic scope

The geographical boundaries of the project include all estuarine waters of the Noosa River estuary including up to the high water mark (Figure 1). The political, social and community boundaries include all parties required to successful deliver on the project objectives including local and state governments, Commonwealth Government, community groups, private corporations, private trusts and foundations and individuals.

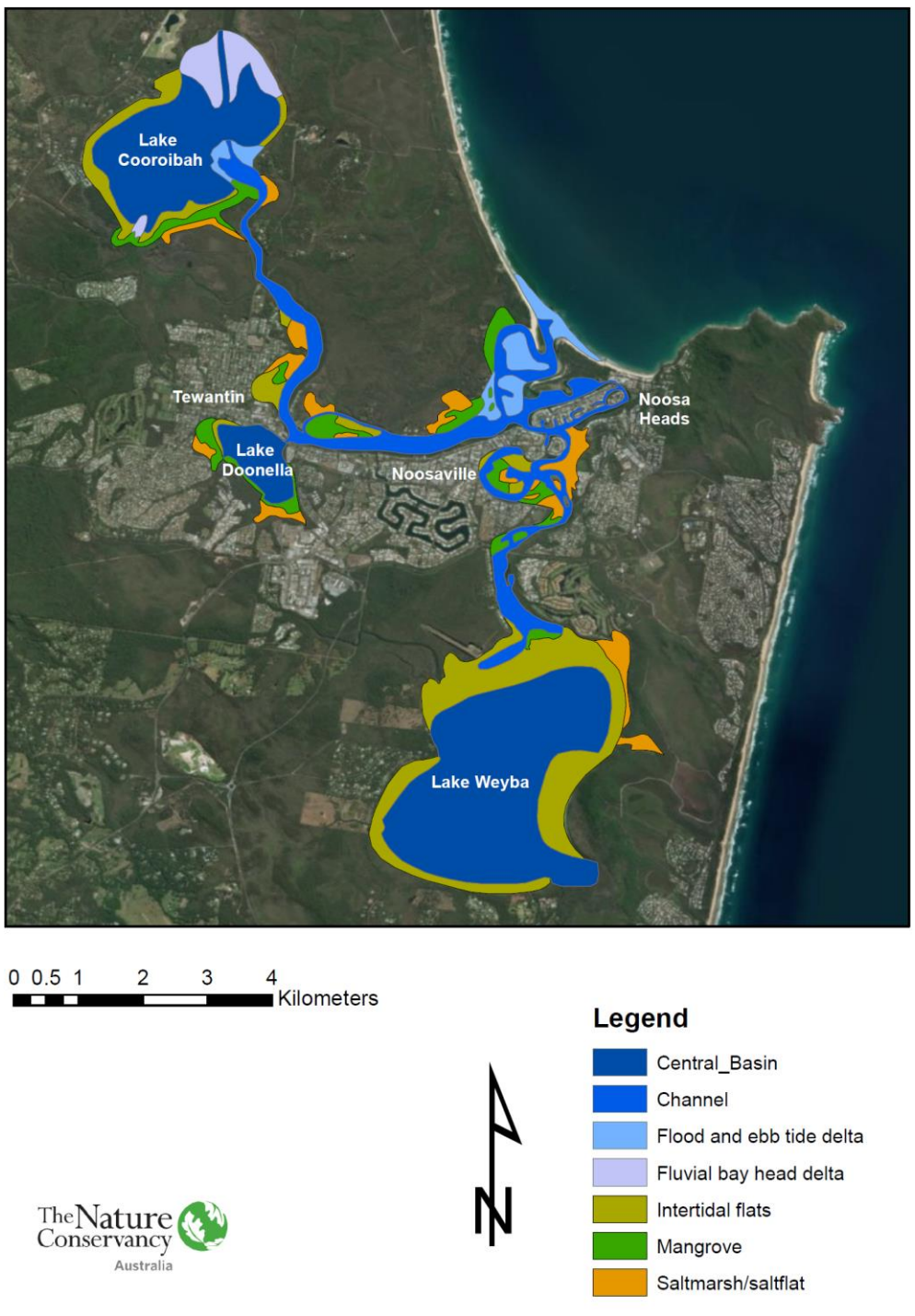

Figure 1. Geographic extent of the Project area within the Noosa River estuary.

3. Introduction

Shellfish ecosystems, which are created predominately by the rock oyster (*Saccostrea glomerata*), and native flat oyster (*Ostrea angasi*), were historically extensive along the coastline of southern and eastern Australia. Since European arrival, these bivalve ecosystems have declined in extent and condition largely as a result of unsustainable fishing methods which removed much of the shellfish ecosystem structure[1]. This loss was further aggravated by a decline in water quality, sedimentation of bays and estuaries and possibly the introduction of new diseases. Since the loss of shellfish ecosystems in Australia largely occurred outside of living memory, only recently have we begun to understand the true historic extent of shellfish ecosystems and the critical role they play in supporting fish production, natural water purification and biodiversity.

Oyster-dominated shellfish ecosystems were once a dominant feature of the Noosa River estuary, feeding the local Kabi Kabi Traditional Owners and early European settlers in the region. The commercial oyster industry, in the Noosa River, commenced in the 1870's or 1880s, and ceased, having become economically unviable, by the 1940's[2].

Since 2015, Noosa Shire Council (NSC) and The Nature Conservancy (TNC) have worked together to build a deeper understanding of the environmental significance and long-term sustainable management options for the Noosa River. This has included:

Noosa River Expert Workshop, Powerhouse Museum, 2014
A two day workshop, hosted by TNC on behalf of The Thomas Foundation and Noosa Parks Association, comprising 12 academic and NGO estuary scientists. The workshop identified 14 conservation activities that could lead to a healthier Noosa River, with shellfish ecosystem restoration listed as a priority action in addition to prawn restocking and Kin Kin sediment management. These activities (including further scoping studies) were later jointly funded by NSC, Noosa Parks Association, The Thomas Foundation and the Noosa Biosphere Reserve Foundation.

TNC Oyster Restoration Scoping Study, 2015
TNC and Ecological Service Professionals Pty on behalf of NSC and others undertook a short, five-month ecological assessment to quantify oyster densities across 11 intertidal and subtidal sites within the estuary. The study confirmed high densities of oyster recruitment particularly around Weyba Creek, the main channel around Tewantin, and in the narrow channel between Goat Island and Noosa North Shore. The project recommended installing a number of pilot reefs for further assessment.

University of Queensland Historical Ecology of the Noosa Estuary fisheries, 2015
Ruth Thurston from the University of Queensland undertook a historical ecology study on behalf of TNC and NSC in the Noosa River estuary to develop an understanding of historical fisheries productivity, including shellfish. The study confirmed shellfish ecosystems used to exist in the estuary and were commercial harvested in the early 1900s. Fish populations were also significantly larger in the past than they are today.

University of Sunshine Coast, Bring Back the Fish, 2018-2020
A three-year study which installed a series of experimental 'reef units' consisting of coir bags filled with oyster shell at 15 sites across the estuary. The project studied the structural integrity, oyster recruitment, fish and invertebrate community assemblages and human interactions with the reefs. This project collected important ecological information that will support the final design and implementation of shellfish ecosystem restoration in this Project.

NSC and TNC in addition to other organizations with an interest in the River's sustainability (including Noosa Parks Association, The Thomas Foundation and Noosa Biosphere Reserve Foundation), through a series of dialogue and presentations to Noosa Shire Council, recognized the strategic priorities of both organizations and of others would be more effectively served through a formal partnership, rather than on an individual project basis. This led to the development of the formal *Alliance and Funding Agreement (July 2019)* between TNC and TNSC, and the formulation of this Project, which is the main delivery mechanism of the TNC-NSC Partnership.

Project activities
The primary activities of the project involve laying a composite substrate, or bed of local rock rubble and dried oyster shell, on which rock oysters, and associated species, settle, grow and eventually 'cement' together to form the oyster-dominated ecosystem.

To restore shellfish ecosystems, juvenile native oysters (pre-seeded onto recycled shells in a hatchery) or adult oysters will be mixed with the restoration substrate and deployed in specific configurations at pre-selected restoration sites within the intertidal and shallow subtidal areas of the Noosa River estuary.

The oyster ecosystems will be accessible to the general public. A duty of care for the ecosystems will be sort from waterways users, to ensure the survival and continued natural development of the ecosystems occurs, thus keeping management costs low and the return on investment maximised.

Activities associated the project, and consequent improvement in the ecological health of the estuary, will help support the regional economy through job creation and promotion of river care and ecotourism.

The project is modelled on successful shellfish restoration projects in Victoria, South Australia, Western Australia, New South Wales and the United States[3].

The underlying habitat substrate, which is deployed by the project, and on which the oysters and other invertebrate species settle and grow naturally, will be refined specifically for the Noosa River estuary by TNC technical staff in collaboration with members of the Project's Technical Advisory Group (TAG) and consultant engineers.

The results of this work will be at a standard acceptable to accompany permit applications from government including for a Resource Allocation Authority, for work within Fish Habitat Areas, Tidal Works permits, or other relevant permits as deemed necessary by government.

Long term goal
The long-term goal, which extends beyond the three year life of the existing project, is to measurably improve the health (including fish productivity and water quality) of the Noosa River estuary, i.e. at the system or estuary scale of the Noosa River, thereby increasing the environmental, social and economic benefits provided by the restoration efforts to the local community, and to ensure there is a MER system in place to track and quantify progress in the long term.

Work stages
The initial restoration work takes 3-5 years, while monitoring and reporting on the performance (success/failures) of the oyster beds may continue well beyond this timeframe.

This Project is split into three stages to reduce ecological and financial risks. The application of an adaptive management framework at each stage of the Project, whereby learnings from previous stage are included in the planning of future stages, is central to this risk management approach. These three broad stages are:

1. *Optimal design and siting* (2020) which includes pre-planning to determine the optimal design, locations and most cost-effective method of shellfish ecosystem restoration;

2. *First site implementation* (2020-2021) which will restore oyster beds at two sites in the estuary to fine tune the restoration methods, and designs, and check that the most cost-effective systems are in place; and,

3. *Scaled up restoration* (2021-2022) where additional restoration substrates are deployed in the estuary at all suitable and approved sites.

[1] Gillies CL, McLeod IM, Alleway HK, Cook P, Crawford C, Creighton C, et al. (2018) Australian shellfish ecosystems: Past distribution, current status and future direction. PLoS ONE 13(2): e0190914. https://doi.org/10.1371/journal.pone.0190914
[2] Thurstan, R. H. (2015). Historical ecology of the Noosa Estuary fisheries. *Report to Noosa Council, The Thomas Foundation and The Nature Conservancy*.
[3] The Nature Conservancy (2015) Measuring the Recreational Fishing Benefits of a Restored Oyster Habitat, online via http://www.nature.org/media/texas/hmr_final_distribution.pdf

Parallel work
Parallel to the core oyster ecosystem restoration work, the project will explore and test the feasibility to restore seagrass habitats in Lake Cooroibah (and potentially elsewhere) to reduce sediment resuspension and increase invertebrate and fish biomass in the estuary. The Project will also provide additional technical expertise and support to Noosa Council to support the council's wider river management planning and management system, as requested, and as is outlined in the terms of the Alliance and Funding Agreement between TNC and Noosa Council.

The project also provides additional technical advice to the Noosa Council and stakeholders, on request as well as opportunities for participation and learning, either through volunteering, supporting student projects or participation in learning events (where COVID-19 restrictions permit).

Project team
The following is a list of the core group of practitioners who are responsible for designing, implementing, and monitoring the restoration sites:

Craig Bohm, The Nature Conservancy - Project Coordinator - Responsible for monitoring design, planning and overall project coordination

Dr. Simon Reeves, The Nature Conservancy – Oceans Scientist - Responsible for managing data collection and analysis and coordinating the diving plan (see Appendix 1), *Reef Life Survey*, oyster density/growth fieldwork and Report cards

Simon Branigan, The Nature Conservancy – Operations Manager (Oceans) – Responsible for oversite of project delivery and technical advisor.

Dr. Chris Gillies, The Nature Conservancy – Project Sponsor and advisor, responsible for approving resources, monitoring design and undertaking *Reef Life Survey* and oyster density/growth fieldwork.

Dr. Boze Hancock, The Nature Conservancy – Expert Restoration Scientist with TNC's Global Oceans Team focusing on providing science support for marine habitat restoration, particularly through quantifying the ecosystem services these habitats provide human communities, such as coastal protection, fish production and improved water quality.

Project Technical Advisory Group (TAG) - from project stakeholder groups with an interest in technical delivery of the project, including monitoring and evaluation.

Subject Matter Experts will be consulted with at key times during the monitoring program for guidance, expertise and review. These experts include, but not limited to:

Other experts will be included as required to provide advice on MER components throughout the project's delivery. The framework for monitoring activities and responsibilities can be seen in
Figure 1.

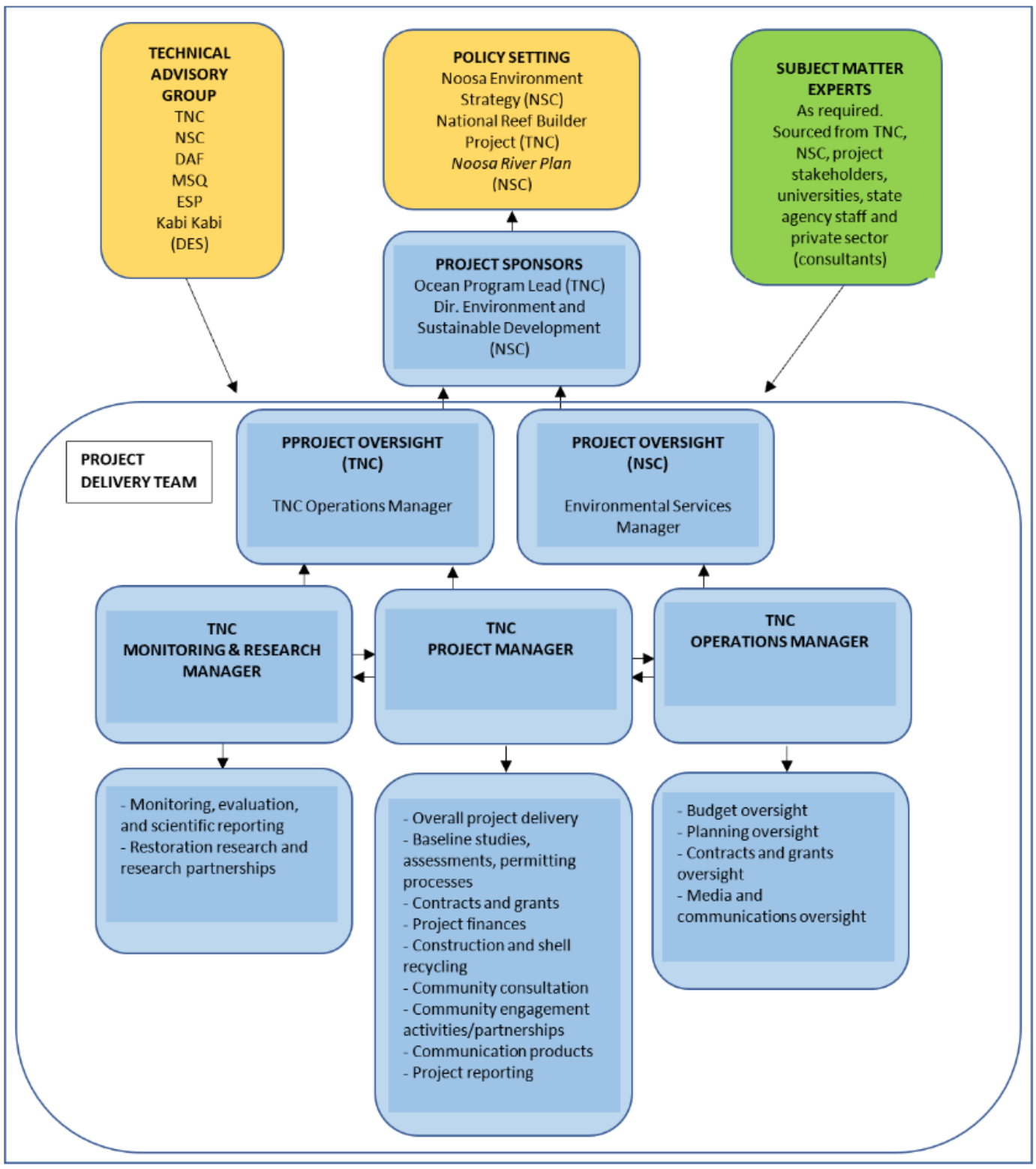

Figure 1: Project team chart with key responsibilities for project deliverables including monitoring

4. Timeline

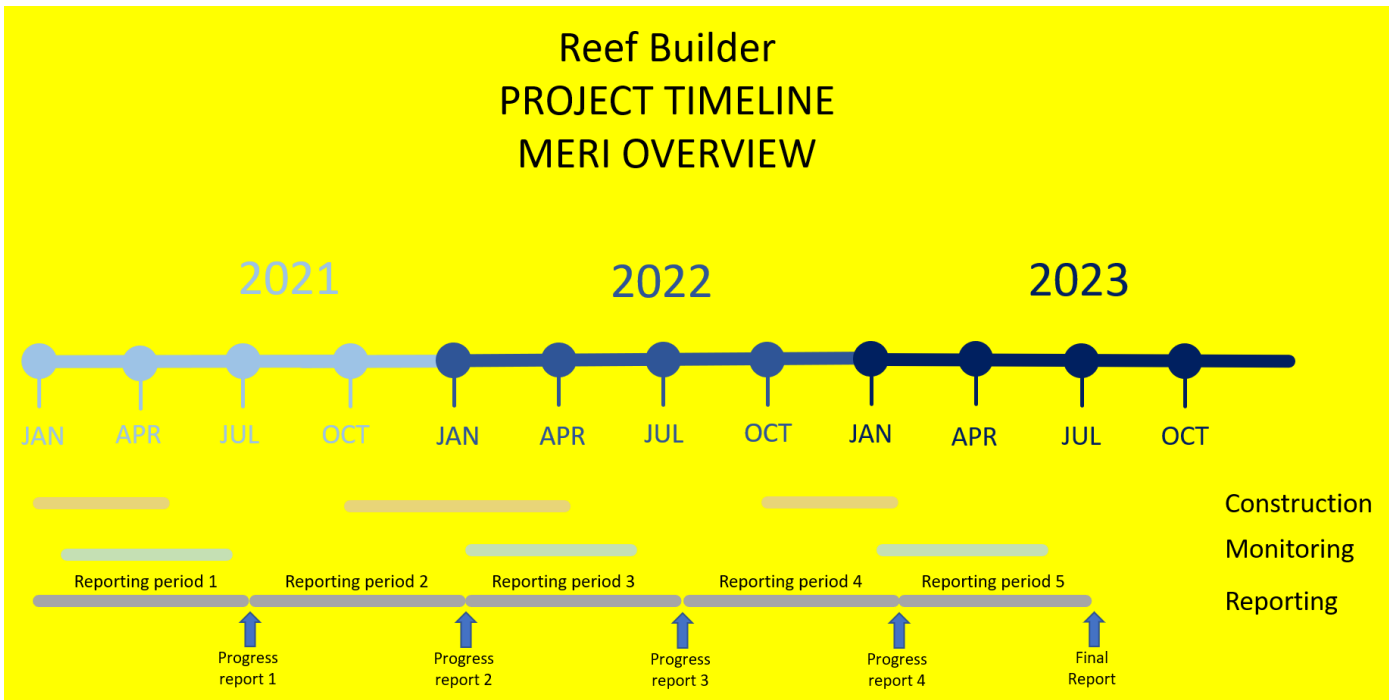

Figure 3. Indicative summary of the overarching project timeline for Reef Builder. The timeline shows key reef construction, monitoring and reporting periods.

For more detail of monitoring activities within the Project, see **Error! Reference source not found.**.

5. Targets, goals and objectives

The development of the monitoring, evaluation and reporting (MER) process follows a MER framework as outlined in
Figure 4: Framework of monitoring, evaluation and reporting process for TNC shellfish restoration projects, which follows the Open Standards for the Practice of Conservation. Definitions of MER level terminology is show on the left and an example of each.

At the highest level, there are broad restoration targets with goals and objectives which hierarchically convey the objectives of the project. Each target can have multiple goals and objective. Each objective can have at least one indicator (but potentially more) that assesses whether the objective has been met. Thus, each target could have single or multiple goals that can be outlined by single or multiple objectives that are in turn measured by single or multiple indicators, with each indicator being measured by a specific method. The process outlined here is derived from the Open Standards for the Practice of Conservation[4].

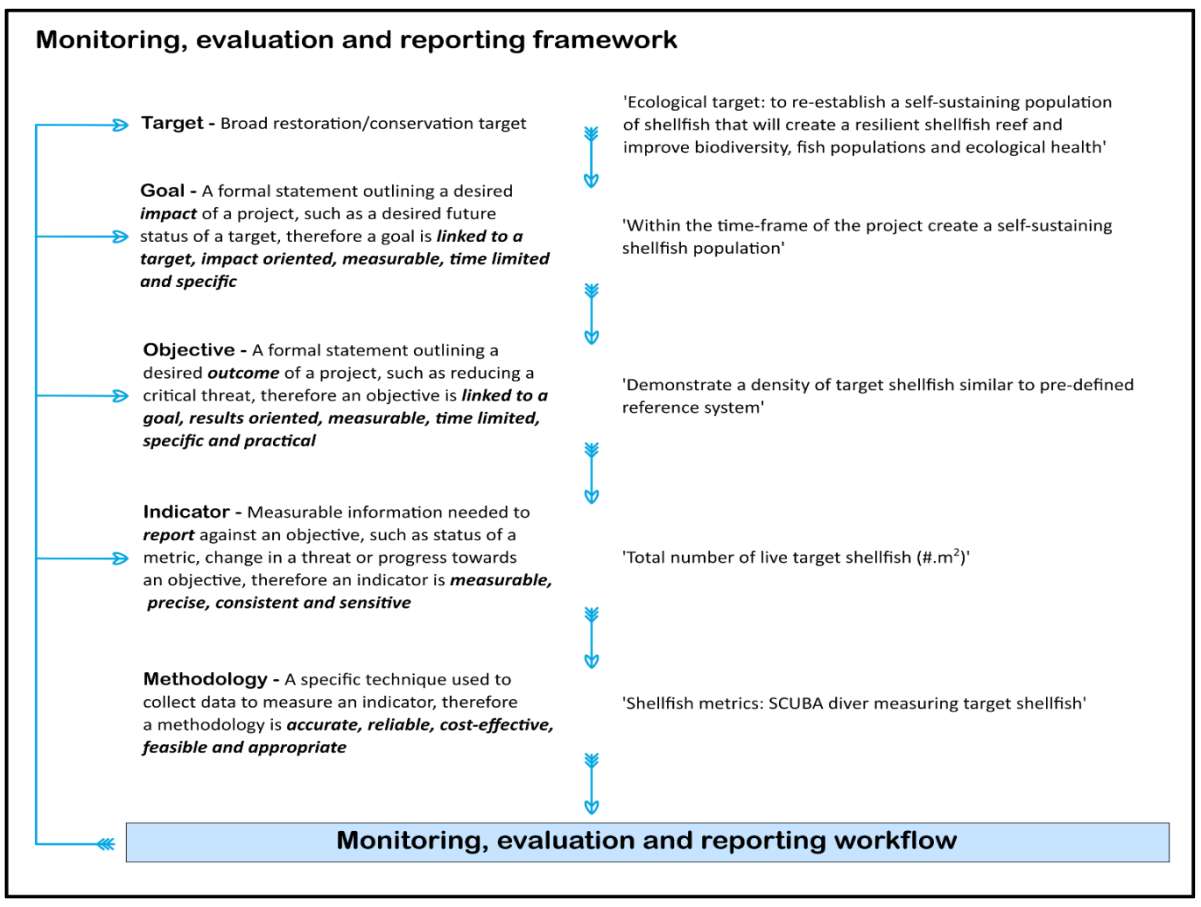

Figure 4: Framework of monitoring, evaluation and reporting process for TNC shellfish restoration projects, which follows the Open Standards for the Practice of Conservation. Definitions of MER level terminology is show on the left and an example of each on the right

5.1 Construction target

Vital to the restoration of shellfish reef habitats is the construction of a reef base that forms the 'skeleton' which shellfish inhabit and build upon and creates a living reef for other fish and invertebrates. The initial reef-base is constructed from locally sourced rock and recycled shell, giving the seeded shellfish a helping hand to boost the restoration process. Construction of the reef-base follows established best practice project management, restoration and siting protocols. The construction goals and objectives measure whether the Project has delivered on the construction targets defined by the Project.

5.2 Environmental target and reference ecosystem

The ecological goals and objectives underlying the Project's environmental target (Appendices 2, 3 and 4) have been developed in accordance with best practice restoration monitoring guidelines[5 6 7] and the current reference system developed to guide the restoration of native shellfish reefs[8 9].

[4] http://cmp-openstandards.org/
[5] The Nature Conservancy et al, Oyster Habitat Restoration Monitoring and Assessment Handbook.
[6] Mcdonald *et al* (2016). National standards for the practice of ecological restoration in Australia, Restoration Ecology, *Vol. 24, No. S1, pp. S4–S32*.
[7] Conservation Measures Partnership (2013) Open Standards for the Practice of Conservation Version 3.0, accessed online via http://cmp-openstandards.org/wp-content/uploads/2014/03/CMP-OS-V3-0-Final.pdf
[8] Gillies, C. L., Crawford, C. and Hancock, B. (2017), Restoring Angasi oyster reefs: What is the endpoint ecosystem we are aiming for and how do we get there?. Ecol Manag Restor, 18: 214-222. doi:10.1111/emr.12278
[9] McAfee, D., McLeod, I. M., Boström-Einarsson, L., & Gillies, C. L. (2020). The value and opportunity of restoring Australia's lost rock oyster reefs. *Restoration Ecology*, *28*(2), 304-314.

In the absence of a true reference ecosystem (typically an example natural ecosystem under environmental conditions comparable to those of the restoration site), a reference system identifies reference conditions from the scientific literature and expert opinion to guide appropriate indicators and benchmarks.

The *environmental target* for Reef Builder is to create living shellfish reefs at 13 sites around Australia (including Noosa) that are dominated by native oysters and/or mussels and colonised by a diverse assemblage of associated organisms such as other shellfish, bryozoans, crustaceans, barnacles, calcareous polychaetes and fish.

Through restoration efforts, the reefs will transform existing mud/sandy bottom habitats with low species diversity (Figure 5a) into structured habitats (Figure 5b) that mature over a period of 6-12 years are typically highly biodiverse (Figure 5c). For a conceptual graphical timeline of the development of native shellfish reefs, see Figure 6.

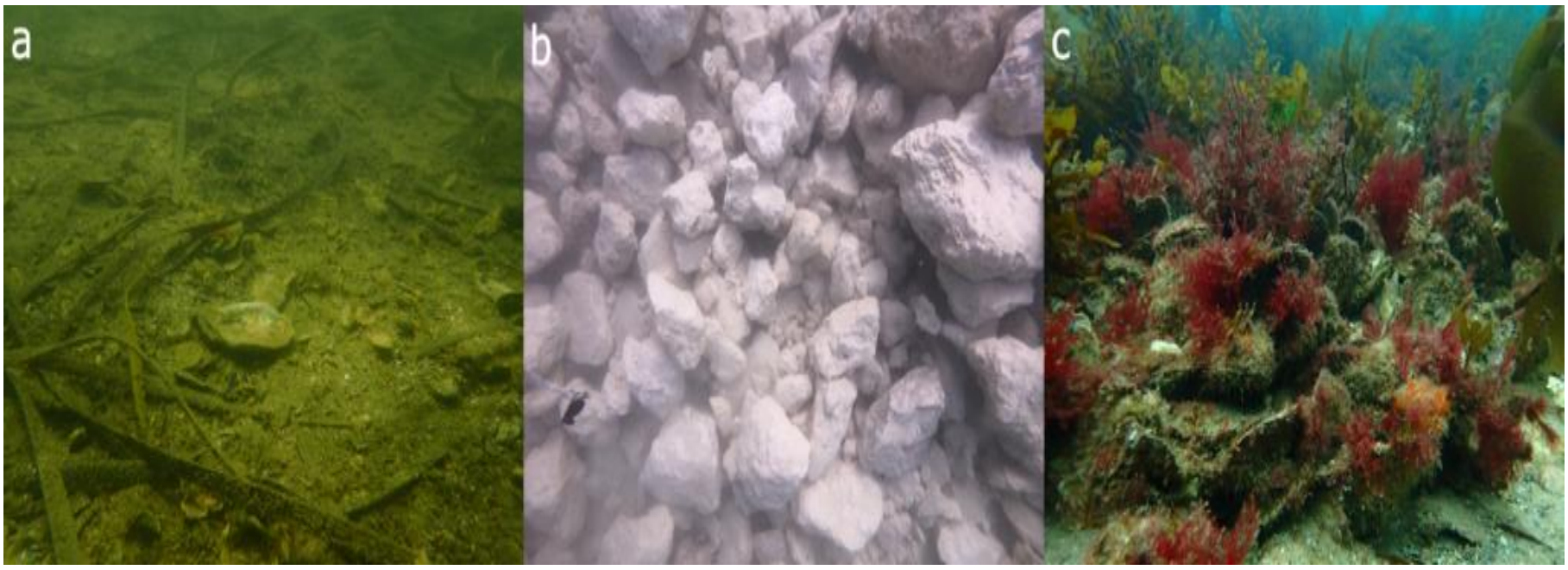

Figure 5: Example of expected ecological transition due to reef building from a) existing sand/muddy extinct reef habitats to b) newly laid reefs and c) eventual new shellfish reef ecological communities.

The Nature Conservancy and monitoring partners will measure several key environmental indicators (Appendices 3 and 4) before and after reef construction to assess how the reefs are developing against their predefined ecological baselines (Figure 6).

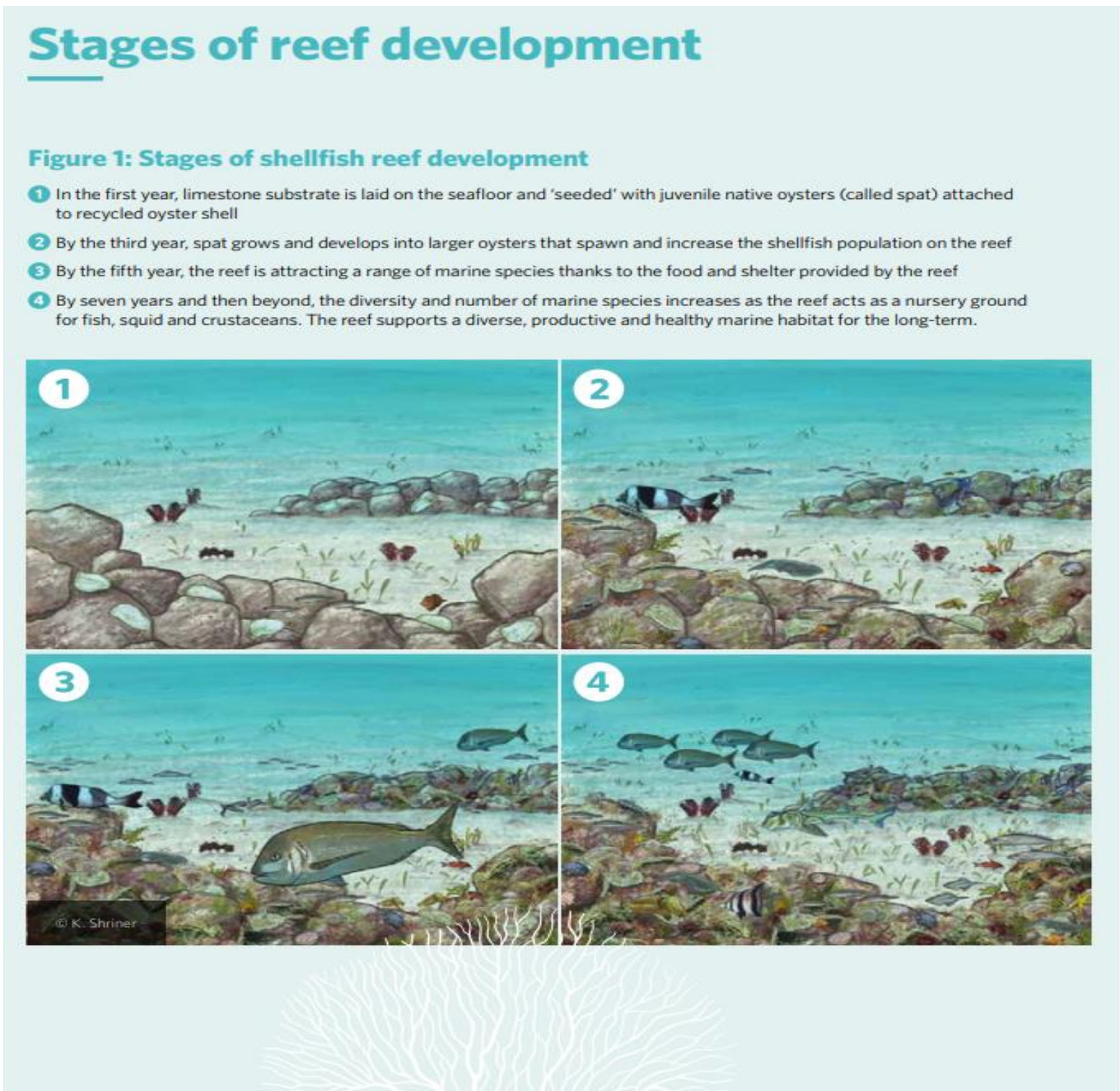

Figure 6. Stages of reef development © The Nature Conservancy

5.3 Social and economic targets

Restoration is profoundly a human undertaking, and human influence, both positive and negative, dictates the future of restored and unrestored ecosystems. The social facets of restoration (e.g. engagement, stewardship and capacity building) are fundamental in building environmental optimism and shifting community focus away from ecosystem decline towards conservation, restoration and recovery whilst ensuring social-licence. Additionally, the economic aspects of restoration are central to assessing restoration feasibility and long-term sustainability. Therefore, the ability to measure social and economic aspects is essential to assessing the success of a restoration project

6. Data procurement and repository

All construction, environmental, social and economic data collected as part of the monitoring and evaluation program (including videos and photos) by The Nature Conservancy, or third parties will be housed in an online database and management system. This system will be compatible with contemporary statistical packages that The Nature Conservancy will use to analyse project impact (e.g. statistical software 'R') and communicate project outcomes (e.g. through a digital Project dashboard). All Reef Builder data will be maintained in a cloud-based data management system.

The results of the monitoring and evaluation program will be summarised in the Final Project Report with updates included in the online Reef Builder dashboard.

7. Indicators and methods

The indicators and methods used to monitor and evaluate the Project are aligned with the Project's goals and objectives and will in-turn inform the targets. The matrix showing how the targets flow on to goals, objectives, indicators and methods can be seen in

Appendix 1. Reef Builder locations

Location and description	New or existing location	Species	Estimate reef area
Oyster Harbour (Albany) This project will expand on the recently constructed 1 ha of native flat oyster reefs restored by TNC in Oyster Harbour in 2018-20. Monitoring of the existing reefs has demonstrated early success, with up to 80% of oysters surviving, high numbers of new juvenile oysters naturally settling on the reefs, and a clear boost to fish abundance and diversity. Local community support for this project was highly reflected by the 250+ volunteers that helped with reef building activities such as shell cleaning and bagging. **Key stakeholders:** WA Government, Harvest Rd Oceans, Albany Shellfish Hatchery, City of Albany, Albany Port Authority, South Coast NRM and community groups.	Existing	Native flat oysters	4-5 ha
Swan-Canning Estuary (Perth) Building on the current work by TNC and supported by The Minderoo Foundation, Lotterywest, WA Government and Perth's philanthropic community, the additional investment will support up to a further 3 ha of native blue mussel reefs in the lower Swan-Canning estuary. Commonwealth investment will leverage existing investments to deliver an ecosystem-scale reef array over a total bottom area of up to 10 ha. In June this year, TNC constructed 16 test reefs throughout the lower estuary, which will be seeded in December 2020 with 2+ million juvenile mussels currently being grown by a local mussel farmer. **Key stakeholders:** DBCA, DPIRD, Harvest Rd Oceans, Recfishwest, local government, local community groups, Perth Region NRM, Ozfish Unlimited.	Existing	Native blue mussels	2-3 ha
Peel-Harvey Estuary (Mandurah) This project will restore up to an additional 3 ha of blue mussel reefs, extending TNC's current project to establish 0.3 ha of mussel reefs. There is a high level of community support, demonstrated by the 120 volunteers signed up to participate in the 'mussel gardening' program, where local community members grow mussels from juveniles to adults in specially designed baskets. Noongar Traditional Owner involvement is embedded within the program. **Key stakeholders**: Alcoa Foundation, Noongar Traditional Owners, Peel Development Commission, Peel Harvey Catchment Council, Recfishwest, City of Mandurah, Shire of Murray, WA Government.	Existing	Native blue mussels	2-3 ha
Glenelg (Adelaide metro) This project will build on the TNC-South Australian Government partnership to restore native flat oyster reefs along Adelaide's metropolitan coastline. Wide community consultation led by TNC in February 2020 received 1500 responses from the public which indicated community support for restoring oyster reefs at Glenelg. **Key stakeholders:** City of Holdfast, SA Government, SARDI, local oyster growers, Kaurna Traditional Owner, local community groups	Existing	Native flat oysters	2-3 ha
Onkaparinga (southern Adelaide metro) Complementing the reef array further north at Glenelg, this project will deliver up to 5 ha of new oyster reefs in the Onkaparinga region along the southern Adelaide metro coastline. This site is already known to be suitable for reef building and supported by the Onkaparinga community via the habitat suitability and public consultation surveys led by TNC in 2019-20. **Key stakeholders:** City of Onkaparinga, SA Government, SARDI, Kaurna Traditional Owner, local oyster growers, local community.	New	Native flat oysters	4-5 ha
Kangaroo Island (American River) This new project plans to deliver up to 4 ha of new oyster reefs at Kangaroo Island through close working relationships between TNC and local project partners. The project will bring substantial opportunities for engaging natural resource management, local oyster growers and food and wine tourism on Kangaroo Island and provide a much-needed economic boost to the local community. **Key stakeholders**: KI Council, DEW, SARDI, KI Landscapes (NRM), local oyster farmers, food and wine tourism operators, Kaurna, Ngarindjerri, Narungga.	New	Native Flat oysters	3-4 ha
Port Phillip Bay (St Kilda, Mornington & Bellarine Peninsulas) Building on the existing 5.5 ha of shellfish reefs restored by TNC from 2017-20, this project will extend the reef array by up to an additional 5 ha across key sites in Port Phillip Bay (St Kilda, Mornington and Bellarine Peninsulas). Monitoring of 2.5 ha of shellfish reefs built from 2017-2019 has confirmed their success, with up to 80% of shellfish surviving and good natural recruitment from wild stocks. The reefs are proving to be important nursery habitats for an array of species, including pink snapper, whiting, hulafish and snapping shrimp. More than 600 volunteers have supported this work through various citizen science activities, shell collection and cleaning and reef monitoring. **Key stakeholders:** Victorian Government, HSBC Australia, private funders, CMAs, Traditional Owners, fishers, divers, marine-care groups.	Existing	Native flat oysters & Native blue mussels	4-5 ha
Gippsland Lakes (Lakes Entrance) This new project will establish up to 5 ha of shellfish reefs across the Gippsland Lakes between Metung and Lakes Entrance. The increased habitat will improve fishing and crabbing within the key tourist focal areas, support the local fishing, tackle and boat hire businesses. **Key Stakeholders:** Victorian Government, East Gippsland CMA, Traditional Owners, Destination Gippsland, Lakes Entrance Fishing Club, local businesses and general community.	New	Native flat oysters & Native blue mussels	4-5 ha
Derwent Estuary (Hobart) This new project will establish up to 5 ha of native flat oyster reefs in the Derwent Estuary, Hobart. The project will work closely with oyster growers and shellfish hatcheries who have been hit hard by COVID-19 in addition to the marine science community, Tasmanian Aboriginal Council, Tarfish and the local community. The project has undertaken extensive community consultation over the last three years and is ready to commence work in 2021. **Key stakeholders**: NRM South, Tarfish, Derwent Estuary Program, Tasmanian Aboriginal Centre, University of Tasmania.	New	Native flat oysters	4-5 ha
Karuah River (Port Stephens) This project will build on the NSW Government 1 ha reef established in May 2020 in partnership with local oyster growers and the community. The project is working in abandoned oyster lease areas and using remnant oysters to reseed the new reefs. Initial monitoring indicates the reefs are being seeded by millions of young oysters. **Key stakeholders:** NSW Government Department of Primary Industries, local oyster growers, local fishers.	Existing	Sydney rock oysters	3-4 ha
Botany Bay (Sydney) This new project will restore both native flat oyster and Sydney rock oysters in the heartland of Sydney's fishing community. Extensive coastal infrastructure around the Bay has reduced fish nursery and reef areas, significantly reducing recreational fishing opportunities. The project will engage the Sydney business community in corporate philanthropy and volunteering and work with fishers, community groups and schools to recovery the Bay's lost shellfish reefs. **Key stakeholders:** Greater Western Local Land Service, NS Sports Fishers Assoc. Ozfish Unlimited, NSW Government, La Perouse Local Aboriginal Land Council, local community groups.	New	Native flat oysters & Sydney rock oysters	4-5 ha

Sapphire and Eurobodalla Coast (between Narooma and Eden) This new project will work closely with the shellfish aquaculture and recreational fishing communities to restore native flat oysters and potentially Sydney rock oysters in one or several coastal rivers on the NSW Sapphire Coast. The region's tourism and aquaculture areas have been hit hard by both COVID-19 and recent bushfires and this project will take a community-based approach to restoration, supporting mental wellbeing through community volunteering and participatory activities. **Key Stakeholders:** NSW Government, NSW Oyster Growers, local fishing businesses, community groups.	New	Native flat oysters	2-3 ha
Sunshine Coast – Noosa River A further 1 ha of Sydney rock oyster reefs is proposed to be restored in the Noosa River Estuary, building on the ~1 ha of oyster reefs already in development. The Commonwealth project will leverage the $2.4 million investment by TNC and Noosa Shire Council. **Key stakeholders:** Noosa Shire Council, Kabi Kabi, Tourism Noosa, Community Resources Ltd, Mooloolaba River Fisheries, Ecological Service Professionals, Noosa Biosphere Reserve, Noosa Integrated Catchment Assoc. various community groups.	New/ Existing (location dependant)	Sydney rock oysters	1 ha (+1 ha under the TNC-Noosa Council Partnership)

Appendix 2: Targets, goals, objectives and associated performance indicators Timelines for when monitoring will be undertaken are shown in Figure 3.

The methods for monitoring the ecological indicators are adapted from the Oyster Habitat Restoration Monitoring and Assessment Handbook[10] with detailed methods provided in **Error! Reference source not found.**

Methods for monitoring social and economic indicators are developed from measuring contractor, community and stakeholder involvement with Project activities. This involves the collection of data on metrics such as the number of workshop/forum attendees, number of media mentions and labour hours. Details for these methods are provided in **Error! Reference source not found.**

8. Evaluation

8.1 Environmental performance indicators

The experimental design for ecological indicators (listed in Appendix 2) is based on a Before-After-Control-Impact (BACI) design[11], adapted to shellfish reef restoration[12]. To evaluate the ecological impact and assess the performance of the reef in meeting its targets, it is necessary to perform both pre- and post-construction monitoring and contrast against control sites located in two different adjacent habitats, i.e. soft sediments and seagrass (Figure 7). This enables comparison to a 'negative reference' (i.e. soft-sediment, as if the restoration action never occurred) and another 'positive reference' (i.e. seagrass, another structured biogenic habitat). The soft-sediment and seagrass reference sites are located ≥ 500 m from the restoration site, but still within an area of comparable environmental conditions (Figure 7).

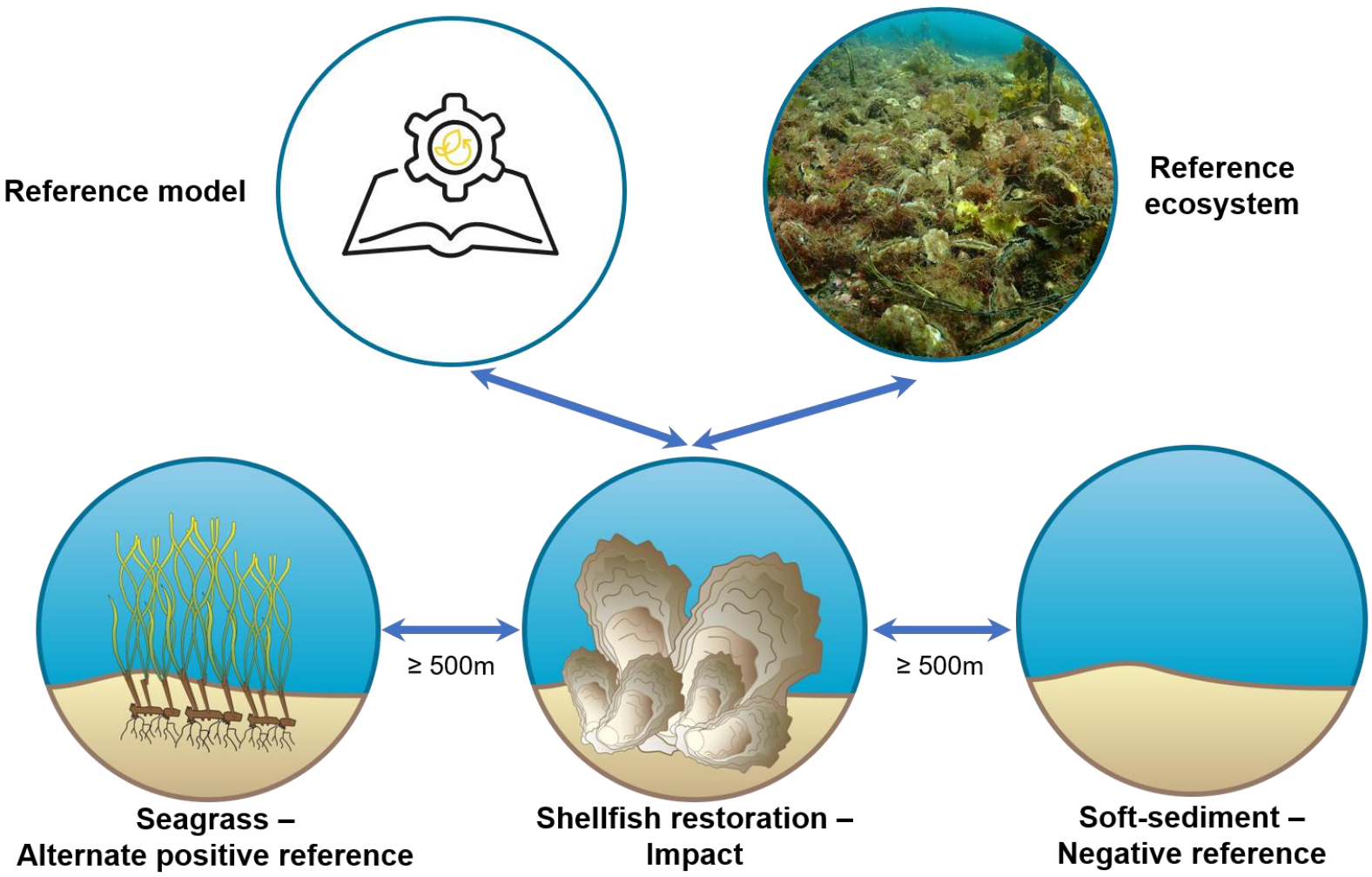

Figure 2: Diagram of the monitoring design, including the shellfish reef restoration site (impact), seagrass site (alternate positive reference) and soft sediment site (negative reference) – see bottom panel. If an existing, comparable shellfish reef ecosystem is present, this acts as a preferential reference site (top panel).

8.2 Social and economic performance indicators

Socio-economic indicators will be evaluated by analysing data collected by the Project Coordinators and pre- and post-construction testimonials from key stakeholders and the community. Evaluation of performance indicators will be done by standard analysis workflows, ensuring clear and consistent evaluation products. Each indicator will be assessed against a planned benchmark (output and timeframe) and will be allocated a score relative to their deviation from that benchmark. This scoring will be consistent with those allocated for the construction and environmental targets.

8.3 Project efficiency indicators

Project efficiency indicators will be evaluated by reviewing the Project deliverables and budget against established outputs and timeframes, as stipulated in the Grant Agreement. Each indicator will be assessed using the same approach outlined for socio-economic indicators above.

8.4 Evaluation steps

Summarise

Initially for each performance indicator, the data will be compiled and summarised returning the mean, standard deviation, standard error. Metrics will also be visualised by plotting time series plots that track how each metric progresses through time in comparison to its benchmark (see *Trend* section below).

Score

The summarised data is then used to calculate a score based on its deviation from a benchmark value. This benchmark will be either (i) pre-defined in reference to a known condition, e.g. 50 shellfish per m^2, which defines a viable population density similar to that found on natural oyster reefs (Gillies *et al.* 2017*)*, or (ii) if no pre-determined benchmark exists, the indicator will be measured against its mean value recorded from relevant reference locations. The results are then standardised by determining the percentage deviation of the measure compared to the benchmark value (in either a positive or negative direction) and allocated to one of six 'report-card' score categories, i.e. grade A+ (excellent) to D (very poor) or ND (no data; see Figure).

[10] The Nature Conservancy et al, Oyster Habitat Restoration Monitoring and Assessment Handbook.
[11] Underwood, A. J. (1994). On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological applications*, *4*(1), 3-15.
[12] The Nature Conservancy et al, Oyster Habitat Restoration Monitoring and Assessment Handbook.

Trend

The trend for each indicator will be assessed by fitting the raw data to a linear model. The significance of the t-value, that assesses whether the coefficient is significantly different to zero, will first be examined. If the metric is not significant, the slope will be assigned to the 'Stable' category. If slope is significant, the value of the slope coefficient is then categorized into one of six trend categories (see Figure).

Additional analysis

Where necessary, additional analyses will be undertaken to statistically assess the trend of restoration success across all Reef Builder locations using a meta-analysis approach. The data will be evaluated using the R language and environment for statistical computing alongside RStudio, which allows scripts of code to be created and ensures standard analysis workflows and evaluation products.

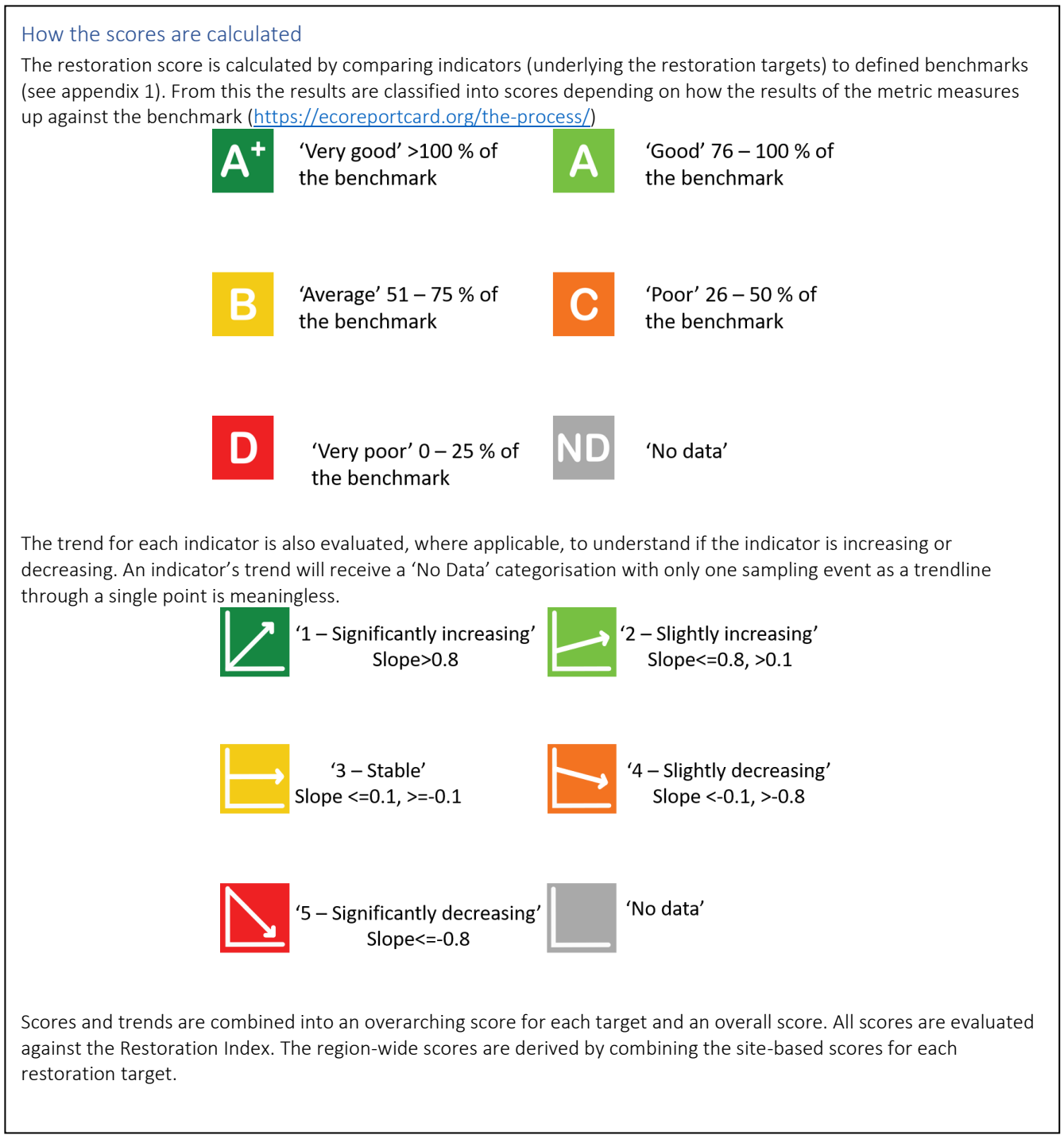

Figure 8: How score and trend is calculated and categorized.

9. Reporting

The following reports will be produced in line with the terms of the Alliance and Funding Agreement and Reef Builder contract:

9.1 Progress reports

Progress reports will be produced every 6 months in line with a schedule agreed to between TNC and NSC. These reports will summarise progress against targets, goals and performance indicators specified in the Agreement and include project highlights. These reports will be made publicly available via the TNC and NSC websites, and other platforms as agreed by the two parties. Summaries of the field monitoring results will also be included and display infographics aimed at donors, project partners, restoration practitioners, community groups and the general public.

9.2 Financial statements

Financial statements will be developed in line with requirements specified in the Alliance and Funding Agreement and as formally agreed between TNC and NSC. The financial statements will be included in the 6 monthly and annual project reports. The financial statements will form the basis for the evaluation of the indicators that sit under the project efficiency targets.

9.3 Technical MER reports

Additional technical MER reports will also be provided annually to report on the scientific aspects of the project. These reports will include details of the monitoring data collected and an evaluation of how this relates back to the primary targets for the project. The audience for the annual technical report is academic and government scientists, project partners, restoration practitioners.

9.4 Final project report

The final project report will present an overview of the project achievements against the project deliverables; a financial statement; and, an analysis of the project's performance against ecological, social and efficiency indicators.

The final report will specifically focus on reporting:

- Achievement against outputs (e.g. number of oysters, survivability of oysters, area of ecosystem restored, presence/absence of fish at the restoration sites et cetera);

- Impact on stakeholders (e.g. through testimonials and surveys); and,
- Project efficiency.

The report will make recommendations towards long term 'impact' monitoring such as the contribution of oyster ecosystems towards sediment management, fish productivity and tourism.

The report will include recommendations from the end of project evaluation. The evaluation will consider achievements against the project goals as well as the nature and strength of the partnership between TNC and NSC.

Table 1: Project reporting schedule

Report	Due
6 monthly progress report including financial statement	28 February each year
Annual project report including financial statement	31 August each year
Annual technical MER report	31 August each year
Final Project Report including final evaluation and recommendations for long term 'impact' monitoring	30 September 2022

10. Monitoring, Evaluation and Reporting Workflow

Figure 9 provides an outline of the monitoring, evaluation and reporting workflow described in the sections above.

Figure 9: Restoration targets and MER workflow

11. Data management

The project will follow global best practice in data management as outlined in the British Ecological Society's Guide to Data Management in Ecology and Evolution[13].

Principles include standardized and consistent procedures to collect, process, check, validate and verify data. Data and information will be openly shared, proactively released, licensed to promote re-use and housed on the Australian Ocean Data Network (AODN).

Detailed records of the providence of any oysters (adults, larvae or spat) that are introduced to the Noosa River estuary from other estuarine system/s will be kept and provided to NSC and the Department of Agriculture and Fisheries (DAF).

The project will only source oyster brood stock from the Noosa River estuary and return oyster spat to the estuary from those brood stock. In doing so, the project and the hatchery will follow all required Queensland biosecurity protocols and permit conditions related to that activity.

[13] Alpert P, Baier A, Baker L, Bartomeus I, Beckerman A, Brophy C, Buckley Y, Burdon R, Canham C, Coulson T, Demes K, Dray S, Dyer A, Freckleton R, Gibson D, Newton E, O'Hara B, Hill C, Pearse W, Pettorelli N, Piper F, Raby C, Salguero-Gomez R, Suryawanshi K, Warren P, Wilson K (2014) A Guide to Data Management in Ecology and Evolution. British Ecological Society, London

Appendix 1. Reef Builder locations

Location and description	New or existing location	Species	Estimate reef area
Oyster Harbour (Albany) This project will expand on the recently constructed 1 ha of native flat oyster reefs restored by TNC in Oyster Harbour in 2018-20. Monitoring of the existing reefs has demonstrated early success, with up to 80% of oysters surviving, high numbers of new juvenile oysters naturally settling on the reefs, and a clear boost to fish abundance and diversity. Local community support for this project was highly reflected by the 250+ volunteers that helped with reef building activities such as shell cleaning and bagging. **Key stakeholders:** WA Government, Harvest Rd Oceans, Albany Shellfish Hatchery, City of Albany, Albany Port Authority, South Coast NRM and community groups.	Existing	Native flat oysters	4-5 ha
Swan-Canning Estuary (Perth) Building on the current work by TNC and supported by The Minderoo Foundation, Lotterywest, WA Government and Perth's philanthropic community, the additional investment will support up to a further 3 ha of native blue mussel reefs in the lower Swan-Canning estuary. Commonwealth investment will leverage existing investments to deliver an ecosystem-scale reef array over a total bottom area of up to 10 ha. In June this year, TNC constructed 16 test reefs throughout the lower estuary, which will be seeded in December 2020 with 2+ million juvenile mussels currently being grown by a local mussel farmer. **Key stakeholders:** DBCA, DPIRD, Harvest Rd Oceans, Recfishwest, local government, local community groups, Perth Region NRM, Ozfish Unlimited.	Existing	Native blue mussels	2-3 ha
Peel-Harvey Estuary (Mandurah) This project will restore up to an additional 3 ha of blue mussel reefs, extending TNC's current project to establish 0.3 ha of mussel reefs. There is a high level of community support, demonstrated by the 120 volunteers signed up to participate in the 'mussel gardening' program, where local community members grow mussels from juveniles to adults in specially designed baskets. Noongar Traditional Owner involvement is embedded within the program. **Key stakeholders**: Alcoa Foundation, Noongar Traditional Owners, Peel Development Commission, Peel Harvey Catchment Council, Recfishwest, City of Mandurah, Shire of Murray, WA Government.	Existing	Native blue mussels	2-3 ha
Glenelg (Adelaide metro) This project will build on the TNC-South Australian Government partnership to restore native flat oyster reefs along Adelaide's metropolitan coastline. Wide community consultation led by TNC in February 2020 received 1500 responses from the public which indicated community support for restoring oyster reefs at Glenelg. **Key stakeholders:** City of Holdfast, SA Government, SARDI, local oyster growers, Kaurna Traditional Owner, local community groups	Existing	Native flat oysters	2-3 ha
Onkaparinga (southern Adelaide metro) Complementing the reef array further north at Glenelg, this project will deliver up to 5 ha of new oyster reefs in the Onkaparinga region along the southern Adelaide metro coastline. This site is already known to be suitable for reef building and supported by the Onkaparinga community via the habitat suitability and public consultation surveys led by TNC in 2019-20. **Key stakeholders:** City of Onkaparinga, SA Government, SARDI, Kaurna Traditional Owner, local oyster growers, local community.	New	Native flat oysters	4-5 ha
Kangaroo Island (American River) This new project plans to deliver up to 4 ha of new oyster reefs at Kangaroo Island through close working relationships between TNC and local project partners. The project will bring substantial opportunities for engaging natural resource management, local oyster growers and food and wine tourism on Kangaroo Island and provide a much-needed economic boost to the local community. **Key stakeholders**: KI Council, DEW, SARDI, KI Landscapes (NRM), local oyster farmers, food and wine tourism operators, Kaurna, Ngarindjerri, Narungga.	New	Native Flat oysters	3-4 ha
Port Phillip Bay (St Kilda, Mornington & Bellarine Peninsulas) Building on the existing 5.5 ha of shellfish reefs restored by TNC from 2017-20, this project will extend the reef array by up to an additional 5 ha across key sites in Port Phillip Bay (St Kilda, Mornington and Bellarine Peninsulas). Monitoring of 2.5 ha of shellfish reefs built from 2017-2019 has confirmed their success, with up to 80% of shellfish surviving and good natural recruitment from wild stocks. The reefs are proving to be important nursery habitats for an array of species, including pink snapper, whiting, hulafish and snapping shrimp. More than 600 volunteers have supported this work through various citizen science activities, shell collection and cleaning and reef monitoring. **Key stakeholders:** Victorian Government, HSBC Australia, private funders, CMAs, Traditional Owners, fishers, divers, marine-care groups.	Existing	Native flat oysters & Native blue mussels	4-5 ha
Gippsland Lakes (Lakes Entrance) This new project will establish up to 5 ha of shellfish reefs across the Gippsland Lakes between Metung and Lakes Entrance. The increased habitat will improve fishing and crabbing within the key tourist focal areas, support the local fishing, tackle and boat hire businesses. **Key Stakeholders:** Victorian Government, East Gippsland CMA, Traditional Owners, Destination Gippsland, Lakes Entrance Fishing Club, local businesses and general community.	New	Native flat oysters & Native blue mussels	4-5 ha
Derwent Estuary (Hobart) This new project will establish up to 5 ha of native flat oyster reefs in the Derwent Estuary, Hobart. The project will work closely with oyster growers and shellfish hatcheries who have been hit hard by COVID-19 in addition to the marine science community, Tasmanian Aboriginal Council, Tarfish and the local community. The project has undertaken extensive community consultation over the last three years and is ready to commence work in 2021. **Key stakeholders**: NRM South, Tarfish, Derwent Estuary Program, Tasmanian Aboriginal Centre, University of Tasmania.	New	Native flat oysters	4-5 ha
Karuah River (Port Stephens) This project will build on the NSW Government 1 ha reef established in May 2020 in partnership with local oyster growers and the community. The project is working in abandoned oyster lease areas and using remnant oysters to reseed the new reefs. Initial monitoring indicates the reefs are being seeded by millions of young oysters. **Key stakeholders:** NSW Government Department of Primary Industries, local oyster growers, local fishers.	Existing	Sydney rock oysters	3-4 ha
Botany Bay (Sydney) This new project will restore both native flat oyster and Sydney rock oysters in the heartland of Sydney's fishing community. Extensive coastal infrastructure around the Bay has reduced fish nursery and reef areas, significantly reducing recreational fishing opportunities. The project will engage the Sydney business community in corporate philanthropy and volunteering and work with fishers, community groups and schools to recovery the Bay's lost shellfish reefs. **Key stakeholders:** Greater Western Local Land Service, NS Sports Fishers Assoc. Ozfish Unlimited, NSW Government, La Perouse Local Aboriginal Land Council, local community groups.	New	Native flat oysters & Sydney rock oysters	4-5 ha

Sapphire and Eurobodalla Coast (between Narooma and Eden) This new project will work closely with the shellfish aquaculture and recreational fishing communities to restore native flat oysters and potentially Sydney rock oysters in one or several coastal rivers on the NSW Sapphire Coast. The region's tourism and aquaculture areas have been hit hard by both COVID-19 and recent bushfires and this project will take a community-based approach to restoration, supporting mental wellbeing through community volunteering and participatory activities. **Key Stakeholders:** NSW Government, NSW Oyster Growers, local fishing businesses, community groups.	New	Native flat oysters	2-3 ha
Sunshine Coast – Noosa River A further 1 ha of Sydney rock oyster reefs is proposed to be restored in the Noosa River Estuary, building on the ~1 ha of oyster reefs already in development. The Commonwealth project will leverage the $2.4 million investment by TNC and Noosa Shire Council. **Key stakeholders:** Noosa Shire Council, Kabi Kabi, Tourism Noosa, Community Resources Ltd, Mooloolaba River Fisheries, Ecological Service Professionals, Noosa Biosphere Reserve, Noosa Integrated Catchment Assoc. various community groups.	New/ Existing (location dependant)	Sydney rock oysters	1 ha (+1 ha under the TNC-Noosa Council Partnership)

Appendix 2: Targets, goals, objectives and associated performance indicators

Goal	Objective	Indicator	Metric	Method	Planned Output or benchmark	Frequency/Timing	Restoration	Soft-sediment	Alternate reference	Responsibility
				Intertidal						
CONSTRUCTION TARGET: Build resilient new reefs – Construct shellfish reefs at 13 locations across Australia, following established best practice project management, restoration and siting protocols.										
GOAL 1: Within the timeframe of Reef Builder demonstrate construction of resilient reef structures	***OBJECTIVE 1. Construct the reef to meet design and Project outputs***	i 1. Total area of constructed reef	m^2 or ha	RTK-GPS or Unoccupied aircraft survey	[Project to define in m^2 or ha]	One survey early post-construction	X	-	-	TNC/Delivery partner
		i 2. Reef footprint	m^2 or ha	RTK-GPS or Unoccupied aircraft survey	[Project to define in m^2 or ha]	One survey early post-construction	X	-	-	TNC/Delivery partner
		i 3. Reef coverage over seafloor in restoration area	%	RTK-GPS or Unoccupied aircraft survey	15-25%	One survey early post-construction	X	-	-	TNC/Delivery partner
		i 4. Total reef-base deployed	tonnes or m^3	Order and delivery dockets	[Project to define in tonnes or m^3]	Early post-construction	X	-	-	TNC/Delivery partner
ENVIRONMENTAL/ECOLOGICAL TARGET: Improve local biodiversity – Establish self-sustaining oyster and/or mussel populations and associated ecological communities to levels at or above standard ecological benchmarks at each of the 13 locations										
GOAL 2. Within the timeframe of Reef Builder rebuild local shellfish populations	***OBJECTIVE 2. Demonstrate a density of target shellfish similar to a pre-defined reference system***	i 5. Total shellfish deployed	Total number of individuals deployed	Data collected by Project Mgr in consultation with Hatchery Mgr	[Project to define in number of shellfish]	Once following shellfish seeding	X	-	-	TNC/Delivery partner/ Hatchery
		i 6. Total number of live target shellfish	(count/m^2)	Intertidal quadrat surveys	> 50/m^2 (*O. angasi)*, 200?/m^2 (*S. glomerata*), 1000 /m^2 (*M. planulatus/gall oprovincialis*)	Before reef construction and after shellfish seeding	X	X	X	MER partners/Delvie ry partner
GOAL 3. Within the timeframe of Reef Builder demonstrate the creation of habitat that benefits fish	***OBJECTIVE 3. Demonstrate more fish post reef construction***	i 7. Total abundance of fish (g/m^2, kg/ha)	Relative counts	Stereo BRUVS	> baseline	Before reef construction and after shellfish seeding	X	X	X	MER partners
GOAL 4. Within the timeframe of Reef Builder demonstrate that reef construction enhances marine biodiversity	***OBJECTIVE 4. Demonstrate an increase in biodiversity***	i 8. Species richness of mobile epifauna	(% cover, counts)	Cores and photoquadrats	Richness > control/ baseline (#/m^2)	Before reef construction and after shellfish seeding	X	X	X	MER partners/Delive ry partner
ECONOMIC TARGET: Boost local employment – Employ maritime construction, earthmoving, aquaculture, engineering and NRM businesses in resource procurement and construction of shellfish reefs at each of the 13 locations										
GOAL 5. Within the timeframe of Reef Builder demonstrate the benefits of shellfish reefs to local economies	***OBJECTIVE 5. Demonstrate delivery of jobs***	i 9. Number of local contractors engaged	Number of local contractors/ businesses used	Data collected by Project Mgr	120	Ongoing throughout Project	X	-	-	TNC/Delivery partner
		i 10. Total no. of full-time jobs within the Project (local, national and international)	Number of FTE positions during Project	Data collected by Project Mgr	170	Ongoing throughout Project	X	-	-	TNC/Delivery partner
	OBJECTIVE 6. Capture cost associated with shellfish restoration	i 11. Cost of restoration projects	Costs per category per Project	Data collected by Project Mgr	No output just collation	Ongoing throughout Project	X	-	-	TNC/Delivery partner
SOCIAL TARGET: Strengthen community engagement – Harness community interest, support and participation by providing opportunities for media, community involvement and volunteering at each of the 13 locations										

Goal	Objective	Indicator	Metric	Method Intertidal	Planned Output or benchmark	Frequency/Timing	Restoration	Soft-sediment	Alternate reference	Responsibility
GOAL 6. Within the timeframe of Reef Builder engage the community in long-term stewardship of the shellfish reef	***OBJECTIVE 7. Demonstrate engagement by the local community***	i 12. Total number of community events	No of community events for the Project (e.g. public forums, volunteer events)	Data collected by Project Mgr	150	Ongoing throughout project	X	-	-	TNC/Delivery partner
		i 13. Attendees at public consultation meetings	No of attendees at public forums	Data collected by Project Mgr	No output just collation	Ongoing throughout project	X	-	-	TNC/Delivery partner
		i 14. Community and partner organisations engaged	Number of community and partner groups engaged	Data collected by Project Mgr	No output just collation	Ongoing throughout project	X	-	-	TNC/Delivery partner
	OBJECTIVE 8. Demonstrate media engagement	i 15. Media engagement	No of times the Project is mentioned in the media (excludes Project organisation's social media accounts)	Media Monitoring, data collected by Project Mgr	26	Ongoing throughout project	X	-	-	TNC/Delivery partner
	OBJECTIVE 9. Demonstrate involvement opportunities for community members to participate in marine restoration	i 16. Total no. of volunteers	No of community volunteers contributing to citizen science or restoration activities	Data collected by Project Mgr	No output just collation	Ongoing throughout project	X	-	-	TNC/Delivery partner
		i 17. Volunteer hours donated	No of volunteer hours donated over project	Data collected by Project Mgr	No output just collation	Ongoing throughout project	X	-	-	TNC/Delivery partner
GOAL 7. Monitor water quality to demonstrate that construction of the reef enhances marine ecological health	***OBJECTIVE 10. Explore the capacity for the developing ecosystem to enhance marine ecological health and reduce water turbidity***	i 18. Physical conditions within tolerance ranges for target shellfish	Salinity, temperature, pH and dissolved oxygen within tolerance range of target shellfish	Data collected by Project Mgr	Water quality within tolerance ranges for target shellfish	6 monthly	X	-	-	TNC/Delivery partner
	OBJECTIVE 11. Explore the capacity for the developing ecosystem to reduce water turbidity	i 19. Turbidity/susp solids around restoration site reduced	Change compared to baseline and controls for turbidity (NTU/mg.L) and water clarity (Secchi depth)	turbidity/secchi disk	Secchi depth > baseline	Monthly	X	-	-	TNC/Delivery partner
GOAL 8. Within the timeframe of the project improve knowledge, education and practical skills in marine restoration for practitioners, users and community members	***OBJECTIVE 12. Demonstrate improved knowledge and education for individuals in marine restoration***	i 20. Improved knowledge and education for individuals and end users	Number of students (secondary, tertiary and postgraduate)	Data collected by Project Mgr	10	6 monthly	X	-	-	TNC/Delivery partner
		i 21. Improved educational resources for individuals	Number of resources available to individuals (videos, practitioner reports, academic articles, workshops, conference presentations, podcasts, infographics etc.)	Data collected by Project Mgr	No output just collation	6 monthly	X	-	-	TNC/Delivery partner

Goal	Objective	Indicator	Metric	Method Intertidal	Planned Output or benchmark	Frequency/Timing	Restoration	Soft-sediment	Alternate reference	Responsibility
	OBJECTIVE 13. Demonstrate improved practical skills for individuals to undertake marine restoration	i 22. Individuals and end users improve practical skills in marine restoration	Number of interns or work placements	Data collected by Project Mgr	10 individuals and end users	6 monthly	X	-	-	TNC/Delivery partner
GOAL 9. Demonstrate responsible fiscal management throughout the project	***OBJECTIVE 14. How has financial investment been leveraged***	i 23. Total financial investment leveraged (including In-kind)	Summarise leverage investment/co-investment include in-kind	Data collected by Project Mgr	50% on baseline	6 monthly	-	-	-	TNC
	OBJECTIVE 15. Project delivered within budget	i 24. Project outputs delivered within budget	Cumulative expenditure report, Annual progress report	Data collected by Project Mgr	Delivered within +/- 10% of forecast budget	8 month cumulative and annual report	-	-	-	TNC
Goal 10. Demonstrate Technical Advisory input throughout the project	***OBJECTIVE 16. Demonstrate effective technical advice provided throughout project***	i 25. TAG meetings coordinated quarterly and attended by key personnel	Summarize TAG meeting details, # attendees	Data collected by Project Mgr	10 meetings	6 monthly	-	-	-	TNC
	OBJECTIVE 17. Restore each site to meet environmental conditions set in approvals	i 26. Permit conditions met	To be determined once conditions have been set through approvals	Data collected by Project Mgr and Contractors as required	90% of conditions met	Annually	-	-	-	TNC
GOAL 11. Demonstrate effective project management throughout project delivery	***OBJECTIVE 18. Demonstrate timely and effective project management and delivery***	i 27. No of project milestones delivered within specified timeframe	% delivered on time	Data collected by Project Mgr	75% of milestones delivered effectively on time	Ongoing throughout project	-	-	-	TNC
GOAL 12. Demonstrate insignificant impact on coastal erosion	***OBJECTIVE 19. Demonstrate that coastal erosion caused by the restoration works is insignificant***	i 28. Coastal erosion within 100m up or downstream of a restoration site is not attributable to the restoration works	% change in shoreline profile	Data collected by Project Mgr and Contractors as required	90% coastline change detected is not attributable to the restoration works	6 monthly (visual observation) Annually (photo comparison)	X	-	-	TNC/Delivery partner

Appendix 3: Intertidal monitoring methods

An overview of monitoring methods is provided below with key performance indicators. These methods are adapted from the Oyster Habitat Restoration Monitoring and Assessment Handbook[14].

CONSTRUCTION TARGET

Reef structure and elevation (topography) surveys

Intertidal reefs

Oyster reef layout, morphology and dimension and topographical surveys will be conducted using a combination of different traditional and innovative methods adapted from Windle et al. (2019) and Genchi et al. (2020). Methods below outline a low cost, less involved (RTK-GPS) and a higher cost, more involved (Unoccupied Aircraft System) method. Decisions should be made between the project team about the appropriate method for the project.

1. Reef structure

RTK-GPS Method

A real-time kinematic (RTK) GPS will be used to monitor the intertidal oyster reef at a spring low tide. The RTK (GPS) shall use a base station correction to achieve a maximum of 3cm-level accuracy.
To calculate reef area, an RTK GPS will be used to make continuous measurements of 1m increments while walking along the perimeter of each reef patch.
To calculate the reef elevation profile, RTK GPS transects will be taken along the approximate centerline of the long axis of each reef patch with continuous measurements of 1m increments.

Unoccupied Aircraft Systems

A multi rotor aircraft equiped with a camera and a survey grade RTK GPS capable of 2cm horizontal error, 5 cm vertical error and a groun sample distance (GSD) of 2.5cm will be used on the oyster reef area.
Ground control points (GCPs), typically black and white 'checker' targets with defined center points, shall be used to help increase geolocation accuracy of UAS imagery, which can also help during the structure from motion photogrammetry process. Before each flight, the center of 4 to 10 GCPs should be surveyed using an RTK GPS. All UAS imagery shall be processed with a photogrammetry software to output RGB orthomosaics and digital surface models (DSMs) in the appropiate UTM Zone and projection. The DSMs shall be created using an inverse distance weighting method, allowing for surface smoothing at 1.12 to 2.21 cm/pixel. DSMs generated by the UAS surface model heights shall be converted to elevations in the Australian Height Datum (AHD) to create a digital elevation model.

2. Elevation - topographical survey

RTK-GPS Method

Five RTK GPS transects using a 1 m survey interval will be conducted across the intertidal area sites of the oyster reef and bare sediment control.
Transects will occur at spring low tide and will run along the intertidal longitudinal gradient of the site, from the highest intertidal to the low water mark.
Within each habitat, the five transects will be equidistantly separated along the habitat range. To ensure that transects are run consistently through the years, each transect will be georeferenced.

Unoccupied Aircraft Systems

A multi rotor aircraft equiped with a camera and a survey grade RTK GPS capable of 2cm horizontal error, 5cm vertical error and a GSD of 2.5cm will be used on the oyster reef area and the bare sediment control area. To ensure a high degree of overlap, the flight path was designed as straight flight lines sampling a grid pattern within each

[14] The Nature Conservancy et al, Oyster Habitat Restoration Monitoring and Assessment Handbook

habitat area. The flight average height and flight speed will be adjusted to the characteristics of each particular monitoring site.
Ground control points (GCPs), typically black and white 'checker' targets with defined center points, shall be used to help increase geolocation accuracy of UAS imagery, which can also help during the structure from motion photogrammetry process. Before each flight, the center of 4 to 10 GCPs was surveyed using an RTK GPS. All UAS imagery shall be processed with a photogrammetry software to output RGB orthomosaics and digital surface models (DSMs) in the appropiate UTM Zone and projection. The DSMs shall be created using an inverse distance weighting method, allowing for surface smoothing at 1.12 to 2.21 cm/pixel. DSMs generated by the UAS surface model heights shall be converted to elevations in the Australian Height Datum (AHD) to create a digital elevation model.

Expected deliverables

a. Report of survey including appropriate metadata. TNC will advise about the metadata format

b. ArcGIS compatible shapefiles of reefs with area and volume calculations of reef extent

c. ArcGIS compatible file of topographic data

d. Cross sections over reefs: one long axis, three short axis cross sections and a measure of rugosity

e. Plan of survey overlaid on high-resolution aerial imagery in appropiate formats. TNC will advise about the format.

f. 3D animated flythrough of the reefs

Indicators

i1. Total area of constructed reef – the total area of constructed reef
i2. Project footprint – Minimum total area encompassing all reefs, determined from project GIS outputs
i3. Percent reef coverage – The percentage of the project footprint covered by re-constructed reef

ENVIRONMENTAL TARGET

General environmental monitoring design

The design described below represents a minimal monitoring design and balances statistical power with time efficiency and cost effectiveness. The primary aim of the monitoring is a comparison between areas where shellfish reefs are restored and where they are not. An impact or restored area is compared to an area of soft-sediment that serves as a reference of what would occur if restoration was never undertaken – generally termed a 'negative reference'. There would ideally also be a 'positive reference', or an area of natural shellfish reef that can act as a guide to the anticipated restoration trajectory and performance of a restored reef in a given system. However, this is often not the case and a reference system is typically used instead[15][16]. Secondly, it is also beneficial to contrast the performance of restored shellfish reefs with an alternative structured habitat within a system. For the subtidal Reef Builder sites, seagrass has been selected as this alternate positive reference, given that it is common in many bays and estuaries and typically has a habitat value similar to that of shellfish reefs. For the intertidal Reef Builder sites where remnant oyster reefs are not present, mangrove forests have been selected as the appropriate intertidal positive reference.
At any given restoration location under Reef Builder, up to four habitats could be monitored (Figure 11). At a minimum, only the first two habitats may be monitored if the latter two are not present within comparable environmental conditions as the restoration site.

[15] Gillies, C. L., Crawford, C. and Hancock, B. (2017), Restoring Angasi oyster reefs: What is the endpoint ecosystem we are aiming for and how do we get there?. Ecol Manag Restor, 18: 214-222. doi:10.1111/emr.12278

[16] McAfee, D., McLeod, I. M., Boström-Einarsson, L., & Gillies, C. L. (2020). The value and opportunity of restoring Australia's lost rock oyster reefs. *Restoration Ecology*, *28*(2), 304-314

1. The restoration site (yellow outlined polygon)
2. A soft sediment site – negative reference (brown area)
3. A seagrass/mangrove reference site – alternate positive reference (green area)
4. A natural shellfish reef site – positive reference (where present)

An important consideration when choosing monitoring sites is to reduce any confounding influences, such as changes in hydrodynamics or water quality between monitoring sites. It therefore becomes a balancing act to minimise spatial dependence (i.e. closely situated sites that influence each other), yet avoid the monitoring and restoration sites having significantly different environmental conditions. To get around these issues, once a restoration location and project area has been identified, the statistical program R, the package MBHdesign[17] and habitat and bathymetry layers can be used to generate a randomised, spatially-balanced transect design (Figure 11). Alternately, expert and local knowledge can be used to select relevant spatial separation for transects and locate them within each habitat to minimise spatial dependence.

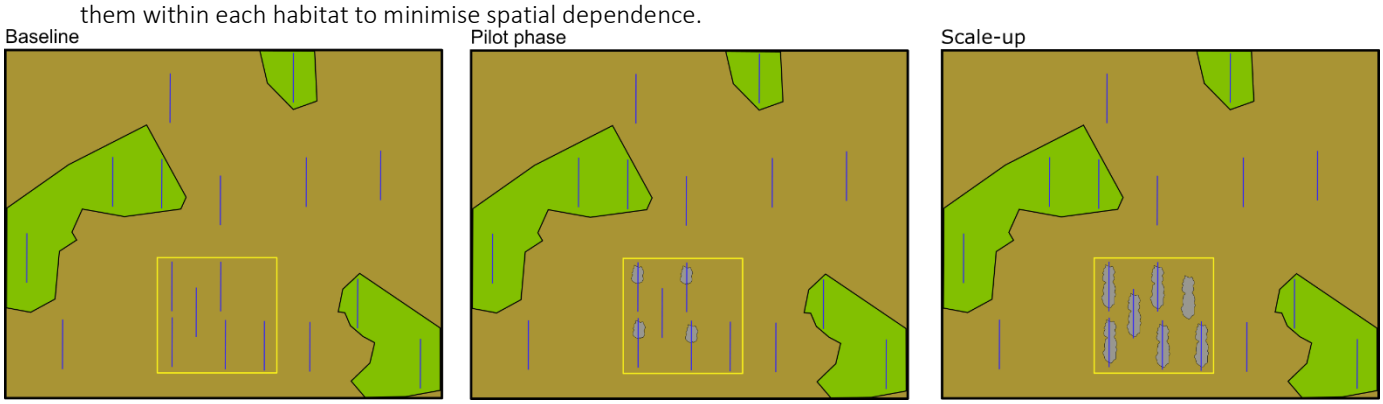

Figure 15. A schematic of a randomised, spatially-balanced monitoring design for Reef Builder. At a given location, a project area is defined encompassing three habitat types: (1) the reef restoration area – yellow polygon and grey reef structures; (2) soft-sediment – brown; and (3) seagrass – green (or other designated habitat). Within each habitat, each monitoring methodology is undertaken and replicated equally. Vertical lines = underwater visual census (6 per habitat).

Intertidal methods

Target shellfish

Method

Sampling will occur at spring low tide using 50 x 50 cm quadrats to undertake a count and size assessment of shellfish on three 10 m transects within each habitat type. **Quadrat placement should be randomised using two independent random number sets produced by using a random number generator. The first random number set identifies a distance along the 10 m base transect where a perpendicular transect is then laid. The length of the perpendicular transect should be the mean width of reef patches being surveyed. The second random number set identifies a distance on the perpendicular transect, such that quadrats are randomly sampled across the entire reef patch area.** Ten (10) replicate 50 x 50 cm quadrats will be placed per transect and a photograph per quadrat obtained. **Additionally, shellfish (oysters and mussels) size should be measured** using callipers. Measure the distance from the hinge axis to the distal margin of the shell (shellfish height- see Figure 12) of ten (10) target shellfish (10 each for oysters and mussels) across the size range of shellfish observed. Shellfish density **(oysters and mussels) per quadrat will be measured by counting all live target shellfish on substrate up to 10 cm deep into the reef. If shellfish are dense within a 50 x 50 cm quadrat subsample using a 25 x 25 cm quadrat placed in the bottom left corner of the larger quadrat.**

[17] Foster, SD. MBHdesign: An R-package for efficient spatial survey designs. *Methods Ecol Evol*. 2021; 12: 415– 420. https://doi.org/10.1111/2041-210X.13535

a) Restoration reefs – base transects should be aligned along the longest axis of reef patches; multiple reef patches can be combined to achieve a transect distance of 10 m.
b) Soft-sediments or other reference ecosystem – base transects should be aligned parallel to shore along a depth contour and placed in equivalent tidal heights to restored reef arrays.
c) Mangroves – base transects should be aligned parallel to shore along a depth contour.

Density of live target shellfish is calculated in two parts for intertidal shellfish surveys:

1. **Percentage cover** – Percentage cover will be calculated from the quadrat photographs by scoring benthic composition under 20 random points using Squidle+.
2. Oyster density – The density of oysters per quadrat (m^2), will be calculated by multiplying the average density of shellfish from the smaller quadrats (25 x 25 cm) by the percentage cover of the larger quadrat.

Deliverables

d) Datasheets for archive
e) Data uploaded to data portal

Equation 2: $shellfish.m^2 = (shellfish\ per\ sampling\ unit) * multiplyer$
Equation 4: $Shellfish_i = mean\ shellfish\ per\ m^2 * area\ of\ reef\ (m^2)$

Indicators

i 6. Total number of live target shellfish – the number of live shellfish, including recruits, per m^2. The mean density (Equation 2) of live shellfish provides a measure when compared to the benchmark for the target species.

Fish community

At each intertidal reef site, the fish community will be sampled from the reef, adjacent bare sediment and mangroves areas (or remnant oyster reefs if present). Sampling will occur at slack high AM tides

Stereo-BRUVS

Three SeaGIS stereo Mini-BRUV frames with a stainless steel 0.5 m arm with bait bag will be independently deployed in each habitat. Within each habitat, cameras will be separated by at least 20 m. Additionally, on oyster reefs will be deployed on separate reef patches. Cameras will be left recording for 30 minutes. Bait will consist of three slightly crushed pilchards (*Sardinops sagax*).

Video processing:

Videos will be processed through EventMeasure software. Fish will be identified to the lowest taxonomic level possible and the MaxN per species will be obtained as the maximum number of individuals of the same species present in a frame at a time across each video (Cappo 2004). For each stereo-BRUV deployment, the length of each will be measured. Fish lengths will be recorded alongside MaxN as total length (tip of fish nose to tip of the longest caudal lobe). Total length will be used as this equates to the minimum legal length (MLL) .

Deliverables

a) EventMeasure files for each video
b) Confirmation and details of calibration of stereo-BRUV systems
c) Datasheets for archive
d) Data uploaded to data portal

Indicators

i 7. Total abundance of fish (g/m2, kg/ha) – Total biomass of the fish assemblage over the area of survey.

Macroinvertebrate community

At each reef site, macroinvertebrates will be sampled from the reef, adjacent bare sediment and mangroves areas (or remnant oyster reefs if present). Sampling will occur at low tide.

Method 1: Cores. Six samples in each habitat (2 per transect) will be obtained using hand corers (internal diameter 10 cm) to a depth of 10 cm. Cores will be randomised using a random number set and taken from the centre of two corresponding quadrats per transect. Content from the core will be placed in a plastic bag and kept on ice in the field and stored frozen until further analysis.

Laboratory analysis:

All fauna retained on a 500µm sieve will be identified to the lowest taxonomic level possible and enumerated. Larger invertebrates (5.6 mm) will be identified to species level and counted. Invertebrates from sieves will be stored in 90% ethanol and will be processed in no more than a month following survey. Problem species, e.g. mudworm *Polydora* spp. and cornflake worms Platyhelminthes, were also recorded. The percentage of SRO and non-native oyster was also confirmed by opening and identifying 10 randomly chosen oysters from each core.

Deliverables

a) Datasheets for archive
b) Data uploaded to data portal

Indicators

i 8. Species richness of macroinvertebrates – Count of species found on the reef; a key measure of biodiversity. Combination

3.3 Economic and Social Targets

Metrics on the social and economic impact of reef restoration construction (e.g. community engagement, job delivery) will be collected by Project Managers through Project records and tracking workflows).

A. Economic methods

Economic considerations are central to assessing shellfish restoration feasibility and long-term sustainability of restoration programs.

Through progress reporting, the Project Manager will capture the total number of people and hours that worked directly and indirectly (in-kind) on the Project. Labour and FTE can be coded by ANZCO (Australian and New Zealand Standard Classification of Occupations, 2013) and ANZSIC (Australian and New Zealand Standard Industrial Classification, 2006) categories to ensure reporting in the language of the Australian Federal Government.

Skill level

The labour and FTE will also be further categorised based on the ANZSCO skill level defined below. The five skill levels in ANZSCO are defined in terms of formal education and training, previous experience and on-the-job training. The determination between skill levels is based on the following definitions.

SKILL LEVEL 1

Occupations at Skill Level 1 have a level of skill commensurate with a Bachelor degree or higher qualification. At least five years of relevant experience may substitute for the formal qualification. In some instances, relevant experience and/or on-the-job-training may be required in addition to the formal qualification.

SKILL LEVEL 2

Occupations at Skill Level 2 have a level of skill commensurate with one of the following:
NZ Register Diploma, or
AQF Associate Degree, Advanced Diploma or Diploma.

At least three years of relevant experience may substitute for the formal qualifications listed above. In some instances, relevant experience and/or on-the-job-training may be required in addition to the formal qualification.

SKILL LEVEL 3
Occupations at Skill Level 3 have a level of skill commensurate with one of the following:
NZ Register Level 4 qualification
AQF Certificate IV or
AQF Certificate III including at least two years of on-the job training.
At least three years of relevant experience may substitute for the formal qualifications listed above. In some instances, relevant experience and/or on-the-job-training may be required in addition to the formal qualification.

SKILL LEVEL 4
Occupations at Skill Level 4 have a level of skill commensurate with one of the following:
NZ Register Level 2 or 3 qualification or
AQF Certificate II or III.
At least one year of relevant experience may substitute for the formal qualifications listed above. In some instances, relevant experience may be required in addition to the formal qualification.

SKILL LEVEL 5
Occupations at Skill Level 5 have a level of skill commensurate with one of the following:
NZ Register Level 1 qualification
AQF Certificate I or compulsory secondary education. For some occupations a short period of on-the-job training may be required in addition to or instead of the formal qualification.
The following table indicates the relationship between major role groups and skill levels. It shows the predominant skill levels which are associated with the occupations in each major group.

Skill levels are classified into a set of groups (Table 3.2).

Table 3.2: Major role and predominant skill level.

Major Group		Predominant Skill Levels
1	Managers	1, 2
2	Professionals	1
3	Technicians and Trades Workers	2, 3
4	Community and Personal Service Workers	2, 3, 4, 5
5	Clerical and Administrative Workers	2, 3, 4, 5
6	Sales Workers	2, 3, 4, 5
7	Machinery Operators and Drivers	4
8	Labourers	4, 5

For Reef Builder monitoring purposes, skill level has been further simplified into 'skilled' and 'unskilled':
Skilled – skill level 1, 2 & 3 / Unskilled – skill level 4 & 5.

Industry types

Organisations providing the delivery of Reef Builder can also be categorised into industries based on the Australian and New Zealand Standard Industrial Classification, 2006 (Table 3.3):

Table 3.3: Industry categories used for monitoring

A	AGRICULTURE, FORESTRY AND FISHING
B	MINING

C	MANUFACTURING
D	ELECTRICITY, GAS, WATER AND WASTE SERVICES
E	CONSTRUCTION
F	WHOLESALE TRADE
G	RETAIL TRADE
H	ACCOMMODATION AND FOOD SERVICES
I	TRANSPORT, POSTAL AND WAREHOUSING
J	INFORMATION MEDIA AND TELECOMMUNICATIONS
K	FINANCIAL AND INSURANCE SERVICES
L	RENTAL, HIRING AND REAL ESTATE SERVICES
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES
N	ADMINISTRATIVE AND SUPPORT SERVICES
O	PUBLIC ADMINISTRATION AND SAFETY
P	EDUCATION AND TRAINING
Q	HEALTH CARE AND SOCIAL ASSISTANCE
R	ARTS AND RECREATION SERVICES
S	OTHER SERVICES

Enterprise/organisation size

Additionally, each organisation contributing to Reef Builder will also be categorised as a micro, small, medium or large enterprise using both the Australian Tax Office (ATO) and Australian Bureau of Statistics (ABS) definitions, with ATO based on turnover and ABS on how many employees an enterprise employs.

ATO

- Large Business: turnover > $250 million
- Medium business: turnover >$10 million ≤ 250 million
- Small business: turnover >$2 million ≤ 10 million
- Micro-business: ≤ $2 million

ABS

- a micro-business employs between 0-4 persons
- a small business, between 5-19 persons
- a medium business, between 20 and 199 persons; and
- a large business employing 200 or more persons

Method

Jobs per Project should be tracked on a regular basis (monthly) by collating all information from contractors and staff involved in the Project.

Contractors can use the jobs tracking log. This log tracks jobs alongside delivery of Project activities. The log can then be supplied back to TNC Project Managers upon completion and reporting on the activity outcomes.

Data entry

Project managers should use the data entry template provided by TNC to collate all jobs data. Descriptions of data captured in the template are given below.

- Project – Entered from a drop-down list of all Project IDs, new projects can be added in the 'Project code' tab.
- Projectcode – Prefilled when 'Project' is entered
- State – The state the project occurs in, prefilled when 'Project' is entered
- Activity – The project activity that the employment falls under. Select from drop-down list.

Project activity descriptions are given in Table 3.4.

Table 3.4: Restoration project activities

Reef Building Bathymetric, hydrological assessments, oyster bed engineering and certifications, rock and shell material procurement, substrate transportation and storage, barge mobilisation and oyster substrate deployment, loading, staging, load site security, commercial diving and vessel hire, independent construction and engineering assessments
Hatchery and seeding Procurement of oysters, hatchery/farmer engagement, shell transport, commercial diving and deployment, vessel hire, recycled shells collection, permitting, record keeping and reporting.
Reef integrity and performance assessment Pre-substrate deployment site assessments (bottom ecology, surface profiles, oyster densities, vulnerable habitats mapping (e.g. seagrass), river uses analysis (e.g. boating, fishing), post habitat deployment surveys, data analysis, WHS and safety plans, operational equipment, vessel hire, final engineering assessment, periodic + special + final reports.
Community engagement, volunteering and media Community engagement products, engagement coordination, sub-contractor identification, contracting and management, volunteer briefings, volunteer recruitment, community seminars, bilateral stakeholder meetings, personal protective equipment, shell cleaning and supply equipment, volunteer insurance, catering, media statements, media management, social media, vessel hire (for media events), brochures, banners and education material production and distribution.
Project Management Production of Project Management Plan, Monitoring Evaluation and Reporting Plan, Communications Plan, project risk assessments, plan and risk refinements and revisions, internal operational plans and plan reviews, government permitting, legal, technical science support, essential business services

- **Date_start** – The date the reporting period for the employment activity started. Value needs to be entered.
- **Date_end** – The date the reporting period for the employment activity ended. Value needs to be entered.

- **Organisation** – The organisation the employee works for, input is via a drop-down box. If the organisation is not in the list, it can be added via the 'Organisation' tab. This is a dynamic list and will automatically populate the drop-down list when an organisation is added. When a new organisation is added, the enterprise size will need to be determined based on ATO and ABS classification (see Enterprise/organisation size section above). Select from drop-down list.
- **Enterprise_size** – Automatically filled when 'Organisation' cell is filled.

Industry – The industry the employee activity is from.

The list is from the Australian and New Zealand Standard Industrial Classification, 2006. Select from drop-down list.

- **Ind_division** – The broader industry division, automatically fills based on input from 'Industry'.
- **Direct_inkind** – Is the activity paid directly from Reef Builder funds or indirectly (in-kind). Drop-down list with two options: 'Direct', 'Inkind'. Select from drop-down box.
- **Occupation** – The occupation of the employee/s. Select from a drop-down box of recognised occupations from ANSCO Australian and New Zealand Standard Classification of Occupations, 2013.
- **Skill_level** – The skill level as determined by the occupation from ANSCO, automatically filled based on input for 'Occupation'.
- **Skill** – As determined by the 'Occupation'.
- **Div_ANSCO** – Broad occupation division from ANSCO, automatically filled based on input for 'Occupation'.

- **Workers** – The number of workers of the same industry and occupation delivering the activity. Value needs to be entered.
- **Loc_wrk** – Whether the worker/s are employed local, intrastate, interstate or international. Select from drop-down box.

Definitions of local workers are given in Table 3.5.

Table 3.5: Definitions of locality of worker categories

Locality of worker	Definition
Local	Travels daily to work site
Intrastate	Same state as work site but not local, i.e. cannot travel daily to work site
Interstate	Different Australian state to work site
International	Different country to worksite

- **Work_type** – Whether the work is full-time, part-time or casual. Select from drop-down box.
- **Hours** – Hours worked. Value needs to be entered.
- **FTE** – Calculates full-time equivalent based on yearly billable hours of 1650.

Indicators

i 9. Number of local contractors engaged - Summarise number of local contractors/businesses used

i 10. Total no. of full-time jobs across the Project (local + national + International) - Summarise FTE across project activities

Tracking financial costs

The aim of cost tracking for Reef Builder is to enable better business decisions to be made in terms of allocating resources to restoration. Better systematic accounting for costs will also enable cost-benefit analyses to be done more frequently optimising decisions when allocating limited resources[18] Costs can either be **economic** or **financial**.

Economic costs relate to the overall cost to society by using a resource (e.g. material or labour). They are measured in terms of 'opportunity costs' of a resource. This cost is the value of that resource in its next best alternative use, i.e. labour used to build reefs could also be used to build bridges.

Financial costs relate to monetary transactions made. These costs are important to both private and public sector schemes. In the private sector, financial viability and profitability are important to the success of a project and motivates investors. For the public sector, assessments of financial costs is important when judging the level of resources and funding required to deliver a project[14]

The main cost categories are typically broken down into **capital** and **operational** costs.

Capital costs/expenses (CAPEX) are costs to implement a restoration initiative.

Operational costs/expenses (OPEX) are shorter-term costs to keep a restoration initiative going (internal costs).
Capital and operational cost categories are listed in Table 3.6. Each cost category can be further subdivided as administration (stationary, internet etc), equipment (boats, excavators, barges etc), materials (rock, paper, shellfish), labour (wages) or expenses (food and accommodation).

[18] Spurgeon, J. (1999). The socio-economic costs and benefits of coastal habitat rehabilitation and creation. *Marine Pollution Bulletin*, *37*(8-12), 373-382.

Table 3.6: Examples of OPEX and CAPEX

Capex_list	Opex_list	Cost/Expense sub-category
Feasibility	Management (to control and enhance the development of the site)	Administration (stationary, internet)
Construction	Evaluation and analysis	Equipment
Site surveys		Materials
Objective setting	Compliance (e.g. legal fees, permits i.e. MACA consent, development approval etc)	Labour
Design	Marketing and communications	Expenses (food, accommodation)
	Government relations	
Permitting	Finance/accounting	
Site preparation	Community/stakeholder engagement	
Stock (brood stock, seed stock)	Tendering	
Transport (e.g. of materials and stock)	Reporting	
Monitoring		
Maintenance (to maintain the site e.g. reseeding, fixing damage)		

Method

The Nature Conservancy already has a financial tracking system, so to avoid double handling, cost data will be collected from the actual expenses reporting for Project budgets, then de-identified and submitted in bulk to the data portal. Costs will be summarised by Project code across Project activity categories (Table 3.4) for expense types (Table 3.7).

Table 27. Expense type

Expense type
Personnel
Fringe
Other Expenses
Contractual
Travel
Communications
Supplies & Equipment

Indicators

i 11. Costs of restoration projects - Summarise costs across projects per activity and expense type.

B. Social Methods

Measuring the social aspects of restoration is a crucial component of restoration in meeting the promise of 'triple bottom line' impact (social, environmental and financial). The social component to Reef Builder is to build stewardship of shellfish reefs and the environment. Stewardship can be broken down into demonstrating that there are

opportunities for local communities to be involved in restoration activities through volunteering and to protect and care for shellfish reefs and the environment.

A key aspect of stewardship is not only for local communities to have opportunities, but also to know that individuals and groups are motivated to engage and take part in these opportunities. Therefore, data on the number of community programs, number of volunteers, attendance at events and metrics on media engagement will be collected by Project managers through Project tracking.

Volunteering is defined here as 'time willingly given for the common good and without financial gain.' This definition was developed by Volunteering Australia in 2015 and adopted by all states and territories.

Method

Project managers monitor on an ongoing basis, using the templates listed below.

Volunteering and events

The volunteers data entry template should be used to collate volunteer data across Projects. An additional resource to track volunteering and attendance at events and meetings is the volunteer and event log that can be printed off and used directly to collect data for specific events. A description of data captured in the Project volunteer and events template is below (Figure 3.9).

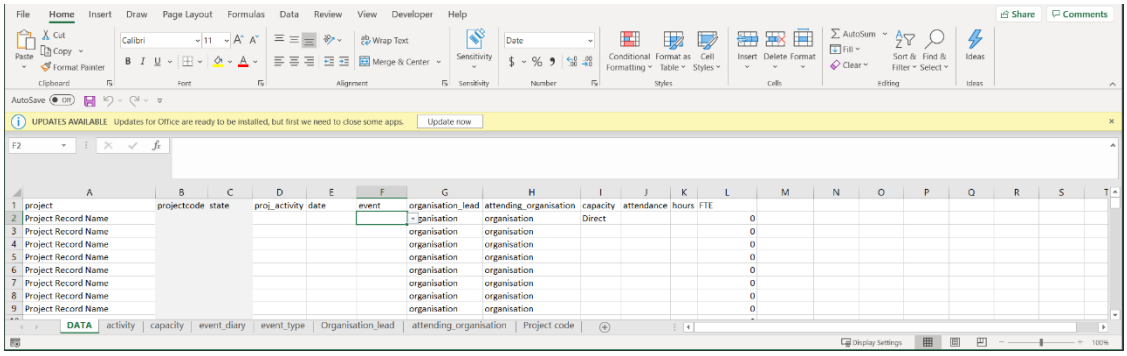

Figure 3.9. Volunteer and event data entry template.

- **Project** – Entered from a drop-down list of all project IDs. New projects can be added in the 'Project code' tab.

- **Projectcode** – Prefilled when 'Project' is entered.

- **State** – The state the Project occurs in, prefilled when 'Project' is entered

- **Proj_activity** – The Project activity that the employment falls under as per Table 6. Select from drop-down list.

- **Date** – The date the Project event occurred. Value needs to be entered.

- **Event** – The type of event (input is via a drop-down box). If the event type is not in the list, it can be added via the 'Event_type' tab. This is a dynamic list and will automatically populate the drop-down list when an event type is added.

- **Organisation_lead** – The organisation leading the Project (input is via a drop-down box). If the organisation is not in the list, it can be added via the 'Organisation_lead' tab. This is a dynamic list and will automatically populate the drop-down list when an organisation is added.

- Attending_organisation – The organisation the volunteer/s or attendee/s are affiliated with. If none, the input is 'no organisation'. Input is via a drop-down box - if the organisation is not in the list, it can be added by adding to the list in the 'Attending_organisation' tab. This is a dynamic list and will automatically populate the drop-down list when an organisation is added.

- Capacity – In what capacity is the attendee/s taking part in the event? Drop-down list with three-options: 'Direct', 'Volunteer', 'In-kind'. Select from drop-down box.

- Attendance – The count of attendees. Value needs to be entered.

- Hours – How long was the event/volunteering activity? Value needs to be entered.

- FTE – Calculates full-time equivalent employment based on yearly billable hours of 1650.

Media

Media mentions are tracked by The Nature Conservancy's MarComms team. To avoid double handling, MarComms will produce a report for Reef Builder with media mentions broken down by Project for pre-determined reporting periods.

Indicators

i12. Total number of community events – Total number of restoration project events, these can be categorised as: public information, restoration activities (e.g. shell cleaning, shellfish deployment, construction), citizen science, fundraising, stewardship (e.g. friends of, land/coast-care) or technical advisory groups. This is a measure of the opportunities provided/developed by a project or program

i13. Attendees at public consultation meetings – The total number of people attending project/program events. This is a measure of active engagement by the local community into different aspects of the restoration project

i14. Community and partner organisations engaged - Demonstrates that the restoration project has built local capacity and engaged community and partner groups

i15. Media engagement – This is a measure of how actively the wider community engages with a restoration project/program. Tracks how often the restoration project is mentioned in traditional and social media.

i16. Total no. of volunteers – Total number of community volunteers contributing to citizen science, restoration or other project activities

i17. Volunteer hours donated – Tracks the number of hours committed by volunteers to citizen science, restoration or other project activities. Volunteer hours can be used to understand the value of volunteer 'labour' i.e. if the project paid appropriately skilled workers to undertake equivalent work.

Volunteer contributions are calculated by the median wage and an additional 15% for superannuation, payroll and administration costs converted to an hourly rate. The value of volunteer labour can then be used to establish the total value of volunteers leveraged by the project or the in-kind benefit.

Annex 4: Additional monitoring parameters in line with the Noosa Alliance and Funding Agreement obligations

A. Monitoring Water Quality

Salinity, temperature, pH and dissolved oxygen within tolerance range of target shellfish

Standard methods apply

Indicator

i 18. Physical conditions within tolerance ranges for target shellfish

B. Turbidity

Estuaries with high levels of total suspended solids (TSS), or highly turbidity reduces light penetration into the water column. A lower light regime affects the growth and often vitality of aquatic flora and fauna. When the sediments settle, they smother benthic organisms, causing changes in habitat structures and can contribute to the persistence of bacteria and viruses harmful to oysters and other marine species.

As ecosystem engineers, oysters filter substantial quantities of estuarine water. The rate of filtration however, varies with size, density, level of overall turbidity, temperature and responses other ecological cues and stress. Measuring the turbidity of water around the shellfish beds relative to other areas in the estuary, gives an indication as to the filtration impact of the oysters at a site or across multiple sites in the estuary.

Method: Secchi disc

The most basic of methods is to employ a Secchi disc. This is a plain, white circular disc, some 30 centimetres in diameter, which is mounted on a pole, or line, and is lowered into the water. When the disc is no longer visible record the depth, as indicated on the pole or line, then raise the disc until it is visible. Measure the depth again. The average of the two depths gives a reading, which can be compared with reference or baseline information.

Method: Turbidity meter

Where available, employing the use of a turbidity meters or probes is an efficient alternative way of measuring water turbidity to using a Secchi disc. Water turbidity is determined by measuring the fractural scatter of light in the water column and measurements compared to reference or baseline information.

Indicator

i 19. Turbidity/susp solids around restoration site reduced

C. Social and economic data

Indicators

i 20. Improved knowledge and education for individuals and end users - Number of students (secondary, tertiary and postgraduate) engaged in project activities directly or through a project partner.

i 21. Improved educational resources for individuals - Number of resources available to individuals (videos, practitioner reports, academic articles, workshops, conference presentations, podcasts, infographics etc.) to support community understanding and acceptance of the project.

i 22. Individuals and end users improve practical skills in marine restoration - Number of interns or work placements with the project team or its partner projects (supported financially by the project).

i 23. Total financial investment leveraged (including In-kind) - Summarise leverage investment/co-investment including in-kind contributions from contractors and partners.

i 24. Project outputs delivered within budget - Cumulative expenditure report, Annual progress report against project cost categories (Table 4.1).

Table 4.1: Cost categories and expenditure report format

PROJECT COSTS	Total Budget $	FY20 Expenditure $	FY21 Expenditure $	Total Expenditure $	Remaining Budget $
Reef Building Bathymetric, hydrological assessments, oyster bed engineering, rock and shell material procurement, construction and engineering assessments.					
Hatchery and seeding Procurement of oysters, hatchery/farmer engagement, shell transport, recycled shells collection, permitting, record keeping and reporting.					
Reef integrity and performance assessment Pre-substrate deployment site assessments (bottom ecology, surface profiles, oyster densities, vulnerable habitats mapping (e.g. seagrass), river uses analysis (e.g. boating, fishing), data analysis, WHS and safety plans, operational equipment, periodic reports.					
Community engagement, volunteering and media Community engagement products, engagement coordination, sub-contractor identification, contracting and management, volunteer briefings, volunteer recruitment, stakeholder meetings, personal protective equipment, media statements, media management and education material production and distribution.					
Project Management Production of Project Management Plan, Monitoring Evaluation and Reporting Plan, Communications Plan, project risk assessments, plan and risk refinements and revisions, government permitting, legal, technical science support					
Total expenditure					

D. Technical Advisory Group

The Project Manager is supported by the Noosa Technical Advisory Group (TAG), formed for the Project. The TAG's purpose is to:

- Support detailed project planning for the *Noosa Oyster Reef Restoration Project* that will see reefs re-established in the Noosa River estuary by June 2022.
- Provide ongoing expert advice on the implementation of the Project Plan, and support in overcoming legislative, scientific and practical barriers that occur during the term of the project.
- Ensure that the Project meets all technical, statutory and policy requirements in a timely manner to the satisfaction of relevant decision-making authorities.
- Ensure actions within the Project Plan are effectively delivered and communicated to all stakeholders.

The composition of the Noosa TAG is:

- The Nature Conservancy – Oceans Operations Manager + Oceans Restoration Scientist
- Noosa Shire Council – Environmental Services Manager
- Department of Environment & Science - Water quality and aquatic ecosystems expertise
- Department of Agriculture & Fisheries - Fisheries, permits and biosecurity expertise
- Maritime Safety Queensland - Regional Manager and Noosa local officer (on occasion)
- Kabi Kabi Traditional Owner – For technical expertise
- Independent aquatic ecologist/biologist – With in depth ecological knowledge of the Noosa River estuary

Indicator

i 25. TAG meetings coordinated quarterly and attended by key personnel - Summarize TAG meeting details, # attendees and/or out of session contributions, particularly endorsements of annual reports.

E. Compliance with permit conditions

Permits are issued from government agencies with conditions. Those conditions are requirements of receiving permission to restore shellfish reefs. Conditions of each type of permit received is track and compliance with those conditions tracked (Table 4.2).

Table 4.2: Presentation format for reporting against permits

Permit Type	Permit condition	Status – Met / Not Met	Comments/Feedback
Resource Allocation Authority	Condition 1		
	Condition 2		
Development Consent	Condition 1		
	Condition 2		
General Fisheries Permit/s	Condition 2		
	Condition 2		

Indicator

i 26. Permit conditions met - 90 percent of permit conditions met

F. Deliverables against Alliance and Funding Agreement

Progress against the project deliverables as outlined in the Alliance and Funding Agreement between TNC and Noosa Council are tracked and reported on 6 monthly (Table 4.3).

Table 4.3: Example summary project milestone report format

#	Deliverable	Progress
1.1	1 Technical Advisory Group with TOR established	
1.2	1 Project Manager appointed	
1.3	1 Project Implementation Plan completed and endorsed by Noosa Council 1 Detailed Risk Assessment included 1 Communications and Media Plan completed 1 Monitoring, Evaluation and Reporting Plan completed	
1.4	3 community engagement forums facilitated 3 media statements released	
1.5	3 six monthly status updates submitted to Noosa Council 3 annual reports submitted to Noosa Council	
2.1	1 Habitat suitability model developed which incorporates industry, Kabi Kabi and public interests	
2.2	1 set of 'all' relevant state and local permits for oyster reef restoration obtained	
2.3	1 set of engagement records provided to Noosa Council of public and stakeholder consultations, including one-on-one meetings, open forums, media, etc.	
3.1	1 consultation completed 1 volunteering opportunities identified	
3.2	1 volunteering program defined 1 volunteering program implemented	
4.1	1 approval from Noosa Council secured to restore 2 trial restoration sites 2+ sites recovered with at least overall 80 m shore length of reef constructed	
4.2	1 approval from Noosa Council secured to restore an additional 2+ sites 2+ additional sites recovered with at least an overall additional 600m^2 surface area	
4.3	1 related reef monitoring program established	
	2 six monthly status reports submitted 2 annual monitoring and evaluation report cards produced and published	
5.1	1 workshop facilitated	
5.2	5 peer review reports submitted to Noosa Council during the three-year term of this Agreement, if requested by Noosa Council.	
5.3	3 study tours facilitated during the three-year term of this Agreement, if requested by Noosa Council.	
5.4	1 Conservation Action Plan developed, as required 1 set of Community Workshops facilitated, as required.	
5.5	1 new formal networking connections facilitated to assist Noosa Council with ongoing and future marine conservation activities, as requested	
5.6	1+ presentations given at national conference/s over 3 years 1+ presentations given at international conference/s over 3 years	
5.7	1+ New corporate/ government/ philanthropic alliances formed 1+ New in-kind support/financial funding contributions secured	
5.8	1 Habitat mapping report, habitat suitability model, PhD study or similar output completed and presented to Noosa Council	

Achieved, On Track, Delayed, On Hold

Indicator

i 27. No of project milestones delivered within specified timeframe - % delivered on time

F. Coastal Erosion Monitoring

The project is required to monitor the impact of the restoration works on coastal erosion 100m upstream and downstream of the oyster reef patches.

Visual inspection – 6 monthly

Visual inspection is carried out 100m upstream and downstream of a restoration footprint and the the % change in shoreline profile estimated. If the change is deemed significant, it is reported and a detailed investigation launched.

Monitoring by photo records annually and recording of percentage change in shoreline 100m upstream and downstream of a restoration footprint is undertaken.

Indicator

i 28. Coastal erosion within 100m up or downstream of a restoration site is not attributable to the restoration works