Rebuilding Australia's Lost Shellfish Reefs

2024 *Reef Builder* Final Summary Report

Australian Government

The Nature Conservancy Australia

The Nature Conservancy acknowledges Aboriginal and Torres Strait Islander peoples as Traditional Custodians of this nation.

We pay our respects to ancestors and Elders, past and present.

We are committed to honouring the continued deep spiritual, cultural, social, environmental and economic connection of First Nations peoples to Country and their rich contribution to society.

***Reef Builder* was led by The Nature Conservancy, with generous grant funding from the Australian Government and co-contributions from public and private partners.**

***Reef Builder* Program Principle Investigators:**
Simon Reeves (Restoration Science and Monitoring & Evaluation)
Simon Branigan (Restoration Practice)

Suggested citation: The Nature Conservancy Australia (2024) *Reef Builder* Final Summary Report. A report prepared for the Department of Climate Change, Energy, the Environment and Water by Branigan, S., Bohm, C., Bossie, A., Breschkin, S., Connell, M., Dahle, K., Dal Pozzo, B., Nedosyko, A., V., Valesini, F. The Nature Conservancy Australia, Melbourne, 40p.

Front cover photo: TNC's Simon Branigan diving underwater at Margaret's Reef, Port Phillip Bay (VIC) showing Australian Flat Oysters. Credit: Jarrod Boord/Streamline Media

Photo: Australian Flat Oysters, Georges Bay (TAS). Credit: Jarrod Boord/Streamline Media.

Contents

Glossary 4

Executive Summary 6

At a Glance 8

Background 9 - 10

Building the Reefs 11 - 20

Case Study: Sapphire Coast (NSW) 21

Case Study: Kangaroo Island (SA) 22

Case Study: Swan-Canning Estuary (WA) 23

Building the Ecosystem 24 - 25

Case Study: Port Phillip Bay (VIC) 26

Case Study: Glenelg (SA) 27

Case Study: Noosa (QLD) 28

Case Study: Boosting Fish Populations 29

Building Community 30 - 31

Case Study: Noosa (QLD) 32

Case Study: Gippsland Lakes (VIC) 33

Case Study: Noosa (QLD) 34

Lessons Learnt 36 - 37

Our Next Phase of Restoration: 2024-2030 38 - 39

Glossary

Reef patches

A shellfish habitat (i.e., an oyster reef or mussel bed) is defined as patches of living and non-living oyster/mussel shell (or reef substrate with and without live oysters/mussels). **Reef patches** are the spatial area of restored shellfish reefs/beds.

Restoration footprint

Restoration footprint is the total area of **Reef patches** and is calculated as the sum of area of all **Reef patches** at a **Restoration location**.

Restoration locations

Restoration locations are an aggregation of all sites where monitoring has been carried out. The term is inclusive of **Restoration area**.

Restored reefs

Restored reefs are counted towards the '60 Shellfish Reefs Target' for TNC by meeting the following criteria: i) **Reef patches** exceeding 250 m^2 (individual or mosaic) with at least one **Reef patch** exceeding 5 m^2 and a maximum distance between **Reef patches** of 30 m in mosaics, ii) **Restoration area** exceeding 0.5 ha, and iii) distance to nearest neighbouring **Restored reef** is equal to or greater than 2 km unless ecologically distinct (e.g. intertidal vs. subtidal reefs).

Restoration area

Restoration area or restored ocean area is the area where ecological benefits (e.g., increase in fish biomass, improvement of water quality) are experienced from reef restoration. **Restoration areas** are obtained by calculating the minimum convex hull around all **Reef patches** (including a 5 m buffer around the patches) in a **Restoration location**, capturing the interstitial space between **Reef patches**.

Monitoring sites

Monitoring sites are the lowest spatial level where monitoring is carried out at fixed sites repeatedly over time. Monitoring data is collected at a point in space through time at a **Monitoring site**.

Monitoring sites also include data collected at positive and negative control sites or reference sites such as seagrass sites, soft-sediment sites, and shellfish reef reference sites. The type of **Monitoring site** is determined by the type of habitat e.g., 'shellfish reef' **Monitoring sites**, 'seagrass' **Monitoring sites**, or 'soft-sediment' **Monitoring sites**.

Restoration project

Restoration projects are an aggregation of **Restoration locations** for the purpose of geographic representation. **Restoration projects** can be one-to-one i.e., the **Restoration project** has only one **Restoration location** (e.g., 'Glenelg') or one-to-many where one **Restoration project** has multiple **Restoration locations** (e.g., 'Port Phillip Bay' or 'Swan-Canning Estuary').

Photo: Globefish amongst mussels and restored shellfish reef in Dromana, Port Phillip Bay (VIC). Credit: Jarrod Boord/Streamline Media.

Executive Summary

***Reef Builder* was a partnership between The Nature Conservancy (TNC) and the Australian Government and has supported Australia's largest marine restoration initiative to date. This $20 million Program sought not only to restore near-extinct shellfish reefs at 13 project geographies across southern Australia, but also to provide much needed economic stimulus to regional and metropolitan economies impacted by the COVID-19 pandemic, and those devastated by the 2019 bushfires.**

Shellfish reefs, created when millions of oysters and mussels settle onto each other, are natural solutions to some of our greatest conservation challenges. They **improve coastal water quality**, **boost fish stocks**, **provide homes for a diverse range of sea life**, **generate regional employment**, and **protect Australia's coastal communities and shorelines from coastal erosion**. Once expansive across Australia's estuaries and bays, most of these natural habitats have been decimated since the 1800s by years of commercial harvesting, sedimentation, pollution, introduced species and disease. Fewer than 8% of our natural shellfish reefs remain across southern Australia's coastline today, rendering them functionally extinct.

Delivered between 2021 and 2023 in collaboration with government, natural resource management organisations, industry, First Nations groups, community groups, recreational fishers and universities, *Reef Builder* has **restored over 40 hectares of lost shellfish reefs across 13 projects** spanning Western Australia, South Australia, Victoria, Tasmania, New South Wales and Queensland. These reefs have been seeded with **30 million native oysters and mussels** to initiate the restoration process and their ecological development monitored post-construction. This restoration work generated **425 new employment opportunities** for local communities, which was 2.5 times greater than the anticipated employment target. These jobs were primarily within small-to-medium enterprises, a vital driver of our economy, and the majority of people employed worked locally.

Engaging community also underpinned the success of the Program, with **185 stakeholder and community events**, involving participation from over **5,200 community members**. This included over **300 volunteers**, who contributed 2,900 hours to the on-ground delivery of the *Reef Builder* outcomes, such as through TNC's *Shuck Don't Chuck* shell recycling initiatives, shellfish gardening, and water quality and fish monitoring.

Combined with the shellfish reef restoration initiatives delivered by TNC and partners since 2015, a total of **21 shellfish reefs covering a restoration area of 62 hectares have now been restored** across southern Australia. This is a considerable advancement towards TNC's broader goal of rebuilding 60 reefs across Australia by 2030 and recovering 30% of these lost habitats. *Reef Builder* has demonstrated that the restoration of shellfish reefs at a national scale is possible, and that the flow-on benefits to people and nature are significant (see **Figure 1**).

This *Reef Builder* Summary Report provides an overarching synthesis of the key ecological and socio-economic outcomes of the Program, and includes a selection of project case studies which help share the story of our three year delivery journey. It also includes key lessons learnt, as well as anticipated next steps towards 2030. Accompanying this broad overview is a more detailed ***Reef Builder* Monitoring and Evaluation Report**, which summarises key analyses of the Program data, and assesses level of success in achieving the Program targets and goals.

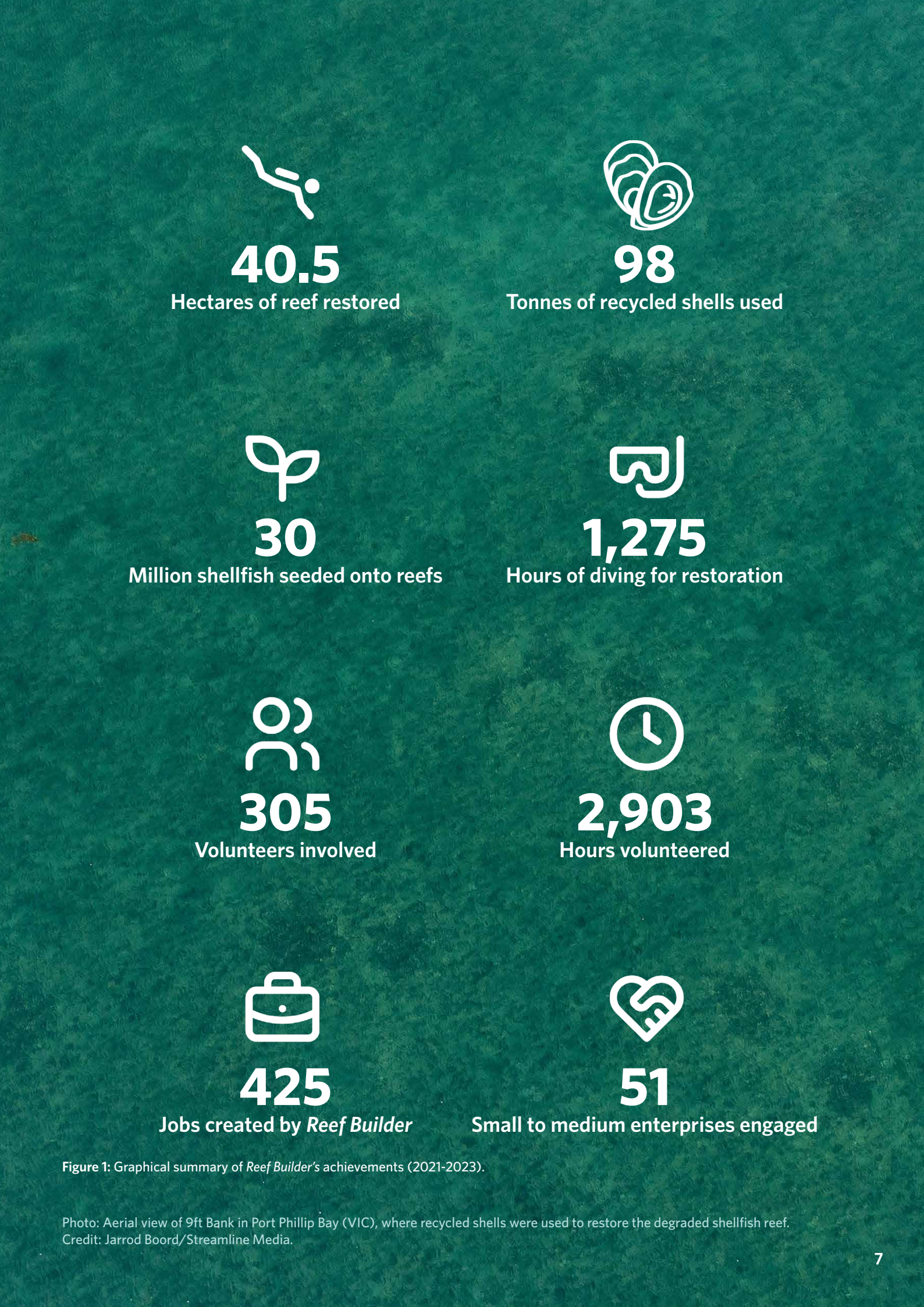


Figure 1: Graphical summary of *Reef Builder's* achievements (2021-2023).

Photo: Aerial view of 9ft Bank in Port Phillip Bay (VIC), where recycled shells were used to restore the degraded shellfish reef. Credit: Jarrod Boord/Streamline Media.

At a Glance

The *Reef Builder* Program was underpinned by four key targets and six goals each aimed at specific, measurable, realistic, and time-bound (SMART) outcomes. The key achievements of *Reef Builder* over the duration of the Program are summarised in **Table 1**.

Table 1: Summary of *Reef Builder* Program Targets and Key Outcomes.

PROGRAM OBJECTIVE (2021 - 2023)	STATUS
1. Build new reefs Construct shellfish reefs at 13 project locations, following established best practice project management, restoration and siting protocols. *Goal 1 - Demonstrate construction of resilient reef structures*	**Completed.** Shellfish reefs were rebuilt through 13 project locations, totalling an area of ocean deriving benefits from restoration of 40.5 ha. When combined with shellfish reefs rebuilt prior to *Reef Builder*, the total area restored is 61.9 ha.
2. Improve local biodiversity Establish oyster and mussel populations and enhance associated ecological communities compared to benchmark ecological targets at each of the 13 projects. *Goal 2 - Rebuild a local shellfish population* *Goal 3 - Demonstrate the creation of habitat that benefits fish* *Goal 4 - Demonstrate that construction of the reef enhances marine biodiversity*	**Completed.** 30 million native shellfish (oysters and mussels) were seeded onto the reef bases across the 13 projects. 1,275 hours SCUBA diving undertaken to construct, seed and monitor development of the reefs. Fish biomass (for pelagic species) was typically greater at restored reefs than in nearby non-restored (reference) habitats. Species richness (spanning fish and invertebrates) was typically higher following reef restoration, and at restored reef locations compared to nearby non-restored (reference) habitats.
3. Boost local employment Create up to 170 jobs through employing 120 local contractors from maritime construction, earthmoving, aquaculture, engineering and natural resource management businesses across resource procurement, reef construction and reef monitoring activities. *Goal 5 - Demonstrate the benefit of shellfish reefs to local economies*	**Completed.** 425 direct jobs created. 51 local contractors were engaged.
4. Strengthen community engagement Harness community interest, support and participation by communicating project progress and success through media opportunities, an online project dashboard, interactive graphics and a project video, as well as creating community volunteering opportunities. *Goal 6 - Engage the community in long-term stewardship of the shellfish reef*	**Completed.** 537 media events with a combined reach of 203 million viewers. 185 stakeholder and community events with 5,219 people attending. 2,903 hours of volunteering by 305 volunteers.

Background

Until the start of the 20th century, Australia was home to vast shellfish reefs, stretching across the southern half of the country, and as far north to at least the southern tip of the Great Barrier Reef and up to the mid-west coast of Western Australia. Shellfish reefs are largely dominated by three bivalve species in the geographic range The Nature Conservancy (TNC) currently works within, including Sydney Rock Oysters (*Saccostrea glomerata*), Australian Flat Oysters (*Ostrea angasi*) and Blue Mussels (*Mytilus galloprovincialis*) – see **Figure 2**.

These shellfish reefs filtered the water, buffered waves reducing coastal erosion and were vital nursery grounds for fish and other marine life. After years of wild commercial harvest, sedimentation, water pollution, introduced species and disease, our natural shellfish reefs have virtually disappeared – only 8% of Sydney Rock Oyster reefs and 1% of Australian Flat Oyster reefs remain in Australia today, with similar trends observed globally[1][2]. Further work is required to ascertain the extent of the loss of their Blue Mussel counterparts, but field surveys to date have shown a significant decline in mussel reefs across their range.

Figure 2: (Left to right) - Port Stephens Sydney Rock Oyster restored *Reef Builder* reef, remnant Blue Mussel reef at Nyerimilang Jetty adjacent to the Gippsland Lakes *Reef Builder* restoration project, restored Australian Flat Oyster reef at Wilson Spit, Port Phillip Bay, one of the *Reef Builder* restoration locations.

Oysters and mussels are ecosystem engineers, settling onto each other to form hard reef structures similar to coral reefs, either in the intertidal or subtidal areas of estuaries and embayments. The disappearance of these reefs from much of Australia's coastline has changed how our coastal ecosystems function, with a host of negative flow-on effects such as reduced water quality, fish abundance, natural shoreline protection, livelihoods and socio-cultural connection to our waterways.

To reverse this decline, TNC has been leading shellfish reef restoration efforts in Australia since 2015, in partnership with the public and private sectors (see **Figure 3**).

[1]Gillies, C.L., McLeod, I.M., Alleway, H.K., 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]Gillies, C.L., Castine, S.A., Alleway, H.K., Crawford, C., Fitzsimons, J.A., Hancock, B., Koch, P., McAfee, D., McLeod, I.M., zu Ermgassen, P.S.E. (2020). Conservation status of the oyster reef ecosystem of southern and eastern Australia, Global Ecology and Conservation, vol. 22 , pp. 1-16 , doi: https://doi.org/10.1016/j.gecco.2020.e00988.

Figure 3: Timeline of *Reef Builder* milestones.

This effort has built on TNC's 25 years of restoration experience in the United States and elsewhere and has been tailored to suit local conditions. Port Phillip Bay in Victoria was the first restoration project location established in Australia, followed by Windara in the Gulf St Vincent in South Australia, then Oyster Harbour in Albany, Western Australia. Crucially, these projects demonstrated that shellfish reefs can be restored at scale and their social, economic and ecological benefits returned to coastal communities. In 2021, in partnership with the Australian Government and local delivery partners, TNC commenced the *Reef Builder* Program, providing the opportunity to more fully expand the restoration of Australia's lost shellfish reefs at 13 restoration projects from Perth in Western Australia to Noosa in Queensland.

To track the progress of the *Reef Builder* Program towards the key targets and goals (see **Table 1**), TNC developed a comprehensive Monitoring, Evaluation and Reporting (MER) Framework. This framework includes the monitoring of the ecological (e.g. shellfish populations, habitat benefits for fish and other biodiversity) and socioeconomic (e.g. benefits to local economies and communities) outcomes. The monitoring information was collected by TNC, project partners and consultants and housed on two separate data systems, developed as part of the Program – the Monitoring, Evaluation and Learning Data (MELD) Hub (see the 'Building the Ecosystem' section) and PMO365. The scale of this Program is unprecedented in terms of marine restoration in Australia, so having efficient, reliable and secure ways to upload and store the data, then evaluate the outcomes has been critical to our success.

For the construction (e.g. amount of rock and shells used) and socioeconomic (e.g. employment opportunities, volunteer participation) data, TNC set-up a project portfolio management system called PMO365. PMO365 worked as a project management tool during the implementation of all stages of projects, a repository for all the key data and had built in BI capabilities to create dashboards for results. Both MELD Hub and PMO365 have empowered TNC and partners to make informed decisions about future restoration actions at scale and share the stories of impact and success.

This Summary Report provides a broad overview of the key *Reef Builder* ecological and socio-economic outcomes delivered between 2021 and 2023, with a series of case studies featuring some project highlights. It is accompanied by a more detailed ***Reef Builder* Monitoring and Evaluation Report,** which summarises analyses of all data collected during the *Reef Builder* Program, and the level of success in achieving the Program targets, goals and objectives[3]. It further outlines the methods used and the underpinning monitoring and evaluation approach.

[3]The Nature Conservancy Australia (2024) *Reef Builder* Monitoring and Evaluation Report. A report prepared for the Department of Climate Change, Energy, the Environment and Water by Bayraktarov, E., Rullens, V., Valesini, F., Branigan, S., Martinez-Baena, F., and Reeves, S. The Nature Conservancy Australia, Melbourne, 77p.

PROGRAM OBJECTIVE 1

Building the Reefs

Shellfish reef restoration was implemented through 13 *Reef Builder* restoration projects between 2021 and 2023. This work expanded on several TNC and partner-led restoration projects carried out between 2015 and 2020. During *Reef Builder,* over 40 hectares of shellfish reefs were restored at 26 restoration locations from Perth to Noosa. Rebuilding these reefs used 46,600 tonnes of rock and 98 tonnes of recycled shells.

The restoration projects were in: (1) Western Australia (WA) – Albany North, Albany South and Swan-Canning Estuary; (2) South Australia (SA) – Glenelg, Onkaparinga, and Kangaroo Island; (3) Victoria (VIC) – Port Phillip Bay and Gippsland Lakes; (4) Tasmania (TAS) – Derwent River; (5) New South Wales (NSW) - Port Stephens, Botany Bay and Sapphire Coast (Wagonga Inlet); and (6) Queensland (QLD) – Noosa. See **Figure 4**.

Figure 4: The 13 restoration projects at which shellfish reefs were restored during the *Reef Builder* Program (2021-2023). 'Existing' projects are those at which TNC and partners had initiated reef restoration prior to 2021 and were expanded during *Reef Builder*, while 'New' projects are those at which shellfish reefs were started during *Reef Builder.* NOTE: the Gulf St Vincent is an additional project at which shellfish reefs were restored by TNC and partners prior to 2021 but was not expanded during the *Reef Builder* Program. Hence, it has not been counted towards the 13 restoration projects.

Photo: Blue Mussels on limestone at Freshwater Creek, Swan River (WA). Credit: Scott Breschkin/TNC Australia.

An overview of the restoration projects and specific locations, restoration approach, key stakeholders, target species and total reef area restored are summarised in **Table 2**.

Table 2: *Reef Builder* restoration projects and their accompanying locations. 'New' indicates shellfish reef restoration projects which started during the *Reef Builder* Program (2021-2023), while 'Existing' refers to TNC-led and partner projects initiated between 2015 and 2020 and expanded during the *Reef Builder* Program. Restored reefs are counted as restoration locations that contribute towards TNC's '60 Shellfish Reefs Target' if they meet the following criteria: (i) comprise reef patches exceeding 250m^2 (individual or mosaic) with at least one reef patch exceeding 5m^2 and a maximum distance between reef patches of 30m in mosaics; (ii) their restoration area exceeds 0.5 ha, and (iii) the distance to the nearest neighbouring reef is equal to or greater than 2km, unless ecologically-distinct (e.g. intertidal vs subtidal reefs).

1. Swan-Canning Estuary

Western Australia

The Swan-Canning Estuary lies in the heart of Perth. It covers an area of ~40 km^2 and comprises two rivers (Swan and Canning) that flow into a wide central receiving basin with an adjoining entrance channel which is permanently open to the Indian Ocean at Fremantle. This project expanded upon the 0.7 hectares of pilot mussel reefs restored by TNC in 2020.

Restoration approach
Blue Mussel reefs were restored using locally sourced rock for the reef substrate and seeded with wild capture mussel stock from a local aquaculture farm. The stock were initially settled on longlines, grown out to adult size, then deployed onto the reef bases.

Key stakeholders
Department of Biodiversity, Conservation and Attractions (DBCA), Whadjuk Traditional Owners and Derbarl Yerrigan knowledge holders, Department of Premier and Cabinet, Department of Primary Industry and Regional Development (DPIRD), Department of Planning, Lands and Heritage (DPLH), Department of Transport (DOT), Harvest Road Oceans, South East Regional Centre for Urban Landcare, Murdoch University, University of Western Australia, Minderoo Foundation, LotteryWest, Recfishwest, Australian Sailing, OzFish Unlimited, Local Government Associations, and local community members.

Project Statistics

Restored reefs
1. Attadale
2. Freshwater Bay
3. Point Walter

Restored locations
1. Attadale
2. Freshwater Bay Southern
3. Freshwater Bay Northern
4. Point Walter

New/existing
Existing

Target species
Blue Mussel

Restoration period
2020-2023

Project restoration area
New: 5.2 ha
Existing: 0.7 ha
Total: 5.9 ha

2. Albany North and 3. Albany South

Western Australia

The Albany North and South *Reef Builder* projects are situated in Oyster Harbour, a permanently open estuary that covers an area of ~15 km^2 and is located on the south coast of Western Australia. This project expanded on the restoration 0.4 ha of oyster reefs by TNC in 2018-2020.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate and seeded with juvenile oysters. These juveniles, derived from local broodstock, were initially reared and settled onto cultch (recycled shell) in the hatchery, then grown out for ~6-months on a local aquaculture farm before deployment.

Key stakeholders
South West Aboriginal Land and Sea Council, DPIRD, Department of Water, Environment and Regulation (DWER), DOT, DPLH, Albany Shellfish Hatchery, Harvest Road Oceans, City of Albany, Southern Ports Albany, Southern Aboriginal Corporation, Albany Heritage Reference Group Aboriginal Corporation, University of Western Australia, South Coast Natural Resource Management, recreational and commercial fishers, Albany Senior High School, the local Menang Elders and community members.

Project Statistics

Restored reefs
4. Oyster Harbour Northern
5. Oyster Harbour Southern

Restored locations
5. Green Island
6. Waterski site
7. Oyster Harbour Northern
8. Oyster Harbour Southern

New/existing
Existing

Target species
Australian Flat Oyster

Restoration period
2018-2023

Project restoration area
New: 2.3 ha
Existing: 0.4 ha
Total: 2.7 ha

4. Glenelg

South Australia

Glenelg is a beach-side suburb along the Adelaide metropolitan coast, located on the shore of Holdfast Bay in Gulf St Vincent. This project built on the TNC-South Australian Government partnership to restore Australian Flat Oyster reefs along Adelaide's metropolitan coastline from 2019-2020.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate and seeded with hatchery-reared juvenile oysters that were derived from local broodstock and settled on cultch.

Key stakeholders
Kaurna Traditional Owners, City of Holdfast, Department of Environment and Water (DEW), Department of Infrastructure and Transport (DIT), Primary Industries and Resources South Australia (PIRSA), Adelaide Club, Friends of Gulf St Vincent, South Australian Research and Development Institute (SARDI), University of Adelaide, Flinders University, local oyster growers, Green Adelaide, Recfish South Australia, and local community groups, schools, recreational divers and fishers.

Project Statistics

Restored reefs
6. Glenelg

Restored locations
9. Glenelg

New/existing
Existing

Target species
Australian Flat Oyster

Restoration period
2019-2023

Project restoration area
New: 1.2 ha
Existing: 0.9 ha
Total: 2.1 ha

5. Onkaparinga

South Australia

Onkaparinga is a coastal area located to the south of the Adelaide metropolitan area within the Gulf St Vincent.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate and seeded with hatchery-reared juvenile oysters that were derived from local broodstock and settled on cultch.

Key stakeholders
Kaurna Traditional Owners, City of Onkaparinga, DEW, DIT, PIRSA, SARDI, Flinders University, University of Adelaide, Adelaide Club, Friends of Gulf St Vincent, Green Adelaide, Recfish South Australia, local oyster growers, local community, schools, recreational divers and fishers.

Project Statistics

Restored reefs
7. O'Sullivan Beach

Restored locations
10. O'Sullivan Beach

New/existing
New

Target species
Australian Flat Oyster

Restoration period
2021-2023

Project restoration area
Total: 1.9 ha

6. Kangaroo Island

South Australia

Kangaroo Island is Australia's third-largest island, situated to the south-west of the Gulf of St Vincent.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate. Oyster larvae were reared from local Kangaroo Island broodstock in an Adelaide-based hatchery (SARDI), then transported to Kangaroo Island. In addition, 500,000 larvae were transported to Kangaroo Island and 'remotely set' on cultch on the wharf at the restoration site. The juvenile oysters were grown out for a minimum of 4 months at the hatchery and a subset of remote-set individuals on a local oyster farm then seeded onto the reef base.

Key stakeholders
Kangaroo Island Council, DEW, DIT, Environmental Protection Authority (EPA), PIRSA, Kangaroo Island Landscape Board, Kangaroo Island Tourism Alliance, American River Boat Shed, American River Progress Association, Kingscote Progress Association, Kangaroo Island Shellfish, OzFish Unlimited, University of Adelaide, Recfish South Australia, Flinders University, local oyster farmers, food and wine tourism operators, local community and schools.

Project Statistics

Restored reefs
8. Nepean Bay - Eastern Cove

Restored locations
11. Nepean Bay - Eastern Cove

New/existing
New

Target species
Australian Flat Oyster

Restoration period
2021-2023

Project restoration area
Total: 1.9 ha

7. Port Phillip Bay

Victoria

Port Phillip Bay is a major embayment covering an area of nearly 2,000 km^2 and largely surrounded by urban areas, including the city of Melbourne. This project expanded on an existing 1.8 ha of shellfish reefs restored by TNC from 2017-2020.

Restoration approach
Mixed Australian Flat Oysters and Blue Mussel reefs were restored using locally sourced rock for the reef substrate. The reefs were first seeded with hatchery-reared juvenile oysters derived from local broodstock and settled on cultch. They were then seeded with Blue Mussels which were naturally recruited onto longlines and grown out by a local farmer for at least six months.

Key stakeholders
Kulin Nation Traditional Owners, Albert Park Yachting and Angling Club, Department of Energy, Environment and Climate Action (DEECA), Parks Victoria, Victorian Fisheries Authority (VFA), Deakin University, University of Melbourne, Victorian Shellfish Hatchery (VSH), Melbourne Water, OzFish Unlimited, Southern Ocean Environmental Link, VRFish, recreational fishers, divers, marine-care groups, hospitality sector.

Project Statistics

Restored reefs
9. Dromana
10. Margaret's Reef
11. Wilson Spit

Restored locations
12. Dromana
13. Margaret's Reef
14. Wilson Spit

New/existing
Existing

Target species
Australian Flat Oyster, Blue Mussel

Restoration period
2017-2023

Project restoration area
New: 4.7 ha
Existing: 6.1 ha
Total: 10.8 ha

8. Gippsland Lakes

Victoria

The Gippsland Lakes are one of Australia's largest coastal lagoons and wetlands, covering more than 400km^2. The area is also listed as a wetland of international importance under the Ramsar Convention in recognition of the outstanding coastal wetland values. This restoration project was led by TNC with support from the East Gippsland Catchment Management Authority (EGCMA).

Restoration approach
Mixed Australian Flat Oyster and Blue Mussel reefs were restored using locally sourced rock for the reef substrate. The reefs were seeded with hatchery-reared juvenile oysters derived from local broodstock and settled on cultch. Additional oysters and mussels were also seeded onto the reefs, sourced from a local 'Shellfish Gardening' initiative.

Key stakeholders
Gunaikurnai Land and Waters Aboriginal Corporation, EGCMA, DEECA, VFA, Parks Victoria, VSH, Destination Gippsland, Gippsland Lakes Angling Game and Sports Fishing Club, Friends of Nyerimilang, Gippsland Ports, Metung Primary School, Nungurner Primary School, local businesses and community.

Project Statistics

Restored reefs
12. Nyerimilang

Restored locations
15. Nyerimilang

New/existing
New

Target species
Australian Flat Oyster, Blue Mussel

Restoration period
2021-2023

Project restoration area
Total: 2.5 ha

9. Derwent River

Tasmania

The Derwent River Estuary covers an area of ~198 km^2 and bisects the city of Hobart before opening into the D'Entrecasteaux Channel. This new project was led by Natural Resource Management South in partnership with TNC.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate and seeded with hatchery-reared juvenile oysters that were derived from local broodstock and settled on cultch.

Key stakeholders
Tasmanian Aboriginal Centre, Derwent Estuary Program, EPA, Department of Natural Resources and Environment Tasmania, CSIRO, Bruny Island Oyster Growers Association, Kingsborough Council, Marine Safety Tasmania, Marine Solutions, University of Tasmania, Oysters Tasmania, TasPorts, Tasmanian Association for Recreational Fishing, OzFish Unlimited, Tasmanian Parks and Wildlife Service, Marine Solutions, local schools and community.

Project Statistics

Restored reefs
13. Taroona
14. Woodbridge

Restored locations
16. Taroona
17. Woodbridge

New/existing
New

Target species
Australian Flat Oyster

Restoration period
2021-2023

Project restoration area
Total: 1.4 ha

10. Sapphire Coast

New South Wales

The Sapphire Coast is a coastal region of southeastern New South Wales. The project is located in Wagonga Inlet, Narooma, a drowned river valley estuary that is permanently open to the ocean and covers ~7km^2. This new project was co-funded and co-delivered by TNC, Eurobodalla Shire Council and NSW DPI Fisheries. It is a 'living shorelines' project that combined restoration of subtidal oyster reefs, intertidal oyster reefs and riparian vegetation to protect the shoreline from coastal erosion and build natural ecosystem resilience.

Restoration approach
Subtidal Australian Flat Oyster reefs and intertidal Sydney Rock Oyster reefs were restored using locally sourced rock as the reef bases. The Flat Oysters were first reared to the larvae stage from local broodstock at a hatchery near Port Stephens, transported to Wagonga Inlet and remotely set on cultch. The juvenile oysters were then seeded onto the subtidal reef bases. There is an abundant remnant population of Sydney Rock Oysters in Wagonga Inlet that are naturally recruiting onto the intertidal reef bases. For the shoreline works, an existing degraded seawall was removed, the slope of the bank reshaped, then planted out with endemic plant species. There have also been major improvements to public access to the shoreline area, such as a boardwalk, look-out and educational signage.

Key stakeholders
Joonga Land and Water Aboriginal Corporation Rangers, Wagonga Local Aboriginal Land Council, BIG4 Narooma East's Holiday Park, Nature Coast Marine, NSW National Parks and Wildlife Services (NPWS), NSW Department of Planning and Environment Crown Lands, NSW Marine Parks, NSW Marine Estate Management Authority, Eurobodalla Shire Council, NSW Department of Primary Industries (DPI) Fisheries, Transport for NSW, local oyster growers, OzFish Unlimited, local fishing businesses and community groups.

Project Statistics

Restored reefs
15. Wagonga Inlet - Intertidal

Restored locations
18. Wagonga Inlet - Subtidal
19. Wagonga Inlet - Intertidal

New/existing
New

Target species
Australian Flat Oyster, Sydney Rock Oyster

Restoration period
2021-2023

Project restoration area
Total: 0.9 ha

11. Botany Bay

New South Wales

Botany Bay is situated in the Greater Sydney region and is an oceanic embayment with an area of ~38.8km^2 that receives freshwater discharge from the Georges and Cooks rivers.

Restoration approach
Australian Flat Oyster reefs were restored using locally sourced rock for the reef substrate and seeded with hatchery-reared juvenile oysters that were derived from local broodstock settled on cultch.

Key stakeholders
La Perouse Local Aboriginal Land Council, Gamay Rangers, NSW DPI Fisheries, NPWS, Greater Sydney Local Land Services, Sutherland Shire Council, Transport for NSW, Crown Lands, Port of Botany, Sydney Coastal Councils Group, Georges River Environmental Alliance, Georges River Keeper, Birdlife Australia, NSW Wader Study Group, Oatley Flora and Fauna, Australian National Sportfishing Association, South Sydney Amateur Fishing Association, St George & Sutherland Shire Anglers Club, Sydney Coastal Councils Group, Macquarie University, Sydney Institute of Marine Sciences, University of New South Wales, OzFish Unlimited and local community groups.

Project Statistics

Restored reefs
16. Kurnell - Botany Bay

Restored locations
20. Kurnell - Botany Bay

New/existing
New

Target species
Australian Flat Oyster

Restoration period
2021-2023

Project restoration area
Total: 3.1 ha

12. Port Stephens

New South Wales

Port Stephens estuary is located on the Hunter coast and is ~134km^2 in size. It is a drowned valley system fed by multiple tributaries (including Myall River, Karuah River and Tilligerry Creek) and is permanently open to the ocean via a large deep entrance. This existing project was led by NSW DPI Fisheries in partnership with TNC and built on the 1 ha oyster reefs restored in 2020.

Restoration approach
For the Karuah location, intertidal Sydney Rock Oyster reefs were restored within the footprint of abandoned oyster leases by deploying locally sourced rock into reef patches. The Myall reefs were restored on open intertidal sand flats that had no history of oyster farming. The Port Stephens area has an abundant population of Sydney Rock Oysters which are naturally recruiting onto the reef bases.

Key stakeholders
Worimi Local Aboriginal Land Council, Crown Lands, Port Stephens Council, Myall River Action Club, local oyster growers, local fishers and the general community.

Project Statistics

Restored reefs
17. Karuah (Garuwaguba Ninang)
18. Myall (Bindayimaguba Ninang)

Restored locations
21. Karuah (Garuwaguba Ninang)
22. Myall (Bindayimaguba Ninang)

New/existing
Existing

Target species
Sydney Rock Oyster

Restoration period
2020-2023

Project restoration area
New: 3.1 ha
Existing: 3.3 ha
Total: 6.4 ha

13. Noosa

Queensland

The Noosa River flows south from the Cooloola section of the Great Sandy National Park into Laguna Bay, with the estuarine portion of the waterway covering ~18km^2. The reefs restored in this project are collectively known as the 'Huon Mundy Reefs', named by the Kabi Kabi Traditional Owners after a great spiritual leader and the original name of the Noosa River.

Restoration approach
Sydney Rock Oyster reefs were restored in the intertidal zone using locally sourced rock, which were deployed into an array reef patches over multiple sites. Recycled shell was also augmented between the rock crevices. The reef bases were seeded with hatchery-reared juvenile Sydney Rock Oysters reared from local broodstock and settled on cultch, augmenting natural recruitment from existing oyster populations. Additional seeding was also provided by a local community 'oyster gardening' initiative led by the Noosa Integrated Catchment Association (NICA).

Key stakeholders
Noosa Shire Council, The Thomas Foundation, Noosa Parks Association.

Project Statistics

Restored reefs
19. Noosa Sound

Restored locations
23. Tewantin
24. Goat Island
25. Noosa Sound, West
26. Noosa Sound, East

New/existing
New

Target species
Sydney Rock Oyster

Restoration period
2021-2023

Project restoration area
Total: 0.9 ha

TNC's restoration approach is consistent with the principles and guidelines of the internationally-recognised Society of Ecological Restoration[4]. As described in the 'Building the Ecosystem' section of this report, TNC tracks the recovery of rebuilt shellfish reefs against a reference ecosystem (ideally a natural remnant reef, where available) or alternatively a reference model developed from the scientific literature and/or expert opinion. Other nearby 'structured' habitats such as seagrass and 'unstructured' habitats e.g. bare sediment also serve as vital benchmarks to measure the ecological benefits of the restored reefs over time.

All restoration locations within each project geography were 'substrate limited', meaning that there is no longer suitable reef structure to which shellfish larvae can attach. Many were also 'recruitment limited', meaning that there are insufficient brood-stock of the target shellfish species remaining naturally at a location to produce enough larvae (see 'Building the Ecosystem' section). The first of these limitations necessitated the deployment of locally-sourced rock to recreate a reef base. This was undertaken by a marine construction company in line with reef-design specifications tailored to each location. There are three project case studies presented in this section, Sapphire Coast (NSW), Kangaroo Island (SA) and the Swan-Canning Estuary (WA), which provide an overview of reef restoration activities up to the construction stage. Prior to undertaking reef construction (Stage 5 below), four other key delivery stages were required to be achieved. These included:

Stage 1, Project pre-planning
Pre-planning was conducted in early 2021 for each of the 13 restoration projects and involved (i) detailed scheduling and budget allocations, and (ii) development of supporting Monitoring, Evaluation and Learning (MEL) and Communication Plans. Overarching Project Management and MEL Plans were also developed for the broader Program.

Stage 2, Site selection and suitability
This stage was underpinned by a key decision-support framework called 'Restoration Suitability Modelling' (RSM) that guided the selection of reef building restoration locations for all projects. These quantitative models combine a library of spatial data layers to map areas that are most suitable for building shellfish reefs, and are an important tool for engaging local stakeholders and community in the decision-making process.

The models were developed using three main components, namely environmental suitability (i.e. locations that are most likely to maximise shellfish growth and survival); restoration suitability (i.e. locations where user conflict can be minimised); and stakeholder suitability (i.e. locations supported by the community). The model outcomes were also ground-truthed through diver and drop-camera surveys.

Stage 3, Planning and permitting
Restored reefs for all projects were designed to achieve a conservative balance between ecological and engineering principles, whilst minimising any negative impacts to adjacent habitats and foreshores. This was a key element for all projects, and a requirement of each state's regulatory and permitting processes. The approval pathway differed state-by-state, and often between locations within states. However, a common element was the requirement for a Development Application, similar to that required for building other coastal infrastructure such as bridges and jetties.

Stage 4, Procurement
Tender processes for reef construction and monitoring was carried out for all projects, with tenders assessed against a comprehensive set of criteria. This included the ability to source materials and services from local suppliers wherever practical and financially feasible.

For a detailed overview of the shellfish reef construction methods and monitoring outcomes, refer to the ***Reef Builder*** **Monitoring and Evaluation Report**.

[4]Fitzsimons, J., Branigan, S., Brumbaugh, R., McDonald, T., zu Ermgassen, P. (Eds.). (2019). Restoration Guidelines for Shellfish Reefs. The Nature Conservancy, Arlington VA, USA.

Case Study

Sapphire Coast (Wagonga Inlet) restoration project

Kirk Dahle, South-east Seascapes Coordinator

Wagonga Inlet lies on the foreshore of Narooma on the New South Wales far south Sapphire Coast. A renowned tourism destination due to its unique and beautiful surroundings, Wagonga Inlet is now also home to one of the first living shoreline style restoration projects in Australia as part of the *Reef Builder* Program. The Nature Conservancy (TNC), in partnership with NSW Department of Primary Industries Fisheries, and the Eurobodalla Shire Council worked to restore a variety of ecosystem types at a single location to also demonstrate a multi-habitat seascapes approach to restoration. In addition, TNC and project partners have sourced additional funding through the NSW Environmental Trust, NSW Boating, Camping, and Fishing program, and the Indigenous initiatives component of the NSW Marine Estate Management Strategy to improve public access to the location while incorporating many features to educate and highlight the cultural and ecological significance of this interdisciplinary project.

The Wagonga Inlet restoration project hosts a variety of habitat types in close proximity to one another. This allowed the project to restore subtidal Australian Flat Oyster reefs, intertidal Sydney Rock Oyster reefs, and coastal saltmarsh habitat in a mosaic that has greatly increased the ecological value of the location while improving coastal resilience to erosion by replacing a dilapidated and failing seawall with native saltmarsh vegetation.

The oysters for the Australian Flat Oyster reefs were first reared to the larvae stage at a hatchery near Camden Haven, transported to Wagonga Inlet and remote set on cultch (recycled shell) representing another first for at-scale Australian Flat Oyster reef restoration in NSW. The juvenile oysters were then seeded onto the subtidal reef bases. For the shoreline works, an existing degraded seawall was removed, the slope of the bank reshaped, then 3,500 square metres of restored saltmarsh were planted out with 22 endemic species with a total of over 14,000 tube stock plantings. There have also been major improvements in infrastructure, such as a boardwalk, Jetty/pontoon, look-out (pending completion), beach access ways, cultural artwork including sculptures by local Traditional Owners, as well as extensive educational signage through the restoration area.

Photo: Building of Australian Flat Oyster reef on the Sapphire Coast, Wagonga Inlet (NSW). Credit: Kirk Dahle/TNC Australia.

Case Study

> *Together, we have not only restored critical habitats but also instilled a renewed sense of hope among Kangaroo Island's residents, showcasing the broader impacts of these projects.*
>
> *Anita Nedosyko*
> South Australia Seascapes Coordinator

Kangaroo Island restoration project

Anita Nedosyko, South Australia Seascapes Coordinator

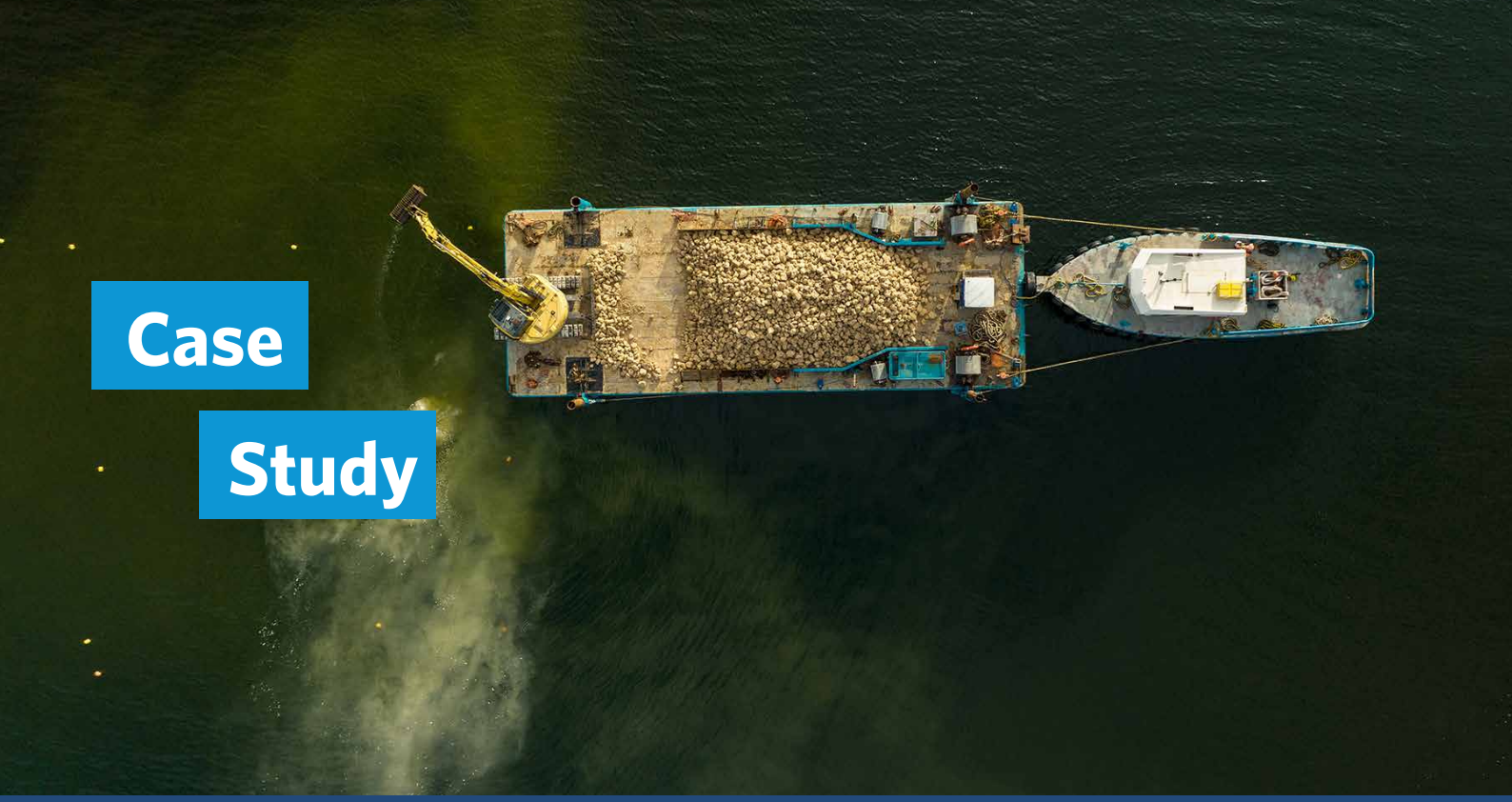
Kangaroo Island, situated just a two-hour drive from Adelaide in South Australia, boasts a unique and diverse temperate marine environment that was once abundant with Australian Flat Oyster reefs. The Kangaroo Island *Reef Builder* restoration project is a collaborative effort between - The Nature Conservancy (TNC) and the South Australian Department for Environment and Water (DEW). The aim of the work was to reintroduce suitable habitat for oysters, restore the myriad of benefits reefs provide and support the recovery of the island's nature-based visitor economy after the devastating bushfires in 2019. Beyond their culinary allure, oysters hold a significant place in the island's identity, supporting local economies through aquaculture while enhancing marine biodiversity and fishing opportunities.

The project's inception involved careful planning, guided by insights from esteemed scientists at the Kangaroo Island Landscapes Board, University of Adelaide, and DEW. Through consultations with the local community, oyster farmers, The Kangaroo Island Council and other key stakeholders, we identified two suitable locations within Nepean Bay for restoration. After careful consideration, a final location, located 4 kilometres offshore from the township of American River and adjacent to the significant marine sanctuary at Pelican Lagoon, was selected.

Engineers played a pivotal role in designing 28 reef units tailored to the island's hydrodynamic conditions. These reef patches were made from a combination of limestone boulders and recycled oyster shells seeded with juvenile oyster spat. Following development approval from the South Australian Government, site setup commenced by our construction contractor, Polaris Marine, at the American River Jetty Wharf on January 28, 2023, marking a significant milestone in the project's progression. The engagement of a nearby limestone quarry facilitated the supply and transport of reef materials, while recycled shells sourced from Pt Lincoln were cleaned by dedicated community volunteers and prepared for seeding at the South Australia Research and Development Institute hatchery.

On March 24, 2023, the final limestone reefs were completed, which was immediately followed by the dispersal of over 3.5 million oyster spat on shell by local commercial divers. The diverse size of the boulders has created a natural looking reef with a wide variety of habitat niches for marine life. The invaluable support and involvement of local businesses on the American River Wharf and pioneering efforts by oyster farmers, such as KI Shellfish, in assisting TNC in trialing Australia's first remote-set of oyster spat on shell, have been integral to the project's success.

Photo: TNC's Anita Nedosyko and Spider Crab on one month old reef, Kangaroo Island (SA). Credit: Jarrod Boord/Streamline Media.



Case Study

Swan-Canning Estuary restoration project

Andy Bossie, Western Australia Seascapes Project Officer

The Swan-Canning Estuary or Derbarl Yerrigan *Reef Builder* restoration project is the only project under the Program to exclusively use Blue Mussels as the target shellfish species and is amongst the largest set of reefs constructed in Australia to date. Reefs were completed using substantial volume of limestone rock to create significant undulation and height above the riverbed. In addition to *Reef Builder* funding, the project received financial and technical support from Lotterywest, the Minderoo Foundation, the Department of Biodiversity, Conservation and Attractions (DBCA) and numerous high-profile WA philanthropists.

The Nature Conservancy (TNC) went through a lengthy and thorough feasibility, site suitability and reef design process in the Swan-Canning Estuary. Not only were reefs sited in locations that were best suited to shellfish survival but, input from Traditional Owners (Whadjuk) and local stakeholders called for a structural and technical engineering requirement that required specialised planning. For example, the entire river is considered a sacred site and as such significant disturbance of the riverbed is not culturally acceptable. To reduce any likely impacts, modelling showed that reef patches need to be a minimum 20m apart at the Point Walter and Attadale locations. In addition, to negate scouring at these locations, larger reef patches were built 22m apart with the long edge aligned to the main current direction.

DBCA, as project partners and the key management authority for the waterway, provided exceptional guidance through the development application permitting process, which is challenging to navigate for novel restoration activities such as shellfish reefs. The TNC team overcame significant hurdles from a construction constraint perspective, with help provided by the Australian Department of Defence in accessing the load-out site for the six-month long construction period. Local construction contractor, Jetty and Marine Constructions, used a relatively organic approach, within allowable design and permitting specifications, to create a total combined 28 separate reef patches across four restoration locations. The resulting reefs have a very natural feel to them, with some reefs reaching heights of 2m above the riverbed.

No other shellfish restoration project in Australia has attempted to seed reefs with adult Blue Mussels on the same scale as the Swan-Canning Estuary. To achieve this, TNC partnered with Harvest Road Oceans (HRO) to design and implement a novel 'surface-seeding' method. The HRO vessel moved accurately back and forth over the reef structure dropping 500 kilograms of adult mussels at a time. After 3 months of seeding effort, a total of 160 tonnes of Blue Mussels had been deployed on the reefs. We look forward to monitoring the reefs, in conjunction with DBCA, into the future.

Photo: Barge deploying limestone rock, Swan-Canning Estuary (WA). Credit: Michael Bond/Overland Media.

PROGRAM OBJECTIVE 2

Building the Ecosystem

TNC's ecological restoration work strives to re-establish self-sustaining populations of Sydney Rock Oysters, Australian Flat Oysters and Blue mussels that will create a resilient shellfish reef and improve biodiversity, fish populations and ecological health. To track the recovery of the reefs over time a comprehensive MER Framework has been developed and the ecological monitoring data is housed on our MELD Hub. This a world-leading online platform for collating, visualising and reporting restoration monitoring data. The MELD Hub provides users with the ability visualise how restored reefs are performing over time through curated dashboards, images and video.

For the majority of *Reef Builder* projects, the next phase of reef restoration following the construction of the reef bases was to rebuild the local shellfish populations for the target species of interest. Most of the project locations were 'recruitment limited', meaning that they lacked sufficient nearby broodstock (i.e. mature, reproductively capable shellfish) to naturally populate the new reef bases (see **Table 2** and the case studies in the 'Building the Reefs' section). Around **30 million native shellfish** (oysters and mussels) were seeded onto *Reef Builder* restoration locations, which included almost **21 million Australian Flat Oysters**, **590,000 Sydney Rock Oysters** and almost **8 million Blue Mussels**.

Seeding was not required for the Port Stephens restoration locations as there is high natural recruitment of the target species, Sydney Rock Oysters. This was also the case for Blue Mussels in Gippsland Lakes, Victoria. Glenelg was found to have the highest densities of Australian Flat Oysters (see Glenelg case study), which was from both oysters seeded onto the reefs and natural recruitment from nearby remnant oysters.

The shellfish seeded at the *Reef Builder* restoration locations were sourced from hatcheries and aquaculture farmers from local broodstock and in line with each of the states' biosecurity regulations. The hatcheries reared both Australian Flat Oysters and Sydney Rock Oysters and settled the juvenile oysters, called 'spat', onto recycled and cured shell (known as 'cultch'). For the Kangaroo Island and Sapphire Coast projects, TNC set-up temporary remote setting facilities, due to the large distance between the hatcheries and restoration locations. The hatcheries still reared oysters to the free-swimming larval stage, but then the larvae was transported to the remote setting facility to be settled onto the cultch.

For the Swan-Canning Estuary and Port Phillip Bay restoration projects, the Blue Mussels were sourced from aquaculture farmers.

Photo: Bald Octopus on the Dromana restored reef, Port Phillip Bay (VIC). Credit: Elgin Associates.

The mussels were from wild sources, with the larvae naturally settling onto longlines, then grown out to adult size.

For oysters, commercial divers seeded the reefs by hand spreading the seeded cultch across the reef bases. However, the mussels were seeded using a more mechanical approach, from custom made infrastructure fabricated by contractors. There is typically geographical differences in shellfish survival and the monitoring results illustrate this. As such, contingencies are in place to reseed some of the restoration locations, if required, as a standard step in TNC's reef restoration approach.

All restoration locations were monitored to measure the benefits to fish and other marine biodiversity. Reef Life Survey (RLS) was the primary method to collect this information, an approach widely practiced in temperate and tropical reefs throughout the world. This involved monitoring both reef sites, and neighboring habitats where no restoration was occurring, both before and after reef restoration, (i.e. a 'Before-After-Control-Impact' monitoring design).

Remote underwater videos were also used to track fish abundance and diversity using the BACI design (see the **Boosting Fish Populations case study** as an example).

As anticipated, pelagic and reef-associated fish numbers and diversity varied between restoration locations, with Port Phillip Bay (e.g. Snapper, see case study) and Albany (e.g. Little rock whiting, Yellow-tail scad) recording the highest results for fish abundance. Many restored reef locations had a higher fish abundance compared to control sites (e.g. soft sediment and seagrass), demonstrating the habitat benefits of shellfish reefs.

For enhancements to broader biodiversity such as smaller cryptic fish species (e.g. Big-bellied seahorse, Hulafish), invertebrates (e.g. Nudibranch, Seastars) and marine mammals (e.g. Dolphins) on the restored subtidal reefs, during the latest monitoring event in 2022 or 2023, the majority (79%) of restoration locations demonstrated notably higher species richness compared to baseline conditions before restoration was carried out. This trend does vary with the age of reefs, however, which is testament to the rapid impact shellfish reefs can have on bolstering the biodiversity of coastal ecosystems.

For a detailed explanation of the MER Framework and all ecological monitoring outcomes, refer to the ***Reef Builder*** **Monitoring and Evaluation Report**.

Photo: Flathead and Blue Mussels on limestone rocks at Freshwater Creek, Swan River (WA). Credit: Scott Breschkin/TNC Australia

Case Study

Port Phillip Bay restoration project

Scott Breschkin, Victoria Seascapes Project Officer

Under *Reef Builder*, nearly five hectares of new shellfish reefs were restored across three restoration locations (Dromana, Margaret's Reef and Wilson Spit) in Port Phillip Bay. Restoration works in the bay began back in 2017 with a total of almost 11 hectares of restored ocean area to date across these locations as well as 9ft Bank, a pre-*Reef Builder* location. Nearly 5 million Australian Flat Oysters and over 750,000 Blue Mussels were seeded onto the Port Phillip Bay restoration locations to kickstart the recovery process.

Port Phillip Bay covers an area of nearly 2,000 km^2, largely surrounded by urban areas and includes the traditional Sea Country of the Wadawurrung and Bunurong people of the Kulin Nation, who held representation on the project Technical Advisory Group (TAG). Restoration locations are dispersed across the western (Wilson Spit), northern (Margaret's Reef) and southern (Dromana) parts of the bay. Environmental conditions are highly variable between locations, from the clear waters and coarse sands at Dromana, to the silty, low visibility environments more typical of Margaret's Reef and Wilson Spit. There is at least two years of post-construction monitoring data available for some of these restored reefs.

The Nature Conservancy (TNC) engaged Elgin Associates to conduct the adapted Reef Life Survey monitoring before and after construction during *Reef Builder.* The monitoring approach was supplemented by TNC conducting its own 'rapid assessments' in between monitoring events, to get a snapshot of how shellfish growth and survival was tracking.

For all restoration locations in Port Phillip Bay, mean densities of Australian Flat Oyster have remained consistently above the benchmark of 50 adult individual oysters/m^2 and were highest at Margaret's Reef and Dromana after 19 to 24 months (386 and 339 individuals/m^2, respectively) and at Wilson Spit after 25 to 30 months (1,289 individuals/m^2). For Blue Mussels, highest mean densities were found at Margaret's Reef after 7 to 12 months (9,614 individuals/m^2) and after 1 to 6 months at Wilson Spit (6,772 individuals/m^2). Very few mussels have survived at Dromana and densities have declined notably at Wilson Spit, despite the high numbers observed in the first year. The low densities of mussels at these restoration locations are attributed to high predation rates by native Eleven-Arm Seastars. Natural recruitment and survival of mussels have been observed at Margaret's Reef, with a mean density of individuals/m^2 recorded for reefs older than 30 months. This restoration location is progressing well towards a benchmark for Blue Mussels of adult individuals/m^2.

At all restoration locations, shellfish are helping to build the foundation of the reef ecosystem, which in turn is supporting a diversity of marine life. All restoration locations are monitored along with soft sediment reference sites, which indicate what comparable biodiversity would be like should no restoration have occurred. For all restoration locations there was higher diversity compared to soft sediment locations. The highest mean pelagic fish biomass per transect was recorded at Dromana, Margaret's Reef and Wilson Spit after 25 to 30 months with over 100kg, 60kg and 30kg recorded on average per transect respectively.

Post construction, the highest number of species recorded on the restored reef locations was at Wilson Spit (41 species at 13 to 18 months), followed by Dromana (38 species at 25 to 30 months) and Margaret's Reef (37 species at 13 to 18 months). At Dromana, large schools of juvenile fish were commonly observed including Snapper, Silver Trevally, Yellowtail Scad, Southern Goatfish and Bridled Leatherjacket, while large schools of Australian Herring were observed at Margaret's Reef.

While there are notable differences between the three restoration locations, the monitoring data indicates they are moving towards the benchmark shellfish ecosystem and are supporting a range of fish and invertebrates. All restored reefs have higher biodiversity and biomass than reference soft sediment sites, and the trajectory towards the target system is looking very positive.

Photo: Australian Flat Oysters on limestone rock surrounded by seaweeds, Port Phillip Bay (VIC). Credit: Jarrod Boord/Streamline Media.

Case Study

Glenelg restoration project

Anita Nedosyko, South Australia Seascapes Coordinator

This restoration project, a collaboration between The Nature Conservancy (TNC) and the South Australian Department for Environment and Water, focused on rebuilding Australian Flat Oyster reef ecosystems offshore Adelaide's popular Glenelg beach. In 2020 (pre-*Reef Builder*) and 2021 (*Reef Builder*), 28 low-profile reef patches covering 2.1 hectares were constructed at the site. The selection of Glenelg followed extensive mapping exercises along the Adelaide metropolitan coastline, refined by expert review and community feedback.

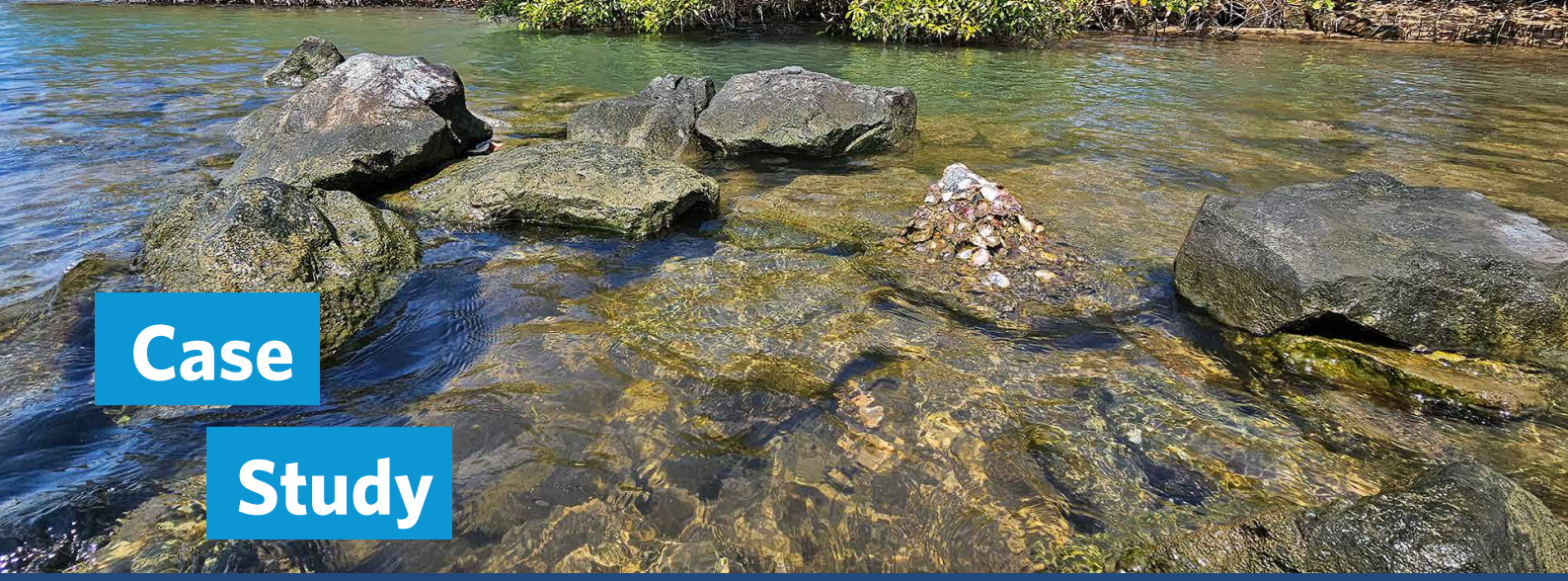
Initial oyster spat trials yielded promising results, indicating the presence of wild adult oysters nearby. The construction of the limestone reefs coincided with oyster spawning seasons in the Gulf St Vincent, and shortly after 2.5 million hatchery-raised oyster spat grown on recycled shells were seeded onto the reefs. A temporary fishing closure was immediately implemented to facilitate successful reef establishment and was lifted after one year to allow for fishing activities.

Early post-construction observations by divers revealed millions of oyster recruitments on the limestone boulders.

Monitoring efforts have confirmed that there are high densities of Australian Flat Oyster populations at Glenelg after two years at 2,436 individuals/m^2, meeting restoration success benchmarks.

Our collaboration with The University of Adelaide and AusOcean involved deploying live cameras and testing acoustic technology onto the reefs. Their results have shown that playing the sound of healthy reefs underwater during the early stages can boost natural recruitment of oyster spat on nearby reefs by over one-thousand times. The application of this technology can be used to advance natural oyster reef building by decades, particularly in areas where natural recruitment is poor and reef recovery is slow. Our research collaboration was acknowledged by winning the 2023 SA Science Excellence and Innovation Award. Additional species observed on the restored reefs include Squid, Garfish, Pipefish, and Ornate Cowfish.

Photo: Australian Flat Oyster growth on reef, Glenelg (SA). Credit: Dominic McAfee/University of Adelaide.



Case Study

Noosa restoration project

Megan Connell, Queensland Seascapes Project Officer

Between 2019 and 2022, the *Reef Builder* Program, in partnership with Noosa Shire Council and The Thomas Foundation, restored 0.9 hectares of Rock Oyster-dominated shellfish reefs across four carefully selected restoration locations in the lower Noosa River. In the long term, this project aims to restore functioning shellfish reef ecosystems that withstand future climatic challenges and add ecological value and resilience to this heavily used urban estuary.

Early knowledge of oyster populations in the Noosa River was limited and early spat recruitment trials suggested one dominant species of Sydney Rock Oyster present locally (*Saccostrea glomerata*). With assistance from Griffith University's shellfish genetics laboratory, the project confirmed three unique species of Rock Oyster, with a further three species of Pearl Oyster also contributing to the reef building oyster assemblage.

TNC engaged Ecological Service Professionals (ESP) to undertake independent monitoring and evaluation of the reefs' performance using a scientifically rigorous Before-After-Control-Impact (BACI) methodology. ESP confirmed that the dominant pre-reef restoration habitat type in the restoration locations (Noosa Sound East and West and Goat Island) was bare sand, with mud and rubble dominant at the Tewantin restoration location.

In March 2023 (six months post reef construction), seagrass (*Halophila ovalis*) began colonising sand spaces between the reef patches at both Noosa Sound East and West locations. Propagules of red mangroves (*Rhizophora stylosa*) were recorded settling into crevices on the reef tops, adding further habitat complexity.

In all four restoration locations, foliose macroalgae, predominantly Padina species and turf-forming algae colonised the rocky reef surfaces. However, possibly due to significant summer rainfall in December 2023 and January 2024, this algae cover has since largely disappeared. Future monitoring will determine the extent of change in this dynamic population of foliose algae.

In the 1.5 years since reef construction, wild Sydney Rock Oysters and Pearl Oysters have recruited consistently to all 30 reef patches in all four restoration locations. Even after initially high recruitment of oysters to the reefs (recorded in March 2023), the density of oysters has continued to steadily increase in all areas. The highest density was recorded at Goat Island, with 917 individuals/m^2 in September 2023.

In the pre-restoration survey, a total of nine fish species, from seven families, were recorded across all restoration locations. In March 2023, with the reefs in place, 31 fish species, from 21 families, were recorded across all locations. The highest species richness was recorded at Noosa Sound East after reef deployment, where previously there was only one species of fish recorded. Yellowfin Bream (*Acanthopagrus australis*) and Estuary Glassfish (*Ambassis marianus*) dominated the assemblages, particularly prior to reef deployment, with numerous other species recruiting or occurring around the structured and unstructured habitats within six months after reef structure deployment.

Photo: Sydney Rock Oyster reef at Tewantin, Noosa River (QLD). Credit: Megan Connell/TNC Australia.

Case Study

Boosting fish populations through shellfish reef restoration

Dr. Simon Reeves, NCS Metrics Scientists, sourced from Griffith University-led collaborative research effort and associated journal article *Estimating enhanced fish production on restored shellfish reefs using automated data collection from underwater videos*, published in the Journal of Applied Ecology.

This Griffith University-led research partnership focused on evaluating the impact of restored shellfish reefs on fish populations, particularly looking at the density of juvenile fish and other aquatic life. Three different restoration locations were surveyed (two in Port Phillip Bay, Victoria – Margaret's Reef and Dromana and one off the coast of Adelaide, in Glenelg), comparing areas with restored reefs to those without any reef structures. By using advanced technology, including underwater video cameras and automation software (Fish ID), the research was able to identify and count the fish in these areas rapidly and accurately.

Glenelg, SA | Dromana, VIC | Margaret, VIC

The most observed fish species were more abundant on the restored reefs than in areas without reef structures. In fact, the restored reefs showed an average increase in fish production of over 6,000 kilograms per hectare per year. This increase was primarily due to species that are important for commercial and recreational fishing such as Australasian Snapper.

However, the success of restoration varied from one location to another. In one area, the fish production was exceptionally high (12,000kg per hectare per year), while in another, it was significantly lower (1.4kg per hectare per year). Importantly, this demonstrates that not all reefs are equal in terms of restoration outcomes. This variation suggests that factors such as overfishing and the availability of alternative habitats for juvenile fish can influence fish production from reef restoration.

This research demonstrates that combining underwater video technology with automated data analysis offers a reliable and resource-effective way to monitor fish populations on shellfish reefs.

By providing concrete evidence of the benefits of reef restoration, these findings support the case for investing in the expansion of restoration efforts. This research not only has ecological implications but also holds social and financial benefits, paving the way for a sustainable future for our marine ecosystems.

Photo: Australiasian Snapper swimming underwater at Dromana, Port Phillip Bay (VIC). Credit: Jarrod Boord/Streamline Media.

PROGRAM OBJECTIVE 3

Building Community

The genesis of the *Reef Builder* Program partnership between TNC and the Australian Government was to provide much needed economic stimulus to regional and metropolitan economies impacted by the COVID-19 pandemic, and those devastated by bushfires. This specifically included targets on boosting local employment, whilst also strengthening community engagement through restoring shellfish reefs in 13 project geographies. As an integral part of TNC's MER Framework these outcomes were tracked for all projects and compiled on PMO365 (see the 'Background' section). We collected a vast range of socio-economic information during the project lifecycle stages, including for direct employment (e.g. number of workers and from which industry sector, hours contributed and size of the enterprises), community engagement (e.g. type and number of community events, number of volunteers and hours contributed) and media outreach (e.g. number, reach and type of media engagement in print, radio, television, social media and webinars).

The *Reef Builder* Program has demonstrated that shellfish reef restoration projects at scale can provide significant economic benefits, as illustrated through:

- The creation of **425 employment opportunities** working **100,367 hours**, the majority of which occurred during the reef restoration (232 people) and monitoring and evaluation (112 people) project lifecycle stages. These new jobs spanned a range of industry divisions, with a half from professional, scientific and technical services.

- Direct engagement of **51 organisations**, comprising **96% small-medium enterprises**, with the majority of workers local to the project geography during most of the project lifecycle stages.

- On average, projects employed **33 people**, creating **4.9 full-time equivalent jobs** per project.

The Port Phillip Bay project (65 people) created the most employment opportunities, closely followed by Derwent River (53 people), Gippsland Lakes (53) and Kangaroo Island (39) projects through project management and delivery, shellfish hatcheries (cultivation of oysters) and aquaculture farmers (supply of wild reared Blue Mussels and grow-out of Australian Flat Oysters), quarries (supply and cartage of rock), engineering (reef design), marine construction (reef construction), maritime surveyors (bathymetric surveys), commercial divers (seeding of reefs) and scientific divers (monitoring of reefs).

In addition, the *Reef Builder* Program has also directly strengthened community engagement as well as the longer-term stewardship of shellfish reefs through the facilitation of **185 stakeholder and community events**, with a total of **5,219 people** attending these events across the 13 projects. These events were held at each project lifecycle stage, with reef restoration recording the highest number of events (55) for all projects, followed by monitoring and evaluation, planning and permitting (40), then site selection and suitability (23). The event types included, for example, Technical Advisory Group meetings which formed an integral part of project governance, stakeholder consultation (e.g. with regulators and community for site selection), community forums (e.g. to share project directions and report back on monitoring results) and conferences (e.g. presenting on the *Reef Builder* Program).

There were also a range of opportunities for community members to participate in the restoration process, culminating in the engagement of **305 people** who volunteered a total of **2,903 hours**. This engagement was through a range of different activities, including, for example, oyster gardening and shell recycling (see the Noosa and Gippsland case studies), water quality monitoring, shell recycling through 'Shuck Don't Chuck' projects in Greater Melbourne and Noosa, as well as fish monitoring.

One of our key partners in Port Phillip Bay, Albert Park Yachting and Angling Club, have been involved in the project since its inception in 2015 and throughout *Reef Builder*. Bob Pearce, a committee member from the Club, was among community members interviewed during *Reef Builder* to help better understand the societal benefits of the shellfish reef restoration work. Bob has seen an increase in fish stocks at Margaret's Reef just offshore from the Club, which is one of the four restoration locations in Port Phillip Bay, but also referenced the increased activity of dolphins, seals and penguins.

He explained that in his view, while the fishers benefited, the benefits to the wider community and the ecosystem were far more significant:

> **We're doing this for the community, we're not doing it for the club. And it's not just about the fish, it's about the biodiversity.**
>
> **Since the project has been done, the biodiversity has exploded.**
>
> ***Bob Pearce***
> Albert Park Yachting and Angling Club

Another key component of engaging the community via the *Reef Builder* Program was through media outreach. While this outreach occurred during all project lifecycle stages, reef restoration had the majority of media engagements (~400). The key outreach outcomes included:

- A total of **537 media engagements** with a combined potential **audience reach of 203 million views**, across all media types (print, radio, television, social media and webinars).
- An average of **41 media events** with a potential audience of **1.5 million views** for each project (see the Noosa media case study as an example).
- Most media events resulted from radio (262), followed by print (128), social (86) and TV (59). Traditional media (print, radio and TV) reached a greater potential audience than non-traditional media (social and webinar).
- Webpages for each project and all the media articles have also been compiled, and can be accessed via the *Reef Builder* Program webpage on the TNC Australia website: **natureaustralia.org.au/reefbuilder**

In addition to media, a further important component of the community outreach for *Reef Builder* was the production of a short documentary to bring the restoration story to life and connect with diverse audiences.

The 'Reefs of Resilience' documentary (produced by Streamline Media) traverses the *Reef Builder* journey, from its motivation, to its delivery and its impact.

Watch online
bit.ly/reef-doco

Videos were also produced for the majority of the restoration projects and can be accessed via the *Reef Builder* Program webpage on the TNC Australia website.

For a detailed description of all the socioeconomic outcomes, including media outreach, refer to the ***Reef Builder* Monitoring and Evaluation Report**.

Case Study

Noosa restoration project

Megan Connell, Queensland Seascapes Project Officer

A three-year partnership in Noosa between The Nature Conservancy (TNC), with Noosa Shire Council and The Thomas Foundation resulted in the construction of 30 oyster reef patches at four restoration locations within the Noosa River.

The reefs encompass 497 metres of linear river shoreline, have a restoration footprint of 2,268 m^2 and have impact over an ocean area of 8,700 m^2 (0.9 hectares). Collectively, these reef patches are named the *Huon Mundy Reefs*, by Kabi Kabi Traditional Custodians in honour of the highly respected Dulingbara Spiritual Leader. This restoration project required strategic interpretation and community education activities, with some of the reef locations on the doorstep of Australia's most luxurious homes, as well as the popular boating areas of the river by both private and commercial vessels.

Working with the local community was imperative to the overall success of this project. TNC needed to capture the interest and participation of Noosa's passionate, environmentally conscious community, who live, work and play on the river. Community-led initiatives began with oyster shell recycling and cleaning through the *Shuck Don't Chuck* shell recycling initiative. Over 7 tonnes of oyster shell were collected from local restaurants and seafood distributors in Noosa and diverted away from landfill. Shells were then cleaned by community volunteers and transported to the Bribie Island Research Centre for settlement with Noosa River oyster spat.

Citizen scientists from the community nurtured these juvenile oysters in baskets kept at more than 20 private jetties as part of the Oyster Gardening initiative led by the Noosa Integrated Catchment Association. Community oyster gardeners managed ten kilo baskets of oysters and associated species suspended in a mini reef in the intertidal zone. The volunteer gardeners are community stewards of their oysters and are thus connected to the oyster reef restoration. Through the Noosa Environmental Education Hub, local schools engaged with on water and in classroom experiences as part of the Oyster Gardening Citizen Science initiatives.

Citizen science extended to the Noosa Parks Association sediment study that engaged the local men's shed in hundreds of hours of sediment trap building, which, coupled with many volunteer hours of sediment collection, combined to develop a heat map of sediment distribution across the estuary. This study contributes to a longer-term vision for the Noosa Estuary and its catchment. Continuing to focus on community stewardship is paramount for the *Huon Mundy Reefs*, and Noosa River's ecologically sustainable future.

Photo: Sam Newton, NICA's oyster gardening support officer, brings a full oyster basket back to shore as part of the Noosa Oyster Gardening program. Credit: Juanita Bloomfield/Tourism Noosa.

Case Study

Gippsland Lakes (Nyerimilang) restoration project

Scott Breschkin, Victoria Seascapes Project Officer

The Gippsland Lakes *Reef Builder* restoration project was led by The Nature Conservancy (TNC), with support from the East Gippsland Catchment Management Authority (EGCMA), who coordinated a number of community engagement and citizen science activities. The EGCMA has existing relationships and networks with stakeholders and community groups in the area and were well-placed to lead these engagement activities. Nearly 200 local people were involved with volunteer and engagement activities, with this project including a variety of community engagement and citizen science activities.

The 2.5-hectare restoration location is situated at Nyerimilang (meaning 'chain of lakes' in the local Gunaikurnai language) nearby to Lakes Entrance and Metung. These towns are popular for tourism and retirees, with 32% of the population of Lakes Entrance over the age of 65. The community includes many people with a passion and interest in the marine environment. The restoration project created over 50 employment opportunities, with close to 5 full time equivalent jobs created overall.

This restoration project featured two citizen science initiatives which included oyster gardening and remote underwater video (RUV) fish surveys. Oyster gardeners were located throughout the lakes and included volunteers from the Friends of Nyerimilang, Fraser Island Retreat, Nungurner Primary School, and local residents. Each location had one to two oyster baskets containing juvenile Australian Flat Oysters grown on recycled scallop shells. Volunteers regularly maintained their baskets and monitored a sub sample of shells for growth and survival of oysters, while noting the presence of other species.

A highlight of these citizen science initiatives was taking the volunteers out to the restoration sites, to deploy their shells onto the reef.

The overall restoration project saw great success with engaging and educating a diverse representation of the local community through their direct involvement in restoration activities.

The RUV fishing initiative involved seven volunteers from the Gippsland Lakes Angling Game and Sports Fishing Club deploying RUVs on to the reefs to monitor fish communities. The fishing club was very supportive of this activity and the volunteers were keen to learn about what fish were utilising the reefs.

The highlight of these community engagement initiatives was hosting a 'round-robin' day of activities for over 50 students from two local primary schools. Students rotated through activities hosted by Bug Blitz Trust, TNC and EGCMA, aimed at helping students to understand the ecology, history, connectiveness and importance of the Gippsland Lakes environs, and how they can help to look after it.

As a community engagement tool, the most successful activity was hosting free community boat trips at the conclusion of the project. Attendance on these trips was higher (48 people) than at community forums (maximum 24 attendees) and they provided a fantastic opportunity to take community members out to the restoration sites, giving a comprehensive overview of the project. The informal nature of the trips provided an opportunity to answer lots of questions and helped connect community members with other like-minded locals.

Photo: Volunteers from the *Friends of Nyerimilang* learning about oyster gardening. Credit: Friends of Nyerimilang.

Case Study

Turning the tide of community sentiment in Noosa

Vanessa Billy, Communications Manager

At the beginning of the Noosa *Reef Builder* Project, also collectively known as the *Huon Mundy Reefs*, the Noosa community appeared divided over the benefits the shellfish reef restoration would provide.

The Nature Conservancy (TNC), with the support of our project partners Noosa Shire Council and the Thomas Foundation, developed numerous community engagement initiatives, including a media outreach strategy to promote the wider benefits of shellfish reefs directly to a passionate community committed to the health of the Noosa River.

Critically, media outreach and social posts complemented the various community engagement activities including: shell recycling; oyster gardening and seeding of the newly-built reefs by volunteers; and promoting the involvement of local community members in these activities.

Slowly and progressively, positive articles were reported by the local news outlet, which, along with the positive feedback from the community engagement activities, saw the beginnings of a collective change of heart within the local people.

With the broader community on board and echoing support for the reefs, TNC focused on strengthening relationships with local news outlets, inviting them to attend community events and speak to volunteers. Over time, this approach proved incredibly successful and valuable for the *Huon Mundy Reefs*. The Noosa Today paper, following the seeding event with volunteer gardeners, ran a very positive article about the project, and has since been providing regular updates on the project, with a positive sentiment.

From the ABC Breakfast show...

On International Day of Girls and Women and Science 2022, ABC Radio Sunshine Coast invited Megan Connell, TNC's Queensland Seascapes Project Officer, to talk about her work in conservation. Upon hearing about the *Huon Mundy Reefs* from Megan, the producer decided to run a piece for television. After months of work taking a crew from the restaurants and seafood wholesalers taking part in *Shuck Don't Chuck,* through to the Bribie Island Aquaculture centre and the seeding of the reef event with volunteer gardeners, the ABC ran a radio and TV piece which was picked up across all regional stations and by ABC National in November 2022.

The total coverage of the *Huon Mundy*'s story by the ABC exceeded 15 million viewers, and the reefs featured on the ABC Breakfast Show on 24 November 2022.

...to the red carpet.

From that moment onward, there was no barrier preventing the *Huon Mundy Reefs*, their spat, and the big screen. On 7 June 2023, following months of collaboration with the film team out on the water, '*The Oyster Gardener*', a short documentary by production company Regenerator, made its debut at the Sydney Film Festival and was subsequently made available on ABC iView. The film delves into high school student Jolie's passion for the Noosa River and her apprehensions regarding its future. It chronicles her progression from a volunteer shellfish gardener at her school to participating in the seeding of the *Huon Mundy Reefs*.

Photo: '*The Oyster Gardener*' cast, crew and TNC staff at the premiere at Sydney Film Festival, (left to right), Kim Ingles, Jolie May, Julia Loersh, Jayde Harding and TNC's Megan Connell. Credit: Sydney Film Festival

Photo: Seahorse rests near mussels on restored shellfish reef in Gippsland Lakes (VIC). Credit: Jarrod Boord/Streamline Media.

Lessons Learnt

The *Reef Builder* Program provided an opportunity for TNC to expand on our direct experience and further refinement in our approach to shellfish reef restoration at scale. The *Reef Builder* team has developed a catalogue of lessons learnt from the delivery of this Program, which will form a set of recommendations going forward. The following list of lessons learnt drew on the experience of our marine restoration practitioners, Program managers, Data & Science Team, and the wider support staff within TNC.

1 Project delays were primarily related to contractors and permitting bottlenecks, as opposed to scope creep. To maintain project schedule and timelines it is recommended to:

- Plan future projects with sufficient lag time for monitoring (minimum six months) between pilot reefs, full-scale build and post construction monitoring.
- Where possible seek to have finalised designs, approvals and permitting conditions in place prior to marine construction tenders to avoid project variations that result in cost increases and project delays.
- Where multiple marine construction contractor options exist, minimise potential delays through greater spread of contractors across restoration projects. In addition, if only a single marine construction contractor is the successful tenderer for more than one project, ensure staging of builds aligns with permitting timelines and contractor availability.

2 TNC undertook an internal delivery method for Project Delivery, through maintaining a team of local project coordinators with shared specialist support staff (GIS, contracting, legal and communications) which underpinned the success of the *Reef Builder* Program. Continued success under this model relies on:

- Maintaining established relationships with project partners, contractors and key stakeholders for effective delivery and leveraging additional in-kind contributions.
- TNC to consider delivery by third party partners where local organisations exist with capacity, expertise and local relationships such as the case of the Derwent River restoration project where NRM South was contracted.

3 Crucial to maintaining the science behind TNC work on shellfish reef restoration, Monitoring and Evaluation comprised a significant component of both project budget and duration, with success underpinned by:

- Contracting of commercial scientific marine divers for reef monitoring, however, for future projects consideration should be given to increasing contractor scope to include the analysis of data collected.
- Continuing to regularly review the MER Framework for shellfish reef restoration. Simplified and streamlined methodology will reduce monitoring costs, allow improved comparative learnings across restoration projects and identify monitoring opportunities best undertaken by internal staff, contractors or in some situations by suitability experienced and qualified community volunteers.
- Further leveraging of funding and partnerships in increasing capacity for ongoing monitoring of reefs beyond project duration.

4 Undertaking marine restoration at this scale, across multiple public waterways with each restoration project having unique management and regulatory frameworks presented challenges in terms of project delays and liability conditions not feasible to TNC as an NGO. To assist in the permitting and approvals process:

- TNC to continue to work with state governments, and key regulatory agencies, to establish liability conditions and clarify long-term ownership commitments of restored reefs on public lands at the project initiation.
- TNC to continue to work at the state level on streamlining the approvals and regulatory

pathways for marine restoration at scale and also to assist in long-term strategic planning.

5 Construction and seeding of reefs with shellfish species was a major cost component of the *Reef Builder* Program, and provided numerous logistical challenges that were met. Key learnings from across all restoration projects include:

- Continue the model of having a TNC project coordinator per restoration project and ensure construction contractors have a dedicated project manager for the duration of the build. This will assist in positive relations and consistent messaging with the community, compliance with building approval conditions and identifying any potential construction issues early.
- Continue close relationships with local shellfish hatcheries, often sole suppliers within each state. Identify early where geographical and financial constraints require a remote setting facility to be established and or investigate alternative methods for seeding such as deploying recycled and cured shell to enhance natural recruitment.
- Building off the success of the *Shuck Don't Chuck* shell recycling projects in Greater Melbourne and Noosa, explore opportunities to establish similar shell recycling projects within each state, providing access to material and reduced costs for seeding of reefs. Shell recycling projects provide a unique opportunity to leverage community engagement and volunteerism in an otherwise construction-dominated project.

6 TNC's core vision for a world in which people and nature thrive depends on maximising opportunities to engage with local community and Traditional Owner groups in all aspects of our project work. Stakeholder and community engagement was a key component of the *Reef Builder* Program, and success was recognised due to:

- Traditional Owner engagement early in the project pre-planning stage, through establishing and maintaining formal relations with groups beyond seeking heritage approvals.
- Community engagement initiatives including community shellfish gardening in Noosa, *Shuck Don't Chuck* shell recycling projects in Greater Melbourne and Noosa and the engagement of OzFish Unlimited for community-based monitoring in the Swan-Canning Estuary.
- Promoting all the benefits of shellfish reefs to a broad audience including to recreational fishers and diving communities and provide research opportunities to academia.

Communications and media activities resulted in high public awareness of the *Reef Builder* Program, and support from local communities.

TNC continues to adapt how we promote shellfish reef restoration, of which by nature is largely out of sight, by:

- Adoption of emerging technologies to communicate restored reef outcomes, including the use of remote underwater drones and 360-degree video. Recognising the impact of visual imagery as a communication tool for broader community engagement, as complimentary to technical reports.
- Continue to communicate the science of shellfish reef restoration, including outcomes, through regular community forums, newsletters and local media opportunities.

2024-2030

Our Next Phase of Restoration

Restoring 30% of Australia's lost shellfish reefs.

Looking ahead to 2030, our focus remains set on restoring 30% of our lost shellfish reefs nationally, equating to 60 restored reefs on average, and rerouting their trajectory from near-extinction to the recovery of self-sustaining ecosystems.

Achieving this target will help Australia meet its commitments under the 2022 Kunming-Montreal Global Biodiversity Framework, and specifically Target 2 to 'restore 30% of all degraded ecosystems by 2030'. For our coastal ecosystems and communities, it will also **return an estimated 300 ha of lost reef habitats** to our estuaries and bays, **produce 100,000 kg of fish each year**, **filter 600 billion litres of seawater** (equivalent to the waste water generated by 6.3 million Australians), **remove 67,500kg of nutrient pollution**, and **produce 2,700 direct jobs** in maritime construction, aquaculture and science and produce ongoing economic benefits for fishing and ecotourism industries.

Building on the momentum and learnings from the 21 restored reefs to date, we have mapped potential restoration projects for the remaining 37 reef locations shown in **Figure 5**. These indicative areas will be further refined with local delivery partners, stakeholders and experts to prioritise restoration impact and success. Several, however, are 'shovel-ready' with requisite consultation, planning and permits already secured. We are currently seeking commensurate funding to bring those projects to fruition within this critical window of opportunity.

The *Reef Builder* Program has demonstrated what's possible in terms of restoring these fundamental habitats at impactful scales – **achieving our collective target of restoring 30% by 2030** is within our reach with national-scale partnerships and support.

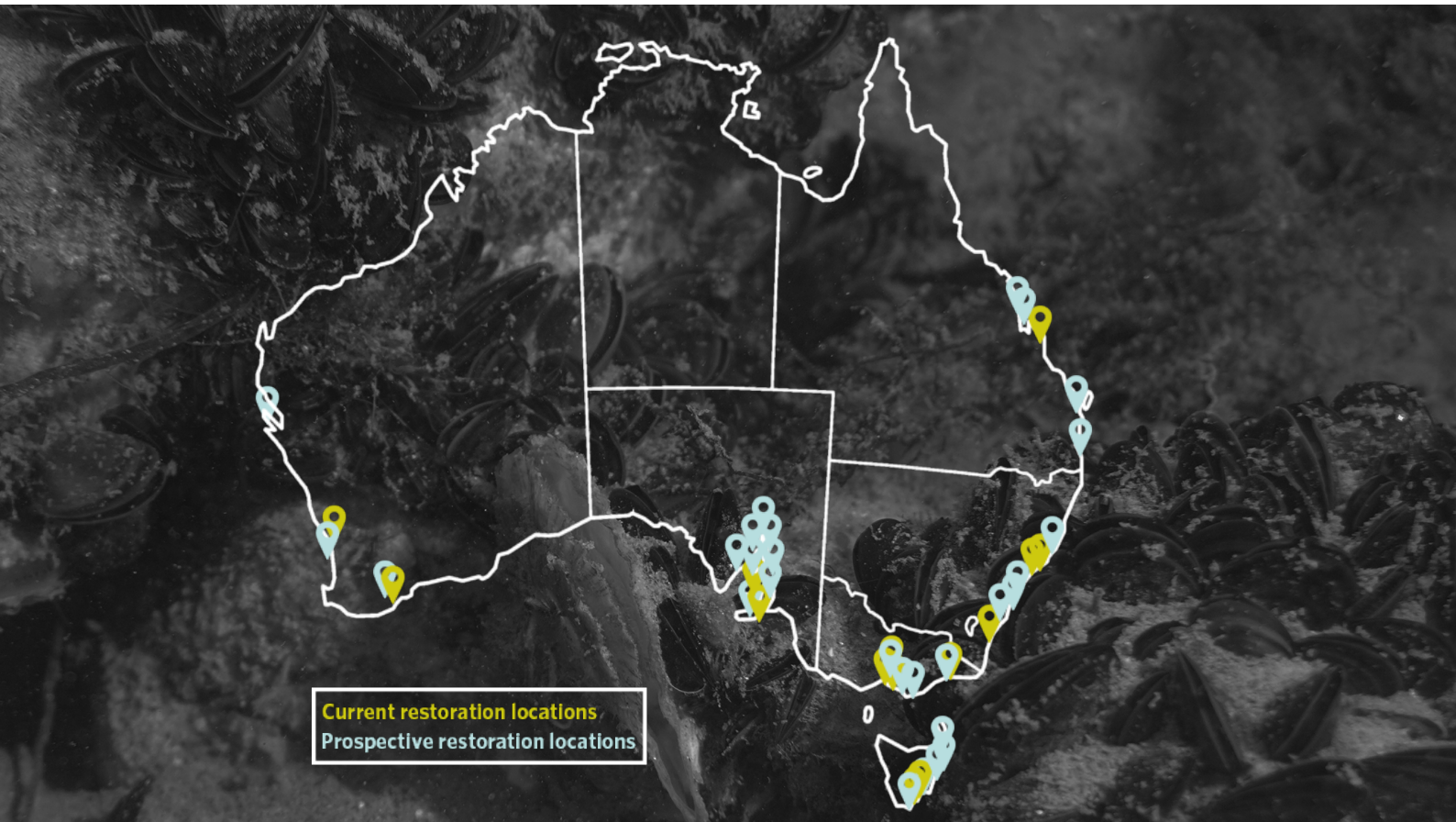


Figure 5: TNC's geographic representation of 60 current and prospective restoration locations towards or 2030 target

Photo: Australian Flat Oyster and Blue Mussel recruits on restored reef, Gippsland Lakes (VIC). Credit: Scott Breschkin/TNC Australia.

Building local capacity

A key pillar of our restoration success – and our ability to achieve the above 2030 target – is the support and expertise of local delivery partners and community members. *Reef Builder* has demonstrated the importance of that support, from sharing deep knowledge and experience, to volunteering thousands of hours to support reef building and shellfish gardening, to backing and growing our *Shuck Don't Chuck* shell recycling program. Through delivery partners such as NRM South in Tasmania, who led the restoration of the shellfish reefs in the Derwent River Estuary with TNC's support, *Reef Builder* has also exemplified how local capacity can be built to expand new restoration projects in the future.

We are committed to continuing to build local partnerships and capacity in shellfish reef restoration across Australia through (i) ongoing co-design of new reefs, (ii) two-way knowledge and skills transfer, (iii) expanding volunteer opportunities, and (iv) further developing and sharing the practical know-how for leading major reef construction projects.

Photo: Blue Mussel seeding using a Bivalve Blaster, Port Phillip Bay (VIC). Credit: Kina Diving.

Accelerating coastal ecosystem repair and resilience

While shellfish reefs alone produce a raft of ecosystem benefits for people and nature, these benefits vastly amplify when shellfish reefs interact ecologically with other foundation habitats across the coastal interface[5][6][7][8].

Our next phase of reef building work will seek opportunities to co-restore shellfish reefs alongside other native coastal habitats spanning the subtidal to intertidal, including kelp, seagrass, saltmarsh and mangroves. In addition to active co-restoration, this will also include opportunities to adapt the design of reef structures to better facilitate the natural recovery of surrounding habitats, such as through buffering wave energy to promote natural seagrass recovery and coastal protection.

This more holistic 'seascape' approach to coastal restoration can greatly accelerate ecosystem repair, leading to far more resilient coastlines that can better sustain environmental impacts, adapt to change, and produce more benefits for coastal communities. When inclusive of blue-carbon storing habitats such as mangroves, saltmarsh and seagrass, these benefits also extend to mitigating further climate change.

While still in an exploratory stage, TNC has begun modelling the potential to co-restore multiple native foundation habitats across Australia's coastal zone, revealing key 'co-restoration hotspots' with the potential to support eight or more foundation habitat-forming species. Capitalising on our vast natural potential to help up-scale our collective impact in restoring our coastal ecosystems is vital to our coastal futures.

[5]Thomsen, M.S., Altieri, A.H., Angelini, C., Bishop, M.J., Bulleri, F., Farhan, R., et al. (2022). Heterogeneity within and among co-occurring foundation species increases biodiversity. Nat. Commun. 13, 1–9. doi: 10.1038/s41467-022-28194-y

[6]Silliman, B.R., Schrack, E., He, Q., Cope, R., Santoni, A., Van Der Heide, T., et al. (2015). Facilitation shifts paradigms and can amplify coastal restoration efforts. Proc. Natl. Acad. Sci. U.S.A. 112, 14295–14300. doi: 10.1073/pnas.1515297112

[7]Reeves, S.E., Renzi, J.J., Fobert, E.K., Silliman, B.R., Hancock, B., Gillies, C.L. (2020). Facilitating Better Outcomes: How Positive Species Interactions Can Improve Oyster Reef Restoration. Front. Mar. Sci. 7:656. doi: 10.3389/fmars.2020.00656

[8]McAfee D., Reis-Santos P., Jones A.R., Gillanders B.M., Mellin C., Nagelkerken I., Nursey-Bray M.J., Baring R., da Silva G.M., Tanner J.E., Connell S.D. (2022). Multi-habitat seascape restoration: optimising marine restoration for coastal repair and social benefit. Front. Mar. Sci. 9:910467. doi: 10.3389/fmars.2022.910467

The Nature Conservancy would like to sincerely thank the Australian Government and all of our partners and stakeholders who helped make the *Reef Builder* Program such a success.

Our collective achievements have impacted on these ecosystems in ways that will continue to benefit people and nature for years, and will continue the vital work of restoring Australia's natural heritage.

For more information
Simon Branigan, Marine Restorations Manager
australia@tnc.org
03 8346 8600
Suite 2-01, 60 Leicester St, Carlton VIC 3053

natureaustralia.org.au

The Nature Conservancy
Australia