Ocean and Coastal Management 256 (2024) 107274

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Healing country together: A seagrass restoration case study from Gathaagudu (Shark Bay)

Elizabeth A. Sinclair [a,b,*], John Statton [a], Rachel Austin [a], Martin F. Breed [c], Richard Cross [d], Alex Dodd [d], Amrit Kendrick [e], Siegfried L. Krauss [b], Bianca McNeair [f], Nykita McNeair [d], Sean McNeair [d], Marika Oakley [d], Patricia Oakley [d], Tiahna Oxenham [d], Nicholas D. Pedrocchi [d,1], Talarah Pedrocchi Roelofs [d], Laetitia Wear [d], Gary A. Kendrick [a]

[a] School of Biological Sciences and Oceans Institute, The University of Western Australia, Crawley, WA, 6009, Australia
[b] Kings Park Science, Department of Biodiversity, Conservation and Attractions, West Perth, WA, 6005, Australia
[c] College of Science and Engineering, Flinders University, Bedford Park, SA, 5042, Australia
[d] Malgana Aboriginal Corporation Ranger Program, Denham, WA, 6537, Australia
[e] Sustain Nature Communication, Claremont, WA, 6010, Australia
[f] Buyungurra Nyarlu Turtle Program, Denham, WA, 6537, Australia

ARTICLE INFO

Keywords:
Amphibolis antarctica
Indigenous rangers
Malgana Aboriginal Corporation
Partnerships
Posidonia australis
Restoration framework
Traditional ecological knowledge
Western science

ABSTRACT

Ecological restoration is a key part of the global solution to help repair damaged ecosystems and moderate climate change. However, there are enormous challenges to contemporary restoration. Solutions that integrate western science and traditional ecological knowledge offer great opportunities to overcome these challenges. Partnerships with Indigenous Ranger programs can assist with solutions to some of the age-old restoration challenges. Managing and caring for a living and dynamic Country is at the heart of wellbeing for all Indigenous Peoples. The act of participating in restoration activities On Country assists with connecting to Country, healing people and Country. We describe the development of a successful partnership between western science and Indigenous traditional knowledge via a collaborative Malgana Aboriginal Corporation Ranger program that included On Country workshop-based knowledge sharing in north-west Western Australia, with a focus on seagrass restoration. Field-based restoration workshops helped people reconnect with Country through two-way knowledge sharing. Additional benefits of the partnership included education and preservation of Malgana language, educating western scientists and general public about Malgana culture, and adapting and field trialling seagrass restoration methods for Gathaagudu. Restoration can be successfully implemented through partnerships that share western science and traditional ecological knowledge.

1. Introduction

> "*If we look after Country, then Country will look after you*"
> Sean McNeair, 2021

The global rate of seagrass decline continues largely due to localized anthropogenic activities, including widespread impacts from climate change (Waycott et al., 2009; Dunic et al., 2021). Reversing this decline by restoring natural ecosystems and the services they provide is challenging and can take decades, even when human impacts are reduced (Marbà et al., 2015). Ecosystem restoration is a well-established practice and globally recognised action to stem biodiversity loss, as highlighted by the United Nations Decade on Ecosystem Restoration (2021–2030).

A shift toward Indigenous co-governance and management arrangements in Australia represents a new approach with opportunities for collaborative research and more effective restoration (Hedge et al., 2020; Cvitanovic et al., 2021). Indigenous people have responsibilities and cultural obligations as custodians of their Country to protect and maintain the health of their peoples, and their participation may be essential for successful ecosystem conservation, management, and restoration (Ens et al., 2015; Fischer et al., 2022; Goolmeer et al., 2022). Partnerships that promote knowledge sharing are increasingly

* Corresponding author. School of Biological Sciences and Oceans Institute, The University of Western Australia, Crawley, WA, 6009, Australia.
E-mail address: elizabeth.sinclair@uwa.edu.au (E.A. Sinclair).
[1] deceased.

https://doi.org/10.1016/j.ocecoaman.2024.107274
Received 20 June 2023; Received in revised form 25 June 2024; Accepted 5 July 2024
Available online 23 July 2024

recognised as best practice and a natural fit for improving ecosystem management, restoration and biodiversity conservation outcomes (Reed et al., 2018; Stori et al., 2019; Wheeler and Root-Bernstein, 2020). 'Seven Pearls of Wisdom' were derived through a community-based training approach to shellfish ecosystem restoration to facilitate productive partnerships including with Traditional Custodians (McLeod et al., 2018).

A successful Native Title determination for the Malgana Peoples in 2018 led to establishment of the Malgana Aboriginal Corporation (MAC) and associated Ranger program. This provided an opportunity to develop a partnership that shares knowledge to develop restoration methods (Tan et al., 2020; Sinclair et al., 2021). Here, we present a case study from Gathaagudu (Shark Bay), Malgana Land and Sea Country, where the Australian Government's National Environmental Science Program (NESP) Marine Biodiversity and Marine and Coastal Hubs supported a 2.5 year partnership between researchers and MAC Rangers to develop genetically informed restoration actions to assist the recovery of a seagrass-dominated ecosystem. The partnership was in response to a significant heatwave event which impacted terrestrial and marine ecosystems along Australia's west coast in 2010/2011 (Ruthrof et al., 2018) that resulted in the damage and loss of approximately 1300 km^2 of seagrasses in Shark Bay (Gathaagudu) (Kendrick et al., 2019; Strydom et al., 2020). We describe a series of seagrass-focused workshops, co-designed to develop a shared understanding and outcomes – enabling people and Sea Country to heal together. We discuss the cultural and environmental benefits of this partnership through workshopping new scalable seagrass restoration methods and show how this knowledge was shared more widely with the local community to improve understanding and caring for the remote World Heritage Area in which they live.

Fig. 1. Seagrass restoration sites in Shark Bay by transplanting (blue circles), assisted natural recovery through engineering substrate and sediment stabilisation (red circles), and seed-based restoration (green circle). Inset: Box indicating location of Shark Bay in Western Australia.

2. Methods

2.1. Cultural and environmental connections

Gathaagudu is located at the western edge of Australia, at the interface of temperate and tropical marine ecosystems (Fig. 1). It is the ancestral home of the Malgana peoples, for which stone artifacts and faunal fragments confirm periods of occupation during the Pleistocene between 30,000 and 18,000 years BP and again in the Holocene from 6000 years BP (Bowdler, 1990). Australian Aboriginal stories reflect genuine and unique observations of post-glacial sea level rise from about 13,070 to 7250 years BP (Nunn and Reid, 2016; Nunn et al., 2022). Stories shared by MAC Rangers about the walking tracks (or song lines) of their ancestors from Denham to Wirruwana (Dirk Hartog Island) and Bernier and Dorre Islands, across the sandy bottom or at low tides and guided by the location of freshwater seeps, are concordant with scientific reporting of sea level change associated with climate cycles (Lewis et al., 2013). The implications of this extraordinary longevity of oral traditions demonstrate effective intergenerational communication in aspects of Malgana culture and Country. Rising sea levels from the end of the last glacial maximum, approximately 8200 years ago (Lewis et al., 2013), mean that much of Malgana Country and cultural heritage is now inundated and lies under the expansive seagrass meadows at the bottom of the sea. Palaeontological data (Bufarale and Collins, 2015) indicate that the seagrass ecosystem within Shark Bay is only a few thousand years old. Carbon-dating of seagrass from sediment cores is consistent with the presence of *Posidonia* meadows in the bay for at least 3000 years (Serrano et al., 2016).

Today, Malgana Country is largely Sea Country with expansive seagrass meadows (or 'wirriya jalanyu' in Malgana language). Healthy seagrass meadows provide a range of ecosystem services including habitat for biodiversity, sediment stabilisation, and carbon storage to mitigate climate change impacts (Orth et al., 2006; Howard et al., 2017). They also provide habitat and food for culturally significant species such as dugongs (*Dugong dugon*, 'wuthuga'), green and loggerhead turtles (*Chelonia mydas* and *Caretta caretta*, 'buyungurra'), mullet (*Mugil* spp., 'mulgarda') and cormorants (*Phalcrocorax varius*, 'wanamalu'). A semi-permanent north-south horizontal salinity gradient (35–70+ practical salinity units) has been maintained following the formation of seagrass-dominated sills and banks which restrict water movement and ocean exchange in the lower gulfs (Kendrick et al., 2012; Bufarale and Collins, 2015). Much of Malgana Sea Country is also included in the UNESCO World Heritage Site, recognised for its "*exceptional natural beauty and aesthetics including outstanding examples of ecological and biological processes and significant habitats for biodiversity*" (IUCN, 1991). This unique hypersaline inverse estuarine system supports high biodiversity including 28 species of sharks ('thaaka'), 1500+ fish species, and 12 species of seagrass (Kendrick et al., 2012).

Large temperate seagrasses, *Amphibolis antarctica* (wire weed) and *Posidonia australis* (ribbon weed), are the dominant habitat-forming species, creating approximately 4300 km^2 of persistent meadows (Walker et al., 1988). Both seagrass species were devastated by an extreme heatwave along the west coast of Australia in 2010–2011 (Ruthrof et al., 2018), with damage and loss to 36% of seagrass cover (approximately 1300 km^2, Strydom et al., 2020). A significant flow on effect throughout the food web led to declining health of culturally-significant animal species and closure of some commercial aquaculture and fisheries (reviewed in Kendrick et al., 2019). Natural recovery of seagrass meadows has been slow (Kendrick et al., 2019), prompting the need for assisted recovery. More detailed knowledge about the restoration potential of seagrass meadows in Shark Bay was

needed to design and implement adaptive management strategies to address large scale loss and respond to future extreme events. The unique life histories of *A. antarctica* and *P. australis* (Fig. 2) permit multiple approaches to restoration and assisting natural recovery.

2.2. Partnering for recognition and cultural benefits

Indigenous Rangers and western scientists have important roles to play in identifying challenges, seeking opportunities, and developing productive relationships (Hedge et al., 2020). One significant barrier is the widespread lack of recognition of Indigenous knowledge (Ogar et al., 2020; Fischer et al., 2022). Partnerships provide an opportunity for equal recognition of knowledges for developing a shared vision to care for and restore Country. Our partnership incorporated 'Seven pearls of wisdom' (McLeod et al., 2018) to improve engagement with Traditional Custodians through:

1. Recognition. Malgana People have inhabited Gathaagudu for at least 30,000 years and were awarded formal access and determination of their Land and Sea Country through the Native Title Act in December 2018.
2. Working together from the beginning. This co-designed project was conceived under the stars at Hamelin Station - Malgana Country - and represents the first partnership between the Malgana Aboriginal Corporation and University of Western Australia.
3. Local employment. The project budget enabled employment for Malgana Rangers during training workshops. Workshop content contributed towards academic certification in Conservation and Land Management, thus providing recognition of all knowledge and upskilling.
4. Knowledge sharing. Two-way knowledge sharing occurred throughout the project and beyond, but was best done in person during informal workshops on Country.
5. Creating a shared vision. Discussions around the role of seagrass in shaping the marine environment generated a shared understanding and desire to look after Sea Country.
6. Early engagement. This project was conceived through informal discussions on Country and maintained through intermittent visits and online communications.
7. Connections. Connectivity between terrestrial and marine ecosystems and species (including humans) and the role of seagrass meadows in shaping the local marine environment was a continuing theme in conversations. Ranger participation in workshops On Country assisted with connecting or reconnecting to Country.

2.3. Partnering for environmental benefits

Initial planning conversations and knowledge sharing workshops were all conducted on Country between August 2018 and June 2022 (Table 1). Malgana Elders formally welcomed all visitors to Gathaagudu at the beginning of each visit and were invited to participate in activities. Workshops were informally structured to allow time to develop relationships, share knowledge of Country, history, biodiversity, culture, and language through storytelling and personal experiences (two-way learning).

The workshops covered a range of topics (Table 1) to share

Table 1
Knowledge sharing events and workshops conducted in Shark Bay between August 2018 and June 2022.

Activity	Date	Location	Western science	Indigenous science	Western participants	Indigenous participants
Initial concept and planning	11–12 Aug 2018	Science fair at Hamelin Station	Seagrass biology and ecology, restoration science	Welcome to Country, Knowledge sharing through storytelling	2	1
Workshop 1	10–11 Aug 2019	Science fair at Hamelin Station, Fowlers Camp	Seagrass biology and ecology, Introduction to an established restoration site via snorkelling, Assisting natural recovery using *Amphibolis antarctica* seedlings	Welcome to Country, Cultural protocols and safety, Two-way learning -Traditional ecological knowledge sharing and storytelling, Malgana language (places, flora and fauna)	7	8
Workshop 2	13–14 Nov 2019	Guischenault Point	Seagrass biology and ecology, Seed-based restoration of *Posidonia australis*	Welcome to Country, Cultural protocols and safety, Two-way learning -Traditional ecological knowledge sharing and storytelling	4	3
Workshop 3	28 Feb - 8 Mar 2020	Dubaut Point, Middle Bluff, Denham	Seagrass biology and ecology, Restoration using adult transplants, Assisting natural recovery using *Amphibolis antarctica* seedlings, monitoring survival and function	Two-way learning -Traditional ecological knowledge sharing and storytelling, Malgana language (places, flora and fauna)	4	4
Workshop 4	11–12 Aug 2020	Dubaut Point, Denham	Seagrass biology and ecology, Assisting natural recovery using *Amphibolis antarctica* seedlings	Cultural protocols and safety, Two-way learning -Traditional ecological knowledge sharing, Malgana language (places, flora and fauna), Knowledge sharing through storytelling, Communication with media (filmimg and interviews)	3	7
Wirriya Jalyanu (seagrass) Festival	5–6 Apr 2021	Denham	Knowledge sharing with the local community via Science talks, Living and museum collections, Seagrass biology and ecology, Seagrass mapping, interactive activities	Welcome to Country, Two-way learning -Traditional ecological knowledge sharing and storytelling, Cultural protocols and safety, Communication with media (filmimg and interviews)	6 (+volunteers)	6 (+volunteers)
Workshop 5 and Community meeting with Elders	8–19 Mar 2022	Denham, Fowlers Camp	Seagrass biology and ecology, Introduction to an established restoration site via snorkelling, Seagrass restoration methods, Risk assessments	Welcome to Country, Cultural protocols and safety, Malgana language (places, flora and fauna), Knowledge sharing through story telling	5	6
Workshop 6	27–30 Jun 2022	Monkey Mia	Seagrass biology and ecology, assisting natural recovery using *Amphibolis antarctica* seedlings	Welcome to Country, Cultural protocols and safety, Two-way learning -Traditional ecological knowledge sharing and storytelling, Malgana language (places, flora and fauna), Communication with media (filmimg and interviews)	4 (+volunteers)	2

knowledge of Sea Country and develop restoration activities within a restoration framework (Miller et al., 2017), adapted for seagrasses (Fig. 3). The framework was developed under five broad themes which incorporated a diversity of knowledge: Planning for restoration, sourcing plant material, optimising establishment, facilitating growth and survival, and ecosystem function, sustainability, and landscape integration. Each theme is a necessary part of planning for conducting and monitoring seagrass restoration. A series of simple questions were developed to identify when additional knowledge was required to achieve successful, long-term restoration (Table S1). Methods were designed to overcome challenges of working in remote areas with reduced technology, higher costs, and fewer personnel. We adapted and trialled methods to restore, assist natural recovery, and monitor seagrasses as outlined below.

2.3.1. Restoration using adult transplants

Transplanting adult shoots is a widely used technique to restore seagrass meadows with variable success (Bastyan and Cambridge, 2008; Statton et al., 2012; van Katwijk et al., 2016). We showed how to collect, prepare, and plant transplants. Adult rhizomes from *P. australis* (with 3–4 shoots) and *A. antarctica* (with 4–6 shoots) were harvested on SCUBA or via snorkelling along the growing edge of local meadows. The transplant material was placed into catch bags and returned to a boat for preparation. Preparation involved ensuring the rhizomes were not damaged, contained a growing shoot, and roots were removed (Hovey et al., 2011). Standard transplanting procedures were used (Bastyan and Cambridge, 2008) on snorkel or via SCUBA in less than 1.5 m depth. Two restoration sites were established adjacent to local source meadows, one each at Middle Bluff and Dubaut Point (n = 50 transplants of *P. australis* and *A. antarctica* each in 25 m^2 plots (Fig. 1).

2.3.2. Seed-based restoration of Posidonia australis

Guischenault Point was identified as a suitable location to collect *P. australis* fruit, as it is one of only two meadows known to produce viable fruit in Shark Bay (Fig. 2; Kendrick et al., 2019; Sinclair et al., 2020). The aim was to identify *P. australis* flowers and fruit, conduct flower counts and then demonstrate a technique to collect mature fruit and extract viable seed which minimises impact to the established meadow. Inflorescence stems up to 0.5 m either side of at least 5 × 5 m transects were counted, with the number of viable fruits, aborted fruits, and unfertilised flowers recorded. The 'Seeds for Snapper' methodology (described in Sinclair et al., 2021) to collect, extract, and sow viable seeds was then demonstrated.

2.3.3. Assisting natural recovery using Amphibolis antarctica seedlings

We used a hessian sandbag approach (Tanner et al., 2014) as a starting point, which is a sustainable, low impact restoration method focused on assisting recruitment of naturally dispersing *A. antarctica* seedlings. Viviparous seedlings develop attached to adult female plants and release when mature over an extended period of time, whereby they continue to grow while dispersing within the water column (Fig. 2). Each seedling has a 'grappling hook' at its base, enabling it to become snagged on seagrass or other fibrous materials, such as hessian, when it finally sinks. The seedlings can then establish roots and anchor into the sandy sediment. Commercially available hessian bags (~0.7 × 0.4 m) and our customised 'seagrass snaggers' (~2.0 × 0.15 m) were filled with local beach sand before being deployed from a boat (Fig. 4). Hessian sandbags were deployed in August 2019 (n = 30; Fowlers Camp) and seagrass snaggers in March 2020 (n = 100; Denham), August 2020 (n = 90; Denham and Dubaut Point) and June 2022 (n = 250, Monkey Mia). They were arranged linearly by snorkelers, perpendicular to the direction of water flow. A 5 m distance between rows removes the hydrodynamic effect the snaggers have on water movement, thus allowing the seedlings to settle, anchor and establish. The hessian was compostable and will break down over approximately 18 months, sufficient time for seedlings to establish. Seedlings that washed naturally into the nearby shallows or onto the beach were collected and dispersed at restoration sites or physically attached to snaggers as an additional enhancement.

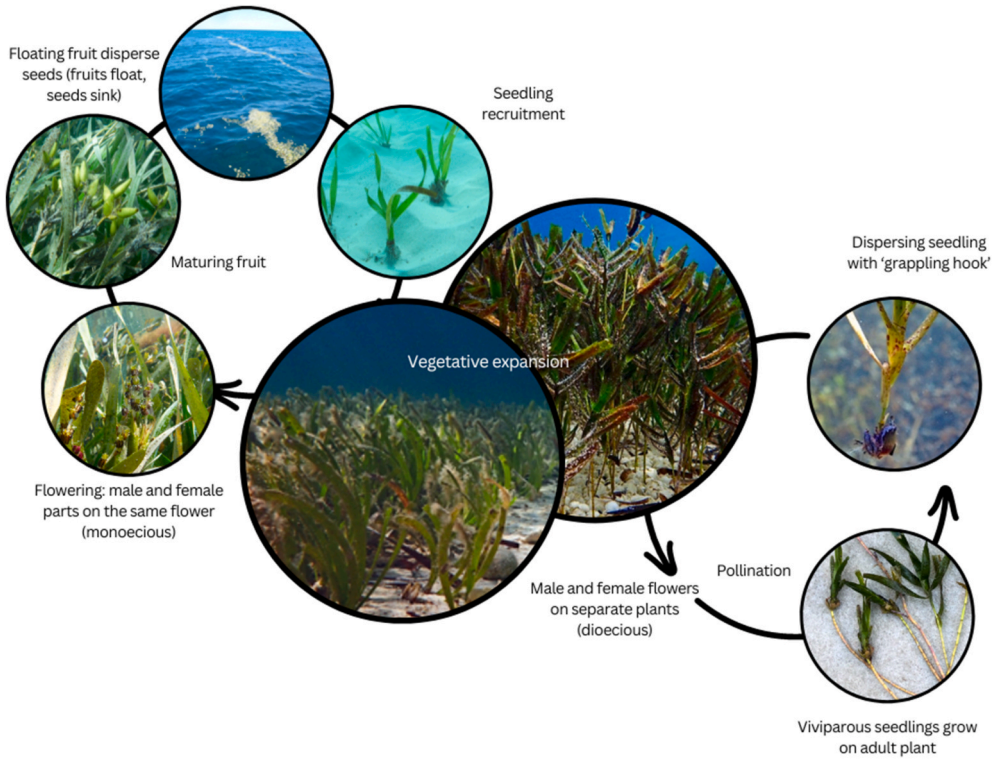

Fig. 2. Life history stages of wirriya jalyanu (left) ribbon weed, *Posidonia australis* and (right) wire weed, *Amphibolis antarctica*. Photos: Angela Rossen, Rachel Austin and Gary Kendrick.

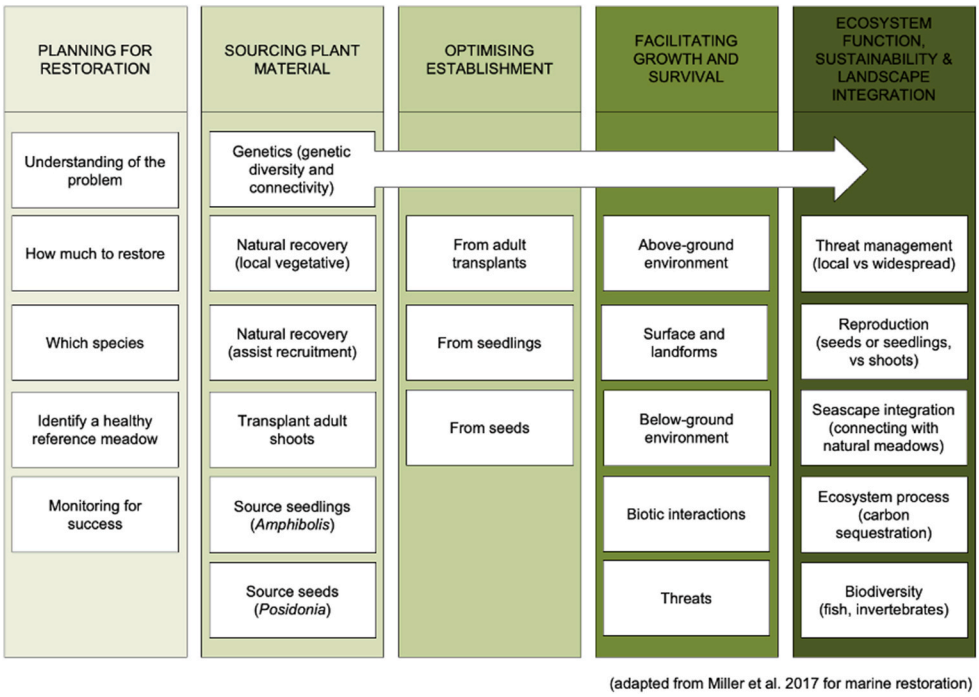

Fig. 3. Restoration framework as a practical guide to decision making for appropriate restoration activities, adapted for marine restoration from Miller et al. (2017). See Table S1 for key questions within each theme.

2.3.4. Monitoring survival and function

Monitoring is an important activity to assess initial survival, establishment, and expansion of transplants, particularly in large perennial species which may take 5–10 years to reach ~100% canopy cover. Survival (presence/absence of visible green shoots above the sediment) and growth (number of shoots) were assessed periodically. Swim overs were conducted at sites where hessian bags and seagrass snaggers were deployed to assess burial, seedling attachment, and observations of use by other species. Biodiversity assessments through fish and benthic macroinvertebrate surveys were also conducted as a measure of return of ecosystem function. Different aged restoration sites were again used as a surrogate for time. Existing five-year-old restoration sites at Useless Loop (at 3, 5, and 7 m depths) were also included as a surrogate for time to maturity. Shoot density counts were conducted in these sites as individual transplants had merged into dense meadows. Three 5 × 1 m belt transects were filmed for identification of fish and benthic macroinvertebrates. We slowly swam benthic transects while identifying and counting the macroinvertebrates present on each transect. This process was repeated in all restoration sites, as well as in adjacent unvegetated sandy patches and naturally occurring meadows for comparison.

2.4. Knowledge sharing with the community

The Wirriya Jalyanu (seagrass) Festival marked the end of our project funding and provided an important opportunity for scientists and MAC Rangers to share knowledge with attendees. The festival committee included scientists, MAC Rangers, and local community members. Shark Bay residents and visitors of all ages were invited to attend the festival to gain a greater understanding about the seagrass ecosystem through public talks and activities. The festival theme of 'Art meets Science' was designed to appeal to a wider audience, sharing knowledge of sea country through with a mix of science, culture, language, and artistic activities.

3. Results

3.1. Partnering for recognition and cultural benefits

Managing and caring for a living and dynamic Country is at the heart of wellbeing for Indigenous peoples; harm to Country degrades Malgana identity, Aboriginal identity, and Australian identity. Since the world was '*soft*', Malgana people have always had a connection to country, to people, lines, skin groups, family matters, hunting and gathering, and traditional learning. It means Indigenous Peoples have a place in history, but also a rite to determine their future. Malgana culture and Country have been profoundly impacted since European settlement, with recent observable changes in the health of culturally significant species (Kendrick et al., 2019). The capacity for human (and environmental) recovery is enormous. Most Malgana people have been separated from their country, culture, and language due to the lack of understanding of Indigenous culture and lore since colonization. Indigenous Ranger partnership programs, such as through this seagrass restoration project, have enabled a re-awakening and sharing of lost knowledges.

Recognition and respect are required to preserve Malgana cultural heritage, and to carry on traditions through teaching, with outside assistance. Addressing these issues through respectful and authentic partnerships provides a unique opportunity for Malgana people to return to Country, strengthen cultural connections and identity, as well as care for Country, as their ancestors before them have done so for thousands of years. Combining traditional ecological knowledge with restoration research and monitoring enabled the development of effective strategies to mitigate further impact of seagrass loss and develop meaningful relationships based on mutual respect, with a two-way learning experience. "*Being on Country is medicine for us*" said Sean McNeair in 2021, but restoring Country has a positive impact on ecosystem health and thus societal health, regardless of ancestry.

Several elements were learned and incorporated to overcome challenges along the way, many specific to developing a new partnership in remote Country. Solutions included the use of informal workspaces to remove potential learning and sharing barriers, finding the 'right person with authority to speak', balanced cultural and gender work groups,

Fig. 4. Workshop activities. (a) Introduction and meeting with Malgana Rangers at Hamelin Station; (b) Hessian bag with wire weed seedlings attached; (c) Filling seagrass snaggers; (d) deploying snaggers over the side of the vessel at a restoration site; (e) MAC Rangers monitoring the snaggers; (f) *Posidonia australis* transplants with colonising *Halodule uninervis*. Photos: Rachel Austin, Laetitia Wear, and Gary Kendrick.

flexibility as cultural practice usually takes priority over work milestones, allowing for informal knowledge sharing through storytelling, artistic expression, visual productions and conversations, and a factsheet which incorporated culture and language (Fig. 4a, Appendix S1).

3.2. Partnering for environmental benefits

The seagrass restoration training activities shared knowledge of the local species, how to collect and transplant adult plants and tested some new methods to reduce the need for SCUBA divers through assisting natural seedling recruitment. We learned that high survival rates could be achieved using adult transplants (greater than 75 % survival up to two years), and that *A. antarctica* transplants grew new shoots more rapidly than *P. australis*. It can take up to two years for *P. australis* to grow new shoots (Statton et al., 2021). A small tropical seagrass, *Halodule uninervis,* was commonly observed naturally recolonising restoration sites (Fig. 4e and f). Monitoring of older transplant sites showed that it will take at least five years for restoration sites to approximate the density and structure of a natural mature meadow, and that transplants grow faster and have higher shoot density in deeper sites (Statton et al., 2021).

The *P. australis* seed collection workshop in November 2019 (late spring) coincided with an extreme, astronomical low-tide event, one which had been predicted by MAC Rangers. The entire seed producing meadow at Guischenault Point was impacted (Fig. 5). A visual gradient of impact varied with depth and exposure to air. Meadows that remained submerged were sun-burned leading to leaf tip or entire leaves browning off (Fig. 5b), while those fully exposed to air at low-tide were completely bleached (Fig. 5c), a phenomenon rarely reported in seagrass meadows. A few shoots retained blackened inflorescences, but all fruit and seed development had aborted. No restoration trials were possible using seed.

We learned through field observations that peak seedling release occurs between June and August when seedlings were observed floating in the water column, attached to the seafloor where rhizome mat was exposed, and often washed up on the beach. The natural hessian bags were heavy and difficult to handle, and we concluded from monitoring three months post-deployment the shape could be improved, since few seedlings had attached (Fig. 4b). An improved design, an elongated 'seagrass snagger' can reduce sediment movement and provide additional substrate for dispersing seedlings to attach when adult meadows have been lost (Fig. 4c–e). No seedlings were attached to snaggers in July 2022 in Denham and some seedlings were observed attached to

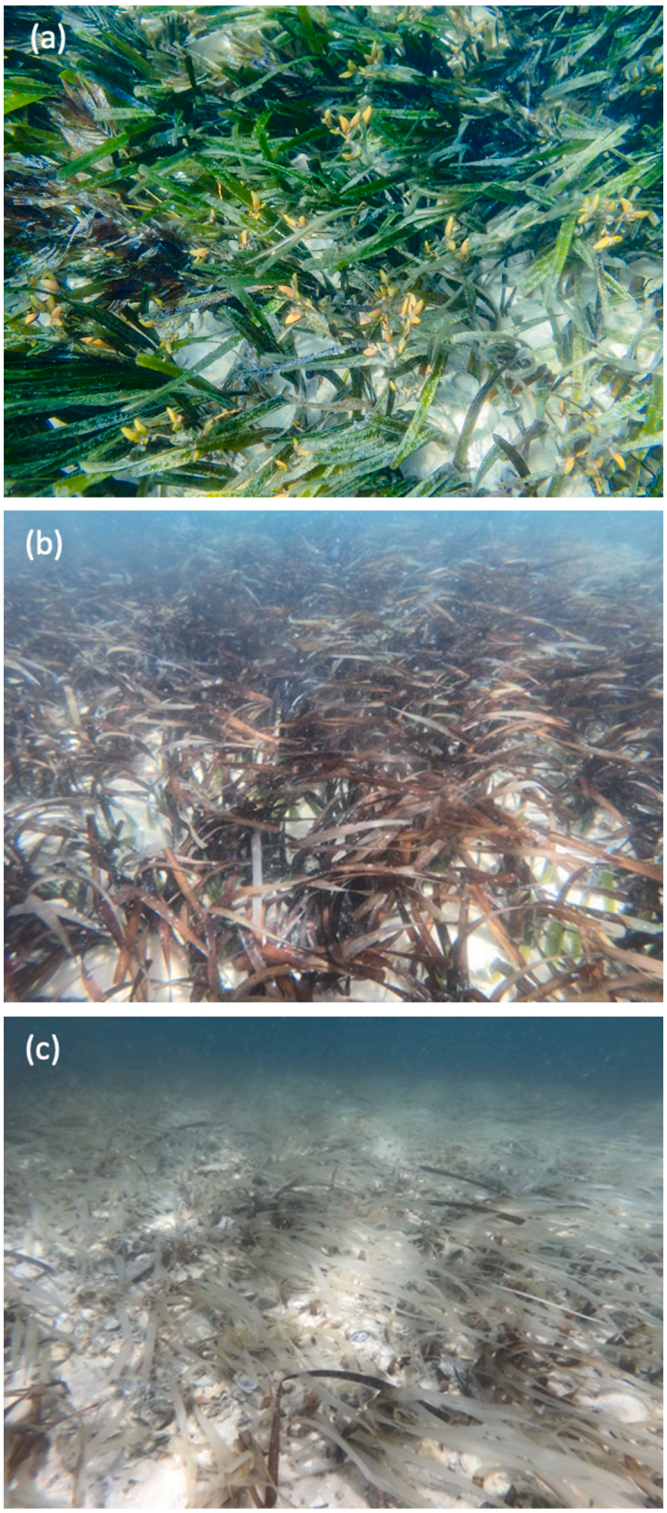

Fig. 5. Seed-based *Posidonia australis* restoration workshop at Guischenault Point: (a) Healthy green *P. australis* meadow with maturing fruit, (b) browned off leaves, and (c) complete bleaching of leaves leading to death of the canopy in December 2019.
Photos: Rachel Austin and John Statton.

snaggers in September 2022 at Monkey Mia, suggesting site selection and timing of snagger deployment will be important factors to consider. Snaggers remained in position and may continue to capture seedlings during the following season, depending on the extent of burial from sediment movement. Ad hoc observations noted the snaggers had provided structure and habitat for small algal species and some fish, with the tropical seagrass, *Halodule uninervis*, colonising areas in between snaggers.

The biodiversity assessment assisted with familiarity of local fish and macroinvertebrates. Fish species diversity was higher in older restoration sites with Butterfish, *Pentapodus vitta*, common in unvegetated sand and mature meadows. Thirteen different macroinvertebrates were observed across all transplant restoration sites for both seagrass species (Statton et al., 2021). Foraminifera were more common in mature meadows. Unvegetated sand had low fish and macroinvertebrate diversity.

3.3. Knowledge sharing with the community

The Wirriya Jalyanu (seagrass) Festival and science talks were attended by more than 140 Shark Bay residents and visitors of all ages. They travelled from as far as Albany and Carnarvon to attend the festival and gain a greater understanding about the seagrass ecosystem in the Bay. The festival theme of 'Art meets Science' meant knowledge was shared in different ways by western scientists, MAC Rangers and other Malgana community members. Activities included public talks, a language and art workshop for children, a student art competition, professional artworks, seagrass mapping, aquaria with seagrasses and marine invertebrates, museum collections, an interactive dance workshop and storytelling. There were many engaging stalls and presenters that brought wirriya jalyanu to the forefront.

> *"It was great to learn about a part of our country that we all take for granted and to see how locals are protecting and preserving this resource'* and *'Seagrass is so important in our lives. No seagrass - no marine life, No marine life - no fish, No fish - no fishing, No fishing - no tourists, No tourists – Sharks Bay will not be anything like we know it now.*
>
> *Long live seagrass!*"
>
> Anonymous community feedback, 2021

4. Discussion

Our partnership demonstrated that with the right resourcing and logistics, there are opportunities to support training workshops that develop expertise in seagrass restoration activities in Shark Bay. Having a local Indigenous ranger training program creates opportunities for local business to take advantage of favourable weather conditions to transplant and monitor larger areas. The next steps include empowering the MAC Rangers to regularly monitor and document both natural recovery and restoration success, to prepare and enact an annual schedule of restoration activities that help build seasonal local economies and increase the ability to restore seagrass at larger scales. Local people and businesses including a Malgana commercial business will also benefit economically through the provision of restoration related employment, such as sewing snaggers, collecting/deploying restoration materials to maintain a healthy and biodiverse marine ecosystem which supports tourism and recreational and commercial fisheries. Larger scale restoration projects will assist in the global challenge to mitigate the effects of climate change through carbon sequestration and biodiversity conservation.

Stakeholder participation in the environmental decision-making process has been increasingly sought and embedded into national and international policy. The complex and dynamic nature of environmental problems requires flexible and transparent decision-making that embraces a diversity of knowledge and values (Reed, 2008). Eight features of best practice participation were identified from a Grounded Theory Analysis of the literature (Reed, 2008). These features emphasised the need to replace a 'tool-kit' approach, with one that emphasises participation as a process. It is argued that stakeholder participation needs to be underpinned by a philosophy that focuses on empowerment, equity,

trust, and learning for a full partnership. This project started as a partnership with Malgana people. Initial project ideas were conceived through early conversations On Country, with a jointly written and funded grant proposal. Knowledge of successful seagrass restoration methods (Tan et al., 2020; Sinclair et al., 2021) has been shared with MAC Rangers through a series of training workshops On Country. These methods were trialled and adapted to local conditions, skills, and working in a remote location. Our approach reflects a continuing partnership between researchers and MAC Rangers and Elders over more than four years, and joint knowledge sharing with the local and wider community. Ultimately, more formal assessments of restoration and biodiversity conservation outcomes are meritorious, but do not capture the multiple benefits from our partnership approach which extended to cultural and social benefits, of which some can be quantified, and others are more challenging (e.g. a culture of mutual respect and 'connection to Country').

4.1. Healing country and people through a shared vision

Benefits to healing people while healing country are not often discussed in terms of local communities and culture (Brancalion et al., 2014). The end goal of this project was to develop a partnership with Traditional Custodians and conduct activities together that heal people and Country. Together, we developed and tested methods to assist the recovery of temperate seagrasses through shared learning and goals. We have established strong lines of communication and coordinated processes for organising and implementing workshops to restore the seagrass ecosystem. The seagrass research and restoration on Malgana Sea Country continues and may also serve as a broader approach for developing applied research and restoration programs in remote and extreme environments, demonstrating the widespread benefits for healing people and Country together.

Malgana knowledge and language is not lost, '*it is sleeping*' and will continue to be re-awakened through ongoing conversations that share and record knowledge. Malgana language can be preserved and revitalised through bilingual teaching and sharing of species (marine and terrestrial) and place names. The revitalisation of Malgana language is essential for ensuring the continuation and transmission of culture, customs, and history, but also important as a mechanism to address biodiversity and climate change in a cultural context. Malgana language does not have words to name the different seagrass species on Gathaagudu. In fact, 'wirriya jalyanu' is a contemporary name for seagrass, meaning 'wirriya' (sea) and 'jalyanu' (grass) were recorded as separate words by the last fluent traditional Malgana speakers (Auntie Ada Fossa, *may she rest in peace*. Malgana Elder, 2019). Word compounding is a method to create new words in language revitalisation (Hobson, 2014), and accepted across Australia as part of contemporary practice in language preservation and protection of traditional Aboriginal words.

Indigenous languages and cultural knowledges have been associated with understanding the patterns of climate change and ways to address its impacts (Australian Human Rights Commission, 2009). Therefore, cross cultural partnerships can assist biodiversity conservation and recovery of natural ecosystems across Australia and beyond. Such partnerships amplify Indigenous voices through sharing in and respecting all knowledges, provide a level playing field for all people and knowledge through the integration of western science and Indigenous knowledge, and build confidence in ranger groups within their local communities. Partnering with Traditional Custodians reflects a new respectful way forward (Fischer et al., 2022) in this era of meeting ambitious global solutions through programs such as UN Sustainability Development Goals, UN Decade on Ecosystem Restoration, and Global Biodiversity Conservation. Sharing knowledge two-ways within the local community provides a platform for on-going engagement and participation in future citizen science-based restoration activities.

4.2. Restoration and return of ecosystem function

We have demonstrated through workshops on conducting and monitoring small scale trials that seagrass meadows can be restored on Country using simple, effective methods. Transplants will take at least five years to establish a meadow, and longer to see comparable ecosystem services, such as biodiversity and carbon sequestration rates to those in natural meadows. Both seagrass species showed high survival rates for transplants, however, new shoot growth varied with site and species. The presence of transplants and snaggers for engineering sediment stabilisation led to natural colonization by smaller tropical seagrasses, *Halodule uninervis* and *Halophila* spp., and algal species. Local site-specific differences (site history, location, restoration effort and methodology, and environmental and biotic factors) and knowledge can be the difference between success and failure of establishing new meadows (via seeds, seedlings, or adult transplants). For example, high herbivore activity on adult transplants relative to natural source meadows previously reported in Shark Bay (Bell et al., 2019) was also observed at Middle Bluff and may significantly impact long-term survival and establishment. Thus, we caution against a 'one size fits all' approach, with site-specific responses a common outcome of many marine restoration projects (van Katwijk et al., 2016; Statton et al., 2018).

Seed-based restoration has enabled a scaling up of restoration in temperate seagrass ecosystems (e.g. Orth et al., 2020; Sinclair et al., 2021). The unusual canopy bleaching of subtidal *P. australis* showed it was sensitive to prolonged exposure to air that lead to a complete loss in annual seed production. Thus, unreliable, patchy, and low seed production by *P. australis* in Shark Bay (Sinclair et al., 2016; Sinclair et al., 2020; this study) suggests seed-based methods will not be possible in Shark Bay. Our modified hessian snaggers increased the edges available for snagging seedlings and were lighter and easier to handle than bags. They are worth further investigation, specifically into an alternative rougher hessian to increase snagging, deployment closer to seedling release time, and more snaggers in areas of high water flow and sediment movement.

Return of ecosystem function is rarely assessed, as restoration site monitoring is often not continued over longer time frames. Epifaunal richness may return within the first few years following restoration, despite low seagrass species diversity, abundance and structural complexity, although some species may require active (re)introductions (e.g. Sievers et al., 2022). Our biodiversity assessment in different aged restoration sites showed early recovery of biodiversity near natural meadows (<50 m), and it continued to increase as transplants established and habitat complexity increased through smaller naturally recruiting seagrasses, drifting and attached seaweeds and epiphytes. Other ecosystem functions, such as becoming self-sustaining through sexual reproduction, sediment stabilisation and carbon sequestration, associated with mature seagrass meadows are expected in increase with time.

Overall, recovery from large scale seagrass loss is a multidecadal process (Kendrick et al., 2019), even with extensive intervention to restore and/or assist natural recovery. Workshops conducted on Country helped to build cross cultural partnerships and develop seagrass restoration methods for Shark Bay. Combining these methods with genomic data (e.g. Edgeloe et al., 2022) and deciding whether to restore to historical baselines or anticipate future conditions remains a key topic for discussion that will influence restoration success in the face of climate change (Coleman et al., 2020), the largest threat to Shark Bay ecosystems. Restoring at appropriate scale continues to be challenging given the scale of loss that occurred from a single extreme event (e.g. Strydom et al., 2020). However, broadening partnerships with local Rangers and communities will increase our ability to be vigilant and to respond rapidly On Country.

5. Conclusion

We described a new partnership between western researchers and Malgana Aboriginal Corporation Rangers to develop seagrass restoration methods to assist with seagrass recovery on Gathaagudu. Our informal operating model provided cross-cultural, economic, and environmental benefits through two-way learning to develop nature-based solutions for climate change mitigation and biodiversity conservation. Knowledge sharing of science, land and sea Country, culture, and language, occurred through a series of informal workshops. The process of knowledge-sharing lead to engagement with people who care about their Country, shared efforts to help Country recover from an extreme climate event (marine heat wave) and develop a partnership on their terms in a program that works On Country. The workshops provided training and employment opportunities and improved connection to Country for Malgana Rangers, some of whom had never lived on Country. Scaling up seagrass restoration activities will continue to create benefits to people on Country. The next steps involve securing long-term funding and wider support to enable the MAC Ranger program and Indigenous lead organisations to expand the scale at which seagrass restoration is conducted.

CRediT authorship contribution statement

Elizabeth A. Sinclair: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Writing – review & editing. **John Statton:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Rachel Austin:** Writing – review & editing, Visualization, Supervision, Methodology, Funding acquisition. **Martin F. Breed:** Writing – review & editing, Investigation, Funding acquisition. **Richard Cross:** Resources, Methodology, Writing – review & editing. **Alex Dodd:** Visualization, Resources, Methodology, Writing – review & editing. **Amrit Kendrick:** Writing – review & editing, Supervision, Project administration, Methodology, Resources. **Siegfried L. Krauss:** Writing – review & editing, Resources, Investigation, Funding acquisition, Methodology. **Bianca McNeair:** Writing – review & editing, Resources, Methodology, Funding acquisition, Conceptualization. **Nykita McNeair:** Resources, Methodology, Writing – review & editing. **Sean McNeair:** Supervision, Resources, Methodology, Project administration, Writing – review & editing. **Marika Oakley:** Writing – review & editing, Resources, Methodology, Project administration. **Patricia Oakley:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Project administration. **Tiahna Oxenham:** Resources, Methodology, Visualization, Writing – review & editing. **Nicholas D. Pedrocchi:** Writing – original draft, Resources, Methodology. **Talarah Pedrocchi Roelofs:** Resources, Methodology, Writing – review & editing. **Laetitia Wear:** Visualization, Resources, Methodology, Writing – review & editing. **Gary A. Kendrick:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Resources, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

This partnership was supported through funds from the Australian Government's National Environmental Science Program (NESP) Marine Biodiversity and Marine and Coastal Hubs, supported by the National Department of Agriculture, Water and Environment, and Western Australian Department of Biodiversity, Conservation, and Attractions and Australian Research Council grants to GAK, MFB, SLK, and EAS (DP180100668, DP210101932). Our seagrass research and restoration workshops were conducted following the principles of the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) code. The original project proposal was jointly written with awarded funds shared equally.Workshops were conducted On Country with full support of the Malgana Aboriginal Corporation, Traditional Custodians of Gathaagudu Land and Sea Country. All training and restoration activities were conducted under valid Department of Biodiversity, Conservation, and Attractions permits (CE006510, CE006511). We thank Harriet Davies for her initial advice on developing successful partnerships; Maryka Gray for inclusion of seagrass restoration training into the Conservation and Land Management certification from the Central Regional TAFE, Western Australia; Perfect Nature Cruises for their contributions to Workshop 6; Malgana language assistance from Auntie Ada Fossa, *may she rest in peace*; the many volunteers: M. Booth, M. Cambridge, J. Edgeloe, M. Fraser, A-M. Frouws, K. Kruger, B. Martin, E. Perez-Wright, Y. Rahayu, and M. Taylor; and two anonymous reviewers for their constructive comments.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2024.107274.

References

Australian Human Rights Commission, 2009. Social Justice Report. Australian Human Rights Commission, Sydney, Australia.
Bastyan, G.R., Cambridge, M.L., 2008. Transplantation as a method for restoring the seagrass *Posidonia australis*. Estuar. Coast Shelf Sci. 79, 289–299.
Bell, S.Y., Fraser, M.W., Statton, J., Kendrick, G.A., 2019. Salinity stress drives herbivory rates and selective grazing in subtidal seagrass communities. PLoS One 14, e0214308.
Bowdler, S., 1990. The silver dollar site, Shark Bay: an interim report. Aust. Aborig. Stud. (2), 60–63.
Brancalion, P.H.S., Cardozo, I.V., Camatta, A., Aronson, J., Rodrigues, R.R., 2014. Cultural ecosystem services and popular perceptions of the benefits of an ecological restoration project in the Brazilian Atlantic Forest. Restor. Ecol. 22, 65–71.
Bufarale, G., Collins, L.B., 2015. Stratigraphic architecture and evolution of a barrier seagrass bank in the mid-late Holocene, Shark Bay, Australia. Mar. Geol. 359, 1–21.
Coleman, M.A., Minne, A.J.P., Vranken, S., Wernberg, T., 2020. Genetic tropicalisation following a marine heatwave. Sci. Rep. 10, 12726.
Cvitanovic, C., Mackay, M., Kelly, R., Wilson, S.K., Waples, K., Nash, K.L., van Putten, E. I., Field, S., Botterill-James, T., Austin, B.J., Beckley, L.E., Boschetti, F., Depczynski, M., Dobbs, R.J., Evans, R.D., Feng, M., et al., 2021. Thirty critical research needs for managing an ecologically and culturally unique remote marine environment: the Kimberley region of Western Australia. Ocean Coast Manag. 212, 105771.
Dunic, J.C., Brown, C.J., Connolly, R.M., Turschwell, M.P., Côté, I.M., 2021. Long-term declines and recovery of meadow area across the world's seagrass bioregions. Global Change Biol. 27, 4096–4109.
Edgeloe, J.M., Severn-Ellis, A.A., Bayer, P.E., Mehravi, S., Breed, M.F., Krauss, S.L., Batley, J., Kendrick, G.A., Sinclair, E.A., 2022. Extensive polyploid clonality was a successful strategy for seagrass to expand into a newly submerged environment. Proc. Roy. Soc. B. 289, 20220538.
Ens, E.J., Pert, P., Clarke, P.A., Budden, M., Clubb, L., Doran, B., Douras, C., Gaikwad, J., Gott, B., Leonard, S., Locke, J., Packer, J., Turpin, G., Wason, S., 2015. Indigenous biocultural knowledge in ecosystem science and management: review and insight from Australia. Biol. Conserv. 181, 133–149.
Fischer, M., Maxwell, K., Nuunoq, Pedersen, H., Greeno, D., Jingwas, N., Graham Blair, J., Hugu, S., Mustonen, T., Murtomäki, E., Mustonen, K., 2022. Empowering her guardians to nurture our Ocean's future. Rev. Fish Biol. Fish. 32, 271–296.
Goolmeer, T., Skroblin, A., Wintle, B.A., 2022. Getting our Act together to improve Indigenous leadership and recognition in biodiversity management. Ecol. Manag. Restor. 23, 33–42.
Hedge, P., van Putten, E.I., Hunter, C., Fischer, M., 2020. Perceptions, motivations and practices for Indigenous engagement in marine science in Australia. Front. Mar. Sci. 5, 533.

Hobson, J., 2014. How do you fill all the gaps in the dictionary? Identifying lexical development strategies for re-awakening Australian languages. In: Zuckermann, G., Miller, J., Morley, J. (Eds.), Endangered Words, Signs of Revival. AustraLex, pp. 1–18.
Hovey, R.K., Cambridge, M.L., Kendrick, G.A., 2011. Direct measurements of root growth and productivity in the seagrasses *Posidonia australis* and *P. sinuosa*. Limnol. Oceanogr. 56, 394–402.
Howard, J., Sutton-Grier, A., Herr, D., Kleypas, J., Landis, E., McLeod, E., Pidgeon, E., Simpson, S., 2017. Clarifying the role of coastal and marine systems in climate mitigation. Front. Ecol. Environ. 15, 42–50.
Kendrick, G.A., Fourqurean, J.W., Fraser, M.W., Heithaus, M.R., Jackson, G., Friedman, K., Hallac, D., 2012. Science behind management of Shark Bay and Florida Bay, two P-limited subtropical systems with different climatology and human pressures. Mar. Freshw. Res. 63, 941–951.
Kendrick, G.A., Nowicki, R.J., Olsen, Y.S., Strydom, S., Fraser, M.W., Sinclair, E.A., Statton, J., Hovey, R.K., Thomson, J.A., Burkholder, D.A., McMahon, K., Kilminster, K., Hetzel, Y., Fourqurean, J.W., Heithaus, M.R., Orth, R.J., 2019. A systematic review of how multiple stressors from an extreme event drove ecosystem-wide loss of resilience in an iconic seagrass community. Front. Mar. Sci. 6, 455.
Lewis, S.E., Sloss, C.R., Murray-Wallace, C.V., Woodroffe, C.D., Smithers, S.G., 2013. Post-glacial sea-level changes around the Australian margin: a review. Quat. Sci. Rev. 74, 115–138.
Marbà, N., Arias-Ortiz, A., Masqué, P., Kendrick, G.A., Mazarrasa, I., Bastyan, G.R., Garcia-Orellana, J., Duarte, C.M., 2015. Impact of seagrass loss and subsequent revegetation on carbon sequestration and stocks. J. Ecol. 103, 296–302.
McLeod, I.M., Schmider, J., Creighton, C., Gillies, C., 2018. Seven pearls of wisdom: advice from Traditional Owners to improve engagement of local Indigenous people in shellfish ecosystem restoration. Ecol. Manag. Restor. 19, 98–101.
Miller, B.P., Sinclair, E.A., Menz, M.H.M., Elliott, C.P., Bunn, E., Commander, L.E., Dalziell, E., David, E., Erickson, T.E., Golos, P.J., Krauss, S.L., Lewandrowski, W., Mayence, C.E., Merino-Martin, L., Merritt, D.J., Nevill, P., Davis, B., Phillips, R.D., Ritchie, A.L., Ruoss, S., Stevens, J., 2017. A framework for the practical science necessary to restore sustainable, resilient and biodiverse ecosystems. Restor. Ecol. 25, 605–617.
Nunn, P.D., Reid, N.J., 2016. Aboriginal memories of inundation of the Australian coast dating from more than 7000 years ago. Aust. Geogr. 47, 11–47.
Nunn, P.D., Ward, I., Stéphan, P., McCallum, A., Gehrels, W.R., Carey, G., Clarke, A., Cook, M., Geraghty, P., Guilfoyle, D., McNeair, B., Miller, G., Nakoro, E., Reynolds, D., Stewart, L., 2022. Human observations of late quaternary coastal change: examples from Australia, Europe and the pacific Islands. Quat. Int. 638–639, 212–224.
Ogar, E., Pecl, G., Mustonen, T., 2020. Science must embrace traditional and Indigenous Knowledge to solve our biodiversity crisis. One Earth 3, 162–165.
Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck Jr., K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Olyarnik, S., Short, F. T., Waycott, M., Williams, S.L., 2006. A global crisis for seagrass ecosystems. Bioscience 56, 987–996.
Orth, R.J., Lefcheck, J.S., McGlathery, K.S., Aoki, L., Luckenbach, M.W., Moore, K.A., Oreska, M.P.J., Snyder, R., Wilcox, D.J., Lusk, B., 2020. Restoration of seagrass habitat leads to rapid recovery of coastal ecosystem services. Sci. Adv. 6, eabc6434.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431.
Reed, M.S., Vella, S., Chalise, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R.K., Oughton, E.A., Sidoli del Ceno, J., van Delden, H., 2018. A theory of participation: what makes stakeholder and public engagement in environmental management work? Restor. Ecol. 26, S7–S17.
Ruthrof, K.X., Breshears, D.D., Fontaine, J.B., Froend, R.H., Matusick, G., Kala, J., Miller, B.P., Mitchell, P.J., Wilson, S.K., van Keulen, M., Enright, N.J., Law, D.J., Wernberg, T., Hardy, G.E. St J., 2018. Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses. Sci. Rep. 8, 13094.
Serrano, O., Lavery, P.S., López-Merino, L., Ballesteros, E., Mateo, M.A., 2016. Location and associated carbon storage of erosional escarpments of seagrass *Posidonia* mats. Front. Mar. Sci. 3, 42.
Sievers, M., Brown, C.J., Buelow, C.A., Hale, R., Ostrowski, A., Saunders, M.I., Silliman, B.R., Swearer, S.E., Turschwell, M.P., Valdez, S.R., Connolly, R.M., 2022. Greater consideration of animals will enhance coastal restoration outcomes. Bioscience 72, 1088–1098.
Sinclair, E.A., Statton, J., Hovey, R.K., Anthony, J.M., Dixon, K.W., Kendrick, G.A., 2016. Reproduction at the extremes: pseudovivipary and genetic mosaicism in *Posidonia australis* Hooker (Posidoniaceae). Ann. Bot. 117, 237–247.
Sinclair, E.A., Edgeloe, J.M., Anthony, J.M., Statton, J., Breed, M.F., Kendrick, G.A., 2020. Variation in reproductive effort, genetic diversity and mating systems across *Posidonia australis* seagrass meadows in Western Australia. AoB PLANTS 12, plaa038.
Sinclair, E.A., Sherman, C.D.H., Statton, J., Copeland, C., Matthews, A., Waycott, M., van Dijk, K.-J., Vergés, A., Kajlich, L., McLeod, I.M., Kendrick, G.A., 2021. Advances in approaches to seagrass restoration in Australia. Ecol. Manag. Restor. 22, 10–21.
Statton, J., Dixon, K.W., Hovey, R.K., Kendrick, G.A., 2012. A comparative assessment of approaches and outcomes for seagrass revegetation in Shark Bay and southern Florida. Mar. Freshw. Res. 63, 984–993.
Statton, J., Dixon, K.W., Irving, A.D., Jackson, E.L., Kendrick, G.A., Orth, R.J., Sinclair, E. A., 2018. Decline and restoration ecology of Australian seagrasses. In: Larkum, A.W. D., Ralph, P., Kendrick, G.A. (Eds.), Seagrasses of Australia: Structure, Ecology and Conservation. Springer Publishing, Cham, Switzerland, pp. 665–704.
Statton, J., Sinclair, E.A., McNeair, S., Kendrick, A., Kendrick, G.A., 2021. Assisting recovery of seagrass in Shark Bay, Gathaagudu. Final report to the National Environmental Science Program. Marine Biodiversity Hub, Australia, p. 88.
Stori, F.T., Peres, C.M., Turra, A., Pressey, R.L., 2019. Traditional ecological knowledge supports ecosystem-based management in disturbed coastal marine social-ecological systems. Front. Mar. Sci. 6, 571.
Strydom, S., Murray, K., Wilson, S., Huntley, B., Rule, M., Heithaus, M., Bessey, C., Kendrick, G.A., Burkholder, D., Fraser, M.W., Zdunic, K., 2020. Too hot to handle: unprecedented seagrass death driven by marine heatwave in a World Heritage Area. Global Change Biol. 26, 3525–3538.
Tan, Y.M., Dalby, O., Kendrick, G.A., Statton, J., Sinclair, E.A., Fraser, M.W., Macreadie, P.I., Gillies, C., Coleman, R., Waycott, M., van Dijk, K.-J., Vergés, A., Ross, J.D., Campbell, M.L., Matheson, F.E., Jackson, E.L., Irving, A.D., Govers, L.L., Connolly, R.M., McLeod, I.M., Rasheed, M.A., Kirkman, H., Flindt, M.R., Lange, T., Miller, A.D., Sherman, C.D.H., 2020. Seagrass restoration is possible: insights and lessons from Australia and New Zealand. Front. Mar. Sci. 7, 617.
Tanner, J.E., Irving, A.D., Fernandes, M., Fotheringham, D., McArdle, A., Murray-Jones, S., 2014. Seagrass rehabilitation off metropolitan Adelaide: a case study of loss, action, failure and success. Ecol. Manag. Restor. 15, 168–179.
van Katwijk, M.M., Thorhaug, A., Marbà, N., Orth, R.J., Duarte, C.M., Kendrick, G.A., Althuizen, I.H.J., Balestri, E., Bernard, G., Cambridge, M.L., Cunha, A., Durance, C., Giesen, W., Han, Q., Hosokawa, S., Kiswara, W., Komatsu, T., Lardicci, C., Lee, K.-S., Meinesz, A., Nakaoka, M., O'Brien, K.R., Paling, E.I., Pickerell, C., Ransijn, A.M.A., Verduin, J.J., 2016. Global analysis of seagrass restoration: the importance of large-scale planting. J. Appl. Ecol. 53, 567–578.
Walker, D.I., Kendrick, G.A., McComb, A.J., 1988. The distribution of seagrass species in Shark Bay Western Australia with notes on their ecology. Aquat. Bot. 30, 305–318.
Waycott, M., Duarte, C.M., Carruthers, T.J.B., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Short, F.T., Williams, S.L., 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proc. Natl. Acad. Sci. U.S.A. 106, 12377–12381.
Wheeler, H.C., Root-Bernstein, M., 2020. Informing decision-making with Indigenous and local knowledge and science. J. Appl. Ecol. 57, 1634–1643.