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Recentering the role of marine restoration science to bolster community stewardship

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ABSTRACT

The restoration of marine habitats is becoming a primary strategy for managing healthy coastal ecosystems, but initiatives often fail due to conflicts with social or industry activities. Confronting the challenge of expanding marine restoration for the 'Ocean Decade', this paper explores the ways that researchers could improve the way Governments and practitioners engage stakeholders with restorations of high socio-ecological and economic value. We seek to recenter the role of scientific knowledge-making in marine restoration by incorporating culturally informed socio-economic well-being into restoration practice; a process for encouraging greater marine stewardship by an engaged, more ocean literate public set to co-benefit from successful restoration practices. Using Australia's shellfish reef restoration program as a case study, we underscore the value of understanding diverse perspectives on marine restoration to foster a more inclusive restoration practice, one that nurtures a meaningful knowledge base to shift how restoration is viewed, engaged with, and funded.

1. Introduction: Society's role in marine ecosystem recovery

Coastal waters provide food, support diverse economic livelihoods, and foster socio-cultural connections to marine life for billions of humans worldwide. Consequently, our coastal culture, economy, and social well-being is closely tied to our relationship with the sea (Fleming et al., 2019), and its sustainable management is foundational to meeting the goals of the *United Nation's* 'Ocean Decade' (2021–2030). This 'Ocean Decade' is born of urgent necessity; our ever-increasing use and abuse of marine ecological goods and services are pushing coastal ecosystems to collapse worldwide (Jackson et al., 2001; Halpern et al., 2019). Human encroachment and exploitation have turned socially and ecologically valuable marine habitats into fragile ecosystems with little chance of natural recovery within meaningful timescales. Without effective environmental solutions and governance, we risk the collapse of coastal ecosystems.

Encouragingly, solutions to repair and sustainably use coastal seas are emerging. We are entering an era where habitat restoration is becoming the primary tool for managing ecological function (i.e., the UN 'Decade on Ecosystem Restoration', 2021–2030). And there is growing recognition that socio-ecological relationships — relationships between societal groups (industry, government, and community), and societal relationships with the environment — play a critical role in determining the success of marine restoration efforts (Abelson et al., 2020; DeAngelis et al., 2020; Fischer et al., 2021, Fig. 1). Furthermore, 'ocean literacy' has entered the scientific and educational vernacular for public understanding on the inextricable interconnection between humanity and the ocean, including our fundamental dependence on the ocean for social well-being (Cava et al., 2005; Kelly et al., 2022). However, restoration research remains overwhelmingly fixated on the ecological processes of restoration (Wortley et al., 2013; Bayraktarov et al., 2020), too often neglecting research on the major human motivations that enable the restoration (i.e., social and economic well-being; Aronson et al., 2010; McAfee et al., 2021a).[1] This major shortcoming of restoration research only increases the discrepancy between scientific recommendations and their practical implementation, as decision-makers must weigh multiple socio-economic and environmental considerations (Abelson et al., 2016). Additionally, failure to incorporate socio-ecological components into restoration research misses opportunities to inspire, engage, and educate society (i.e. enhance

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[1] While the restoration of the natural 'fish factories' (e.g. kelp forests) and filtration systems (e.g. oyster reefs) reflect some of the proactive efforts to repair and sustainably manage coastal ecosystems, such initiatives are unable to offset marine overextraction and environmentally-damaging human behaviour.

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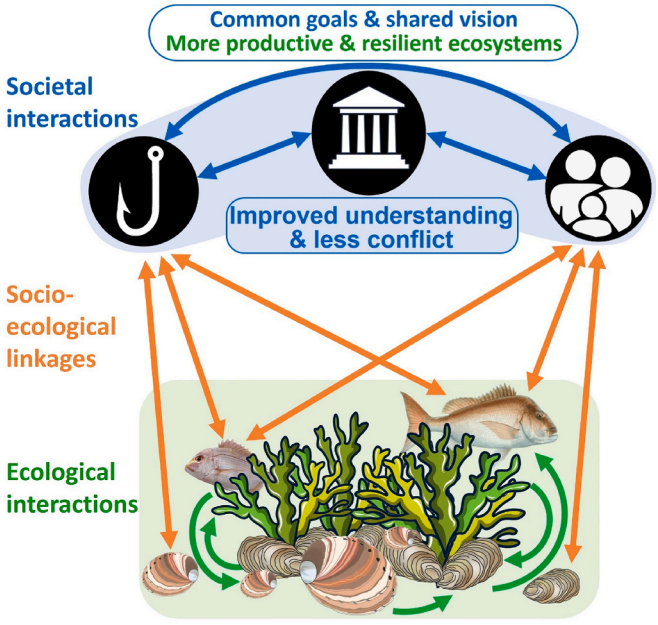

Fig. 1. Investigating the social interactions, ecological processes, and their linkages, will help inform restoration practice that is socio-ecologically sustainable and economically productive. Social research (blue) assesses how the perspectives of industry and the community change so that government can be involved positively. Ecological research (green) assesses which combinations of species boost habitat recovery and productivity. By integrating these socio-ecological findings (orange), we can build community and industry support for large-scale restoration. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

ocean literacy) on our interconnection with the sea (e.g., Kibler et al., 2018; McAfee et al., 2021b).

In this paper, we describe an approach to restoration research designed to increase community and industry participation in restoration to facilitate its long-term socio-ecological success – that is, achieving mutually beneficial outcomes for society and nature (Geist and Galatowitsch 1999). This approach recognises that successful restoration requires efforts that are founded not only on scientific rigour, but also local knowledge, community support, social adaptability, and successful industry partnerships (e.g., Walters et al., 2017; Cinner et al., 2019). We describe how we are applying this multi-disciplinary approach for restoration research to Australia's largest reef restoration program to recover lost shellfish reefs (McAfee et al., 2022). In alignment with the 'Ocean Decade' implementation plan, we recognise that environmental "solutions will deliver optimal benefits if they build upon robust ocean science that is co-designed and co-delivered by a diverse range of stakeholders" (UNESCO-IOC 2021). This kind of socially-engaged restoration research may inform more effective ways to inspire and educate the public and foster industry participation via improved ocean literacy (Ashley et al., 2019; Hein et al., 2019; Fiore et al., 2020). Such research may help create the foundations for a more inclusive practice that nurtures a paradigm shift in how restoration is viewed, engaged with, and funded.

2. Prioritising a socio-ecological approach for marine restoration

Effective governance and industry solutions to curb marine habitat loss are complicated by the many overlapping social and economic activities associated with the sea (Clarke et al., 2013). Indeed, historical government interventions in the use of coastal zones has been mired in mistrust and vexation; conflict with conservation efforts is common if local livelihoods are not considered (Bennett 2018). For example, where the formation of marine protected areas is perceived to displace local community activities, they can be met with community resistance and non-compliance (Kirkman 2013; Bennett and Dearden 2014) that may render the initiative politically unsustainable (Fabinyi et al., 2010). By contrast, governance that proactively engages with social perceptions and diverse end-user needs can identify practices that facilitate or hinder water management and other environmental solutions (Orlove and Caton, 2010), creating the necessary social legitimacy for intervention (McAfee et al., 2020). Put differently, governance efforts that identify and leverage the socio-economic perceptions of key stakeholders (i.e., coastal communities and marine industries) can meaningfully enhance the socio-ecological success of restoration.

A socio-ecological approach to restoration naturally provides a platform for knowledge exchange between the communities impacted by the restoration, and the researchers, decision-makers, and practitioners that enable the restoration. Such a socio-ecological dialogue is critical to identify the mutual dependences between society and nature, such as how specific human activities (e.g., fishing) shape the environment, and in turn, how environmental health supports social well-being (e.g., job creation, flood prevention; Geist and Galatowitsch 1999; Fischer et al., 2021). Such knowledge exchange may even facilitate the necessary cognitive and behavioural shifts needed to encourage more responsible use (e.g. low-impact fishing practices) and stewardship of marine ecosystems (McAfee et al., 2021b). Importantly, beyond exchange between impacted communities and restoration enablers, a socio-ecological approach may require analysis of how past historical conflicts between community groups, industry, and conservation initiatives have impacted public and commercial perceptions of the restoration process. This can help inform the social priorities of ecological restorations (Abelson et al., 2016), such as targeting greater fish production to boost regional tourism of recreational fishers. Mapping such social outcomes is critical because the socio-ecological perspectives and practices of coastal communities and industries inform how resources are valued and shared (McAfee et al., 2021b).

Informed environmental decision-making requires both diverse knowledge sources (natural sciences, local and indigenous, socio-economic, political etc.) and representation of diverse values and uses (HYDíaz et al., 2018). Establishing a forum for knowledge exchange on how nature contributes to local livelihoods, both positively and negatively, allows the decision-making process to use local knowledge to inform project goals and characteristics that meet diverse local needs (DeAngelis et al., 2020). Such an inclusive, collaborative approach to co-designed environmental solutions not only builds social legitimacy for the solution (Kelly et al., 2022) but provides opportunity to address the Ocean Decade goal of enhancing 'ocean literacy' in policy and community engagement (UNESCO-IOC 2021). Research on aligning environmental policy-making with diverse cultural perspectives, socio-ecological well-being, and economics, is needed to transform restoration to a practice that changes the way society values and cares for nature.

3. Reef restoration case-study

In this section, we (1) describe the process by which social legitimacy was gained for the construction of Australia's first large-scale oyster reef restoration, and (2) outline a multi-disciplinary approach to restoration research to engender greater social and industry participation for the long-term socio-ecological stability of marine restorations. This approach transcends traditional disciplinary boundaries by combining fundamental research on the ecological processes that enable habitat recovery, with social research on how ecological recovery influences social perceptions of restoration.

Our case study focuses on oyster reefs because they are considered a critical component of robust marine ecosystems. Oyster reefs once characterised temperate coastlines worldwide, but today are among the most degraded marine ecosystems globally (Beck et al., 2011; McAfee

and Connell 2021). In Australia, highly productive oyster reefs supported Indigenous economies over millennia and across thousands of kilometers of coastline (Reede-Myers et al., 2022), but are now considered functionally extinct (Gillies et al., 2020). Following European settlement of Australia, oyster reefs supported colonial settlements and an economically significant oyster dredge fishery until these reefs were all but eradicated within a century of colonisation (Alleway and Connell 2015). Despite their historical socio-economic significance, few people are aware these reefs ever existed (Alleway and Connell 2015). Nevertheless, recent scientific recognition on the extent of ecological change and, therefore, the need for ecological repair, has sparked change in how coastal systems are managed (McAfee et al., 2020, 2022). Today, to support coastal society and resilient ecological communities, a nationwide restoration program (*The Nature Conservancy's* "Reef Builder" program) is underway to restore the socio-ecological benefits oyster reefs once provided (e.g., more fish, cleaner coastal waters, ecologically resilient communities). Yet, despite this early political success for reef restoration, the long-term socio-ecological success remains contingent on broad community support and stewardship.

For Australia's first large-scale reef restoration (South Australia's Windara Reef), social legitimacy was generated through a multi-faceted community engagement program run through the informative years of the project; from project conceptualisation, to formalisation, and construction and monitoring. In the following sections, we tease apart the actions taken to encourage social participation and build legitimacy during each phase of this project, and describe research to understand the enabling factors for this restoration so they can be disseminated and replicated elsewhere.

3.1. Conceptualisation

This restoration project was born from a 2014 State election commitment to create an unspecified recreational fishing resource, an initiative to offset the impact of new marine protected areas that had displaced disgruntled fishers (Kirkman 2013). Close consultation with the fishing community was therefore a government priority for conceptualising the project. To facilitate publicly-informed decision-making, the State Government led two forms of community and industry engagement: (i) a public consultation process that included both face-to-face and online public forums to gather public opinion on what form these projects should take, and (ii) an independently chaired advisory group that incorporated recreational fishing and local community representatives (McAfee et al., 2021b). Coincidently, at this same time, the ecological baseline of the extinct oyster reefs in the State was published (i.e., 1500 km of lost oyster reef; Alleway and Connell 2015), suggesting that oyster reef restoration could provide an alternative, nature-based solution to repair local fish populations and the recreational fishing experience.

During initial consultation, the recreational fishing community expressed their preference for artificial fishing structures. Many fishers voiced their scepticism of government overregulation once the structures were built, while many members of the broader public were concerned that artificial fishing structures would only contribute to overfishing (i.e., "just an attempt by government to appease all those disgruntled recreational fishers"; McAfee et al., 2021b). Qualitative analysis of the public discourse on this project at the time (2015–2016) revealed a transition from broad scepticism to a more optimistic outlook as discussions transitioned from artificial structures to oyster reef restoration (McAfee et al., 2021b). The 2015 publication of the historical baseline for local oyster reefs assisted this transition by providing a conceptual model for the restoration of a lost ecosystem (McClenachan et al., 2012), and by supporting an enticing historical narrative with which to engage the public on ecological recovery (Kittinger et al., 2015). This shift, from scepticism of artificial structures to optimism for a nature-based solution, was communicated through public forums with evidence on the fish-producing benefits of oyster reefs (zu Ermgassen et al., 2015) and successful restoration case-studies from the United States.

3.2. Formalisation

To formalise the project, the government-facilitated advisory group was broadened to include stakeholder representatives for any group identified as potentially impacted by the project (e.g., recreational and commercial fishers, aquaculture and tourism industries, local community and conservation groups). This platform for knowledge exchange provided direct linkages between the stakeholders and decision-makers, allowing stakeholder concerns to be voiced and resolved early in the decision-making process (McAfee et al., 2021b). Furthermore, an online forum gave the broader public the opportunity to vote on where they wanted the restoration located. In proactively working to incorporate stakeholder interests into the goals of the project, this socially-informed pathway for decision-making ultimately built public and industry support for the solution (McAfee et al., 2021b).

Although considerable public licence was generated for the restoration project, enacting policy to restore a locally extinct ecosystem was still inherently risky; for example, there was no guarantee that oysters would colonise or survive, no natural reefs against which to measure success, and no certainty the reefs would not be destroyed by a storm. Yet, government decision-makers were willing to take this risk. Knowledge on the underlying thought processes that enabled this risk taking is lacking, limiting the lessons learnt from these now socio-politically and ecologically successful project (discussed in the following section). To address this knowledge gap, we are conducting qualitative semi-structured interviews (Kallio et al., 2016) with the key personnel that enabled the project (i.e., government and conservation managers) to understand the underlying motivations and cultural influences that influenced their decision-making, including the specific constraints and opportunities (social, financial, political). While certain social and practical components of these projects will be State-specific, there are no doubt lessons to be learnt from the decision-making pathways undertaken in South Australia that may foster lessons for other national or international initiatives.

3.3. Construction and monitoring

The State Government's strategic management goal for the restoration seeks to build community and industry participation for its long-term stewardship. To this end, public engagement initiatives continued through construction and monitoring of this first restoration (Windara Reef), and into the State's successive oyster reef restorations (new projects initiated in 2020, 2021, and 2022; McAfee et al., 2022). For example, the advisory group established in 2015 to realise the project continues to meet to this day, and community groups (e.g., Friends of Windara Reef) have maintained engagement through project updates and volunteer opportunities. A more ocean literate public is now also evident, at least in terms of knowledge on habitat restoration, as two independent community groups have successfully lobbied council funding to lead their own restorations (e.g., Estuary Care Foundation SA; estuary.org.au).

The early social and political success of these restorations appears clear (new reefs being built by government and community). But to ensure ongoing project stewardship and knowledge-building on the socio-ecological dependencies of restorations, particularly the various ways different people view and use nature (orange arrows in Fig. 1), we advocate social research be incorporated into long-term restoration monitoring programs. For these restorations, face-to-face surveys are being conducted to capture public knowledge and perceptions on these restorations (at boat ramps, on coastal foreshores, and in urban centres). These surveys revealed the groups that the engagement campaign had either succeeded or failed to reach; for example, 75% of all rural respondents have some knowledge of their local reef restorations, whereas

just 14% of non-recreational fishers who live in metropolitan areas were aware of these projects that are among the largest marine restorations in Australia (unpublished data). Furthermore, these ongoing surveys reveal striking differences between rural and metropolitan participants in terms of their environmental concern and the perceived benefits of these restorations. For example, metropolitan participants are 4 times more likely than rural participants to identify improved water quality as the key benefit of restoration, whereas rural participants were twice as likely to identify increased fish abundance as the key outcome (unpublished data). Such knowledge can identify where communication efforts should be targeted and improve messaging campaigns by identifying which leverage points are likely to cultivate interest from each community (Hine et al., 2016).

4. Discussion: Restoration's role in creating ocean literacy for the ocean decade

A key outcome of the Ocean Decade is understanding the many ways coastal seas contribute to human well-being, culture, and sustainable development (UNESCO-IOC 2021). Such knowledge is needed if people are going to value and support marine restorations; projects will need to embody the human values that motivate public engagement and ongoing stewardship of nature (Perring et al., 2018, McAfee et al., 2021a). As demonstrated by our restoration case-study, some governments are awake to the reality that the sustainability of marine management requires an engaged society, literate on the benefits of the solution. Yet, concerningly, social research remains on the periphery of marine restoration research (Bayraktarov et al., 2020), despite its potential to illuminate the key social processes that enable restoration success (DeAngelis et al., 2020). The coupling of social and ecological research – including via the aforementioned public surveys designed to track how social knowledge and perceptions change as restorations change – has the potential to inform where and how to invest in public engagement. This vital socio-ecological knowledge could help change the way people support, value, and fund restorations (BenDor et al., 2015).

The Ocean Decade identifies an 'inspiring and engaging' ocean as a key outcome for enhancing ocean literacy (UNESCO-IOC 2021), and ecological restorations appears particularly well placed to inspire, engage, and educate. Public engagement on the need for restoration often involves rich historical narratives of past productive seas and unsustainable socio-ecological practices (e.g., overfishing; Kittinger et al., 2015), combine with messages of hope for rebuilding productive ecosystems (Duarte et al., 2020). Such narratives of loss and optimism appear particularly effective at grabbing an audience's attention (McAfee and Connell 2019). And the narrative of oyster reef loss and recovery appeared to resonate and inspire the public with the described restoration initiative. From practically no public awareness of the loss of South Australian oyster reefs in 2015 (Alleway and Connell 2015), just two years of public engagement managed to build the necessary support and social legitimacy for the State Government to enact the first large-scale oyster reef restoration in Australia (McAfee et al., 2021b). Our subsequent social surveys have confirmed high community awareness of these restoration, but also identified disengaged communities (i.e., non-recreational fishers in metropolitan areas). Of particular note, the ocean literacy generated from the engagement campaign has led to two independent community-led restoration initiatives, an outcome that embodies the aspirations of the Ocean Decade.

Contemporary marine restoration practice is still relatively young. The scale and manner by which we restore marine habitats is changing, and social perceptions will change with it. For example, new restoration techniques aimed at accelerating restoration processes (e.g., multi-habitat restorations [McAfee et al., 2021c]; marine soundscape manipulation [Williams et al., 2021]) may elicit different public responses, positive or negative, that may alter social perceptions (Fig. 1). Capturing how social perceptions change with restoration practice and as restored ecosystems mature (e.g., longitudinal social research), will better conceptualise complexity in socio-ecological restorations, including emergent cultural practices and social adaptability (Fabinyi et al., 2010). This could be achieved by repeating social surveys every few years, a process for maintaining knowledge on how best to engage community and industry on restoration stewardship and compliance.

The greatest hurdle to the long-term success of restorations is ongoing financing (Aronson and Alexander 2013), and the restoration agenda described here is no exception. The political will and social licence for expanding the restoration initiative is clear (McAfee et al., 2022), but the government funding that has driven these restorations is unlikely to continue without private and/or industry buy-in. Social and economic research could play a pivotal role here. For example, personal motivations and environmental attitudes are core to people's willingness to support conservation initiatives (Greiner 2015), and public surveys could identify community groups with heightened willingness to 'crowdfund' restoration efforts (Gallo-Cajiao et al., 2018). Private and corporate investment in restoration is also growing (BenDor et al., 2015), as is corporate responsibility to act environmentally (Baroth and Mathur 2019). Ethnographic research could help identify such funding sources by revealing the underlying values and principles that motivate corporate decision-makers (e.g., semi-structured interviews), particularly those corporations impacted by marine restorations (e.g., commercial fishing industry). And as restorations improve the socio-economic well-being of coastal communities, this may result in residents' new willingness to pay for restorations, either through voluntary restoration levies or through taxation (MacDonald et al., 2015, Iftekhar et al., 2017).

Oyster reef restoration is fast becoming a mainstream solution for managing socio-ecological sustainability worldwide (e.g., Hernandez et al. 2018; Pogoda et al., 2019; McAfee et al., 2022). While many of the decision-making, social, and practical components of the South Australian case-study described here may be context-specific, there are doubtless lessons to be learnt to inform decision-making at other state, national, or international scales. For example, the strategy to focus engagement on the fish production benefits of oyster reef restoration was well-founded, as quantified by the social surveys. This narrative building centred on a topical issue for South Australians; the recent decline of fish stocks and its impact on the socio-economically important recreational fishing community (over a million hours of recreational fishing per annum; Giri and Hall 2015). While this focus on fish is unlikely to resonate with populations that lack a strong connection to their coastal seas, a similar focusing-in on the values and fears of the intended audience is likely to resonate. For example, in New York harbour – where oyster reefs were similarly lost and largely forgotten over a century ago – public engagement on the potential benefits of New York oyster restorations fuelled desires to harness the 'infrastructural' power of oyster reefs to mitigate storm surges from extreme weather events (e.g., Hurricane Sandy in 2012)(Wakefield 2020). The campaign to use oyster restoration as a solution to reduce storm impacts involved highlighting the natural services of oysters using metrics the public can understand and appreciate, including biodiversity benefits and socio-economic gains to rationalise the project (Wakefield 2020: 773). The successful campaign materialised in the USD$60 million Living Breakwaters project – a 2-mile artificial oyster reef in New York Harbour that is calculated to save USD$263 million in damages should another 100-year storm event like Hurricane Sandy occur, while annually generating USD$15 million for the economy and engaging 23,500 students with nature-based solutions (SCAPE 2021). This New York project, much like the Australian restorations described in this paper, enables oysters to modify other natural processes (wave energy and fish production, respectively) in order to improve social and economic well-being.

Although restoration projects carry considerable risk of failure, regardless of their place of implementation, what we seek to highlight is the considerable engagement generated through the sustained effort to

improve public understanding of the benefits of these projects. As the implemented restoration projects mature – be they in South Australia or on the coasts of New York City – there is significant scope to study how local communities understand the ongoing value of such projects, particularly where the project meets or misses its intended goals. Where such research maintains public engagement with ecological progress, it might reveal the socio-ecological talking points that sustain social support, promote community stewardship, and build ocean literacy.

5. Conclusion

For marine restorations to be successful, an integrated social and ecological monitoring program offers potential to deliver multiple scientific, policy, and engagement outcomes. What motivates people to care about restorations is less likely to be ecological outcomes, but rather the value-laden social and economic goals for which the ecological outcomes provide the means (Geist and Galatowitsch 1999; Martin 2017). Therefore, social analysis of the community values that motivate public interest will allow informed decision-making on the project goals likely to resonate with stakeholder communities. Such knowledge will provide valuable insight on the hopes and fears of stakeholders impacted by restorations, knowledge that can improve the resonance of engagement efforts. Importantly, when combined with improved public literacy on restoration initiatives, this knowledge can improve understanding between policy-makers and stakeholder communities, a process for creating a shared vision on common goals for restorations that lead to more sustainable environmental solutions and enhanced community stewardship of marine ecologies.

Perspective article

Science for Ocean Sustainability - An Earth System Governance perspective.

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.

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