Biological Conservation 313 (2026) 111573

Contents lists available at ScienceDirect

Biological Conservation

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

Policy analysis

Creating a global kelp forest conservation fundraising target: A 14-billion-dollar investment to "help the kelp"

Aaron M. Eger [a,b,*], Julia K. Baum [c,d], Tom Campbell [e], Bruno Cevallos Gil [f], Hannah S. Earp [g], Annalisa Falace [h], Jan Freiwald [i], Sara Hamilton [j], Steve I. Lonhart [k], Keith Rootsaert [l], Makena Åsa Rush [m], Jasmin Schuster [d], Brian Timmer [d], Adriana Vergés [a,b]

[a] University of New South Wales (UNSW), Sydney, Australia
[b] Kelp Forest Alliance, Sydney, Australia
[c] University of Victoria, Victoria, Canada
[d] The Kelp Rescue Initiative, Bamfield Marine Sciences Centre, Bamfield, Canada
[e] West Coast Kelp, Bamfield, BC, Canada
[f] Universidad Científica del Sur, Lima, Peru
[g] Institute of Marine Research, His, Norway
[h] University of Trieste, Trieste, Italy
[i] Reef Check Foundation, Santa Cruz, USA
[j] The Oregon Kelp Alliance, Port Orford, USA
[k] Monterey Bay National Marine Sanctuary, Santa Cruz, USA
[l] Giant Giant Kelp Restoration, Monterey, USA
[m] University of California Santa Cruz, Santa Cruz, USA

ARTICLE INFO

Keywords:
Finance
Kelp forests
Biodiversity
Marine
Conservation
Funding

ABSTRACT

Kelp forests are vital marine ecosystems that support high biodiversity and provide essential economic and cultural services along one-third of the world's coastlines. However, many of these underwater forests are declining worldwide, prompting international initiatives to set ambitious conservation goals. The Kelp Forest Challenge, a global, grassroots initiative, aims to protect 3 million and restore 1 million ha of kelp by 2040. Achieving such area-based targets requires significant financial investment. Here we present the development of a global finance target for kelp forest conservation, formulated through a multi-stakeholder consultation and cost scenario analysis. We describe the methods used, including expert workshops and comparisons with analogous initiatives for coral reefs and mangroves. Three cost scenarios (low, medium, high) were identified for both kelp restoration and protection efforts based on global hectare targets and unit cost data. We estimate that total funding needs range from approximately $1.9 billion to $58 billion (USD), depending on cost assumptions. By using the middle cost assumptions, we propose a fundraising target of ~$14 billion. The consultation process reached consensus on adopting the medium-cost scenario as a realistic yet ambitious funding target. In the discussion, we examine the implications of this target in the context of global conservation frameworks, addressing uncertainties (e.g., regional cost variability and knowledge gaps) and outline future research needs. This work provides a data-informed financial benchmark to mobilize resources for kelp forest restoration and protection, aligning kelp conservation with other global marine conservation "breakthrough" initiatives.

1. Introduction

Kelp forests, formed by large brown seaweeds (order Laminariales and Fucales) (Coleman and Wernberg, 2017; Steneck et al., 2002), are among the most productive and ecologically important marine ecosystems on the planet (Wernberg et al., 2019). These forests fringe roughly one-third of the world's coastlines, creating structurally complex habitats that support hundreds of species, including micro and macro fauna and economically important species such as abalone and lobsters (Desmond et al., 2018; Mayfield et al., 2012; Smale et al., 2022).

* Corresponding author at: University of New South Wales (UNSW), Sydney, Australia.
E-mail address: aaron.eger@unsw.edu.au (A.M. Eger).

https://doi.org/10.1016/j.biocon.2025.111573
Received 14 June 2025; Received in revised form 15 September 2025; Accepted 16 October 2025
Available online 26 October 2025

In economic terms, the ecosystem services provided by kelp (including fisheries habitat, nutrient and carbon cycling) have been valued at over $500 billion USD per year (Blamey and Bolton, 2018; Eger et al., 2023; Vasquez et al., 2014). Despite their importance, kelp forests have received comparatively less global conservation attention than coral reefs or mangroves (Valckenaere et al., 2023).

Globally, kelp forests are in decline due to a combination of climatic and anthropogenic stressors (Wernberg et al., 2024). It is estimated that 40–60 % of kelp forest ecosystems worldwide have been degraded or lost in the last 50 years (United Nations Environment Programme, 2023). Indeed, kelp forests are the most vulnerable temperate marine ecosystem to climate change (Ruane, 2024) and over 3 million ha of kelp is considered to be in a degraded state (Eger et al., 2024a). In some regions, declines have been catastrophic: for example, giant kelp (*Macrocystis pyrifera*) forests in Tasmania, Australia have collapsed with over 95 % loss of dense canopy cover since the 20th century (Butler et al., 2020), bull kelp (*Nereocystis luetkeana*) forests along Northern California's coast suffered a >95 % decline following marine heatwaves and urchin outbreaks in the 2010s (Rogers-Bennett and Catton, 2019), and the fucoid *Cystoseira* spp. has had major declines in the Mediterranean (Tamburello et al., 2022). To date, the level of effective management, spatial protections, and area under restoration for kelp ecosystems remains low. Only about 16 % of the world's kelp forest area falls under any form of marine protection, less than 2 % is in fully protected zones, and similarly, only ~19,000 ha of kelp forest area has been restored over the last seven decades (Eger et al., 2024b). This mismatch between ecological importance and conservation coverage highlights the need for enhanced global efforts and funding for kelp forest conservation.

Responding to these challenges, the international kelp forest community of practice has launched initiatives to safeguard kelp ecosystems. Notably, the Kelp Forest Challenge, established via community consultation in 2023, set a bold goal of restoring 1 million ha and protecting (via marine protected areas, spatial management, or Otherwise Effective Conservation Measures) 3 million ha of kelp forests by the year 2040 (~30 % of the observed distribution) (Eger et al., 2024a). This target reflects a shared vision to reverse kelp forest declines on a global scale. It also aligns with broader international conservation commitments, including the Kunming-Montreal Global Biodiversity Framework's "30 × 30" goal of protecting 30 % of marine and terrestrial habitats by 2030 (Convention on Biological Diversity, 2022). Restoration actions follow an IUCN approved typology while protected areas allow for a range of management options, while respecting local communities and stewardship. However, achieving the Kelp Forest Challenge's area-based objectives will require substantial financial resources for on-the-ground actions including restoration projects, long-term management of kelp forests, monitoring, and community engagement.

Experience from other ocean habitat initiatives suggests that defining a clear financing target can galvanize support and guide resource mobilization. Under the high-level "*Ocean Breakthroughs*" framework (Ricketts and Olutoke, 2024), for instance, global conservation targets for mangroves and coral reefs have been coupled with investment objectives of $4 billion (Andersen, 2024) and $12 billion (Suggett et al., 2024), respectively. These figures provided a benchmark for success, helping to attract funding and partnerships commensurate with the scale of work needed. By comparison, kelp forest conservation has not yet been associated with a dedicated global funding target. To address this gap, the Kelp Forest Alliance (KFA, www.kelpforestalliance.com - (Eger et al., 2022a)) – a global network of kelp researchers, conservationists, and stakeholders, undertook a consultative process to develop a Kelp Breakthrough Finance Target. The goal was to estimate how much funding would be required to meet the kelp protection and restoration goals, and to set a tangible fundraising target that can be presented to policymakers, philanthropic foundations, and international initiatives. Here, we describe the outcome of that process. We outline the methodology used to derive cost estimates for kelp conservation at scale, present the resulting funding scenarios, and discuss the rationale for the chosen target. By formalizing these findings in a scientific context, we aim to strengthen the evidence base and emphasize the urgency for investing in kelp forest conservation.

2. Methods

2.1. Consultation process

To establish a global kelp conservation finance target, we engaged in an iterative stakeholder consultation. We convened three virtual workshops between January and March 2025, involving participants who were invited via email from the global Kelp Forest Alliance conservation community (N = 845) including scientists, restoration practitioners, NGOs, and policy experts (30 participants across 10 countries).

As the workshop did not involve the collection of personal, sensitive, or health-related data, and participants were engaged in their professional capacity as subject-matter experts, formal human ethics approval was not required. All participants were informed of the purpose and format of the workshop in advance via email and provided informed consent to participate by confirming their attendance and contributing during sessions. Invitations for authorship were extended to anyone who participated in the workshops or consulted on the manuscript. We define expertise as individuals with recognized experience in kelp forest conservation or restoration, including scientists, policy professionals, and practitioners with published work, institutional affiliations, or leadership roles in relevant initiatives. Invitations were extended to individuals meeting these criteria, and final participation reflected this intended sample frame across academic, NGO, and government sectors.

Workshop methods followed a structured three-phase approach: (1) Participants were presented with background context for the Kelp Forest Challenge and other global conservation agendas as well as a series of global restoration and protection scenarios, followed by open discussions of the pros and cons of each approach; (2) based on these discussions, we synthesized key points into a set of draft quantitative targets; and (3) targeted discussions were then held to assess the relevancy and applicability of the draft targets, leading to refinement and presentation of a final proposed target. Meeting slides are contained in the supplementary materials. A consensus was reached during the final session, with no participants expressing objections to the agreed outcomes during the session or thereafter.

Key discussions focused on what creating an "ambitious yet achievable" funding goal for kelp might look like, how to include economic complexities (purchasing power, currencies, etc.), the total area needing intervention, the unit costs of different intervention types, and how to account for variability and uncertainty in those costs.

2.2. Estimating area needs

The first step was to define the scope of the kelp forest area to be funded for protection and restoration. We based these figures on the Kelp Forest Challenge targets and current progress toward those targets. According to the latest assessment of the progress toward the Challenge (Eger et al., 2024b), approximately 16 % of the world's kelp forests have some protection or conservation management, noting that only ~1.6 % are "fully protected", e.g., restrict fishing or other harmful activities. Consequently, roughly 1.4 million ha of additional kelp forests would need to be brought under sustainable management or protection to reach the 3-million-hectare protection goal. Likewise, out of 1 million ha targeted for restoration, approximately 980,000 ha remain to be restored (accounting for existing or ongoing restoration efforts). These figures reflect the "gap" to achieve the overall kelp conservation objectives; thus, we adopted 980,000 ha (restoration) and 1,400,000 ha (protection) as the basis for our funding calculations.

2.3. Cost scenarios for restoration and protection

Costs for kelp forest restoration can vary widely depending on the methods used, local context, and project scale. To capture this uncertainty, we developed three cost per hectare scenarios for restoration, all costs are in USD:

- **Low-cost scenario:** $1000 per hectare – representing the most inexpensive methods under ideal conditions (e.g., urchin removal with quicklime) (Eger et al., 2020).
- **Medium-cost scenario:** $10,000 per hectare – representing an average cost observed in large-scale, multi-method, kelp restoration programs, such as those in Japan and Korea (Eger et al., 2020).
- **High-cost scenario:** $100,000 per hectare – representing resource-intensive projects at smaller scales with high upfront costs (e.g., laboratory-reared outplanting or reef construction) (Eger et al., 2022b).

The lowest-cost figure ($1 k/ha) corresponds to interventions including targeted culling of overgrazing sea urchins using quicklime or a volunteer workforce, which can rapidly allow kelp to regrow at minimal expense. The medium value (~$10 k/ha) is the observed kelp restoration cost for large established programs. The highest cost figure ($100 k/ha) reflects complex efforts involving extensive infrastructure for prolonged aquaculture of kelp, or small-scale projects, which can be costly per unit area. For restoration, we assumed that the quoted cost per hectare, especially in medium and high scenarios, implicitly includes post-restoration monitoring for up to 10 years (typically adding up to $1000/ha in total). This assumption was made because restoration projects often integrate monitoring and maintenance, and restoration tends to be costlier than protection initiatives on a per-area basis.

For protection costs, we focused on the expenses of establishing and managing marine protected or managed areas. We drew on a global MPA cost database (Balmford et al., 2004) that surveyed annual running costs for 83 MPAs and indexed those costs for a conservative level of inflation (1.6 % - (National Institutes of Health, 2024)) from 2004 to 2024. From this, we approximate three representative annual cost levels per hectare of MPA:

- **Low:** $125 per hectare per year – characteristic of large, offshore, or less strictly managed MPAs with lower enforcement costs.
- **Medium:** $650 per hectare per year – an intermediate cost reflecting many typical MPAs with moderate management and enforcement efforts.
- **High:** $1300 per hectare per year – corresponding to smaller or highly regulated MPAs in costly regions (e.g., near urban areas in developed countries).

These per-hectare annual costs encompass a range of management activities including patrolling/enforcement, ecological monitoring, community outreach, and administrative overhead. We also allowed for 5 years of post-development monitoring and maintenance of each protected area. In each scenario, the per-hectare annual cost was multiplied by 5 to estimate a five-year cost per hectare of protected kelp forest. For example, under the medium scenario, $500/ha/year translates to $2500 per hectare over five years. This multi-year approach aligns the finance target with near-term action, recognizing that long-term protection (through 2040 and beyond) would require sustained funding beyond the initial five years.

Using the above area targets and unit cost assumptions, we computed total funding requirements for each combination of restoration and protection scenario. All cost figures are presented in US dollars and, unless otherwise noted, represent the cumulative amount needed for the targets.

3. Results

3.1. Funding requirements under different scenarios

Combining the restoration and protection estimates yielded a range of total funding scenarios for global kelp forest conservation (Table 1). The low-cost scenario for both restoration and protection yield an estimated $1.9 billion needed to meet the targets, whereas the high-cost scenario for both components would require an estimated $58.2 billion. The medium-cost scenario for both restoration and protection, considered the most realistic, resulted in an intermediate funding target of approximately $14.4 billion (Fig. 1).

These estimates represent the cumulative investment needed to achieve the protection of 1.4 M ha and restoration of ~0.98 M ha of kelp forests (as per the Challenge goals), given different assumptions about per-hectare costs. Several patterns emerge from the scenario analysis. First, restoration costs dominate the total in most scenarios, especially in the high-cost case. For example, in the High–High scenario ($58 B), over 85 % of the total is attributable to the restoration component (nearly $49 B for restoration alone at $100 k/ha), whereas protection (at $1300/ha/yr for 5 years) contributes about $9 B. Even in the Medium–Medium scenario ($14.4 B), restoration expenses ($9.8 B) make up roughly 69 % of the total, with protection ($4.6 B) accounting for the remainder. This imbalance reflects the fact that active ecological restoration of kelp forests is generally far more resource-intensive per unit area than establishing MPAs, which primarily incur management and personnel costs. Conversely, in the Low–Low scenario, the two components are closer in magnitude ($0.98 B for restoration vs $0.89 B for protection).

Second, the mid-range (medium) scenario of approximately $14 billion aligns with funding targets for comparable ecosystems: it is about three times higher than the mangrove conservation investment target ($4 B) and of the same order of magnitude as the coral reef target (~$12 B). This medium scenario was identified by the stakeholders as the most appropriate balance between ambition and feasibility (further discussed below). Notably, the medium scenario assumes a cost of $10 k per hectare for restoration, which may be achievable at scale if cost-effective methods are implemented, and approximately $650 per hectare per year for protection, which is a realistic average for well-managed MPAs.

3.2. Recommended finance target

After reviewing the scenario outcomes, the consultation participants reached a consensus to adopt the Medium–Medium scenario as the kelp finance target. In practical terms, this means a global fundraising target on the order of $14 billion (approximately $14.4 B as calculated) would be set to support kelp forest conservation efforts over the coming years. This target was deemed "ambitious but achievable," in line with the objective of keeping pace with other global conservation initiatives and the scale of kelp forest decline. For communication and planning purposes, the value may be presented as a round figure (e.g., "$14 billion by 2040 for kelp forests"), acknowledging the inherent uncertainty in such estimates. The finance target encompasses funding from all sources, including national governments, multilateral funds, private philanthropy, corporate contributions, and innovative finance mechanisms,

Table 1
Estimated total funding required (in billion USD) to protect ~1.4 M ha of kelp forests (for 5 years) and restore ~0.98 M ha of kelp forests, under low, medium, and high unit cost scenarios for each. The bolded values indicate the **medium** scenario selected as the final target.

Total cost estimate ($USD B)		Restoration		
		Low	Med	High
Protection	Low	1.9	10.7	50.0
	Med	5.5	**14.4**	53.6
	High	10.1	18.9	58.2

Fig. 1. Area and finance based targets for achieving the Kelp Forest Challenge.

that can be marshalled to protect and restore kelp at the global scale. By setting this quantified target, the Kelp Forest Alliance and partners aim to create a rallying point to attract investments and track progress in financing kelp conservation.

4. Discussion

The development of a global kelp forest conservation finance target represents a proactive step in aligning kelp ecosystems with international conservation funding frameworks. The selected target of $14 billion reflects a compromise between scientific guidance and practical considerations. Although the target is larger than the funding calls for coral reefs, it is comparable to the call for mangroves. These similarities and differences are partly due to the global extent and restoration costs of the ecosystems. Dollar per-hectare, kelp restoration is much costlier than mangrove restoration (Saunders et al., 2020) and kelp forests have a much larger distribution compared to coral reefs (Duarte et al., 2022; UNEP-WCMC, WorldFish Centre, WRI, 2021). We now examine the underlying considerations, uncertainties, and implications of the finance target, and suggest directions for future refinement and implementation.

4.1. Basis for the medium-scenario selection

The choice of the medium cost scenario as the basis for the finance target was influenced by multiple factors. *Regional cost variation* was an important consideration, kelp restoration costs can be significantly higher in developed countries (due to labour and permitting costs) or in remote regions (due to logistical challenges). Conversely, some regions may achieve lower costs with community-led efforts or simpler techniques. By using a moderate cost estimate ($10 k/ha for restoration), we implicitly averaged across regional differences, aiming for a middle ground that would neither grossly overestimate nor underestimate

needs. Additionally, selecting the medium scenario helps account for the expectation that as restoration efforts scale up, efficiencies and cost reductions may occur (e.g., through shared infrastructure, improved methodologies, and learning-by-doing). From a goal-setting perspective, the medium-cost target was also seen as more motivational: a very high number (e.g., $50+ billion) might be discouraging to stakeholders and financiers, while a very low number (e.g., $2 billion) could undervalue the ecosystem and fall short of achieving meaningful recovery.

Another consideration was the balance of funding sources. The finance target is envisioned to be met through a mixed portfolio of contributions, not relying on any single sector. Government budgets will play a role, but private philanthropic foundations, impact investors, and even emerging blue carbon (Kuwae et al., 2022; McHenry et al., 2024) or biodiversity (Flammer et al., 2025) finance mechanisms could also contribute. Notably, kelp forest conservation lacks dedicated carbon credit frameworks at present (because kelp carbon sequestration dynamics are complex), but ongoing research into blue carbon accounting for macroalgae could eventually enable carbon-market funding for kelp projects (e.g., such as in Japan's J-Blue credit) (Kuwae et al., 2022) or national accounts for blue carbon (McHenry et al., 2024). In the meantime, framing the target within broader ecosystem service benefits (such as fisheries enhancement and nutrient removal) may attract diverse funding sources. The inclusion of corporate and philanthropic donors is explicitly acknowledged in the target's formulation, broadening the base beyond public funds.

4.2. Uncertainties and limitations

Estimating a global funding need for ecosystem conservation inherently involves uncertainties (Carwardine et al., 2010; Lechner et al., 2014). In our approach, we identified several areas of uncertainty and potential refinement, including variations in kelp forest extent data, economic conditions, technological change, and future environmental conditions. For instance, the total global area of kelp forests is not mapped with complete precision and different estimates of kelp distribution (Eger et al., 2024a; Jayathilake and Costello, 2021; Pessarrodona et al., 2022) would alter the hectare targets (though the chosen values were based on best available global data). We noted economic factors like currency exchange rates and purchasing power parity (Taylor, 2003) as possible refinements (since costs in developing countries vs. developed can differ in real terms). We considered adjusting for such factors, but doing so would introduce additional layers of complexity and assumptions, each with their own uncertainties. Ultimately, the decision was made to "keep it simple," using broad average cost figures and global area totals, rather than disaggregating by country or region. This simplicity sacrifices some precision but makes the target more straightforward to communicate. It also avoids compounding uncertain variables. As more data become available, for example, more detailed breakdowns of restoration costs by region or improvements in global kelp cover mapping, future analyses could refine the cost model and adjust the target accordingly. Additionally, there is inherent uncertainty in the efficacy of restoration (Kimball et al., 2015; Rohr et al., 2018): not every dollar spent will necessarily yield a hectare of kelp restored if projects fail due to unforeseen factors (marine heatwaves, storms, urchin outbreaks, etc.). We did not explicitly factor in the expansion or contraction of restored area or the need for repeat interventions, which could increase true costs, but the high-cost scenario can be seen as a proxy buffer for lower restoration success rates.

4.3. Regional variation

While the finance target is global, implementation will occur through numerous local and regional projects. Cost variation among these projects will be large and there is an opportunity for regions or countries to create area specific conservation and finance targets (Beger et al., 2015; Butchart et al., 2015). For example, some regions may require less restoration and therefore need less funding. Moreover, the cause of kelp declines will differ regionally, and effort required to enact successful restoration will vary accordingly. Regions with lower labour costs and simpler permitting may also require less funding to achieve both protection and restoration goals. The target therefore should be interpreted with flexibility to allocate funds in a way that maximizes ecological return on investment to priority areas.

At the global level, we will need to balance prioritizing "cheaper per hectare" wins in the short term (to get momentum and quick gains in area restored/protected), (McCreless et al., 2013), while also investing in a few high-profile, higher-cost projects that push the envelope of technology or address keystone sites (e.g., restoring kelp in a biodiversity hotspot site even if cost per hectare is high) (Chauvenet et al., 2020). Over time, a portfolio of projects under the global target can be balanced to achieve both area goals and equitable regional representation (Kimball et al., 2015).

4.4. Future directions

Establishing a finance target is only a first step. Moving forward, several actions and research efforts are needed to enhance the effectiveness of this initiative. First, refining cost estimates with real-world data from pilot projects will be important. As new kelp restoration projects are implemented (some of which may be catalysed by the attention from this funding target), they will generate data on actual costs and outcomes. The Kelp Forest Alliance hosts an active database that records restoration projects, their outcomes, and pertinently, their costs (https://kelpforestalliance.com/restoration-projects). Future projects can actively contribute to this database and help to validate real world costs vs. our estimated costs. Second, further work is needed to integrate ecosystem service valuation and co-benefits into the funding rationale. For example, kelp forests contribute to fisheries productivity and carbon uptake; quantifying these benefits or potential losses in monetary terms, e.g., (Blamey and Bolton, 2018; Cevallos et al., 2024; Vasquez et al., 2014) can strengthen the case for investment by linking it to climate and food security funding streams. Global estimates of $500 billion/year or $111,400/ha/year in services, while broad, indicate that the return on investment for saving kelp forests could be extremely high when considering the societal benefits. Developing region-specific business cases (e.g., how kelp restoration could boost a local fishery's economic output) could also help to attract local funding, social license, and political support for kelp restoration and protection.

Finally, it will be crucial to monitor and report on progress toward the kelp finance target (Brooks et al., 2015). Regular updates (e.g., an annual "state of kelp finance" report) could track how much funding has been pledged or spent toward the $14 billion goal, how many hectares of kelp forest have been protected or restored with those funds, and what the outcomes have been (Eger et al., 2024b). This transparency will help maintain accountability and momentum. It will also allow for course corrections, if certain approaches are not yielding expected results, resources can be reallocated. The Kelp Forest Alliance currently hosts a knowledge hub that can track area under restoration, management or protection, and funding raised and meets these needs. Further, the Alliance and its partners can coordinate and motivate action within the kelp conservation community.

5. Conclusion

Kelp forests have historically been underrepresented in global conservation funding despite their immense ecological and economic value. By outlining a dedicated global finance target for kelp forest conservation (~$14 billion under a mid-range scenario), this study provides a tangible figure around which scientists, conservationists, community members, policymakers, and funders can unite. Achieving this target would enable the protection and restoration of millions of hectares of kelp habitat, helping to stabilize and restore some of these ecosystems,

thus increasing their many socioeconomic benefits. Importantly, setting the target has also illuminated the underlying cost structure and assumptions, allowing for greater clarity in what it will take to save kelp forests worldwide.

The finance target is ambitious, but it is commensurate with the scale of the challenge and aligned with other global efforts to save vital marine ecosystems. If realized, the investment would not only secure kelp forests and the biodiversity they harbour but also sustain the invaluable services they provide to coastal communities and global climate regulation. Moving forward, broad collaboration will be required, among scientists, NGOs, governments, Indigenous communities, and the private sector, to mobilize resources and implement kelp conservation actions on the ground. The establishment of this target is a pivotal step in that direction, signalling that kelp forests are emerging as a priority in the global conservation agenda. With continued research, innovation, and adaptive management supporting this initiative, there is cautious optimism that kelp forests can be given a fighting chance to recover and thrive for future generations.

CRediT authorship contribution statement

Aaron M. Eger: Writing – review & editing, Writing – original draft, Project administration, Methodology, Conceptualization. **Julia K. Baum:** Writing – review & editing. **Tom Campbell:** Writing – review & editing, Investigation. **Bruno Cevallos Gil:** Writing – review & editing, Investigation. **Hannah S. Earp:** Writing – review & editing, Investigation. **Annalisa Falace:** Writing – review & editing, Investigation. **Jan Freiwald:** Writing – review & editing, Methodology. **Sara Hamilton:** Writing – review & editing, Methodology. **Steve I. Lonhart:** Writing – review & editing, Methodology. **Keith Rootsaert:** Writing – review & editing, Methodology. **Makena Åsa Rush:** Writing – review & editing, Methodology. **Jasmin Schuster:** Writing – review & editing, Methodology. **Brian Timmer:** Writing – review & editing, Methodology. **Adriana Vergés:** Writing – review & editing, Methodology, Conceptualization.

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.

Acknowledgements

The authors would like to acknowledge the contributions of the workshop participants and consultation process.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2025.111573.

Data availability

No data was used for the research described in the article.

References

Andersen, I., 2024. Restoring Mangrove Forests as a Key Nature-based Solution. UNEP: United Nations Environment Programme, Nairobi, Kenya.

Balmford, A., Gravestock, P., Hockley, N., McClean, C.J., Roberts, C.M., 2004. The worldwide costs of marine protected areas. Proc. Natl. Acad. Sci. 101, 9694–9697.

Beger, M., McGowan, J., Treml, E.A., Green, A.L., White, A.T., Wolff, N.H., Klein, C.J., Mumby, P.J., Possingham, H.P., 2015. Integrating regional conservation priorities for multiple objectives into national policy. Nat. Commun. 6, 8208.

Blamey, L.K., Bolton, J.J., 2018. The economic value of South African kelp forests and temperate reefs: past, present and future. J. Mar. Syst. 188, 172–181. https://doi.org/10.1016/j.jmarsys.2017.06.003.

Brooks, T.M., Butchart, S.H.M., Cox, N.A., Heath, M., Hilton-Taylor, C., Hoffmann, M., Kingston, N., Rodríguez, J.P., Stuart, S.N., Smart, J., 2015. Harnessing biodiversity and conservation knowledge products to track the Aichi Targets and Sustainable Development Goals. Biodiversity 16, 157–174.

Butchart, S.H.M., Clarke, M., Smith, R.J., Sykes, R.E., Scharlemann, J.P.W., Harfoot, M., Buchanan, G.M., Angulo, A., Balmford, A., Bertzky, B., 2015. Shortfalls and solutions for meeting national and global conservation area targets. Conserv. Lett. 8, 329–337.

Butler, C., Lucieer, V.L., Wotherspoon, S.J., Johnson, C.R., 2020. Multi-decadal decline in cover of giant kelp *Macrocystis pyrifera* at the southern limit of its Australian range. Mar. Ecol. Prog. Ser. 653, 1–18.

Carwardine, J., Wilson, K.A., Hajkowicz, S.A., Smith, R.J., Klein, C.J., Watts, M., Possingham, H.P., 2010. Conservation planning when costs are uncertain. Conserv. Biol. 24, 1529–1537.

Cevallos, B., Aller-Rojas, O., Aponte, H., Moreno, B., 2024. Carbon capture by stipitate kelp forests in Peru: insights from population assessment of *Lessonia trabeculata* at 15° S. J. Appl. Phycol. 36, 3057–3076.

Chauvenet, A.L.M., Watson, J.E.M., Adams, V.M., Di Marco, M., Venter, O., Davis, K.J., Mappin, B., Klein, C.J., Kuempel, C.D., Possingham, H.P., 2020. To achieve big wins for terrestrial conservation, prioritize protection of ecoregions closest to meeting targets. One Earth 2, 479–486.

Coleman, M.A., Wernberg, T., 2017. Forgotten underwater forests: the key role of fucoids on Australian temperate reefs. Ecol. Evol. 7, 8406–8418. https://doi.org/10.1002/ece3.3279.

Convention on Biological Diversity, 2022. Kunming-Montreal Global biodiversity framework. In: Kunming-Montreal Global Biodiversity Framework Draft Decision Submitted by the President. Montreal, Canada. doi: https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf.

Desmond, M.J., Suarez-Jimenez, R., Nelson, W.A., Hepburn, C.D., 2018. Epifaunal community structure within southern New Zealand kelp forests. Mar. Ecol. Prog. Ser. 596, 71–81. https://doi.org/10.3354/meps12587.

Duarte, C.M., Gattuso, J., Hancke, K., Gundersen, H., Filbee-Dexter, K., Pedersen, M.F., Middelburg, J.J., Burrows, M.T., Krumhansl, K.A., Wernberg, T., 2022. Global estimates of the extent and production of macroalgal forests. Glob. Ecol. Biogeogr. 31, 1422–1439.

Eger, A.M., Vergés, A., Choi, C.G., Christie, H.C., Coleman, M.A., Fagerli, C.W., Fujita, D., Hasegawa, M., Kim, J.H., Mayer-Pinto, M., Reed, D.C., Steinberg, P.D., Marzinelli, E.M., 2020. Financial and institutional support are important for large-scale kelp forest restoration. Front. Mar. Sci. 7, 535277. https://doi.org/10.3389/fmars.2020.535277.

Eger, A.M., Eddy, N., Gleason, M., Layton, C., McHugh, T., Steinberg, P., Vergés, A., 2022a. The Kelp Forest Alliance: a global community of practice to understand, advise, and motivate kelp forest conservation and restoration. Limnol. Oceanogr. 31, 130–132.

Eger, A.M., Marzinelli, E.M., Christie, H., Fagerli, C.W., Fujita, D., Gonzalez, A.P., Hong, S.W., Kim, J.H., Lee, L.C., McHugh, T.A., 2022b. Global kelp forest restoration: past lessons, present status, and future directions. Biol. Rev. 97, 1449–1475.

Eger, A.M., Marzinelli, E.M., Beas-Luna, R., Blain, C.O., Blamey, L.K., Byrnes, J.E.K., Carnell, P.E., Choi, C.G., Hessing-Lewis, M., Kim, K.Y., Kumagai, N.H., Lorda, J., Moore, P., Nakamura, Y., Pérez-Matus, A., Pontier, O., Smale, D., Steinberg, P.D., Vergés, A., 2023. The value of ecosystem services in global marine kelp forests. Nat. Commun. 14, 1894. https://doi.org/10.1038/s41467-023-37385-0.

Eger, A., Aguirre, J.D., Altamirano, M., Arafeh-Dalmau, N., Larissa Arroyo, N., Bauer-Civiello, A.M., Beas-Luna, R., Bekkby, T., Bellgrove, A., Bennett, S., Bernal, B., Blain, C.O., Boada, J., Branigan, S., Bursic, J., Cevallos, B., Choi, C.G., Connell, S.D., Cornwall, C.E., Earp, H.S., Eddy, N., Ennis, L.-A., Falace, A., Ferreira, A.M., Filbee-Dexter, K., Forbes, H., Francis, P., Franco, J.N., Geisler, K.G., Giraldo-Ospina, A., Gonzalez, A.V., Hingorani, S., Hohman, R., Iveša, L., Kaleb, S., Keane, J.P., Koch, S.J. I., Krumhansl, K., Ladah, L., Lafont, D.J., Layton, C., Le, D.M., Lee, L.C., Ling, S.D., Lonhart, S.I., Malpica-Cruz, L., Mangialajo, L., McConnell, A., McHugh, T.A., Micheli, F., Miller, K.I., Monserrat, M., Montes-Herrera, J., Moreno, B., Neufeld, C.J., Orchard, S., Peabody, B., Peleg, O., Pessarrodona, A., Pocklington, J.B., Reeves, S.E., Ricart, A.M., Ross, F., Schanz, F.R., Schreider, M., Sedarat, M., Smith, S.M., Starko, S., Strain, E.M.A., Tamburello, L., Timmer, B., Toft, J.E., Uribe, R.A., van den Burg, S.W.K., Vásquez, J.A., Veenhof, R.J., Wernberg, T., Wood, G., Zepeda-Domínguez, J.A., Vergès, A., 2024a. The Kelp Forest Challenge: a collaborative global movement to protect and restore 4 million hectares of kelp forests. J. Appl. Phycol. 36, 951–964.

Eger, A.M., Eddy, N., McHugh, T.A., Arafeh-Dalmau, N., Wernberg, T., Krumhansl, K., Verbeek, J., Branigan, S., Kuwae, T., Caselle, J.E., Ospina, A.G., Vergés, A., 2024b. State of the world's kelp forests. One Earth 7, 1927–1931. https://doi.org/10.1016/j.oneear.2024.10.008.

Flammer, C., Giroux, T., Heal, G.M., 2025. Biodiversity finance. J. Financ. Econ. 164, 103987.

Jayathilake, D.R.M., Costello, M.J., 2021. Version 2 of the world map of laminarian kelp benefits from more Arctic data and makes it the largest marine biome. Biol. Conserv. 257. https://doi.org/10.1016/j.biocon.2021.109099.

Kimball, S., Lulow, M., Sorenson, Q., Balazs, K., Fang, Y.-C., Davis, S.J., O'Connell, M., Huxman, T.E., 2015. Cost-effective ecological restoration. Restor. Ecol. 23, 800–810. https://doi.org/10.1111/rec.12261.

Kuwae, T., Watanabe, A., Yoshihara, S., Suehiro, F., Sugimura, Y., 2022. Implementation of blue carbon offset crediting for seagrass meadows, macroalgal beds, and macroalgae farming in Japan. Mar. Policy 138, 104996.

Lechner, A.M., Raymond, C.M., Adams, V.M., Polyakov, M., Gordon, A., Rhodes, J.R., Mills, M., Stein, A., Ives, C.D., Lefroy, E.C., 2014. Characterizing spatial uncertainty

when integrating social data in conservation planning. Conserv. Biol. 28, 1497–1511.
Mayfield, S., Mundy, C., Gorfine, H., Hart, A.M., Worthington, D., 2012. Fifty years of sustained production from the Australian abalone fisheries. Rev. Fish. Sci. 20, 220–250.
McCreless, E., Visconti, P., Carwardine, J., Wilcox, C., Smith, R.J., 2013. Cheap and nasty? The potential perils of using management costs to identify global conservation priorities. PLoS One 8, e80893.
McHenry, J., Okamoto, D.K., Filbee-Dexter, K., Krumhansl, K., MacGregor, K.A., Hessing-Lewis, M., Timmer, B., Archambault, P., Attridge, C.M., Cottier, D., Costa, M., Csordas, M., Johnson, L.E., Lessard, J., Mora-Soto, A., Metaxas, A., Neufeld, C., Pontier, O., Reshitnyk, L., Starko, S., Yakimishyn, J., Baum, J.K., 2024. A blueprint for national assessments of the blue carbon capacity of kelp forests applied to Canada's coastline. In: bioRxiv 2024.04.05.586816. https://doi.org/10.1101/2024.04.05.586816.
National Institutes of Health, 2024. Biomedical Research and Development Price Index (BRDPI): Fiscal Year 2024 Update.
Pessarrodona, A., Filbee-Dexter, K., Krumhansl, K.A., Pedersen, M.F., Moore, P.J., Wernberg, T., 2022. A global dataset of seaweed net primary productivity. Sci. Data 9, 484.
Ricketts, P.J., Olutoke, D., 2024. A commentary and critique on progress in ocean and climate change action at recent COP meetings. Ocean Yearb. Online 38, 182–211.
Rogers-Bennett, L., Catton, C.A., 2019. Marine heat wave and multiple stressors tip bull kelp forest to sea urchin barrens. Sci. Rep. 9, 1–9.
Rohr, J.R., Bernhardt, E.S., Cadotte, M.W., Clements, W.H., 2018. The ecology and economics of restoration. Ecol. Soc. 23.
Ruane, A.C., 2024. Synthesis Report of the IPCC Sixth Assessment Report (AR6).
Saunders, M.I., Doropoulos, C., Babcock, R.C., Bayraktarov, E., Bustamante, R.H., Eger, A.M., Gilles, C., Gorman, D., Steven, A., Vanderklift, M.A., Vozzo, M., Silliman, B.R., 2020. Bright spots in the emerging field of coastal marine ecosystem restoration. Curr. Biol. 30, R1500–R1510.
Smale, D.A., King, N.G., Jackson-Bué, M., Moore, P.J., 2022. Quantifying use of kelp forest habitat by commercially important crustaceans in the United Kingdom. J. Mar. Biol. Assoc. U. K. 102, 627–634.
Steneck, R.S., Graham, M.H., Bourque, B.J., Corbett, D., Erlandson, J.M., Estes, J.A., Tegner, M.J., 2002. Kelp forest ecosystems: biodiversity, stability, resilience and future. Environ. Conserv. 29, 436–459. https://doi.org/10.1017/S0376892902000322.
Suggett, D.J., Guest, J., Camp, E.F., Edwards, A., Goergen, L., Hein, M., Humanes, A., Levy, J.S., Montoya-Maya, P.H., Smith, D.J., 2024. Restoration as a meaningful aid to ecological recovery of coral reefs. npj Ocean Sustain. 3, 20.
Tamburello, L., Chiarore, A., Fabbrizzi, E., Colletti, A., Franzitta, G., Grech, D., Rindi, F., Rizzo, L., Savinelli, B., Fraschetti, S., 2022. Can we preserve and restore overlooked macroalgal forests? Sci. Total Environ. 806, 150855.
Taylor, M.P., 2003. Purchasing power parity. Rev. Int. Econ. 11, 436–452.
UNEP-WCMC, WorldFish Centre, WRI, T, 2021. Global Distribution of Coral Reefs, Compiled From Multiple Sources Including the Millennium Coral Reef Mapping Project. Version 4.1, Updated by UNEP-WCMC. Includes Contributions From IMaRS-USF and IRD (2005), IMaRS-USF (2005) and Spalding et al. (2001), C. https://doi.org/10.34892/t2wk-5t34.
United Nations Environment Programme, 2023. Into the Blue: Securing a Sustainable Future for Kelp Forests.
Valckenaere, J., Techera, E., Filbee-Dexter, K., Wernberg, T., 2023. Unseen and unheard: the invisibility of kelp forests in international environmental governance. Front. Mar. Sci. 10, 1235952.
Vasquez, J.A., Zuniga, S., Tala, F., Piaget, N., Rodriguez, D.C., Alonso Vega, J.M., Vásquez, J.A., Zuñiga, S., Tala, F., Piaget, N., Rodríguez, D.C., Vega, J.M.A., 2014. Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem. J. Appl. Phycol. 26, 1081–1088. https://doi.org/10.1007/s10811-013-0173-6.
Wernberg, T., Coleman, M.A., Babcock, R.C., Bell, S.Y., Bolton, J.J., Connell, S.D., Hurd, C.L., Johnson, C.R., Marzinelli, E.M., Shears, N.T., 2019. Biology and ecology of the globally significant kelp Ecklonia radiata. Oceanogr. Mar. Biol. 57, 265–324.
Wernberg, T., Thomsen, M.S., Baum, J.K., Bishop, M.J., Bruno, J.F., Coleman, M.A., Filbee-Dexter, K., Gagnon, K., He, Q., Murdiyarso, D., 2024. Impacts of climate change on marine foundation species. Annu. Rev. Mar. Sci. 16, 247–282.