Policy brief

Marine–climate interventions

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# Enhance responsible governance to match the scale and pace of marine–climate interventions

Emily M. Ogier, Gretta T. Pecl, Terry Hughes, Sarah Lawless, Cayne Layton, Kirsty L. Nash & Tiffany H. Morrison

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Oceans are on the frontline of an array of new marine–climate actions that are both poorly understood and under-regulated. Development and deployment of these interventions is outpacing governance readiness to address risks and ensure responsible transformation and effective action.

BASED ON E. M. Ogier et al. *Nature Climate Change* https://doi.org/10.1038/s41558-025-02291-4 (2025).

## The policy problem

Rapidly changing climatic and oceanic conditions form a clear and urgent mandate for novel interventions to sustain marine ecosystems and the communities that depend on them. Scientific and not-for-profit organizations are already trialling a wide array of new marine–climate interventions. However, the planned upscaling of many of these interventions has highlighted a 'pacing problem', whereby the rate of innovation and deployment is outpacing governance preparedness to anticipate and responsibly manage actions and their impacts. Overcoming these pacing and upscaling challenges is of global importance because new marine–climate interventions pose multiple and cumulative risks and high opportunity costs for marine ecosystems, as well as communities and rights holders at local, regional, global and climate policy scales. However, systematic understanding of the development and deployment of marine–climate interventions remains low. There has been limited empirical investigation into how to understand and resolve the pacing problem between marine governance and climate intervention technology.

## The findings

Our study identifies a wide diversity of marine–climate interventions proposed or already deployed in 37 marine systems. Multiple types of intervention co-occur in all major ocean basins. Most practitioners (71%) report interventions aimed at supporting marine species and ecosystem adaptation, while 29% report interventions aimed at climate mitigation and societal adaptation. Perceptions of climate outcomes vary widely, with low consensus on intended and realized climate benefits of interventions. The practitioner community is science-dominated with limited involvement of public institutions and communities. Arrangements for responsibly governing intervention risks are seldom observed, indicating the pacing problem is indeed present. Intervention assessment and approval are narrowly focused on technical feasibility to meet minimum permitting requirements, with limited assessment of cumulative impacts, public deliberation and management of broader ecological, cultural and social risks and benefits. Identified policy gaps provide clear directions to improve governance readiness for marine–climate interventions.

## The study

We used an online questionnaire to survey the emerging global community of marine–climate intervention practitioners, bringing together critical information on this rapidly emerging field. We gathered data from 332 participants, including the types of novel interventions being developed or deployed, how these interventions are being designed, their geographic distribution and stage of development, types of climate goals and benefits pursued, and the arrangements (if any) for responsible governance. Using these results, we developed a typology of major types and sub-types of novel marine–climate interventions. To track the extent to which governance arrangements are keeping pace with novel marine–climate interventions, we extended existing frameworks for responsible research and innovation to incorporate the governance phase. We examined the arrangements currently used to assess, plan for and manage interventions in marine systems against our responsible governance framework (Fig. 1). Our approach allowed us to assess the extent of governance preparedness in this global arena of emerging technologies.

## Recommendations for policy

- Identify public policy goals for marine–climate action and prioritize building institutional capacity for planning and management of climate mitigation and adaptation.
- Engage early with scientists, investors, affected communities and rights holders to plan for and design interventions to meet marine and climate system public policy goals.
- Marshal public deliberation. Use community planning and bioethical assessment processes to evaluate risks, benefits, missed opportunities and to design safeguards for proposed interventions.
- Require assessments at experimental and pilot scales that consider cumulative and long-term effects, and that take into account projected marine and climatic conditions.
- Build in social and ecological safeguards, such as moratoria, monitoring of and accountability for adverse impacts, measures to reduce negative impacts, and triggers for scaling back or decommissioning.

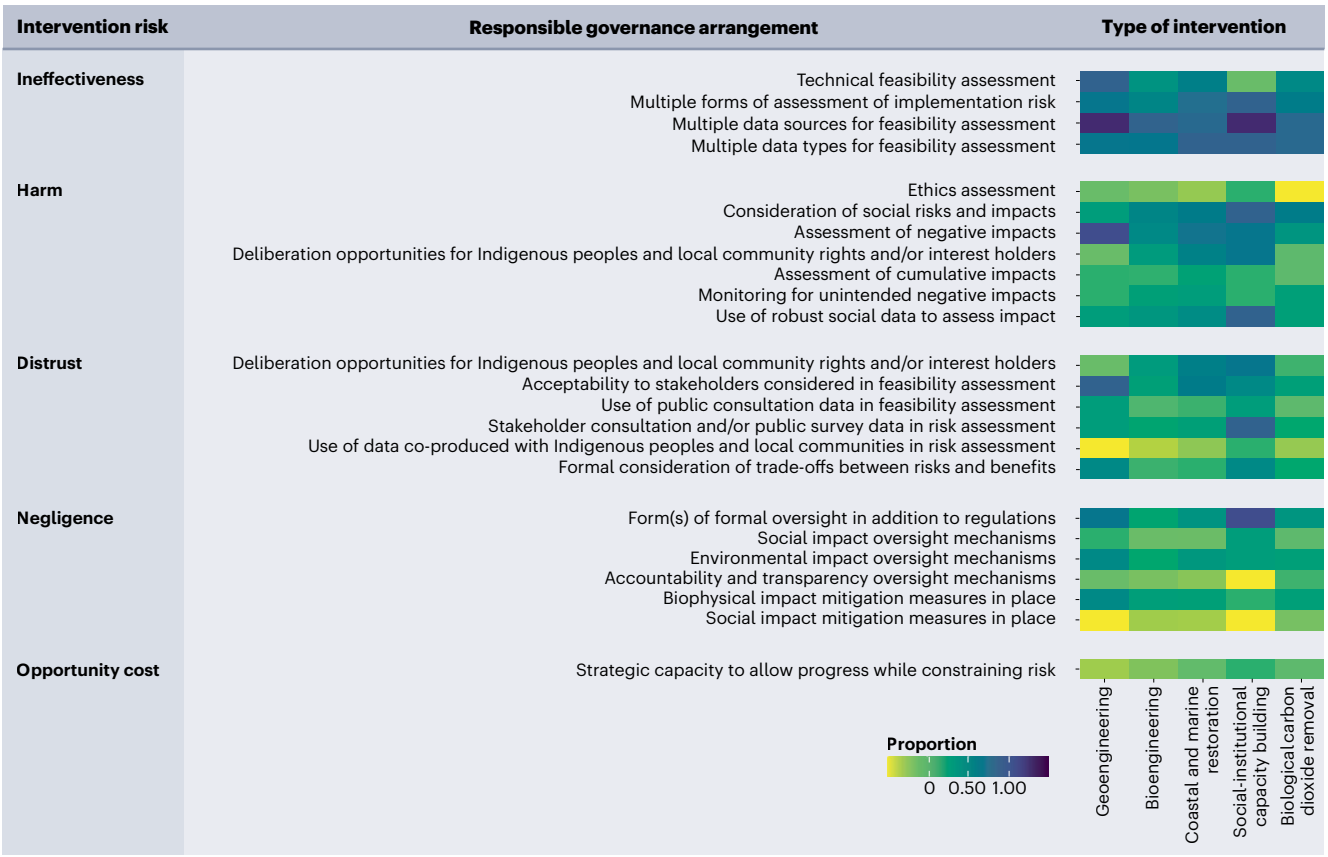


**Fig. 1 | Use of responsible governance arrangements to manage anticipated risks of novel marine–climate interventions.** Interventions are grouped by major type (horizontal axis). Proportion colour scale (yellow to blue) indicates percentage of interventions for which a given governance arrangement was present. Figure adapted from E. M. Ogier et al. *Nat. Clim. Change* https://doi.org/10.1038/s41558-025-02291-4 (2025), Springer Nature Limited.

**Emily M. Ogier[1,2] ✉, Gretta T. Pecl[1,2], Terry Hughes[3], Sarah Lawless[3,4], Cayne Layton[1,2], Kirsty L. Nash[2,3] & Tiffany H. Morrison[3,5,6]**

[1]Institute of Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia. [2]Centre for Marine Socioecology, University of Tasmania, Hobart, Tasmania, Australia. [3]College of Science and Engineering, James Cook University, Townsville, Queensland, Australia. [4]Australian Institute of Marine Science, Townsville, Queensland, Australia. [5]School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Victoria, Australia. [6]Environmental Policy Group, Wageningen University Research, Wageningen, the Netherlands.
✉e-mail: Emily.Ogier@utas.edu.au

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## Further reading

1. Boettcher, M. et al. Navigating potential hype and opportunity in governing marine carbon removal. *Front. Clim.* **3**, 664456 (2021).
**This paper presents different approaches to the development of marine carbon dioxide removal policy.**
2. Morrison, T. H. et al. Overcoming lock-in of science-policy responses to reef heating. *Mar. Polic.* **170**, 106380 (2024).
**This paper provides options for expansion of policy responses to ocean warming and effects on reefs, for more effective and socially equitable outcomes.**
3. Nawaz, S., St-Laurent, G. P. & Satterfield, T. Public evaluations of four approaches to ocean-based carbon dioxide removal. *Clim. Polic.* **23**, 379–394 (2023).
**This paper illustrates the range of public values held for oceans and for climate action and how these influence public debate.**

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## Competing interests

The authors declare no competing interests.