Received: 7 May 2025 | Accepted: 2 February 2026

DOI: 10.1111/1365-2664.70373

BRITISH ECOLOGICAL SOCIETY Journal of Applied Ecology

PERSPECTIVE

Priority research questions to generate decision-grade data to enable coastal ecosystems to mitigate the climate and nutrient crises

Gordon J. Watson[1] | John Aldridge[2] | Louise Anderson[3] | Martin J. Attrill[4] | William E. N. Austin[5,6] | Keisha D. Bahr[7] | Nicola Beaumont[8] | Stefanie Broszeit[8] | Annette Burden[9] | Estela Delgado-Gargiulo[10] | Evangelia G. Drakou[11] | Mike Elliott[12,13] | Karen Filbee-Dexter[14] | Robinson W. Fulweiler[15] | Angus Garbutt[9] | Boze Hancock[16] | Joerg D. Hardege[17] | Joanna Harley[9] | Ian W. Hendy[1] | Jenny R. Hillman[18] | Tim D. Jickells[19] | Ana I. Lillebø[20] | Mariana D. A. C. Lima[21] | Peter I. Macreadie[22] | Paulina Martinetto[23] | Jackie Mellan[24] | Alf Norkko[25] | Ruth Parker[26] | Michael P. Perring[9,27] | Bernadette Pogoda[28] | Jennifer B. Pollack[7] | Joanne Preston[1] | Federica Ragazzola[29] | Justine Saunders[30] | Oscar Serrano[31] | Dan A. Smale[32] | Gemma Smith[12] | Ann Thornton[33] | Simon Thrush[34] | Heidi Tillin[8] | Richard K. F. Unsworth[35,36] | Andrew van der Schatte Olivier[37] | Sophie von der Heyden[38] | Stephen C. L. Watson[8] | Phil Williamson[19] | Claire Woulds[39] | Philline S. E. Zu Ermgassen[40]

Correspondence
Gordon J. Watson
Email: gordon.watson@port.ac.uk

Funding information
UK Research Councils under Natural Environment Research Council, Grant/Award Number: NE/X002357/1; CESAM, Grant/Award Number: FCT/MCTES (UIDP/50017/2020 + UIDB/50017/2020 + LA/P/0094/2020)

Handling Editor: Hedley Grantham

Abstract

1. Nature-Based Solutions, green-finance instruments and policies are now routinely constructed around carbon sequestration/storage (CSS) and nutrient bioremediation (NB). This integration builds on how Market-Based Instruments (e.g. payments-for-ecosystem-services) are regularly used in policies focused on terrestrial ecosystems. In marine and coastal systems poor understanding of CSS/NB biophysical processes and impacts of ecosystem quality/stressors, combined with methods and governance framework knowledge gaps, generate substantial uncertainty in outcomes. Reductions in output confidence preclude integration into Nature-Based Solutions, stifling market-based investment centred on conserving and restoring temperate coastal ecosystems.
2. To navigate this complex, rapidly evolving area, researchers from six continents engaged in a Priority Setting Exercise to generate 25 questions that, if answered within 10 years, will increase robustness, scalability and applicability of CSS/NB

For affiliations refer to page 9.

data across regions and ecosystems. We then used a modal analysis across five categories (time, geographic scale, technology complexity, cost and policy relevance) to expedite research-investment decisions.

3. Questions (numbers in brackets) were organised across six themes as follows: maps/quantitative evidence/long-term data (3), Processes/variability (6), Connectivity (2), Anthropogenic impacts (4), Methods/standards (6), Governance/conservation (4).
4. Questions under methods/standards and governance/trading schemes themes were generally identified to be the cheapest to answer and quickest to complete, whilst still having considerable geographic and policy relevance.
5. *Policy implications*: Identifying the enabling conditions for more efficient and successful approaches will greatly improve our understanding of ecosystem services. Together, these answers will then deliver the decision-grade data necessary to strengthen green-finance opportunities and address urgent climate and pollution (nutrient) crises.

KEYWORDS
blue carbon, kelp, mudflat, oyster, restoration, saltmarsh, seagrass

1 | BACKGROUND

Temperate coastal ecosystems, including biogenic reefs (e.g. bivalve and algal), macroalgal beds, tidal mudflats, saltmarshes and seagrass beds contribute in many material and non-material ways to society (e.g. Beaumont et al., 2014; Heckwolf et al., 2021; Watson et al., 2020). Ecosystem services include C (carbon) sequestration and storage (CSS) and nutrient bioremediation (NB) as well as additional co-benefits such as fish nursery grounds and sediment stabilisation. CSS involves the uptake of atmospheric CO_2 and its long-term storage (see IPCC, 2019 for full definition), whilst NB is defined as 'the regulation of the chemical condition of waters mediated by organism processes linked to N (nitrogen) and P (phosphorous) (Haines-Young & Potschin-Young, 2018).

CSS and NB underpin Market-Based Instruments, Nature-Based Solutions and policy drivers to conserve and restore coastal ecosystems (Brears, 2022). Embedding these ecosystems within Market-Based Instruments linked to nutrient, carbon and, more recently, biodiversity trading schemes is at the forefront of tackling the biodiversity, climate and pollution (nutrient) crises, recognising that the last one is a component of the modification of biogeochemical flows planetary boundary (Rockström et al., 2024). Market-Based Instruments include Payments-for-ecosystem-services, pollution taxes, cap and trade systems and eco-certification (Lockie, 2013). Payments-for-ecosystem-services, in turn, can be defined as being 'voluntary transactions between service users and providers that are conditional on agreed rules of natural resource management for generating offsite services' (Wunder, 2015). Market-Based Instruments can complement regulations by changing economic incentives and, therefore, the behaviour of private actors when deciding upon resource use (Pirard, 2012).

N, P and C are inherent to biogeochemical processes and nutrient cycles regulating food webs, water quality and climate (Beaumont et al., 2014; Watson et al., 2016). To strengthen the development of Market-Based Instruments and Nature-Based Solutions within temperate coastal ecoregions, a coastal ecosystem or species must sequester/remove N, P and/or C via at least one of three pathways: (i) assimilation of N/P/C into biomass through growth of plants/animals that are subsequently removed by harvesting; (ii) denitrification and its intermediates, leading to loss of N to the atmosphere; or (iii) sequestration and storage (burial) in benthic sediments on climate-relevant scales. CSS and NB are currently quantified using a narrow set of biophysical processes. Although CSS is comparatively well studied, many uncertainties remain regarding biogeophysical controls, variability and methodologies (Krause-Jensen & Duarte, 2016; Kristensen et al., 2025; Ward et al., 2024; Williamson & Gattuso, 2022) even when ecosystems/species need to be included in national assessments for example for EU directives or the Convention on Biological Diversity. For NB, simple proxies are available such as estimating nutrient discharges using wastewater treatment data expressed on a population equivalent basis (Office for National Statistics [ONS], 2021), but the paucity of nutrient flow data severely limits the integration into Market-Based Instruments. Linked to these issues is the influence of ecosystem quality/quantity and the impact of anthropogenic conditions that place additional pressures on species and ecosystem functions. The 'triple whammy' (Defeo & Elliott, 2021) of increasing (1) urbanisation and industrialisation, (2) use of natural resources and (3) impacts of climate change and its related stressors means that, globally, temperate coastal ecosystems no longer function as pristine systems.

Nature recovery can be achieved in many ways, through passive restoration by reducing anthropogenic pressures, improving

BRITISH ECOLOGICAL SOCIETY Journal of Applied Ecology

management and active restoration measures such as rebuilding ecosystems, rewilding and eco-engineering (Gann et al., 2019). To fund nature recovery, Nature-Based Solutions and Market-Based Instruments linked to CSS and NB have become central to policy drivers in terrestrial systems (Waltham et al., 2020) and, in some jurisdictions, are now strengthened by legally binding restoration targets by 2030 (e.g. EU, 2022). These drivers underscore the urgent need to refocus short- and medium-term research programmes on scalability to support investment in Nature-Based Solutions and other interventions (Waltham et al., 2020). To help navigate this complex and rapidly evolving field we undertook a Priority Setting Exercise (PSE) with leading researchers. The PSE is a multistage, collaborative approach generating democratically agreed priority questions that, if answered, will increase confidence in the robustness, scalability and applicability of NB and CSS data across diverse coastal temperate systems. To expedite research-investment decisions, the participants scored each question across five categories: time, geographic scale, technology complexity, cost and policy relevance. The ratings generated for each will help prioritise cost-effective policymaking. Without decision-grade data, there are significant risks that incorrect choices around investment will be made, leaving policymakers, regulators and investors with ever more limited options within the necessary planetary boundary-critical timescales.

2 | METHODS

Using the approaches outlined by Sutherland et al. (2013), six relevant temperate coastal ecosystems: bivalve and algal biogenic reefs, macroalgal ecosystem, rocky shore, saltmarsh, seagrass and soft sediment were selected based on known contributions to CSS and NB and generally greater spatial extent in temperate systems compared to other ecosystems (see Watson et al., 2020). Then, participants with relevant expertise (e.g. they research blue carbon/ nutrient bioremediation and the six focal temperate ecosystems and/or are also at the interface of science and policy by providing advice and interpretation of key findings to policy makers) were identified, supplemented through snowball sampling together with ISI Web of Science and Google Scholar searches for authors of pertinent literature. To identify the top 25 questions, we applied the PSE structure of other studies (e.g. Ockendon et al., 2018; zu Ermgassen et al., 2020). PSE filters a long list of candidate questions down to a focused, democratically agreed list of priority questions. All participants were requested to submit an unlimited number of questions to address gaps, which if answered, would improve scalability and increase confidence in CSS and NB data and its value. Submissions were requested to be specific and answerable through scientific research within the near term (i.e. within 10 years). This was chosen to (a) reflect appropriate ecological time-frames for positive change to happen; (b) align with the most generous funding providers for ecosystem conservation/interventions and (c) support high-level policies such as the UN Decade Ecosystem Restoration. Most importantly, we believe ambition is required due to the urgency of the planetary crises facing humanity. Ethical approval was gained from the University of Portsmouth Faculty of Science and Health Ethics Committee (SHFEC 2024-003) with written informed consent from participants.

Twenty-nine participants from six continents (recognising a dominance of participants from northern hemisphere countries) submitted 280 questions. This and subsequent participant numbers were from a pool of 47 researchers who had emailed their interest in being involved at the outset. These were reviewed by the project team leads who removed duplicates and reworded some questions for clarity. The resulting 248 questions were shared with all 47 participants, who were asked to score each question between 0 and 4 (where 0=not important, 4=of highest importance). Thirty participants of the 47 responded and for each question, a mean score was generated, with the top 50% of questions discussed at an online workshop. Prior to the workshop, the shortlisted questions were organised into six themes: (1) maps/evidence/long-term data; (2) processes/variability; (3) connectivity; (4) anthropogenic impacts; (5) methods/standards; and (6) governance/trading schemes/conservation. Duplicates were merged and some rewording applied, with questions then shared again with participants. The participants could reintroduce questions that were below the cut-off, although none were suggested. The six themes and 30 participants were mapped onto facilitator-led themed breakout groups, with themes (1) and (5) subsequently merged due to the low number of questions. Participants selected the breakout group theme with which they most identified.

During the online workshop, the first breakout sessions focused on refining the questions. Each group checked for duplication and clarity of meaning and the facilitator reworded the questions as required. At the end of the polishing exercise, participants received the revised questions to independently select their top 50% of their respective theme. Mean scores were then calculated to generate the ranked list per breakout group. This list was edited again with the option of reinserting any deselected questions and any questions with tied scores were discussed. After the workshop, the remaining questions from each theme were combined into one spreadsheet (44 questions altogether). The 47 participants were then asked to independently select their final top 25. Scores were received from 32 participants; these were combined to generate an overall ranking with five questions sharing the 25th position. Twenty-eight participants then ranked the five again from which the highest scoring question was added to generate the final list.

To facilitate research-investment decisions for each retained question, 23 participants of the 47 assigned a level across five categories: time, geographic scale, data collection complexity, cost and policy relevance. Each category had three levels (time: 1–3 years, 3–5 years, 5–10+ years; geographic scale: local, regional, national; cost: cheap, medium, expensive; data collection complexity: simple, intermediate and complex; policy relevance: low, medium and high). A text description with examples to aid the participants (Table S1) and email clarification if requested. Results were collated and the level mode for each category for each question was calculated.

3 | PRIORITY QUESTIONS ORGANISED BY THEMES

The final 25 questions assigned to the six themes (see above) are presented below with an associated discussion and context. It is important to note that other PSEs covering similar or related topics may have come up with a different set of questions. This will depend not only on the participants but also the context for each PSE; however, the expertise of the selected participants provides a robust foundation to the conclusions we draw. Whilst we acknowledge that not all six ecosystem types are present in all locations and some ecosystems were not included, the questions can be applied across ecosystems and ecoregions in a context-specific way. It is also evident that many of the questions have strong links between themes. The six themes used for organisation were created during the refinement process to help structure the discussions and voting processes. Retaining them here helps interpretation, but also highlights common themes across coastal ecosystems reflected in other priority question studies (e.g. zu Ermgassen et al., 2020). Some questions are focussed on CSS or NB and others include both, which may be because of personal preference by the researcher submitting the question and of the participants during the selection process. Regardless of the focus of the question, it is important to recognise the strength of the connection between CSS and NB in subsequent research.

3.1 | Maps/quantitative evidence /long-term data

Mapping C and nutrient stores will allow policymakers to prioritise how coastal ecosystems are managed, especially as this is reliant on available data. Despite the scientific interest and improvements in remote sensing, many coastal ecosystems, even in more research-intensive countries, are mapped only in low resolution. For some ecosystems such as saltmarshes, the extent estimates can be robust at regional scales, whilst others (e.g. seagrass beds) have poor accuracy and resolution (Watson et al., 2020). Critical evidence gaps also relate to ecosystem condition and resilience metrics, as these directly influence service delivery (Mace et al., 2015). Excluding the prevailing conditions and resilience creates significant performance risks for Market-Based Instruments and also limits scalability for national or disaggregated accounting. Furthermore, significant variability exists in long-term C and N storage estimates, often due to the use of diverse field data and models, etc. in the absence of standardised methods (see Ray & Fulweiler, 2021; Watson et al., 2022). The ability to deliver ecosystem services is further compromised by stressors such as coastal development, pollution and climate change.

Q1. What long-term data do we need to assess outcomes of CSS and NB interventions on the biodiversity and ecosystem functioning of coastal ecosystems?

Q2. How do we best map the vulnerability of stored carbon and nutrient removal functions to pressures such as sea level rise, climate change, pollution at high resolution?

Q3. How good is the evidence for the ability of different coastal ecosystems to deliver effective, long-term CSS and NB?

3.2 | Processes/variability

Scaling up and the broader application of NB and CSS processes are hampered by spatial and temporal complexity such as strong inter- and intra-site variability, particularly at small spatial scales (<3 km, Ricart et al., 2020) and across seasons (Dahl et al., 2020). Sources (e.g. locally generated v. supplied by external sources) and permanence (long-term stability of stores) remain understudied quantitatively. Similarly, the drivers of the variability in nutrient and carbon fluxes remain poorly constrained (Mazarrasa et al., 2021). Despite evidence of regime shifts in some regions (Lovelock & Reef, 2020; Wernberg et al., 2016), there is a poor understanding of the impacts of climate change, although in estuaries and their associated catchments there is increasing qualitative and quantitative knowledge (Kennish et al., 2024). It is expected that climate change will impact the sign and scale of CSS and NB in coastal ecosystems (Lovelock & Reef, 2020; Williamson & Gattuso, 2022). This will influence decision-making around Market-Based Instruments and valuation of CSS and NB, creating uncertainties regarding the outcomes of management scenarios (Waltham et al., 2020).

Q4. Are there scale dependencies (e.g. ecosystem extent, condition and species composition) for CSS and NB?

Q5. How does carbon and nutrient storage evolve over time from newly created or restored to mature systems?

Q6. What are the sources, amounts and labilities of carbon and nutrients stored in coastal sediments and what drives their variability?

Q7. How will global change affect the permanence of CSS in different ecosystems?

Q8. Which key factors influence the carbon and nutrient storage in vegetated and unvegetated marine coastal sediments?

Q9. What is the spatial and temporal variability in the drivers of nutrient and carbon fluxes?

3.3 | Connectivity

Coastal research has traditionally focused on single-ecosystem assessments and their ecological functions (e.g. Oreska et al., 2017). However, this leaves substantial knowledge gaps regarding multi-ecosystem assessments and the effects of connectivity. Where relevant studies do exist, they highlight the importance of coastal ecosystem proximity and spatial configuration in modulating ecosystem services (Asplund et al., 2021). For example, saltmarshes can reduce nutrient and sediment inputs to adjacent seagrasses, thereby enhancing seascape CSS by co-facilitating favourable environmental conditions (Huxham et al., 2018). Treating coastal systems and their adjoining catchments and marine areas as an

Journal of Applied Ecology

integrated social–ecological system encompasses the dynamics in both social and ecological aspects (Gladstone-Gallagher et al., 2022).

Q10. How does the proximity of an ecosystem to other ecosystems within the coastal seascape influence its role in CSS and NB?
Q11. How does seascape connectivity influence the origin and fate of carbon (allochthonous vs. autochthonous) within coastal ecosystems and biotopes?

3.4 | Anthropogenic impacts

Numerous anthropogenic activities across both global (e.g. climate change) and regional/local (e.g. nutrient loading) scales can alter nutrient fluxes and carbon storage (Dahl et al., 2023). Such activities can have detrimental, neutral or positive impacts on CSS-NB capacity (Lovelock & Reef, 2020). For example, catchment degradation can cause tipping points; however, the thresholds of change, together with resistance, resilience and recovery mechanisms, remain poorly constrained (Palacios et al., 2021), limiting our ability to manage ecosystems via Nature-Based Solutions to maximise their CSS and NB capacity. Climate change is regarded as an exogenic, unmanaged pressure in which the causes are external to the ecosystem, but the consequences, such as extensive die-offs and loss of biogeochemical sinks reported for seagrass beds (Arias-Ortiz et al., 2018), need to be addressed inside the respective system. In contrast, ecosystem loss through land-claim is an endogenic managed pressure, in which both the causes and consequences are managed locally (Elliott & Kennish, 2024). Nevertheless, the numerous exogenic and endogenic pressures and their impacts, acting concurrently on coastal ecosystems (see Halpern et al., 2025) need to be better understood, quantified and modelled to aid successful and cost-effective management actions.

Q12. How do anthropogenic pressures (e.g. eutrophication and catchment degradation) influence CSS and NB?
Q13. How will climate change influence future delivery of CSS and NB ecosystem services?
Q14. What are the impacts of cumulative pressures on CSS and NB service delivery and what is the potential for ecological recovery following pressure reduction?
Q15. What are the key drivers/processes of CSS that allow us to better model the effectiveness of ecosystem management, restoration and conservation?

3.5 | Methods/standards

Diverse processes can impact both CSS and NB, including porewater exchange and site-specific biogeochemical processes (Williamson & Gattuso, 2022). Added complexities include challenges in quantifying CO_2 release through calcification (Gattuso et al., 1999) and the effects of methane and nitrous oxide production (Rosentreter et al., 2021). In addition, important processes such as sulphur and inorganic carbon cycling and denitrification are not usually included in CSS estimates, despite being important sources of CO_2 emissions (Wang et al., 2021). Together, inherent uncertainties have to be addressed in defining standardised methods and communicated to stakeholders. Current cost-effective proxies do not always reliably predict NB and CSS. For example, carbon storage in sediments is typically limited to quantifying standing stocks, rather than taking a carbon-stock change approach. This includes assessing the relative labile and refractory fractions as an indication of short or long-term storage capacity, ultimately providing better information about sequestration and storage versus loss from the system.

Q16. What are the uncertainties and cumulative errors around CSS and NB estimates and how can these be communicated?
Q17. How do we identify and harmonise variables and methodologies for comparability and to enable scaling up?
Q18. Are we appropriately measuring CSS and NB in all marine ecosystems and what are the best methods to do this correctly?
Q19. What is the minimum level of primary data needed to standardise and enable viable scaling up of CSS and NB estimates?
Q20. What are the most consistent, rapid, accessible and cost-effective methodologies for quantifying CSS and NB?
Q21. What proxy variables can be used to extrapolate CSS and NB from empirical data to wider spatial and temporal scales?

3.6 | Governance/conservation

Irrespective of answering key scientific 'process' questions, the governance, conservation and management of coastal ecosystems are core elements for the successful scale-up of Nature-Based Solutions (Sánchez-Arcilla et al., 2022). Governance is regarded here as the sum of policies, politics, administration and legislation elements for conservation (Cormier et al., 2022). As such, it is essential to address governance knowledge gaps and give them equal consideration with natural science questions. For example, there may be a mismatch between the legislation implemented by statutory bodies and the conservation or management goals, where governance does not allow permanence of restoration activities to guarantee long-term delivery of CSS-NB benefits (Ruseva et al., 2020). Considering the key gaps and questions in governance, additional to those arising from scientific areas is essential.

Q22. What are the regulatory and governance challenges associated with implementing CSS-NB initiatives?
Q23. How do we design and locate coastal ecosystems to maximise CSS and NB remediation potential?
Q24. What practical knowledge, innovation and skill gaps need to be met to restore temperate coastal ecosystems at the scales necessary to have a significant impact on CSS and NB?

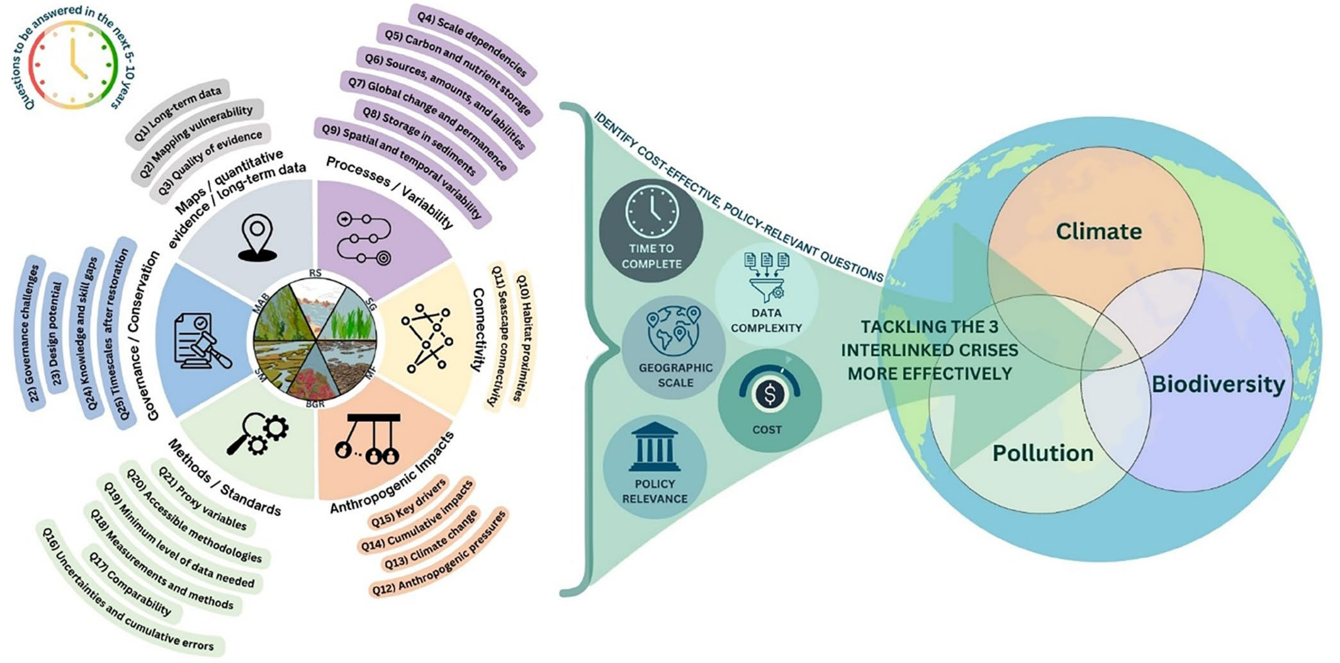

FIGURE 1 Summary of the process to identify the most cost-effective, policy-relevant questions from the six themes and temperate coastal ecosystems to tackle interconnected planetary crises.

Q25. What are the timescales of CSS and NB after restoration and recovery activities to enable achieving reference or mature ecosystem status?

3.7 | Identifying cost-effective, policy-relevant questions

Research topics can be categorised as being 'nice-to-know' (i.e. for scientific curiosity) or 'need-to-know' for high policy relevance. To facilitate research-investment decisions (i.e. generate decision-grade data), the 25 questions were scored across the five categories: time, geographic scale, data collection complexity, cost and policy relevance so that focusing on those that are most 'cost-effective' would expedite policy decisions to tackle the three planetary crises in coastal systems (Figure 1).

We present modal scores for each category (time, geographic scale, data collection complexity, cost and policy relevance) to highlight those questions that are included in the 'need to know' (Table 1). Green signifies 'good', that is the question can be answered in the shortest time, with low cost and using simple data collection methods, but is also relevant at the largest geographic and policy scales. Whilst the mode indicates importance, even among participants there were diverse responses (as such we use shading to indicate the strength of the mode). Only three of the questions were considered to have low policy relevance, whilst 10 were scored as high, being strategic research, driven by a policy need that is expected to influence a regional or national policy. Most participants also indicated that nine questions could be addressed quickly (within 1–3 years) with only two scored as requiring significant funding (>£500,000). However, 18 questions would have to be answered at the national scale (i.e. data collected from multiple sites/coastal ecosystems) and only four questions would require simple data collection methods.

Recognising the subjective nature of the process, Table 1 should be interpreted with a policy in mind. We recommend that decision makers look at questions linked to their key policies as a starting point in the discussion and should also frame the 'how much is enough' for the findings to be actionable to support decision-making. Nevertheless, some broader themes for research-funders can also be extracted. For example, focussing on answering questions in the Methods/standards theme are generally the most cost-effective, low cost and quick to answer with simple data collection methods, but also have medium/high policy relevance. Two questions (22, 24) in the Governance/trading schemes/conservation scheme would also be 'low hanging fruit'. In contrast, although the policy relevance for questions in the Anthropogenic Impacts theme is generally high (e.g. questions 12–14) they would require more time/money and data collection would be a complex process. Table 1 identifies the most cost-effective and policy-relevant questions as indicated by the participants, but there are a number of actions that could expedite data collection. For example, the application of handbooks (e.g. UK saltmarsh code for blue carbon) across countries/regions and to other ecosystems (e.g. mudflats) and services (e.g. NB) would collate best practise and facilitate method harmonisation. This could also be accelerated by existing networks (e.g. European Native Oyster Restoration Alliance) for data sharing and method comparison across ecosystems.

To fund nature recovery, Nature-Based Solutions and Market-Based Instruments linked to CSS/NB have become central to local, regional and global policy drivers (IPCC, 2022). More recently,

TABLE 1 Question mode across categories.

Q#	Theme	Questions	Time to complete	Geographic scale	Data coll. complexity	Cost	Policy relevance
1	Maps/evidence/long-term data	What long-term data do we need to assess outcomes of carbon storage and nutrient bioremediation interventions on the biodiversity and ecosystem functioning of coastal habitats?	5–10+	National	Intermediate	Medium	Medium
2	Maps/evidence/long-term data	How do we best map the vulnerability of stored carbon and nutrient removal functions to pressures such as sea level rise, climate change, pollution at high resolution?	3–5	National	Intermediate	Medium	High
3	Maps/evidence/long-term data	How good is the evidence for the ability of different coastal ecosystems to deliver effective, long-term nutrient bioremediation and carbon storage?	1–3	National	Intermediate	Medium	High
4	Processes/variability	Are there scale dependencies (e.g. for habitat extent, condition, and species composition) for carbon sequestration and nutrient bioremediation?	3–5	National	Intermediate	Medium	Medium
5	Processes/variability	How does carbon and nutrient storage evolve over time from newly created or restored to mature systems?	5–10+	Regional	Intermediate	Medium	Medium
6	Processes/variability	What are the sources, amounts and labilities of carbon and nutrients stored in coastal sediments and what drives their variability?	3–5	Regional	Complex	Medium	Low
7	Processes/variability	How will global change affect the permanence of carbon storage in different habitats?	5–10+	National	Complex	Expensive	High
8	Processes/variability	Which key factors influence the carbon and nutrient storage in vegetated and unvegetated marine coastal sediments?	3–5	National	Intermediate	Medium	Medium
9	Processes/variability	What is the spatial and temporal variability in the drivers of nutrient and carbon fluxes?	3–5	National	Complex	Medium	Low
10	Connectivity (watershed/habitats)	How does the proximity of blue carbon habitats to other habitats within the coastal seascape influence their role in blue carbon storage and nutrient bioremediation?	3–5	Regional	Complex	Medium	Medium
11	Connectivity (watershed/habitats)	How does seascape connectivity influence the origin and fate of carbon (allochthonous vs. autochthonous) within blue carbon ecosystems and biotopes?	3–5	Regional	Complex	Medium	Medium
12	Anthropogenic impacts	How do anthropogenic pressures (e.g. eutrophication and catchment degradation) influence blue carbon storage and nutrient bioremediation?	3–5	National	Intermediate	Medium	High
13	Anthropogenic impacts	How will climate change influence future delivery of CSS & NB services?	5–10+	National	Complex	Expensive	High

(Continues)

TABLE 1 (Continued)

Q#	Theme	Questions	Time to complete	Geographic scale	Data coll. complexity	Cost	Policy relevance
14	Anthropogenic impacts	What are the impacts of cumulative pressures on CSS and NB service delivery and what is the potential for ecological recovery following pressure reduction?	5–10+	Regional	Complex	Medium	High
15	Anthropogenic impacts	What are the key drivers/processes of carbon sequestration that allow us to better model the effectiveness of habitat management, restoration, and conservation?	1–3	National	Intermediate	Medium	Medium
16	Methods/standards	What are the uncertainties and cumulative errors around nutrient bioremediation and carbon storage estimates and how can these be communicated?	1–3	National	Simple	Cheap	Medium
17	Methods/standards	How do we identify and harmonize variables and methodologies for comparability and to enable scaling up?	1–3	National	Simple	Cheap	Medium
18	Methods/standards	Are we appropriately measuring carbon storage and nutrient bioremediation in all marine habitats and what are the best methods to do this correctly?	1–3	National	Simple	Cheap	High
19	Methods/standards	What is the minimum level of primary data needed to and standardize and enable viable scaling up of carbon storage and nutrient bioremediation estimates?	1–3	National	Intermediate	Cheap	High
20	Methods/standards	What are the most consistent, rapid, accessible and cost-effective methodologies for quantifying nutrient bioremediation and carbon storage?	1–3	National	Intermediate	Medium	Medium
21	Methods/standards	What proxy variables can be used to extrapolate carbon storage and nutrient bioremediation from empirical data to wider spatial and temporal scales?	3–5	National	Intermediate	Medium	Low
22	Governance/trading schemes/ conservation	What are the regulatory and governance challenges associated with implementing CSS-NB initiatives?	1–3	National	Simple	Cheap	High
23	Governance/trading schemes/ conservation	How do we design and locate coastal habitats to maximise CSS & NB remediation potential?	3–5	National	Intermediate	Medium	Medium
24	Governance/trading schemes/ conservation	What practical knowledge, innovation & skill gaps need to be met to restore temperate coastal habitats at the scales necessary to have a significant impact on CSS and NB?	1–3	National	Intermediate	Cheap	Medium
25	Governance/trading schemes/ conservation	What are the timescales of CSS & NB after restoration and recovery activities to achieve reference, or mature habitat status?	5–10+	National	Complex	Medium	High

Note: Three levels where green signifies: Lowest; amber: Medium; red: Highest: (time: 1–3 years, 3–5 years, 5–10+ years; geographic scale: Local, regional, national; cost: Cheap, medium, expensive; data collection complexity: Simple, intermediate and complex; policy relevance: Low, medium and high). Strength of mode indicated by shading: (a) participants chose two levels equally (higher chosen), (b) weak: 9–13 participants chose the level; (c) moderate: 14–18, (d) strong: 19–23.

some governments have enacted legislation that supports Market-Based Instruments based on biodiversity (e.g. UK Biodiversity Net-Gain). Despite biodiversity being only sporadically integrated into decision-making (Tinch et al., 2019), it would be important to incorporate the role of biodiversity in CSS/NB; often generating quantifiable co-benefits (Broszeit et al., 2019; Fitzgerald et al., 2021). Other activities such as aquaculture can also provide CSS/NB; for example nutrient accumulated in the biomass of the cultured species which is exported from the system at harvesting (Filippini et al., 2023), although this can be hampered by co-location interactions with the protected coastal ecosystems/other users (Gouvello et al., 2017) and poor water quality (Webber et al., 2021).

There continues to be ongoing academic debate (e.g. Gallagher, 2023; Williamson et al., 2024; Williamson & Gattuso, 2022) on the (un)certainty of climate benefits from vegetated coastal ecosystems that underscores the urgent need to answer the questions generated here. Even as current research resolves some issues, failing to address the questions highlighted here risks the non-delivery of expected benefits. For initiatives to succeed, researchers, investors and policymakers must have confidence that the data are robust and fit for purpose. A continued lack of evidence-grade, decision-ready data could result in issues for certification, potential overcrediting and/or under-reporting of risks, thus impacting potential investor pipelines. It could also contribute to loopholes, misreporting and perverse incentives (Climate Analytics, 2017), as have widely occurred when complex financial incentives for reducing emissions from deforestation/forest degradation have been used in developing countries (Badgley et al., 2022; Correa et al., 2019).

4 | CONCLUSIONS

Using a multistage, collaborative PSE approach, experts from six continents generated 25 questions aimed at increasing confidence in the robustness, scalability and applicability of NB and CSS data, that is making it decision-grade. Prioritising the most policy-relevant questions, combined with quick, cheap and simple data collection methods, will expedite research funding decision-making. Considering that the halfway points of the UN Decades of Ocean Science for Sustainability and of Ecosystem Restoration have already passed, rapid expansion of Market-Based Instruments and Nature-Based Solutions interventions available to practitioners, policymakers and investors across temperate coastal ecosystems should be supported. Whilst effective and scalable ecosystem-specific conservation approaches are still vitally important, there is an ongoing ideological shift towards a multi-ecosystem seascape framework (e.g. McAfee et al., 2022; Preston et al., 2025) and potentially a need to incorporate novel ecosystems too (Schläppy & Hobbs, 2019). This will not only influence NB and CSS scalability, but require Market-Based Instrument integration into this transformative shift of wider conservation policies. However, the current reliance on Market-Based Instruments based on limited CSS and NB data will generate significant risks around delivering what is promised. This will potentially jeopardise the expansion of green-finance to address the climate and nutrient crises, restore degraded coastal ecosystems and enhance human well-being.

AUTHOR CONTRIBUTIONS

All authors (Watson, Gordon J.; Aldridge, John; Anderson, Louise; Attrill, Martin J.; Austin, William E.N.; Bahr, Keisha D.; Beaumont, Nicola; Broszeit, Stefanie; Burden, Annette; Delgado-Gargiulo, Estela; Drakou, Evangelia G.; Elliott, Mike; Filbee-Dexter, Karen; Fulweiler, Robinson W.; Garbutt, Angus; Hancock, Boze; Hardege, Joerg D.; Harley, Joanna; Hendy, Ian W.; Hillman, Jenny R.; Jickells, Tim D.; Lillebø, Ana I.; Lima, Mariana D.A.C.; Macreadie, Peter I.; Martinetto, Paulina; Mellan, Jackie; Norkko, Alf; Parker, Ruth; Perring, Michael P.; Pogoda, Bernadette; Pollack, Jennifer B.; Preston, Joanne; Ragazzola, Federica; Saunders, Justine; Serrano, Oscar; Smale, Dan A.; Smith, Gemma; Thornton, Ann; Thrush, Simon; Tillin, Heidi; Unsworth, Richard K.F.; van der Schatte Olivier, Andrew; von der Heyden, Sophie; Watson, Stephen C.L.; Williamson, Phil; Woulds, Claire; zu Ermgassen, Philline S.E.) contributed to the PSE process and/or the writing and editing of the manuscript.

AFFILIATIONS

[1]Institute of Marine Sciences, School of Environment and Life Sciences, University of Portsmouth, Portsmouth, UK; [2]Centre for Environment, Fisheries and Aquaculture Science, Suffolk, UK; [3]Joint Nature Conservation Committee, Peterborough, UK; [4]School of Biological & Marine Sciences, University of Plymouth, Plymouth, UK; [5]School of Geography & Sustainable Development, University of St Andrews, Fife, UK; [6]Scottish Association for Marine Science, Oban, UK; [7]Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, Corpus Christi, Texas, USA; [8]Plymouth Marine Laboratory, Plymouth, UK; [9]UK Centre for Ecology & Hydrology, Environment Centre Wales, Bangor, Gwynedd, UK; [10]Departamento Interdisciplinario de Sistemas Costeros y Marinos, Centro Universitario Regional del Este (CURE), Universidad de la República, Montevideo, Uruguay; [11]Department of Geography, Harokopio University of Athens, Athens, Greece; [12]International Estuarine & Coastal Specialists (IECS) Ltd, Leven, UK; [13]School of Environmental and Life Sciences, University of Hull, Hull, UK; [14]School of Biological Sciences, The University of Western Australia (M470), Perth, Australia; [15]Department of Earth and Environment, Department of Biology, Boston University, Boston, Massachusetts, USA; [16]Global Oceans Team, The Nature Conservancy, Narragansett, Rhode Island, USA; [17]Biological Sciences, Hull University, Hull, UK; [18]Institute of Marine Science, University of Auckland, Auckland, New Zealand; [19]School of Environmental Sciences, University of East Anglia, Norwich, UK; [20]ECOMARE, CESAM-Centre for Environmental and Marine Studies, Department of Biology, University of Aveiro, Aveiro, Portugal; [21]School of Science, Engineering and Environment, University of Salford, Salford, UK; [22]Centre for Nature Positive Solutions,

Biosciences and Food Technology Discipline, School of Science, RMIT University, Melbourne, Victoria, Australia; [23]Laboratorio de Ecología, Instituto de Investigaciones Marinas y Costeras (IIMyC, UNMdP-CONICET), Mar del Plata, Argentina; [24]Environment Agency, Bristol, UK; [25]Tvärminne Zoological Station, Faculty of Biological & Environmental Sciences, University of Helsinki, Hanko, Finland; [26]Cefas, Lowestoft Laboratory, Suffolk, UK; [27]The UWA Institute of Agriculture, The University of Western Australia, Perth, WA, Australia; [28]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany; [29]Department of Integrative Marine Ecology, Genova Marine Centre, Stazione Zoologica Anton Dohrn, Genoa, Italy; [30]SCANIS Consulting, Huntingdon, UK; [31]Centro de Estudios Avanzados de Blanes, Consejo Superior de Investigaciones Científicas (CEAB-CSIC), Blanes, Spain; [32]Marine Biological Association of the United Kingdom, Plymouth, UK; [33]Conservation Evidence Group, Department of Zoology, University of Cambridge, Cambridge, UK; [34]Science Centre, Auckland, New Zealand; [35]Project Seagrass, Bridgend, UK; [36]Seagrass Ecosystem Research Group, Department of Biosciences, Swansea University, Swansea, UK; [37]Yorkshire Wildlife Trust, York, UK; [38]School for Climate Studies, Stellenbosch University, Matieland, South Africa; [39]School of Geography, University of Leeds, Leeds, UK and [40]Changing Oceans Group, School of Geosciences, University of Edinburgh, Edinburgh, UK

ACKNOWLEDGEMENTS

This research was supported by the UK Research Councils under Natural Environment Research Council award NE/X002357/1 'Sea the Value'. AIL acknowledges financial support to CESAM by FCT/MCTES (UIDP/50017/2020 + UIDB/50017/2020 + LA/P/0094/2020).

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.pk0p2nh3w (Watson et al., 2026).

ORCID

Gordon J. Watson https://orcid.org/0000-0001-8274-7658
Evangelia G. Drakou https://orcid.org/0000-0003-4404-629X
Mariana D. A. C. Lima https://orcid.org/0000-0002-5277-6391
Paulina Martinetto https://orcid.org/0000-0002-9845-5817
Alf Norkko https://orcid.org/0000-0002-9741-4458
Dan A. Smale https://orcid.org/0000-0003-4157-541X
Richard K. F. Unsworth https://orcid.org/0000-0003-0036-9724
Sophie von der Heyden https://orcid.org/0000-0001-9166-976X

REFERENCES

Arias-Ortiz, A., Serrano, O., Masqué, P., Lavery, P. S., Mueller, U., Kendrick, G. A., Rozaimi, M., Esteban, A., Fourqurean, J. W., Marbà, N. J. N. C. C., & Mateo, M. A. (2018). A marine heatwave drives massive losses from the world's largest seagrass carbon stocks. *Nature Climate Change*, *8*, 338–344.

Asplund, M. E., Dahl, M., Ismail, R. O., Arias-Ortiz, A., Deyanova, D., Franco, J. N., Hammar, L., Hoamby, A. I., Linderholm, H. W., Lyimo, L. D., Perry, D., Rasmusson, L. M., Ridgway, S. N., Salgado Gispert, G., D'Agata, S., Glass, L., Mahafina, J. A., Ramahery, V., Masque, P., … Gullström, M. (2021). Dynamics and fate of blue carbon in a mangrove–seagrass seascape: Influence of landscape configuration and land-use change. *Landscape Ecology*, *36*, 1489–1509.

Badgley, G., Freeman, J., Hamman, J. J., Haya, B., Trugman, A. T., Anderegg, W. R., & Cullenward, D. (2022). Systematic over-crediting in California's forest carbon offsets program. *Global Change Biology*, *28*, 1433–1445.

Beaumont, N. J., Jones, L., Garbutt, A., Hansom, J. D., & Toberman, M. (2014). The value of carbon sequestration and storage in coastal habitats. *Estuarine, Coastal and Shelf Science*, *137*, 32–40.

Brears, R. C. (2022). Market-based instruments financing nature-based solutions. In *Financing nature-based solutions: Exploring public, private, and blended finance models and case studies* (pp. 75–104). Springer International Publishing.

Broszeit, S., Beaumont, N. J., Hooper, T. L., Somerfield, P. J., & Austen, M. C. (2019). Developing conceptual models that link multiple ecosystem services to ecological research to aid management and policy, the UK marine example. *Marine Pollution Bulletin*, *141*, 236–243.

Climate Analytics. (2017). *The dangers of blue carbon offsets: From hot air to hot water*. Briefings. https://climateanalytics.org/briefings/the-dangers-of-blue-carbon-offsets-from-hot-air-to-hot-water.

Cormier, R., Elliott, M., & Borja, Á. (2022). Managing marine resources sustainably–the 'management response-footprint pyramid' covering policy, plans and technical measures. *Frontiers in Marine Science*, *9*, 869992.

Correa, J., Van der Hoff, R., & Rajão, R. (2019). Amazon fund 10 years later: Lessons from the world's largest REDD+ program. *Forests*, *10*, 272.

Dahl, M., Asplund, M. E., Deyanova, D., Franco, J. N., Koliji, A., Infantes, E., Perry, D., Björ, M., & Gullström, M. (2020). High seasonal variability in sediment carbon stocks of cold-temperate seagrass meadows. *JGR Biogeosciences*, *125*, 2019JG005430.

Dahl, M., McMahon, K., Lavery, P. S., Hamilton, S. H., Lovelock, C. E., & Serrano, O. (2023). Ranking the risk of CO_2 emissions from seagrass soil carbon stocks under global change threats. *Global Environmental Change*, *78*, 102632.

Defeo, O., & Elliott, M. (2021). The 'triple whammy' of coasts under threat–why we should be worried! *Marine Pollution Bulletin*, *163*, 111832.

Elliott, M., & Kennish, M. J. (2024). A synthesis of anthropogenic impacts and solutions in estuarine and coastal environments. In M. J. Kennish & M. Elliott (Eds.), *Treatise on Estuarine & Coastal Sciences* (Vol. 6, 2nd ed., pp. 1–56). Elsevier.

EU. (2022). European Commission, directorate-general for environment. In *Nature restoration law–For people, climate, and planet*. Publications Office of the European Union.

Filippini, G., Dafforn, K. A., & Bugnot, A. B. (2023). Shellfish as a bioremediation tool: A review and meta-analysis. *Environmental Pollution*, *316*, 120614.

Fitzgerald, M., Gonzalez, K., Funk, J. L., Whitcraft, C. R., & Allen, B. J. (2021). Recovering ecosystem functions in a restored salt marsh by leveraging positive effects of biodiversity. *Ecosphere*, *12*, 03664.

Gallagher, J. B. (2023). An opinion on BlueCAM an Australian blue carbon method to estimate climate change mitigation benefits of coastal wetland restoration by Lovelock et al 2022. *Restoration Ecology*, *31*, e13859.

Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decleer, K., & Dixon, K. W.

(2019). International principles and standards for the practice of ecological restoration. *Restoration Ecology*, *27*, S1–S46.
Gattuso, J. P., Frankignoulle, M., & Smith, S. V. (1999). Measurement of community metabolism and significance in the coral reef CO_2 source-sink debate. *Proceedings of the National Academy of Sciences*, *96*, 13017–13022.
Gladstone-Gallagher, R. V., Tylianakis, J. M., Yletyinen, J., Dakos, V., Douglas, E. J., Greenhalgh, S., Hewitt, J. E., Hikuroa, D., Lade, S. J., Le Heron, R., & Norkko, A. (2022). Social–ecological connections across land, water, and sea demand a reprioritization of environmental management. *Elementa: Science of the Anthropocene*, *10*, 00075.
Gouvello, R. L., Hochart, L. E., Laffoley, D., Simard, F., Andrade, C., Angel, D. L., Callier, M. D., De Monbrison, D., Fezzardi, D., Haroun, R., Harris, A., Hughes, A. D., Massa, F., Roque, E., Soto, D., Stead, S. M., & Marino, G. (2017). Aquaculture and marine protected areas: Potential opportunities and synergies. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *27*, 138–150.
Haines-Young, R., & Potschin-Young, M. (2018). Revision of the common international classification for ecosystem services (CICES V5.1): A policy brief. *One Ecosystem*, *3*, 27108.
Halpern, B. S., Frazier, M., O'Hara, C. C., Vargas-Fonseca, O. A., & Lombard, A. T. (2025). Cumulative impacts to global marine ecosystems projected to more than double by mid-century. *Science*, *389*, 1216–1219.
Heckwolf, M. J., Peterson, A., Jänes, H., Horne, P., Künne, J., Liversage, K., Sajeva, M., Reusch, T. B., & Kotta, J. (2021). From ecosystems to socio-economic benefits: A systematic review of coastal ecosystem services in the Baltic Sea. *Science of the Total Environment*, *755*, 142565.
Huxham, M., Whitlock, D., Githaiga, M., & Dencer-Brown, A. (2018). Carbon in the coastal seascape: How interactions between mangrove forests, seagrass meadows and tidal marshes influence carbon storage. *Current Forestry Reports*, *4*, 101–110.
IPCC. (2019). *Glossary of special report on the ocean and cryosphere in a changing climate*.
IPCC. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of working group II to the sixth assessment report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press.
Kennish, M. J., Paerl, H. W., & Crosswell, J. R. (Eds.). (2024). *Climate change and estuaries* (p. 663). CRC Press.
Krause-Jensen, D., & Duarte, C. M. (2016). Substantial role of macroalgae in marine carbon sequestration. *Nature Geoscience*, *9*, 737–742.
Kristensen, E., Flindt, M. R., & Quintana, C. O. (2025). Predicting climate mitigation through carbon burial in blue carbon ecosystems—Challenges and pitfalls. *Global Change Biology*, *31*, 70022.
Lockie, S. (2013). Market instruments, ecosystem services, and property rights: Assumptions and conditions for sustained social and ecological benefits. *Land Use Policy*, *31*, 90–98.
Lovelock, C. E., & Reef, R. (2020). Variable impacts of climate change on blue carbon. *One Earth*, *3*, 195–211.
Mace, G. M., Hails, R. S., Cryle, P., Harlow, J., & Clarke, S. J. (2015). Towards a risk register for natural capital. *Journal of Applied Ecology*, *52*, 641–653.
Mazarrasa, I., Lavery, P., Duarte, C. M., Lafratta, A., Lovelock, C. E., Macreadie, P. I., Samper-Villarreal, J., Salinas, C., Sanders, C. J., Trevathan-Tackett, S., & Young, M. (2021). Factors determining seagrass blue carbon across bioregions and geomorphologies. *Global Biogeochemical Cycles*, *35*, 006935.
McAfee, D., Reis-Santos, P., Jones, A. R., Gillanders, B. M., Mellin, C., Nagelkerken, I., Nursey-Bray, M. J., Baring, R., da Silva, G. M., Tanner, J. E., & Connell, S. D. (2022). Multi-habitat seascape restoration: Optimising marine restoration for coastal repair and social benefit. *Frontiers in Marine Science*, *9*, 910467.
Ockendon, N., Thomas, D. H., Cortina, J., Adams, W. M., Aykroyd, T., Barov, B., Boitani, L., Bonn, A., Branquinho, C., Brombacher, M., & Burrell, C. (2018). One hundred priority questions for landscape restoration in Europe. *Biological Conservation*, *221*, 198–208.
Office for National Statistics (ONS). (2021). Compendium: Env. Accounts, UK government.
Oreska, M. P. J., McGlathery, K. J., & Porter, J. H. (2017). Seagrass blue carbon spatial patterns at the meadow-scale. *PLoS One*, *12*, 0176630.
Palacios, M. M., Trevathan-Tackett, S. M., Malerba, M. E., & Macreadie, P. I. (2021). Effects of a nutrient enrichment pulse on blue carbon ecosystems. *Marine Pollution Bulletin*, *165*, 112024.
Pirard, R. (2012). Market-based instruments for biodiversity and ecosystem services: A lexicon. *Environmental Science & Policy*, *19*, 59–68.
Preston, J., Debney, A., Gamble, C., Hardy, M. J., Underwood, G. J. C., Garbutt, A., Harley, J., Baker, R., Dunk, R. M., Grigg, M., Hancock, B. T., Hendy, I. W., La Marca, E. C., Murray, J., Pettorelli, N., Pittman, S. J., Reeves, S. E., Robertson, M., Sturrock, A. M., … zu Ermgassen, P. S. E. (2025). Seascape connectivity: Evidence, knowledge gaps and implications for temperate coastal ecosystem restoration practice and policy. *npj Ocean Sustainability*, *4*, 33.
Ray, N. E., & Fulweiler, R. W. (2021). Meta-analysis of oyster impacts on coastal biogeochemistry. *Nature Sustainability*, *4*, 261–269.
Ricart, A. M., York, P. H., Bryant, C. V., Rasheed, M. A., Ierodiaconou, D., & Macreadie, P. I. (2020). High variability of blue carbon storage in seagrass meadows at the estuary scale. *Scientific Reports*, *10*, 5865.
Rockström, J., Donges, J. F., Fetzer, I., Martin, M. A., Wang-Erlandsson, L., & Richardson, K. (2024). Planetary boundaries guide humanity's future on earth. *Nature Reviews Earth & Environment*, *5*, 773–788.
Rosentreter, J. A., Al-Haj, A. N., Fulweiler, R. W., & Williamson, P. (2021). Methane and nitrous oxide emissions complicate coastal blue carbon assessments. *Global Biogeochemical Cycles*, *35*, GB006858.
Ruseva, T., Hedrick, J., Marland, G., Tovar, H., Sabou, C., & Besombes, E. (2020). Rethinking standards of permanence for terrestrial and coastal carbon: Implications for governance and sustainability. *Current Opinion in Environmental Sustainability*, *45*, 69–77.
Sánchez-Arcilla, A., Cáceres, I., Le Roux, X., Hinkel, J., Schuerch, M., Nicholls, R. J., Staneva, J., de Vries, M., Pernice, U., Briere, C., & Caiola, N. (2022). Barriers and enablers for upscaling coastal restoration. *Nature-Based Solutions*, *2*, 100032.
Schläppy, M. L., & Hobbs, R. J. (2019). A triage framework for managing novel, hybrid, and designed marine ecosystems. *Global Change Biology*, *25*, 3215–3223.
Sutherland, W. J., Freckleton, R. P., Godfray, H. C. J., Beissinger, S. R., Benton, T., Cameron, D. D., Carmel, Y., Coomes, D. A., Coulson, T., Emmerson, M. C., & Hails, R. S. (2013). Identification of 100 fundamental ecological questions. *Journal of Ecology*, *101*, 58–67.
Tinch, R., Beaumont, N., Sunderland, T., Ozdemiroglu, E., Barton, D., Bowe, C., Börger, T., Burgess, P., Cooper, C. N., Faccioli, M., & Failler, P. (2019). Economic valuation of ecosystem goods and services: A review for decision makers. *Journal of Environmental Economics and Policy*, *8*, 359–378.
Waltham, N. J., Elliott, M., Lee, S. Y., Lovelock, C., Duarte, C. M., Buelow, C., Simenstad, C., Nagelkerken, I., Claassens, L., Wen, C. K., & Barletta, M. (2020). UN decade on ecosystem restoration 2021–2030—What chance for success in restoring coastal ecosystems? *Frontiers in Marine Science*, *7*, 71.
Wang, F., Tang, J., Ye, S., & Liu, J. (2021). Blue carbon sink function of Chinese coastal wetlands and carbon neutrality strategy. *Bulletin of the Chinese Academy of Sciences*, *36*, 241–251.
Ward, E. A., Cerasuolo, M., Ragazzola, F., Reynolds, S. E., & Preston, J. (2024). Global patterns in seagrass leaf and sediment carbon isotope fractionation have implications for carbon provenance

calculations in blue carbon accreditation. *Ecological Indicators*, *167*, 112546.
Watson, G. J., Aldridge, J., Anderson, L., Attrill, M. J., Austin, W. E. N., Bahr, K. D., Beaumont, N., Broszeit, S., Burden, A., Delgado-Gargiulo, E., Drakou, E. G., Elliott, M., Filbee-Dexter, K., Fulweiler, R. W., Garbutt, A., Hancock, B., Hardege, J. D., Harley, J., Hendy, I. W., … zu Ermgassen, P. S. E. (2026). Data from: Priority research questions to generate decision-grade data to enable coastal ecosystems to mitigate the climate and nutrient crises. *Dryad Digital Repository*. https://doi.org/10.5061/dryad.pk0p2nh3w
Watson, S. C. L., Paterson, D. M., Queirós, A. M., Rees, A. P., Stephen, N., Widdicombe, S., & Beaumont, N. J. (2016). A conceptual framework for assessing the ecosystem service of waste remediation: In the marine environment. *Ecosystem Services*, *20*, 69–81.
Watson, S. C. L., Preston, J., Beaumont, N. J., & Watson, G. J. (2020). Assessing the natural capital value of water quality and climate regulation in temperate marine systems using a EUNIS biotope classification approach. *Science of the Total Environment*, *744*, 140688.
Watson, S. C. L., Watson, G. J., Beaumont, N. J., & Preston, J. (2022). Inclusion of condition in natural capital assessments is critical to the implementation of marine nature-based solutions. *Science of the Total Environment*, *838*, 156026.
Webber, J. L., Tyler, C. R., Carless, D., Jackson, B., Tingley, D., Stewart-Sinclair, P. J., Artioli, Y., Torres, R., Galli, G., Miller, P., Land, P. E., Zonneveld, S., Austen, M. C., & Brown, A. R. (2021). Impacts of land use on water quality and the viability of bivalve shellfish mariculture in the UK: A case study and review for SW England. *Environmental Science & Policy*, *126*, 122–131.
Wernberg, T., Bennett, S., Babcock, R. C., de Bettignies, T., Cure, K., Depczynski, M., Dufois, F., Fromont, J., Fulton, C. J., Hovey, R. K., Harvey, E. S., Holmes, T. H., Kendrick, G. A., Radford, B., Santana-Garcon, J., Saunders, B. J., Smale, D. A., Thomsen, M. S., Tuckett, C. A., … Wilson, S. (2016). Climate-driven regime shift of a temperate marine ecosystem. *Science*, *353*, 169–172.
Williamson, P., & Gattuso, J. P. (2022). Carbon removal using coastal blue carbon ecosystems is uncertain and unreliable, with questionable climatic cost-effectiveness. *Frontiers in Climate*, *4*, 853666.
Williamson, P., Schlegel, R. W., Gattuso, J. P., Andrews, J. E., & Jickells, T. D. (2024). Climate benefits of saltmarsh restoration greatly overstated by Mason et al., 2023. *Global Change Biology*, *30*, 17525.
Wunder, S. (2015). Revisiting the concept of payments for environmental services. *Ecological Economics*, *117*, 234–243.
zu Ermgassen, P. S., Bonačić, K., Boudry, P., Bromley, C. A., Cameron, T. C., Colsoul, B., Coolen, J. W., Frankić, A., Hancock, B., van Der Have, T. M., & Holbrook, Z. (2020). Forty questions of importance to the policy and practice of native oyster reef restoration in Europe. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*, 2038–2049.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1. Text descriptions with examples to aid participant to assign a level across five categories: time, geographic scale, data collection complexity, cost and policy relevance. Email clarification was also provided if requested.

How to cite this article: Watson, G. J., Aldridge, J., Anderson, L., Attrill, M. J., Austin, W. E. N., Bahr, K. D., Beaumont, N., Broszeit, S., Burden, A., Delgado-Gargiulo, E., Drakou, E. G., Elliott, M., Filbee-Dexter, K., Fulweiler, R. W., Garbutt, A., Hancock, B., Hardege, J. D., Harley, J., Hendy, I. W., … Zu Ermgassen, P. S. E. (2026). Priority research questions to generate decision-grade data to enable coastal ecosystems to mitigate the climate and nutrient crises. *Journal of Applied Ecology*, *63*, e70373. https://doi.org/10.1111/1365-2664.70373