
Monograph:
Queirós, Ana, Talbot, Elizabeth, Yannitel-Reinhardt, Gina et al. (2026) MSPACE Recommendations Welsh National Marine Plan. Report.

https://doi.org/10.5281/zenodo.18540975

MSPACE Recommendations **Welsh National Marine Plan**

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MSPACE
Marine Spatial Planning
Addressing Climate Effects

MSPACE Recommendations **Welsh National Marine Plan**

DESIGN BY LANDS

Acknowledgments
The Marine Spatial Planning Addressing Climate Effect project (MSPACE) was funded by the UK Natural Environment Research Council and the Economic and Social Research Council, as part of the Sustainable Management of UK Marine Resources (SMMR) Strategic Priorities Fund (grant NE/V016725/1). The SMMR Programme dedicated funding to marine research in order to address critical gaps in understanding identified by UK policy makers.

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Suggested citation
Queiros, AM, E. Talbot, O. Marcone, G. Yannitel-Reinhardt, A Roca Florido and S. Mair (2026). MSPACE Recommendations: Welsh National Marine Plan. A report of the Marine Spatial Planning Addressing Climate Effects project. 17pp

Published February 2026

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Contents

1 What is MSPACE?

The Marine Spatial Planning Addressing Climate Effects programme (MSPACE) is a highly integrated, multidisciplinary and co-created research initiative, driving forward capability in designing and implementing economically viable and socially acceptable climate-smart marine plans (MSP) (i.e. marine plans that promote climate change adaptation and mitigation). MSPACE was designed to support the ambitions of government policy, the industrial sector, and communities to ensure sustainable management of marine resources and improve the marine environment for the next generation.

We co-created and explored with end-users alternative spatial management scenarios through which changes in marine space uses could enable climate change adaptation (and mitigation) for nature and people. Scenarios focused on actioning opportunities for climate-resilient conservation, fisheries and aquaculture, within the broader lens of marine planning and the many objectives for use of marine space held within the four MSPACE case study planning regions, as well as the wider push to deliver net zero in the UK.

2 Projected climate change impacts and opportunities in Welsh waters

MSPACE first delivered a UK-level synthesis of projected impacts and opportunities that climate change will bring to our marine and coastal waters (Queirós et al., 2024). Supported by the UK Marine Climate Change Impacts Partnership (MCCIP, 2023), we assessed state-of-the-art climate change modelling projections for marine species and habitats, to help identify possible climate change adaptation (and mitigation) pathways for UK waters **(Queirós et al. 2024)**. We considered these results alongside the current distribution of seabed effects by sectors such as fisheries and dredging based on analyses undertaken in the UK for OSPAR and ICES (Sciberras et al., 2023). Providing a technical evaluation of our confidence in all modelling datasets used (Kay et al., 2023), we were able to make recommendations towards climate-resilient management of fisheries, aquaculture and marine conservation, through the lens of Marine Plans (Queirós et al., 2024). The main results for Welsh waters were:

- Welsh waters were found to be sensitive to climate change, affecting marine conservation, fishing grounds and the potential for aquaculture. This was true under both possible futures considered regarding greenhouse gas emissions (leading to 2.4oC and 4oC mean global warming). Climate change sensitive areas (i.e. climate change hotspots) emerged across most of the planning are (Figure 1).

- It is likely that current conservation sites may not continue to provide the same biological and ecological benefits to designated features in the future, as climate change unfolds across the region. This is due to the extensive distribution of climate change hotspots found for benthic and pelagic habitats, and for benthic and pelagic megafauna, throughout the planning area.

- Climate change refugia (i.e. climate resilient areas) for habitat conditions promoting carbon sequestration (i.e. “climate services”, Benyon et al., 2020; Flavell et al., 2020) were found across most of the planning area, including areas that have previously been identified as having high carbon sequestration potential, such as Carmarthen Bay (Robbins et al., 2022). These climate services refugia could help deliver climate change mitigation if field evidence substantiates their potential estimated in MSPACE using modelling, and legislation is introduced that allows the designation of MPAs for the protection of carbon stocks.

Details of these analyses and findings can be found **here**, and the spatial data layers resulting from analyses can be found **here**.

3 Exploration of alternative spatial management futures for Welsh waters

Due to the extent of climate change hotspots identified when analysing results using a mean global warming of 4oC (RCP8.5), we focused the development of adaptation strategies for the EMP region by considering a mean global warming future of 2.4oC only (RCP4.5, in line with current commitments to the Paris Agreement). Based on identified opportunities for adaptation under this emissions scenario (Queirós et al., 2024), MSPACE co-created and explored four alternative hypothetical spatial management scenarios with case-study relevant end-users (Talbot et al., 2025). We started with:

Business as Usual: represents the current distribution of marine activities and conservation sites in Welsh waters. This scenario is contrasted with the Baseline, for which estimates are also provided, and which also reflect the current distribution of marine activities and conservation in the planning area, but exclude projected climate change impacts (Talbot et al., 2025).

Three more, climate-smart scenarios were co-created and explored: these targeted changes in use of marine space (i.e. interventions) in areas where climate change refugia (i.e. areas where individual sectors are estimated to have low sensitivity to climate change , Section 2) were identified (Queirós et al. 2024), towards the development of regional opportunities for climate change adaptation for particular sectors:

- **Conservation**: changes in spatial uses maximise adaptation outcomes for conservation.
- **Food Provision**: changes in spatial uses maximise adaptation for fisheries & aquaculture.
- **Compromise**: considers outcomes for marine conservation, fisheries and aquaculture together, balancing overall adaptation goals in the region. This scenario was informed by prior assessment of the priorities of Welsh stakeholders with regard to marine space (Reinhardt & Danahey Janin, 2025).

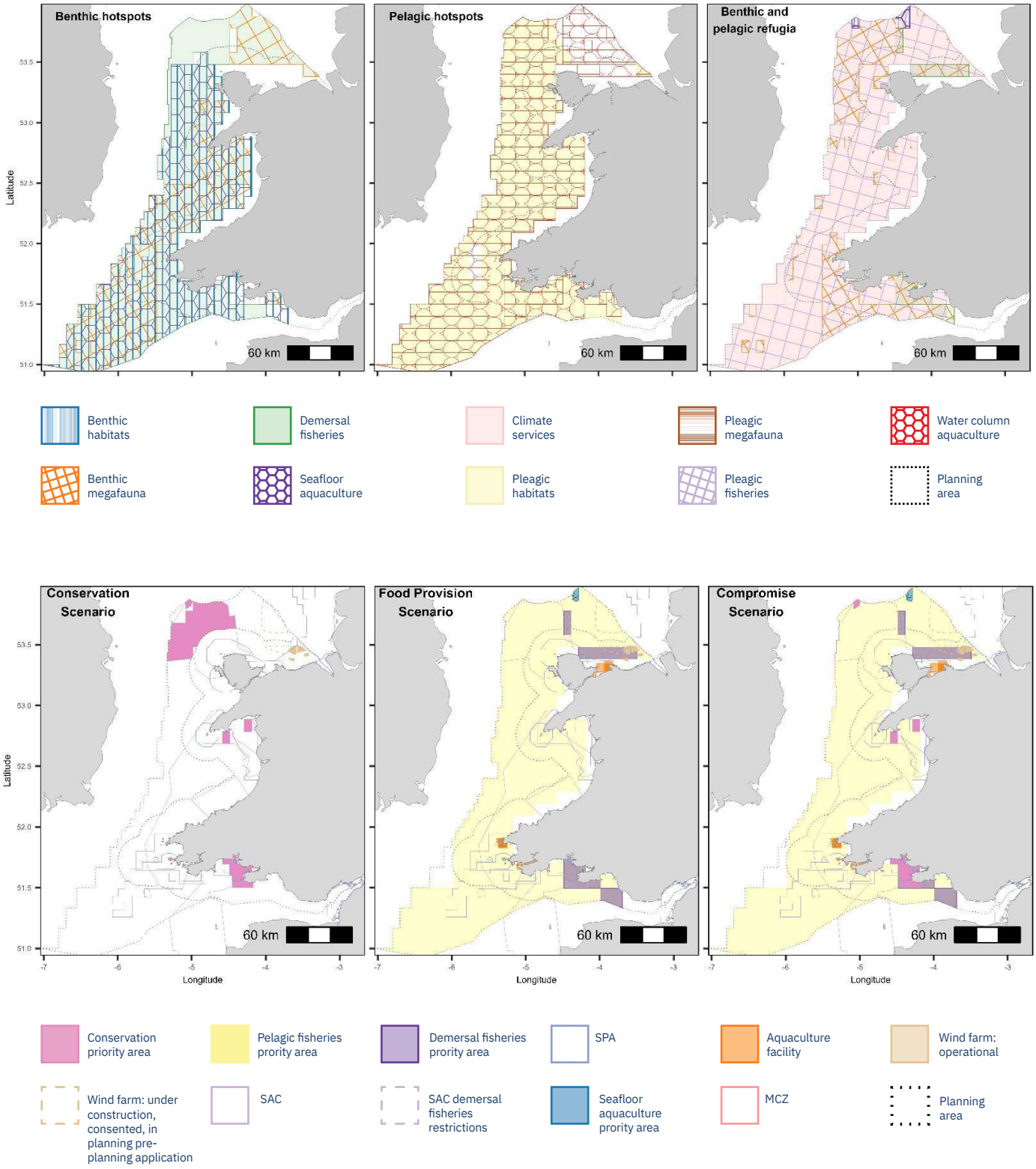

Figure 1: Business as Usual (BAU) scenario (top row) in the Welsh National Marine Plan Area, showing the location of benthic (left) and pelagic (middle) climate change hotspots as well as all refugia (right), for different groups of species, ecological function or sectors, under RCP4.5. Climate-smart scenarios co-developed are shown in the bottom row of figures, highlighting identified priority areas for different sectors in different scenarios (titles). A summary of co-created interventions to support adaptation (and mitigation) is given in the table overleaf.

C1: Avoid, minimise or mitigate human activities which could be incompatible with maintaining good ecological status of benthic megafauna in Carmarthen Bay, Llŷn Peninsula and Sarnau and North Anglesey Marine SACs

C2: Avoid, minimise or mitigate human activities which could be incompatible with maintaining good ecological status of benthic habitats identified within climate change refugia in the North Anglesey Marine SAC.

C3: Avoid, minimise or mitigate human activities which could be incompatible with the delivery of climate services provided by the seabed, in climate change refugia identified within the Carmarthen Bay SAC.

FP1: Avoid, minimise or mitigate proposals for activities that may be incompatible with access by demersal and pelagic fisheries to areas identified as demersal and pelagic fisheries priority areas.

FP2: Avoid, minimise or mitigate proposals for activities that could limit the development of seafloor aquaculture in the identified priority areas for this sector.

CM1: Avoid, minimise or mitigate human activities which could be incompatible with maintaining good ecological status of benthic megafauna in Carmarthen Bay, Llŷn Peninsula.

CM2: Avoid, minimise or mitigate human activities which could be incompatible with maintaining good ecological status of benthic habitats identified within climate change refugia in the North Anglesey Marine SAC.

CM3: Avoid, minimise or mitigate human activities which could be incompatible with the delivery of climate services provided by the seabed, in climate change refugia identified within the Carmarthen Bay SAC.

CM4: Avoid, minimise or mitigate proposals for activities that may be incompatible with access by demersal and pelagic fisheries to areas identified as demersal and pelagic fisheries priority areas.

CM5: Avoid, minimise or mitigate proposals for activities that could limit the development of seafloor aquaculture in the identified priority areas for this sector.

Summaries of co-developed scenarios and their spatial interventions are given in Figure 1 and detailed in Talbot et al. (2025). Areas where changes to spatial management could lead to the use of climate change refugia to deliver climate change adaptation or mitigation for particular sectors are hereafter referred to as **Priority Areas**, and the proposed changes in management in those areas are referred to as **Interventions** (Figure 1).

The performance of the BAU and of each climate-smart scenario was then estimated using environmental, economic and social criteria, which could be used to compare them using a common set of metrics. These estimates can be seen in Table 1, where criteria estimates reflect projected change in each criterion relative to the Baseline, given the projected regional impacts of climate change (BAU), and any additional changes in spatial management designed to promote climate change adaptation and mitigation. A detailed narrative and methodological description for these analyses can be found in Roca Florido et al. (2025) and Talbot et al. (2025).

We found that under the moderate emissions scenario RCP4.5, climate change refugia (areas resilient to climate change) did provide opportunities to conserve climate services, benthic megafauna and benthic habitats, as well as to have resilient pelagic fisheries, demersal fisheries and seafloor aquaculture (Figure 1, top row).

Accordingly, the **Conservation Scenario** (Figure 1) aimed to explore how to use identified climate change refugia for climate services, benthic megafauna and benthic habitats towards their future resilience. Some refugia for benthic megafauna and benthic habitats were identified in several sites which are already designated. The latter were therefore identified as priority areas to support climate change adaptation for nature in Wales. The Conservation Scenario therefore recommends the avoidance, minimisation (or mitigation) of any human activities which may be incompatible with maintaining good ecological status for these species and habitats (**Interventions C1 & C2, Figure 1**). This scenario also recommends avoiding, minimising or mitigate human activities which could be incompatible with the delivery of climate services by the seabed within climate change refugia identified within a designated site (**Intervention C3**, Figure 1). **Intervention C1** (Figure 1) could in this way support recovery and climate-resilience of seabed species populations, including those of sharks, skates and rays of conservation and commercial interest in Welsh waters.

Intervention C2 could maximise climate change resilience of benthic habitats in identified regions. Lastly, **Intervention C3** (Figure 1) may limit direct carbon release and degradation (avoided emissions) of important carbon stocks from sediment disturbing activities such as trawling. When compared to the BAU, small economic losses could be attributed these interventions, but these were estimated to be much smaller than the losses estimated between the BAU relative the Baseline (do nothing, climate change impacts accounted c.f. not accounted for, Table 1; Talbot et al. (2025), Marcone et al. 2025).

In contrast, the **Food Provision Scenario** (Figure 1) was designed so that changes in marine uses could enable prioritisation of access by fishers to a small number of priority areas for demersal fisheries and an extensive priority area for pelagic fisheries (**Intervention FP1**), whilst prioritising expansion of seabed aquaculture in another priority area for the sector **(Intervention FP2**). These interventions could therefore help support climate-resilient food provision in Welsh waters into the future, as well as help secure associated livelihoods. Indeed, significant increases in job numbers, wages and Gross Value Added (GVA) of the Welsh blue economy were estimated in this scenario relative to the status quo (the BAU, Table 1). These were predominantly driven by hypothetical increases in aquaculture production explored under this scenario, although a hypothetical expansion of pelagic fishing activity also contributed to estimated increases, since Wales currently has no active pelagic fleet (Table 1 below; Talbot et al. (2025)).

Finally, the **Compromise Scenario** combined interventions from the other two climate-smart scenarios to deliver a balance of climate change adaptation and mitigation aims (Interventions **CM1-5**, Figure 1). Under this scenario, we also estimated economic benefits to the region, with increases in jobs numbers, wages and GVA relative to the BAU (Table 1; Talbot et al. (2025)).

4 Social acceptability of alternative spatial management scenarios

We tested the social acceptability of climate-smart scenario interventions (Figure 1) through online surveys of marine planning stakeholders, as detailed in Reinhardt (2026). A link to take the survey was shared widely via stakeholder networks and institutional social media networks, and each respondent was required to enter their name and organisation name to ensure no one took the survey more than once. Once collected and validated, respondent names were deleted from the files and cannot be traced to their answers. During the survey, ***respondents were able to access detailed information about the project and of co-created scenarios and their outcomes*** (Table 1; Talbot et al. (2025), Marcone et al. 2026). Of 112 unique and validated respondents, 30 answered the questions that relied on reading the information given, and 7 of these identified as being active in the Welsh National Marine Plan area. Their responses are summarised here, having been analysed in detail in Reinhardt (2026).

This small number of Wales-specific responses does not enable us to draw statistically significant estimates of differences or trends across respondents at the time of writing. However, examining the average responses and response differences across the 4 scenarios, and between responses provided with and without access to information on the socio- economic outcomes of explored scenarios (Table 1 below, as well as further evidence in Reinhardt (2026)) we observe that:

- On average, respondents exhibited higher acceptability for the climate-smart scenarios as alternatives to the BAU when information on the economic and social outcomes of the scenarios was made available than when it was not.
- On average, respondents strongly accepted the climate-smart **Conservation Scenario** as an alternative to the BAU, and this score was highest when information on the economic and social outcomes of the scenarios was made available.
- On average, respondents only marginally accepted the climate-smart **Food Provision Scenario** as an alternative to the BAU (scores just over 5, the mean), and this did not change depending on whether they were able to access information on the social-economic outcomes of the scenario.
- On average, stakeholders accepted the climate-smart **Compromise Scenario** as an alternative to the BAU but only when they could access information on its economic and social outcomes.

These results suggest that consulted Welsh National Marine Plan stakeholders showed strong acceptance for climate-smart scenarios to the status-quo (BAU), with **Conservation Scenario** ranking highest. However, acceptability of climate-smart scenarios could be affected by what type of information about them is presented. The fact that the climate-smart Conservation Scenario received the highest acceptability rating despite what information was provided about the outcomes of the scenario (environmental only, or environmental, economic and social) suggests that the climate-resilience of marine wildlife and habitats is a key concern in Wales. These results also suggest spatial management interventions co-created and explored as part of the MSPACE Conservation scenario (C1-3, Figure 1 and Table 1) may be welcomed by Welsh planning stakeholders, in support of a more climate-resilient future for ocean wildlife.

5 Multiple criteria decision analysis

Multi-criteria decision analysis (MCDA, Marcone et al., 2026) was used to help establish indirectly how the performance of co-created scenarios (Figure 1) aligns with the intrinsic preferences of key stakeholders (who had previously engaged with MSPACE) based on the assessed list of scenario criteria (Table 1).

First, an online MCDA survey was used, mainly targeting experts already involved in MSPACE and marine planning in NI, who were individually contacted by email. During an online interview, respondents were presented with background information about the project and the survey objectives, and answered questions designed to understand their preferences on the criteria list. Importantly, respondents answered questions ***without knowing how co-created scenarios performed on assessment criteria*** (**Figure 1, Table 1)**. The MSPACE team then estimated scenario performance on each criterion, which were combined into the scenario performance matrix (Table 1; Marcone et al. 2026). The scenario performance matrix was then analysed together with preference information collected through the MCDA survey to rank scenarios accordingly (Table 1). Details about MCDA carried out on these data, leading to the scenario rankings listed in Table 1 can be found in Marcone et al. (2026).

Overall, the intrinsic preferences of Welsh respondents were found to be better aligned with the **Food Provision scenario** (rank=1), and were consistently less aligned with Compromise scenario (rank = 4), with the Conservation scenario ranking second (ranking=2) and the BAU ranking third. These results suggest stakeholders in Wales are intrinsically concerned with the climate-resilience of economic and social criteria (maximised in the Food Provision scenario). As in Section 4, these results also make a case for changes to the BAU, in support of climate change adaptation for ocean based sectors like fisheries and aquaculture. However, the contrast between the results from this section and those in Section 4, suggest that once confronted with specific, concrete spatial interventions to consider, and with evidence about their outcomes, support for climate change adaptation for nature may also become acceptable to Welsh National Marine Planning stakeholders.

			Assessment criteria			Baseline*	Scenario performance matrix (% change on Baseline) **			
			Short name (used in survey)	Unit	Scenario design		BAU	Conservation	Food provision	Compromise
ENVIRONMENTAL	1	a.1	Climate-resilient MPA	km2	maximise	23279.61	-80.9	-66.4	-100.0	-70.8
	2	a.2	Climate-resilient fishery area	km2	maximise	5156.27	0.0	-99.8	-99.8	-99.8
	3	a.3	Climate-resilient aquaculture area	km2	maximise	18.90	-100.0	-100.0	1007.2	1007.2
	4	a.4	Total greenhouse gas emissions	kt CO2e/yr	minimise	38.45	-37.4	-60.1	16.8	-5.7
	5	a.5	Potential for marine renewable energy	MW	maximise	0.00	0.0	0.0	0.0	0.0
SOCIAL	6	b.1	Jobs in the food production sector	nr of jobs	maximise	183.95	0.0	-31.2	452.3	441.5
	7	b.2	Job in the recreation and tourism sector	nr of jobs	maximise	9.32	-38.0	-51.4	143.0	129.7
ECONOMIC	8	c.1	Economic contribution of the food production sector (GVA)	£ (millions)	maximise	23.43	-36.3	-52.6	126.7	110.5
	9	c.2	Income in the food production sector (wages)	£ (millions)	maximise	9.02	-36.3	-52.5	126.8	110.6
	10	c.3	Economic contribution of the recreation and tourism sector (GVA)	£ (millions)	maximise	0.19	-36.8	-52.6	147.4	131.6
	11	c.4	Income in the recreation and tourism sector (wages)	£ (millions)	maximise	0.13	-38.5	153.8	153.8	138.5
Scenario ranking based on stakeholder acceptance of climate-smart scenario relative to BAU (without/with social-economic evidence, Section 4)								joint 2/joint 1	joint 2/2	1/joint 1
Aggregated Scenario ranking based on implicit stakeholder preferences (Section 5)							3	4	2	1

*Baseline values give the current distribution of marine activities but ignore the impacts of future climate change.

** Percent change on Baseline is calculated as: % = (100*(Scenario criterion estimate /Baseline criterion estimate)) - 100.

Table 1. Criteria used to assess the performance of co-created alternative spatial management scenarios, and the mean acceptability (Section 4) and implicit preference of stakeholders of said scenarios (Section 5). "GVA" stands for Gross Value Added of a given sector.

6 Recommendations

6.1. Stakeholders of the Welsh National Marine Plan want climate change adaptation measures

We recommend that additional research still needs to be carried out, beyond MSPACE, to find other alternatives that address stakeholder's ecological, social and economic concerns about climate change impacts on the marine environment. Spatial management interventions that help address climate change in Wales and its blue economy are required by policies SOC_10 and SOC_11 of the Welsh National Marine Plan (Welsh Government, 2019). Furthermore, the Implementation Guidance for the Welsh National Marine Plan is explicit in how proposals for marine activities should account for climate change effects over their lifetime, including greenhouse gas accounting (avoid increases) and about limiting impacts on ecosystems and communities as climate change unfolds. Welsh marine planning stakeholder surveys carried out as part of MSPACE indicate that respondents are supportive, in general, of measures that address climate change through marine spatial management. Specifically, our findings suggest respondents have an implicit concern for the climate-resilience of economic and social dimensions of marine space, rather than support for nature (Section 5). The high economic, social, and cultural weight given to the fishing sector in Wales (Duggett et al., 2024) may help explain this finding at least in part, as stakeholders have been found to perceive that additional efforts to support ocean wildlife would be added to an already existing list of sub-optimal conditions for fishing and aquaculture in Wales. However, when presented with concrete options for changes to spatial management to address climate change co-created in MSPACE (Talbot et al. 2025), respondents showed limited acceptance for the two spatial management scenarios that maximised economic and social outcomes (including maximising outcomes for the fishing and aquaculture sectors). Instead, MSPACE survey respondents showed greater acceptance of the climate-smart scenario that maximised adaptation for nature and climate regulation. Whilst initially counter-intuitive, these findings are

We found that consultation on concrete evidence on scenario outcomes was more likely to lead to openness of stakeholders to manage marine space in a climate-smart way, and can help challenge pre-conceptions stakeholders may hold about what impacts nature positive outcomes may have on individuals and their sector(s).

also consistent with research by the Welsh Government, which indicates that whilst concerns about fisheries and aquaculture resilience are very topical among Welsh marine stakeholders, environmental sustainability is also a key concern (Dugget et al. 2024). The metrics MSPACE developed to support spatial management exploration (Table 1), which include environmental, economic and social dimensions of spatial policy scenarios, may therefore prove useful in helping identify strategies for Welsh policy that help meet stakeholders multiple concerns about marine space, as well as the climate targets set out in the Welsh National Marine Plan.

6.2. Translating climate change evidence into metrics stakeholders can relate to is key to gather buy-in for adaptation and mitigation through management of marine space

We found that consultation on concrete evidence on scenario outcomes was more likely to lead to openness of stakeholders to manage marine space in a climate-smart way, and can help challenge pre-conceptions stakeholders may hold about what impacts nature positive outcomes may have on individuals and their sector(s). Indeed, we found that the acceptability scoring of climate-smart scenarios generally increased when survey repondents were able to access evidence of the impacts of scenarios on economic and social dimensions, in addition to their ecological effects. **We therefore recommend** presenting Welsh National Marine Planning stakeholders with specific, alternative spatial management options (including the status-quo, i.e. Business as Usual) during consultations on marine planning (e.g. Figure 1), and alongside, presenting estimates of the environmental, economic and social effects estimated for the spatial management alternatives consulted upon, as shown here in Table 1. Our assessment is that this allows stakeholders to give informed, evidence-based views about specific changes to spatial management that may be under consideration (Section 4), rather than just expressing general views about which topics matter the most to them (Section 5). Together, the MSPACE results suggest that providing stakeholders with explicit estimates of the environmental, economic and social outcomes of changes to marine planning decisions can affect perceptions of, and increase support for, changes to individual policies addressing climate change. This approach also potentially represents a fairer and more transparent way to help decision-makers determine which decisions may best represent the interests of their stakeholders, and thus help them understand what changes to spatial management that could help address climate change may be best suited to their regions across Wales.

6.3 Wider marine planning for climate change adaptation and mitigation in Wales

We co-created alternative spatial management interventions with planning stakeholders to support climate change adaptation and mitigation in Wales (Figure 1), and we measured that these interventions are seen by planning stakeholders in Wales as preferable to the status-quo (Reinhardt 2026, Marcone et al. 2026) though other, more refined alternatives may be needed to gather public support. How marine activities and marine conservation sites are distributed are not currently regulated by Marine Plans across the UK, including in Wales. However, as we look to the future, the current review of the UK Marine Policy Statement, and the current momentum for more spatial prescription in Marine Plans emerging from DEFRA's Marine Spatial Prioritisation Programme may allow for more explicit considerations of these strategies. That momentum is likely to be important in bolstering the ability of the Welsh marine planners to help meet the ambition of the Climate Change Adaptation Plan for Wales and Wales' legally binding target to meet net-zero by 2050 (Welsh Government, 2021). These policy changes may lead to more coordinated response to climate change in Wales, as also sought out by the Welsh Government.

The landscape of planning mechanisms is developing across the UK (e.g. Fisheries Management Plans (Joint Fisheries Statement, 2022)), and new opportunities are emerging for the designation of conservation sites as a consequence of compensatory measures to support the delivery of net-zero (Department for Energy Security & Net Zero, 2025; Ward, 2022). In this context, **we recommend** that these different policy mechanisms must be well integrated with each other and with policies such as the Welsh National Marine Plan: this integration will be key to ensure that mutual objectives on adaptation and mitigation, across policies in Wales, and across the UK nations, are supported well. Indeed, recent research by this team highlighted that siloed approaches to policy and governance, across sectors and across nations, are key stumbling blocks limiting opportunities to deliver climate action through the management of marine space (Queirós et al., 2025). The MSPACE project invested in the co-creation of potential solutions to help address climate change in Wales and the UK as a whole. These solutions have the best chance of becoming actionable through an enabling and well integrated marine planning policy and governance landscape across the UK nations.

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The MSPACE initiative continues as an endorsed UN Ocean Decade Action, helping deliver the vision of the UN Decade of Ocean Science for Sustainable Development 2021-2030.

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