MCCIP 2023

Summary for Policy Makers

Climate-smart management of UK seas

MSPACE
Marine Spatial Planning Addressing Climate Effects

PML Plymouth Marine Laboratory

MCCIP Marine Climate Change Impacts Partnership

Heriot-Watt University

JNCC

Cefas

afbi

SMMR Sustainable Management of UK Marine Resources

UKRI Natural Environment Research Council

UKRI Economic and Social Research Council

Marine Management Organisation

Cyfoeth Naturiol Cymru Natural Resources Wales

Scottish Government Riaghaltas na h-Alba

Climate change is already affecting species and habitats residing in UK seas. These effects are set to increase if greenhouse gas emissions continue to rise and accelerate climate change. More guidance and support are urgently needed to enable planners and other managers of our seas to implement climate-smart solutions, particularly spatial management strategies which integrate, and may be adaptive to, the effects of a changing climate.

In the Early Warning System report, climate projections from the MSPACE project identify where, and for how long, the marine conservation, fisheries and aquaculture sectors could be best supported across UK seas through climate-smart spatial management.

Key Headlines

Climate Change Refugia
MSPACE modelling analyses identify climate change refugia, areas where resilience to climate impacts are found. These areas are limited in extent but could be capitalised upon as part of climate smart planning for conservation, fisheries and aquaculture. Higher greenhouse gas emissions reduce the extent of climate change refugia. Strong emissions curbs represent the best hope for UK marine ecosystems, and a sustainable blue economy.

Marine Conservation
Major climate change impacts emerge sooner than previously thought (the next decade). This may compromise UK conservation targets, including 30 × 30 commitments. Climate change refugia are found primarily for benthic (seabed) habitats that could contribute towards a climate smart MPA network and restoration efforts.

Demersal Fisheries
Climate change hotspots are soon widespread in both scenarios, although conditions become more suitable for warm water commercial species.

Pelagic Fisheries
The future distribution of climate change refugia suggest there are opportunities to preserve Pelagic fleet activity over wide areas.

Aquaculture Sector
For the aquaculture sector, the identification of refugia provides the opportunity to manage the sector despite marine heatwaves and ocean acidification, and may support planning for the farming of shellfish, finfish and seaweed.

Climate change and UK marine planning

Climate change has major implications for the sustainable use of the UK marine environment.

Policies and legislation for marine conservation, fisheries and aquaculture require robust, flexible strategies that account for likely climate change impacts within, and across, marine plan areas. This understanding provides opportunities to harness sectoral growth despite ongoing pressures.

Three major capability gaps need addressing to enable climate-smart marine spatial planning:

1
Establishment of a marine protected area network that effectively supports conservation species and habitats as their distributions respond to climate change.

2
Projections of spatial and temporal climate change effects on wild capture and aquaculture species, to allow sectoral activities that do not hinder adaptation of target species to climate change.

3
Consideration of climate change evidence during planning and licensing. This includes guidance to support the development of the blue economy without compromising the resilience of marine species and habitats to future climate change impacts.

Planning for climate impacts

In addressing these gaps, the practical implications of managing climate-resilient habitats across national boundaries need to be considered to ensure best ecological, social and economic outcomes.

MSPACE utilises state of the art analyses of climate change impact modelling projections for the conservation, fisheries and aquaculture sectors. They cover the short (next decade), medium (mid-century) and long-term (end-century) for both moderate emissions (RCP4.5, 2°C global warming) and high emissions (RCP8.5, 4°C global warming) scenarios.

The models enable the identification of climate change:

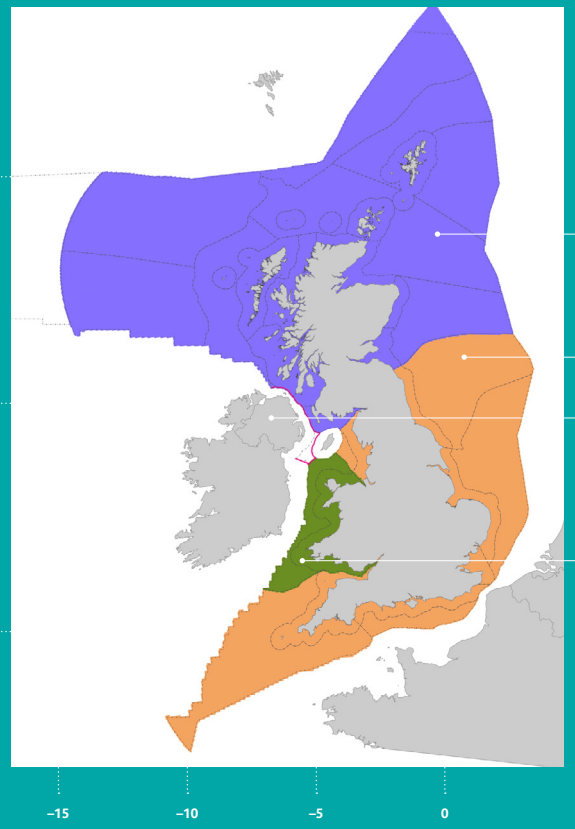
Hotspots

Where climate pressures drive an ecosystem into a new state, beyond its natural variability.

Refugia

Areas that exhibit long term resilience to climate change.

Future growth of the blue economy will need to be carefully balanced with habitat and species conservation needs in all these areas.



UK PLANNING REGIONS

Marine planning is principally a devolved matter. High level messages for the UK are supported by evidence and recommendations presented at the devolved (and regional) level.

SCOTLAND

ENGLAND

NORTHERN IRELAND

WALES

Approach and overview

Methods

Analysis of ocean climate modelling datasets was performed for each sector of interest (conservation, fisheries and aquaculture) comparing a present day reference period (2006–2025) to each possible 20 year time period between 2026 and the end of the century under two different greenhouse gas emissions scenarios:

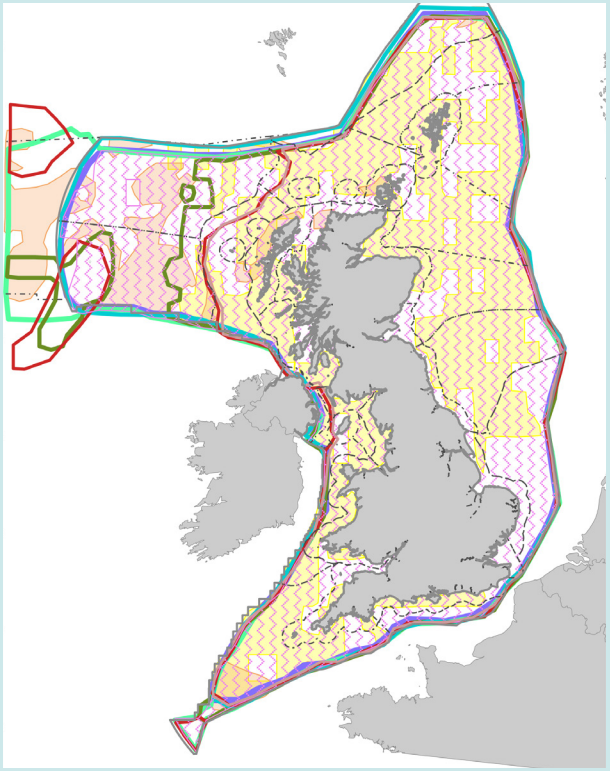
RCP4.5
Strong curbs in global emissions toward climate change mitigation, from 2050 onwards, leading to a mean global warming by the end of the century of ~2.4°C

RCP8.5
Emissions continue to rise steadily throughout the 21st century, leading to mean global warming ~4.3°C

Confidence

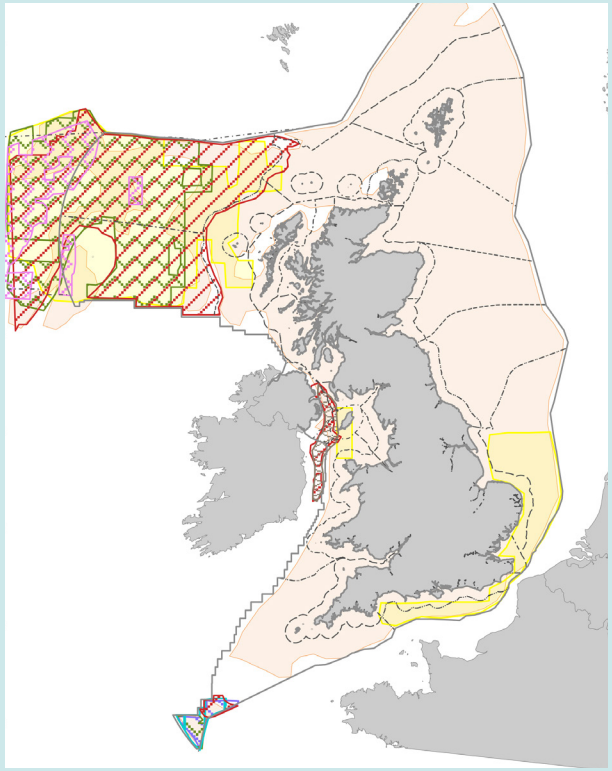
A fully accessible assessment of the confidence in the results presented in this report can be found in Early Warning System Report Annex 1: "Model validation" mccip.org.uk/all-uk/solutions/m-space

Location of long-term climate change refugia (left) and climate change hotspots (right) in the UK EEZ, identified with high agreement between emissions scenarios. The Early Warning System Report includes a wide range of maps for different sectors and emissions scenarios. Please consult Figure 15 in the report for further details.



KEY

- Climate Services
- Pelagic fish
- Demersal fish
- Pelagic megafauna
- Benthic megafauna
- Benthic habitats
- Pelagic habitats
- Pelagic aquaculture
- Benthic aquaculture
- Marine plan areas
- EEZ



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Climate change and marine conservation

The main finding is that there is the potential to protect sites with high conservation value that are resilient to climate change, but in many instances these are not yet designated. Climate impacts appear sooner than anticipated across many other sites of conservation value, including some HPMAs. This could put the UKs 30 × 30 commitments and other conservation objectives at risk.

The impacts of climate change on conservation species and habitats in open water (pelagic) and associated with the seabed (benthic) were analysed based on climate modelling projections, as were projected distributions of prey species for megafauna such as marine mammals, seabirds, sharks, skates and rays in both environments.

A separate case study focused on the potential for HPMA sites in England to provide 'climate services' by storing carbon in marine sediments.

Where could conservation be best supported?

Conservation of Seabed habitats and species

Around 20% of the UK EEZ provides long term climate change refugia under both emissions scenarios, some of which are already designated but many others are not. Climate change refugia also overlap with areas of high conservation value, including one HPMA (Alonby Bay) and the location of OSPAR Threatened and Declining Habitats. This includes significant parts of the Irish Sea, Northern Ireland coast and the West coast of Scotland. These areas are subject to other pressures such as soil dumping, mining and pollution from light at the coast.

Climate change hotspots were identified overlapping many designated sites and restoration sites, presenting further challenges to marine conservation. Many areas of the UK seabed are subject to compound pressures from climate change and trawling, leaving them in a poor state for benthic communities.

Seabed (benthic) habitat: horse mussel *(Modiolus modiolus)* bed with dead man's fingers *(Alcyonium digitatum)* and common starfish *(Asterias rubens)* ©Graham Saunders/SNH

Conservation of open water habitats and species

There are major differences between the two emissions scenarios. Under RCP8.5, less than 10% of the EEZ is projected to harbor climate change refugia by the 2030s, dropping to just 2% towards the end of century. For RCP 4.5, climate change refugia are initially widely spread across the West coast of Scotland and waters between Orkney and Shetland, the West coast of England, the coasts of Wales and Northern Ireland. Some climate change refugia persist off SW England, in the Irish Sea, the west coast of Scotland (in the Inner Hebrides, and the Rockall and George Bligh Banks) into the 2070s.

Conservation of Megafauna reliant on benthic prey and habitats

Substantial areas in the Celtic Sea, off the South coast of England, and in the central North Sea (including where MPAs occur) are identified as climate change refugia under RCP4.5, but as climate change hotspots under RCP8.5. Under RCP4.5, refugia reduce in size over time but large areas in the East and SW coast of England, small patches off the East coast of Scotland, the Welsh coast and regions offshore to the West of the EEZ could remain climate resilient into the 2070s. Many of the climate change refugia occur in areas that experience other pressures such as light pollution and bottom trawling, which could pose a risk to the conservation of marine features.

An edible crab *(Cancer pagurus)* on maerl bed ©Graham Saunders/SNH

Conservation of Megafauna reliant on pelagic prey and habitats

Most areas of the EEZ emerge as climate change hotspots as early as the 2030s under both emissions pathways. Several small areas harbour climate change refugia under RCP4.5 into the 2070s such as off SW England, in the Severn Estuary, off the Rockall bank and to the North-west of Orkney and North of Shetland, although most disappear by the end of the century. Climate change refugia are almost absent throughout the period under RCP8.5.

Grey seal *(Halichoerus grypus)* in the Isles of Scilly ©Lucy Ray

Conservation of Highly Protected Marine Areas and Climate Services

There are currently three areas in England (North-East of Farnes Deep, Allonby Bay & Dolphin Head) chosen to be Highly Protected Marine Areas (HPMAs) with more areas under consideration. One of the 3 English HPMAs is a climate change refuge, but two are climate change hotspots. The siting of new HPMAs could be informed by this report.

When identifying HPMAs, it has been recommended that consideration be given to their potential to store 'blue' carbon.

The ability of UK seabed (benthic) habitats to act as blue carbon stores appears to persist throughout the 21st century across more than 80% of the UK EEZ. As such, the UK MPA network, including HPMAs, could be used to deliver these climate services. It is important to note there is low confidence in the provision of climate services analysis due to a lack of data on carbon sequestration via marine sediments, and inconsistency in model outputs.

Northern gannet *(Morus bassanus)*
©Sally Hinton

Climate change and marine fisheries management

There are more widespread opportunities to preserve traditional pelagic fishing fleets under the moderate emissions scenario. For benthic species, the abundance of some target species could be supported through climate-smart fisheries and conservation management measures under both emissions scenarios.

In UK marine and coastal waters, climate-driven changes including declines of previously abundant species and arrivals of new species are already affecting commercial fisheries. In this analysis, key commercial species, representing the top landings into the UK by value, were assessed for their response to climate change under both emissions scenarios.

Where could fisheries be best supported?

Open water fisheries

The south-east of England emerges as hosting extensive climate change refugia in both emission scenarios considered, so could be an area that supports climate resilience for the sector.

The future distribution of climate change refugia suggest there are opportunities to preserve Pelagic fleet activity over wide areas, including traditional fishing grounds off the South-West coast of England, the Outer Hebrides, and Shetlands. Marine protected areas throughout the UK EEZ overlap with climate change refugia areas for species targeted by pelagic fleets.

Climate change hotspots emerge much earlier, and over a much greater area under higher (RCP8.5) than moderate (RCP4.5) emissions. For RCP 4.5, climate change hotspots only become widespread later this century in areas off the west coast of Scotland, and the northern and central North Sea whilst for RCP 8.5, all target species considered have declined in the UK EEZ after mid-century, except for squid in the south-east of England.

Whiting *(Merlangius merlangus)*. ©Georges Jansoone (JoJan), CC BY 3.0 Wikimedia Commons

Seabed fisheries

Climate change hotspots are soon widespread in both scenarios, although the south and south-east of the UK harbour climate change refugia for target species assemblages until mid-century. Limiting benthic fishing in the near future may help sustain climate-resilience of these fisheries. Only the south-west tip of UK waters show potential for climate resilient benthic fisheries to the end of century, although MCZs preserve fragile habitats here.

For RCP 4.5, most species decline through the 21st century (Nephrops, cod, haddock, plaice, turbot and even warm affiliated sole), but not sufficiently to reduce competition and allow for increases in warmer water species (such as hake) or other species (mussels, edible crab, and saithe) to provide climate change refugia for this aggregated resource.

For RCP 8.5, an increase in warm affiliated species (hake, saithe, white monkfish) actually leads to the widespread occurrence, albeit temporarily, of climate change refugia for the sector in the North Sea although this is accompanied by the loss of species otherwise occurring there, such as plaice. As climate change effects become more severe, there is scope for management measures related to the distribution of demersal fishing pressure in the North Sea, and MPAs, to locally support climate-resilience for more abundant species.

Scallop dredger in the Irish Sea
© Claire Szostek

Climate change and aquaculture

The sector will face increasing risks from climate change, including more marine heatwave events, as well as impacts from ocean acidification. Capitalizing on spatial variations in severity of impacts could help derisk sector growth, balanced with habitat and species conservation needs.

Finfish aquaculture in the UK marine environment is dominated by Atlantic Salmon farmed in Scotland, with Molluscs (mussels and oysters) more prevalent in England, Wales and Northern Ireland. Seaweed farming is the fastest growing aquaculture sector in Europe. At present, there is limited evidence for direct climate change impacts on UK aquaculture, although disease and infestations are being exacerbated by warming and other pressures.

Where could aquaculture be best supported?

Open water aquaculture for finfish and sugar kelp

Without active management, cultivation potential of species presently important may reduce in coming decades as climate change hotspots emerge throughout the EEZ. The mull of Kintyre and the Clyde present less severe heatwaves and ocean acidification conditions, which could help support climate resilient finfish aquaculture. For sugar kelp, areas where farming may decline less or remain viable into mid-century (with high agreement between emission pathways) include much of Scotland's waters, providing scope for sector expansion beyond the firth of forth. The cultivation of new species, more resilient to future climate conditions may need to be considered.

Open Sea Fish Pens
©Jimmy Ramirez

Seabed aquaculture

For seabed aquaculture such as oyster trestle, and Pacific oyster and mussel farmed on the seabed, conditions under both scenarios could support climate-resilient refugia in the Irish Sea, the coast of Northern Ireland, the south-west coast of Scotland and, more dynamically, some areas in the south-east of England, all areas that currently support extensive aquaculture infrastructure.

There is potential for expansion of the shellfish aquaculture sector in these areas, although they also provide climate refugia for conservation species so synergies and trade-offs between conservation objectives and shellfish farming may need to be considered.

For some areas under the RCP 4.5 emissions scenario, such as the Welsh coast and in the Severn, less severe heatwave and ocean acidification conditions are apparent, potentially supporting climate resilient shellfish aquaculture here into the future.

All other seabed habitats, many harboring important aquaculture infrastructure at present, become climate change hotspots for both emission pathways during most of the time period assessed and may require management measures (and the cultivation of different species) to remain sustainable in coming decades.

Shellfish Farm
©Alexey Komissarov

MSPACE modeling analyses provide a powerful tool to support 'climate-smart' spatial planning for a wide range of UK marine policy and legislation. This includes national and regional marine plans, Fisheries Management Plans, and the designation of protected sites.

Next steps

MSPACE will continue to work with the policy and industry communities across the UK Nations, exploring the social and economi viability of actioning the climate-smart recommendations made, focusing on the East Marine Plan, the Welsh Marine Plan, the Marine Plan for Northern Ireland and Orkney Islands Marine Plan.

This summary for Policy Makers (SPM) is based on Ana M Queiros, Susan Kay, Marija Sciberras, Elizabeth Talbot, Mike Kaiser, Robert J. Wilson, Sevrine Sailley, Stefano Marra, Liam Matear, Jose Fernandes, John Aldridge, Rob McEwan, Kate Morris, Caroline Louise McNeill, Joana Nunes, Kirsty Woodcock, Stephen Duncombe-Smith, Adam Smith, Chris Lynam, Cristina Vina-Herbon, Phil Boulcott, Billy Hunter, Ruth Parker, Karen Robinson, Fiona Trappe, Steve Mackinson, Chris Sweeting, Matt Frost and Paul J Somerfield. (2023) Early-warning system: Climate-smart spatial management of UK fisheries, aquaculture, and conservation. A report of the NERC/ESRC Marine Spatial Planning Addressing Climate Effects project. 58 pp. doi: 10.14465/2023.msp02.tec
https://www.mccip.org.uk/all-uk/solutions/mspace

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A high-level summary infographic is also available at: mccip.org.uk/all-uk/solutions/mspace.

All datasets are available here: doi.mba.ac.uk/data/3113.

MCCIP provides a co-ordinating framework for the UK, delivering high quality evidence on marine climate change impacts, and guidance on adaptation advice, to policy advisors and decision-makers.

Cover Image ©Lucy Ray

SMMR Sustainable Management of UK Marine Resources
Natural Environment Research Council
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