MCCIP Marine Climate Change Impacts Partnership

2015

Marine climate change impacts

Implications for the implementation of marine biodiversity legislation

This Report Card looks at climate change and marine biodiversity legislation, with a focus on the legislation used to establish various types of marine protected areas.

Pink sea fan *Eunicella verrucosa* © Keith Hiscock

Key headlines

Climate change is rarely explicitly considered in marine biodiversity legislation, but mechanisms generally exist that could enable climate change issues to be addressed.

The potential impacts of climate change on marine protected areas include features being gained to or lost from sites and, in certain cases, the entire network.

Flexibility is required in responding to climate change impacts on marine protected areas so options such as designating new sites, abandoning old sites and revising management measures may all need to be considered.

With over 1,250 designated features in the UK marine protected area network, identifying where and how these habitats and species are likely to be affected by climate change will be a critical step in managing marine protected areas.

At the current stage of development for the Marine Strategy Framework Directive, further practical consideration of how climate change could affect targets for the achievement of Good Environmental Status is required.

www.mccip.org.uk/mbl

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Introduction

Climate change is recognised as a significant driver of change, with temperature, salinity, ocean acidification, and changes in extreme weather events being the main factors affecting marine biodiversity.

These changes present new challenges to those responsible for the implementation of legislation in the marine environment. As legislation is the key means for ensuring the conservation of marine biodiversity, understanding how climate change needs to be considered, to ensure effective implementation, is vital.

It is important to consider the impact of both climate change and natural variability, and any consequences, in terms of meeting conservation targets and objectives. It is not always easy, however, to distinguish climate change impacts from other drivers.

The implementation of marine protected area legislation was chosen as the specific focus for this Report Card, along with the Marine Strategy Framework Directive (MSFD), as:

- they are key priorities both for the UK and internationally
- the purpose of such legislation is the protection of marine biodiversity
- stakeholders, including government, identified these issues as areas where climate change implications need to be considered

This Report Card starts by showing the degree to which climate change is accounted for in marine biodiversity related legislation. An up-to-date analysis of the UK marine protected area network is then provided. This analysis sets the scene for a fuller discussion on how features in the network could be affected by climate change and the management implications. The MSFD is briefly discussed, and finally the key issues for decision makers to consider in implementing marine biodiversity legislation are presented.

Sources of information

This Report Card is based upon expert analysis and the latest peer-reviewed literature. More information on marine biodiversity legislation and climate change, including source material used for this Report Card, can be found in the online version.

Plymouth Sound and Estuaries Special Area of Conservation © Keith Hiscock

The inclusion of climate change in legislation relevant to marine biodiversity

There are 21 obligations (including conventions and legislation) relevant to marine biodiversity in the UK, which collectively span nearly five decades (1966 - 2013).

Key findings from a review of the obligations:

- **Only three of the obligations make specific reference to climate change, and none of those created before 2008 refer to climate change explicitly.**
- **Ten of the obligations make reference to natural variability and environmental change.**
- **All of the obligations include some formal review and reporting cycles as well as complementary mechanisms where climate change impacts could be considered.**

Obligations (in chronological order)	Does the text of the original legislation explicitly mention climate change?	Does the text of the original legislation include reference to natural variability or broader environmental change?	Is there a review and reporting cycle? And how frequently?	Are there mechanisms within the obligation framework that might allow for impacts of climate change?
International Convention for the Conservation of the Atlantic Tuna (1966)	NO	NO	YES (2-8 years)	YES
EU Common Fisheries Policy (1970, 1983, 1987, 2002, 2013)	NO	NO	YES (annual)	YES
Ramsar Convention (1971)	NO	YES	YES (3 years)	YES
CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)	NO	NO	YES	YES
Bern Convention (1979)	NO	NO	YES	YES
Bonn Convention (Conservation of Migratory Species) (1979)	NO	NO	YES (3 years)	YES
EU Wild Birds Directive (1979, 2009)	NO	NO	YES (3 years)	YES
UK Wildlife and Countryside Act (1981 and subsequent amendments)	NO	NO	YES (5 years)	YES
Convention for the conservation of salmon in the North Atlantic Ocean (1982)	NO	YES	YES (5 years)	YES
Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement (1982)	NO	YES	YES	YES
OSPAR Convention- The Convention for the Protection of the Marine Environment of the North-East Atlantic (1992)	NO	NO	YES (annual & 10 years)	YES
EU Habitats Directive (1992)	NO	NO	YES (6 years)	YES
Convention on Biological Diversity (1992)	NO	NO	YES (10 years)	YES
EU Water Framework Directive (2000)	NO	YES	YES	YES
International Maritime Organisation - Ballast Water Convention (2004)	NO	NO	YES	YES
EU Marine Strategy Framework Directive (2008)	NO (in preamble only)	YES	YES (6 years)	YES
Climate Change Act (2008)	YES	YES	YES (5 years)	YES
Climate Change (Scotland) Act (2009)	YES	YES	YES (5 years)	YES
Marine & Coastal Access Act (2009)	NO	YES	YES (6 years)	YES
Marine (Scotland) Act (2010)	YES	YES	YES (5 years)	YES
Marine Act (Northern Ireland) (2013)	NO	YES	YES (6 years)	YES

Supporting information is provided by Frost et al. (2015). Climate change and the implementation of marine biodiversity legislation in the UK.

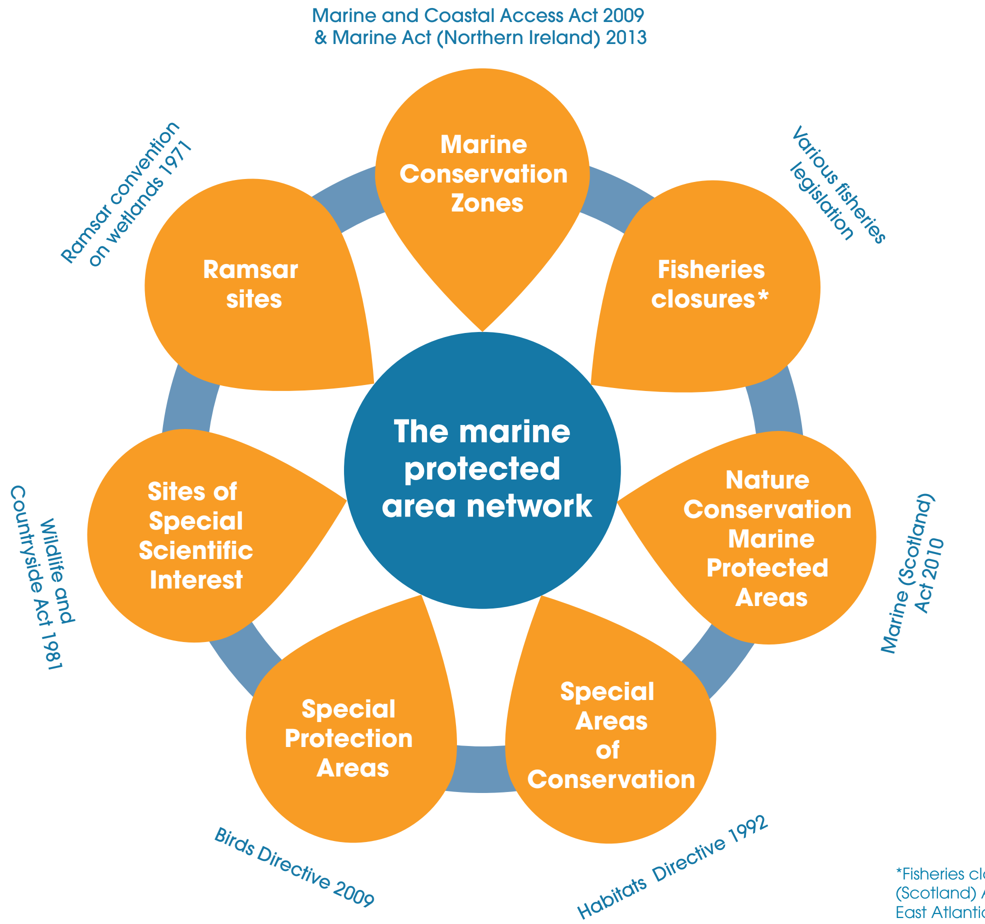
UK marine protected areas

As of August 2015, approximately 16% of UK waters are within marine protected areas including: 108 Special Areas of Conservation (SACs), 110 Special Protection Areas (SPAs), 29 Marine Conservation Zones (MCZs) and 30 Nature Conservation Marine Protected Areas (NCMPAs). Further designations under these mechanisms are expected in the coming years. In addition, fishery closure areas exist to protect seafish in general, as well as for specific species such as sandeels and blue ling, and vulnerable marine habitats.

For the Isle of Man, five fishery closure areas and one marine nature reserve have been established; Jersey has four marine Ramsar sites; and, for Guernsey, there is one marine Ramsar site.

What do we mean by "marine protected area"?

Marine protected areas are parts of the sea that are partly or fully protected from anthropogenic activities. For the purposes of this Report Card, "marine protected area" is a generic term that includes a number of different designations. These designations are considered to contribute to a marine protected area network in the UK.



*Fisheries closures can include: those under the Inshore Fishing (Scotland) Act 1984; regulatory measures under the North-East Atlantic Fisheries Commission; and regulations under the Common Fisheries Policy.

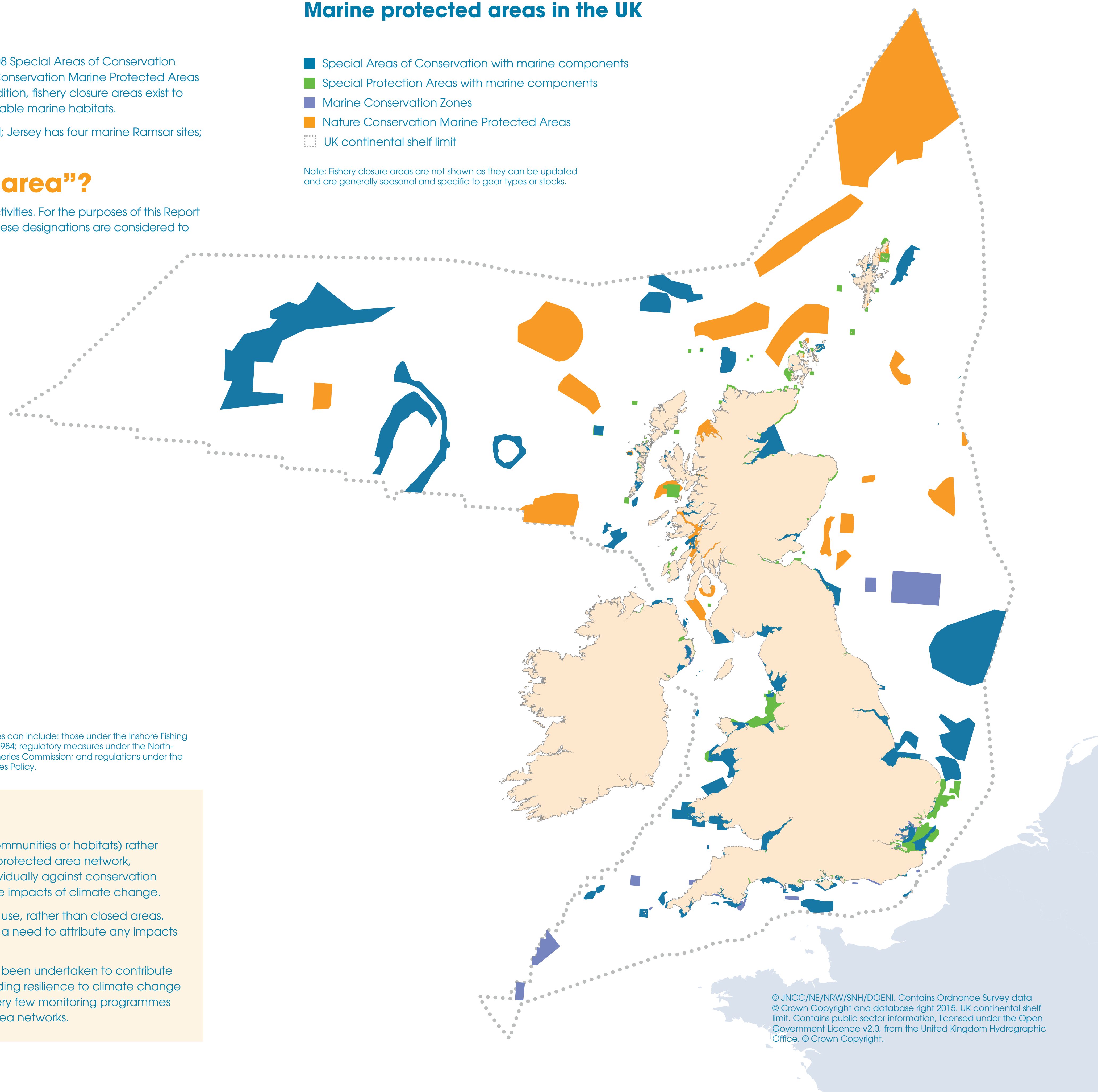
Characteristics of UK marine protected areas

Feature led: Marine protected areas in the UK are established for specific features (species, communities or habitats) rather than marine ecosystems in their entirety. There are 1,253 designated features in the UK marine protected area network, comprising 105 different species and 74 habitats. All of these features need to be assessed individually against conservation targets. It is the features within marine protected areas that are of interest when considering the impacts of climate change.

Multi use: An important characteristic of most UK marine protected areas is that they are multi use, rather than closed areas. This presents challenges when trying to identify appropriate management responses as there is a need to attribute any impacts to human activities, natural variability, climate change or a combination of these factors.

Within networks: The identification and establishment of marine protected areas in the UK has been undertaken to contribute to broader networks (e.g. Natura 2000, OSPAR). The success of these broader networks in providing resilience to climate change needs to be determined through appropriate monitoring programmes. At present, there are very few monitoring programmes worldwide that provide appropriate evidence to assess the functioning of marine protected area networks.

Marine protected areas in the UK



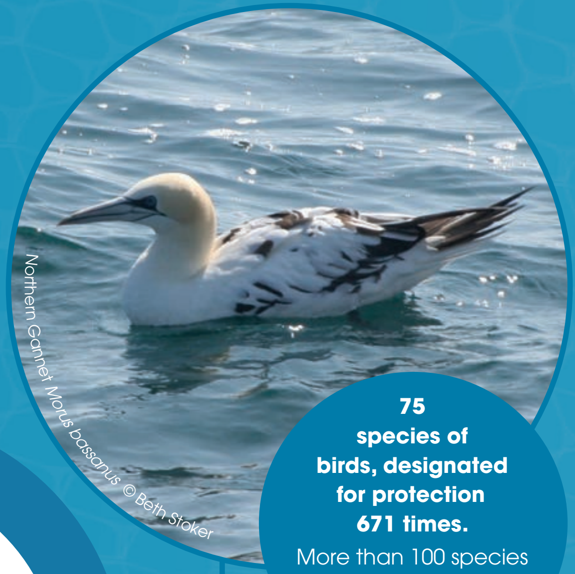
What are the features?

There are many different features designated for protection within the marine protected area network. Individual species and habitats can be designated multiple times across the network, and an individual marine protected area may be designated for multiple species and habitats. The complexity of the varying feature designations provides a challenge in assessing the impacts of climate change on conservation targets.

Grey Seal *Halichoerus grypus* © John Pinnegar. Crown Copyright

5 species of marine mammals, designated for protection 40 times.

Thirty-one species of marine mammal have been recorded in the UK marine environment, including twenty-eight cetacean species, two seal species and one otter species.



Northern Gannet *Morus bassanus* © Beth Stoker

75 species of birds, designated for protection 671 times.

More than 100 species of bird regularly use marine areas in the UK.

Orange roughy *Hoplostethus atlanticus* © JNCC

11 species of fish, designated for protection 24 times.

More than 330 fish species inhabit the seas surrounding the British Isles.

Spiny lobster *Palinurus elephas* © Ross Bullimore

14 species of invertebrates, designated for protection 48 times.

In the UK alone, there are approximately 7,000 species of marine invertebrates.

Note:

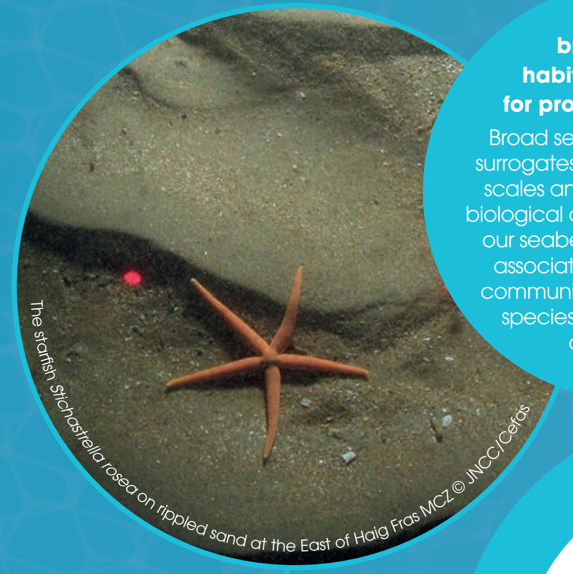
(1) Analysis includes SACs, SPAs, MCZs and NCMPAs designated as of August 2015, with the exception of Skomer MCZ and Strangford Lough MCZ.

(2) Analysis does not include 'seabird assemblages' or 'waterfowl assemblages', which are features of 34 and 41 SPAs respectively.

(3) Analysis includes the Isles of Scilly MCZs as the 11 separate sites.

(4) Information included in the analysis on MPAs and features of MPAs provided by JNCC.

A range of different species and habitats are protected as designated features in the marine protected area network, from tiny species, such as the tentacled lagoon-worm, to broad-scale habitats, such as subtidal sandbanks. These species and habitats all differ in the degree to which they are represented and replicated within the marine protected area network. For example, birds account for 86% of the individual species designations in the marine protected area network, whilst invertebrates account for 6%. Broad, physiographic, topographic and oceanographic habitats account for 75% of the individual habitat designations in the marine protected area network, whilst biological communities (animal, plant and algal) account for 25%.



The starfish *Stichastrella rosea* on rippled sand at the East of Haig Fras MCZ © JNCC/Cefas

41 broad seabed habitats, designated for protection 298 times.

Broad seabed habitats act as surrogates for biodiversity at finer scales and capture the coarse biological and physical diversity of our seabed. These include their associated animal and plant communities, but the individual species of the communities are not listed.

Mussel bed © Blaise Bullimore

15 biological communities dominated by specific animals, designated for protection 41 times.

Some designated features of marine protected areas identify specific animal communities (e.g. mussel beds, *Sabellaria* reefs).

Chesil and the Fleet coastal lagoon

8 physiographic, topographic and oceanographic habitats, designated for protection 56 times.

The UK coastline is complex resulting in a diverse range of coastline physiographic features, such as estuaries, which provide habitats for a huge range of marine communities. There are also oceanographic habitat features such as fronts, and topographic features such as seamounts.

Kelp © SNH

10 biological communities dominated by specific plants or algae, designated for protection 75 times.

Some designated features of marine protected areas identify specific plant and/or algal communities (e.g. seagrass beds, maerl beds, kelp forests).

What could happen to the features?

Many features for which marine protected areas have been designated are potentially vulnerable to climate change, meaning the on-going utility of marine protected areas as a conservation tool could be affected.

Where a marine protected area has been identified for its physiographic (e.g. large shallow inlet and bay) or seabed (e.g. mudflats or rocky reef) features, climate change could result in changes to the constituent flora and fauna, rather than the distribution or extent of the feature itself. Such changes are unlikely to compromise the achievement of conservation objectives. Protecting the healthy condition and functionality of these physiographic and seabed habitats might, in such circumstances, be more important than retaining specific species assemblages.

In contrast, where the main feature of a marine protected area is a biogenic habitat (e.g. seagrass beds) or a species, the consequences of climate change could compromise the achievement of conservation objectives. In a worst-case scenario, species or habitats could be lost entirely from the marine protected area.

As marine protected areas have boundaries based on a present-day snapshot of the distribution and condition of marine habitats and species, the consequences of climate change on marine protected areas could be that:

The quality of the feature changes

For example, in the northernmost Atlantic marine ecosystem, increased carbon dioxide (CO_2) is likely to stimulate the growth of seagrasses such as *Zostera marina*, but the increase in acidity of the seawater will be corrosive to maerl.

Maerl bed © Ross Bullimore

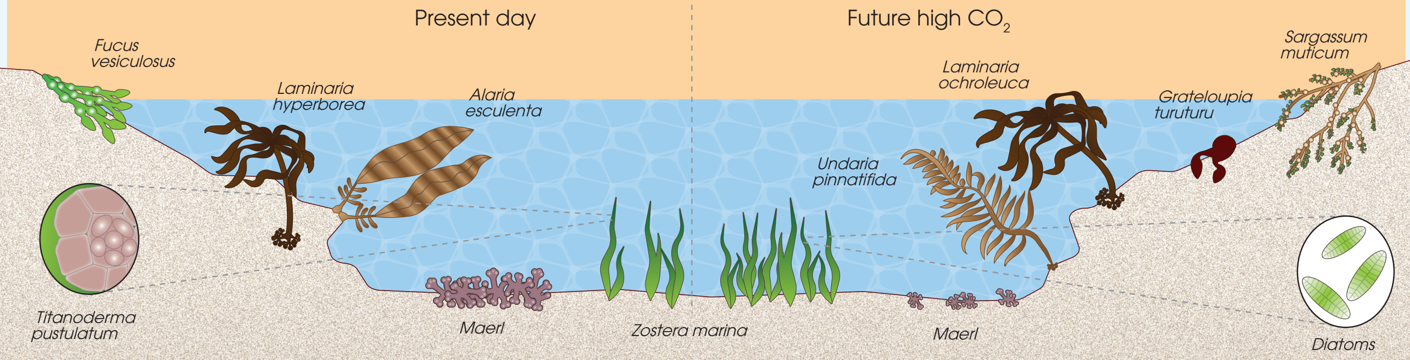
A feature is gained to a particular marine protected area

A marine protected area may become more suitable for the establishment of a designated feature. For example, *Laminaria ochroleuca*, a southern species of kelp is increasing its distribution and abundance in the UK with increasing temperatures and competing with the current dominant species *Laminaria hyperborea*. This may influence the make-up of kelp beds as a designated feature and could require new approaches to management as *L. ochroleuca* is more vulnerable to storm damage and exhibits different biodiversity patterns and ecological processes to *L. hyperborea*.

Laminaria ochroleuca © Keith Hiscock

The composition of the feature changes

This could include a change in biodiversity and increased opportunities for non-native species establishment (e.g. *Sargassum muticum*) that may continue to spread, altering community composition. Changes in biodiversity may be facilitated by increasing levels of carbon dioxide and warming seas which are expected to impact on feature composition. An example is provided below for predicted changes in boreal northeast Atlantic benthic marine flora.

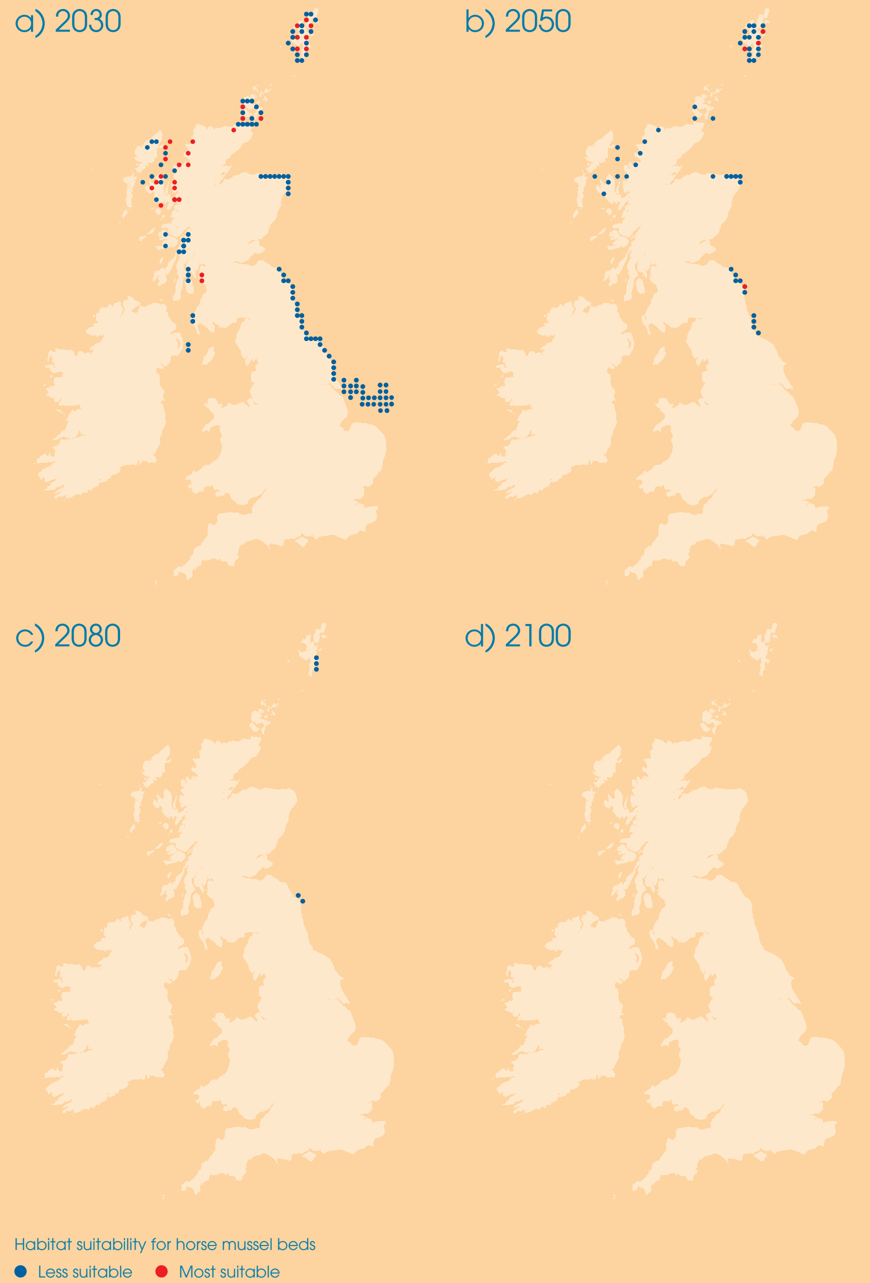


Reproduced with permission of Brodie et al. (2014) The future of the northeast Atlantic benthic flora in a high CO_2 world. Ecology and Evolution. doi:10.1002/ece3.1105

Horse mussel *Modiolus modiolus* © Jim Ellis. Crown Copyright

A feature is lost from the UK marine protected area network

Horse mussel beds (*Modiolus modiolus*) currently appear as a designated feature in ten marine protected areas. Based on the projections below, there is a risk that this feature will no longer be represented in the UK marine protected area network by 2100 due to rising sea temperatures.

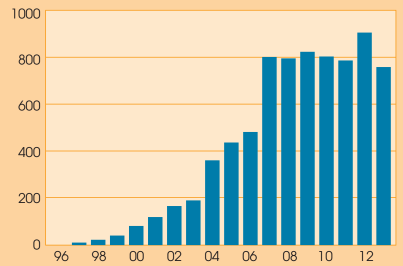


Modified under CC-BY license from Gormley et al. (2013) Predictive habitat modelling as a tool to assess the change in distribution and extent of an OSPAR Priority Habitat under an increased ocean temperature scenario: Consequences for Marine Protected Area networks and management. PLoS ONE. 8(7): e68263. doi:10.1371/journal.pone.0068263

Little egret *Egretta garzetta* © John Pinnegar. Crown Copyright

A feature expands within the UK marine protected area network

Features limited to a single or small number of marine protected areas may expand into other marine protected areas as a result of more suitable conditions. The little egret, protected under the Tamar Estuaries Complex Special Protection Area, has expanded rapidly in the UK. Its first breeding record was in Poole Harbour, Dorset, in 1996; but by 2012, there were over 900 breeding pairs all around the UK.

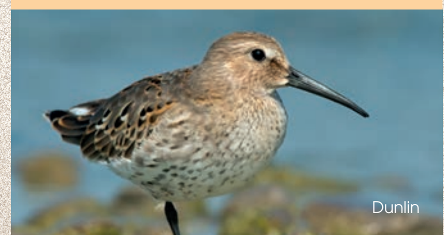


Number of breeding pairs of little egret in the UK by year, based on information from the Rare Breeding Birds Panel.

Reproduced with permission from the British Trust for Ornithology.

A feature is lost from a particular marine protected area

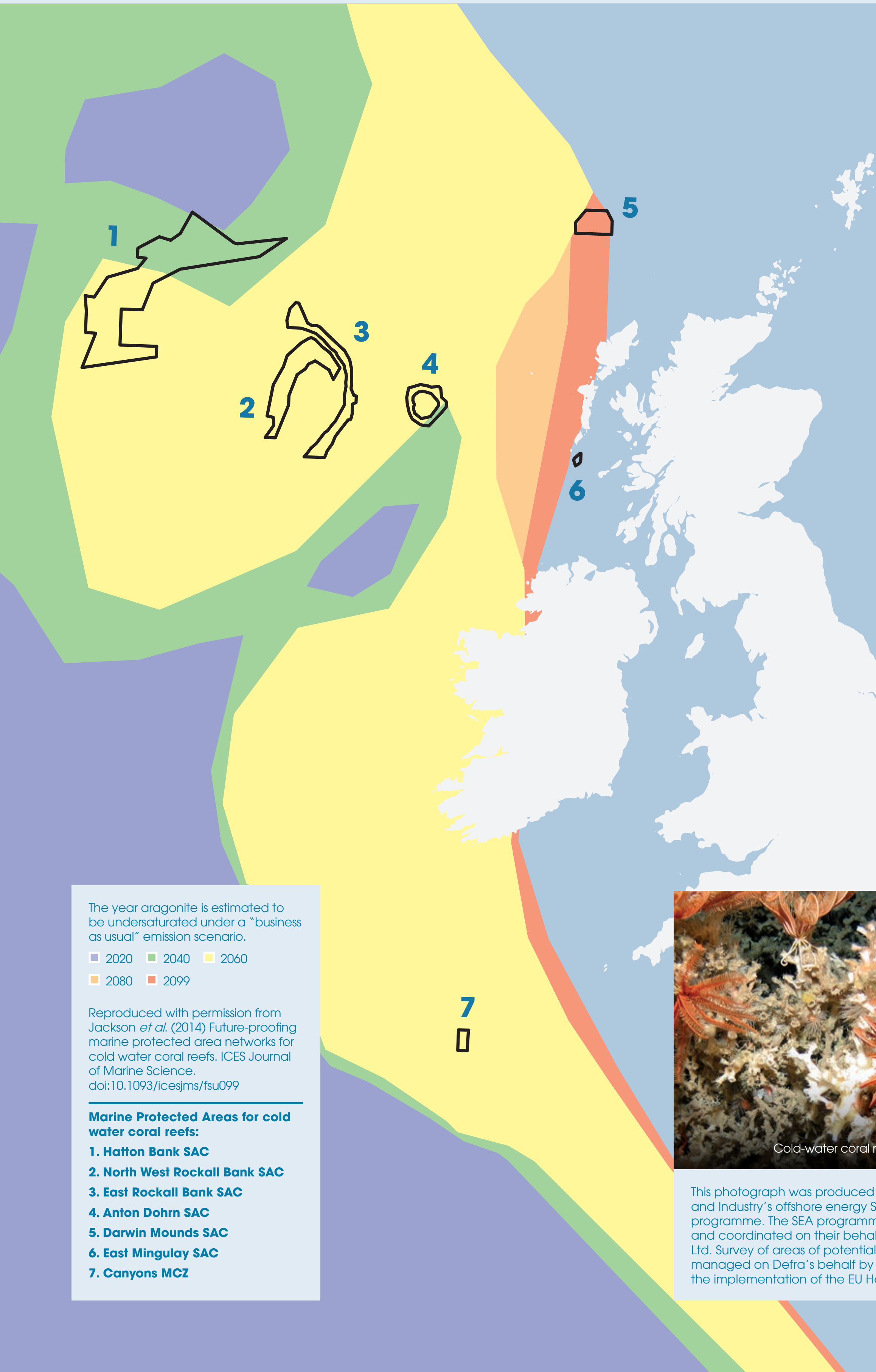
There is increasing evidence that the over wintering distributions of some coastal waders has changed in response to warming. In the last decade there has been a general decline in the use of the UK's east coast sites in favour of the Netherlands by some species, such as dunlins (below), as conditions there have become more favourable.



Dunlin

Marine protected areas and ocean acidification

Rising atmospheric CO_2 emissions are causing an increase in the acidity of the ocean, as more of this CO_2 is dissolved in seawater to form carbonic acid. During this century, it is highly likely that UK waters, ecosystems and habitats will be significantly impacted as CO_2 emissions continue to rise.



Cold water coral reefs

By 2060, over 85% of known cold water coral reefs in UK waters could be exposed to waters that are corrosive to them (as a result of under-saturation of aragonite). Seven marine protected areas are designated for the protection of cold water corals (see map).

The East Mingulay Special Area of Conservation (6) may be one of the few places where cold water corals are still in non-corrosive waters by 2099.

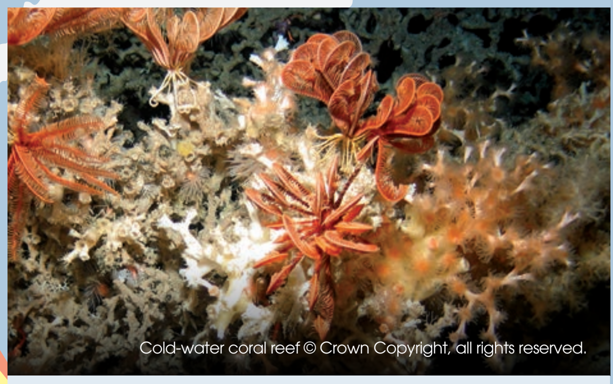
The year aragonite is estimated to be undersaturated under a "business as usual" emission scenario.

- 2020
- 2040
- 2060
- 2080
- 2099

Reproduced with permission from Jackson *et al.* (2014) Future-proofing marine protected area networks for cold water coral reefs. ICES Journal of Marine Science. doi:10.1093/icesjms/fsu099

Marine Protected Areas for cold water coral reefs:

1. **Hatton Bank SAC**
2. **North West Rockall Bank SAC**
3. **East Rockall Bank SAC**
4. **Anton Dohrn SAC**
5. **Darwin Mounds SAC**
6. **East Mingulay SAC**
7. **Canyons MCZ**



Cold-water coral reef © Crown Copyright, all rights reserved.

This photograph was produced as part of the UK Department of Trade and Industry's offshore energy Strategic Environmental Assessment programme. The SEA programme is funded and managed by the DTI and coordinated on their behalf by Geotek Ltd and Hartley Anderson Ltd. Survey of areas of potential reef was funded by Defra and managed on Defra's behalf by JNCC to provide information to support the implementation of the EU Habitats Directive in UK offshore waters.

How can marine protected areas and networks help address climate change?

Work in the United States by the National Oceanic and Atmospheric Administration (NOAA)* has identified that the long-term, site-based nature of marine protected areas provides a distinct advantage in addressing the impacts of climate change.

Marine protected areas do this by:

Providing a focal area where scientific monitoring can take place and the effectiveness of management measures can be assessed.

Water sampling 'rosette' being retrieved from the sea © Dave Sivyer. Crown Copyright.

Providing areas where non-climate stressors can be reduced, potentially leading to beneficial effects outside of the site, such as the protection of bordering habitats and enhanced production of marine species that "spillover" into outside areas.

Providing ecologically connected corridors for shifting species and habitats, with networks of marine protected areas facilitating the range shifts of populations.

Reducing risk and promoting resilience by encouraging as high levels of diversity as possible.

Acting as control areas or sentinel sites for the monitoring of climate change and other impacts, particularly where human activities are controlled and long-term monitoring is used to identify trends.

Protecting habitats that can help mitigate climate change impacts by storing carbon (e.g. salt marshes and seagrass beds).

Sea-lavender, saltmarsh creeks and pans by the Nith Estuary with Criffel beyond, Dumfries and Galloway Area. © Lorne Gill/SNH

Utilising the involvement of stakeholders and local communities to promote public education on marine climate change impacts.

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*Information presented on this page is based on 'Marine protected areas: Building resilience to climate change impacts (2013). Marine Protected Areas Center. NOAA. 4pp'

Management implications for marine protected areas in a changing climate

As the presence, quality or composition of features change, managers may want to consider the following options to ensure that legislation is being implemented in a way that is adaptive to climate change:

Where a marine protected area is designated for multiple features and one or more features are lost then the marine protected area designation may need to be revised.

Example: Small Isles NCMPA

The Small Isles Nature Conservation Marine Protected Area in Scotland is designated for burrowed mud, circalittoral sand and mud communities, horse mussel beds, northern sea fan and sponge communities, shelf deeps, black guillemot, fan mussel aggregations, northern feather star aggregations on mixed substrata and white cluster anemones. These features are likely to respond to climate change differently: from no change (e.g. shelf deep features) to loss of a feature (e.g. horse mussel beds).

Deep-water feather star *Leptometra celtica* © Christine Howson, SNH

If the quality of a feature changes (improves or deteriorates), then adaptive management measures may need to be considered.

Example: Seagrasses

Seagrass beds are expected to benefit from the increased availability of CO_2 for photosynthesis, stimulating growth. This could lead to an increased extent of the feature which may require different management strategies.

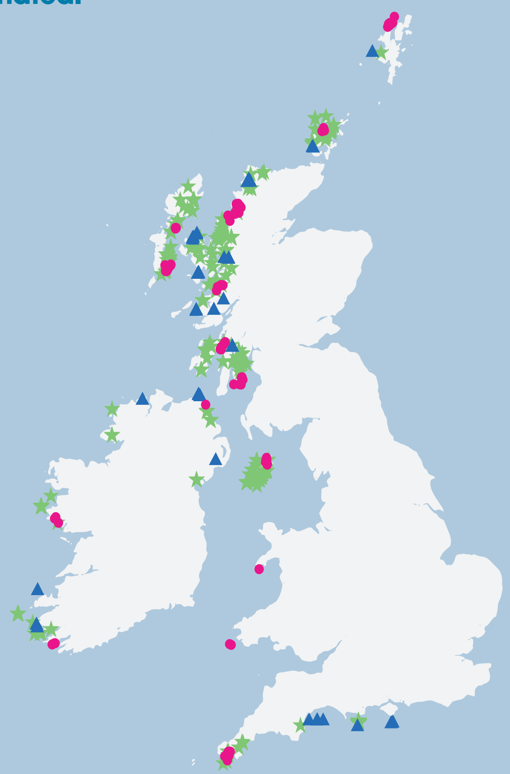
Eelgrass *Zostera marina* Orkney, Northern Isles Area © Sue Scott/SNH

Where a marine protected area is abandoned, but the feature still exists in UK waters, alternative marine protected areas may need to be designated.

Example: Maerl

Maerl beds are found off the southern and western coasts of Britain and Ireland, as far north as Shetland, and are particularly well developed around the Scottish islands and in sea loch narrows, around Orkney, and in the south in the Fal Estuary. Depending on both the species and the climate change driver (i.e. temperature, acidification) maerl beds could be lost from the north or south of the UK. To ensure network coherence and protection of maerl beds, additional marine protected areas in the UK may need to be designated for this habitat (see green stars on map) or the habitat could be added as a designated feature to existing marine protected areas (see blue triangles on map).

- ● Known maerl beds designated within marine protected areas
- ▲ Known maerl beds within marine protected areas, but not designated
- ★ Known maerl beds outside marine protected areas



Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats project (www.emodnet-seabedhabitats.eu), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE).

If the composition of a feature changes, then adaptive management measures may need to be considered.

Example: Wintering waterfowl

Even if wintering waterfowl do not shift their range under climate change, their preferred food source may, meaning that they have to switch prey. Consequently, management plans will need to safeguard a variety of food sources and perhaps reduce human pressures.

Pink footed goose (foreground) and a greylag goose (background) © Lorne Gill, SNH

Where a designated feature expands in range, additional marine protected areas for that feature may need to be considered.

Example: Pink sea fan and red sea fingers

Habitats characterised by southern species such as the pink sea fan *Eunicella verrucosa* and red sea fingers *Alcyonium glomeratum* could increase in extent in response to warming seas. Management responses could include adding the feature to an existing, or creating a new, marine protected area.

Red sea fingers *Alcyonium glomeratum* © Ross Bullimore

Where a marine protected area is designated for a single feature and that feature is lost, then the marine protected area may need to be abandoned.

Example: Lesser sandeel

Sandeels are the only designated feature of Turbot Bank Nature Conservation Marine Protected Area. The Bank is important for sandeels, particularly the lesser sand eel (*Ammodytes marinus*). In British waters this species is at risk from climate change and populations may decline in the future with a warming climate. This could lead to the loss of this species from marine protected areas, such as Turbot Bank.

Sandeels *Ammodytes marinus* © Crown Copyright

© Beth Stoker

What about the Marine Strategy Framework Directive?

What do we mean by "Good Environmental Status" for biodiversity?

Good Environmental Status (GES) is "The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". 11 Descriptors are used to help define what the achievement of GES looks like in practice, four of which are considered to be the biodiversity related descriptors; Descriptors 1 (biological diversity), 2 (non-indigenous species), 4 (food webs) and 6 (seabed integrity).

Climate change implications for achieving Good Environmental Status

The investigation of how climate change may affect the implementation of the MSFD is at an early stage.

An analysis of OSPAR common indicators* concluded that climate change could compromise the achievement of GES for a number of biodiversity indicators. As such, it will be important to understand how management measures to support the achievement, and maintenance, of GES may be affected by climate change.

Examples of some issues that may need to be considered:

Moving baselines: The well documented impacts of climate change on the marine environment have led to concerns over moving baselines. These changes in the marine environment will require an adaptive approach to defining targets, and implementing measures in order to achieve GES. A specific example is for Descriptor 2 (non-indigenous species) where climate change has enhanced the introduction and establishment of non-indigenous species in the MSFD regions (e.g. an increase of tropical species into the Mediterranean Sea; the introduction into the Atlantic of the Pacific Ocean diatom *Neodenticula seminae*). Targets for Descriptor 2 (non-indigenous species) may need to be flexible to accommodate climate mediated introductions.

Suitability of indicators: It is also important to identify species, communities and habitats included as MSFD indicators that may be sensitive to climate change. For species of mammal in the Northeast Atlantic region for example, indicators for Descriptor 1 (biological diversity) have been proposed for grey seal, harbour seal, harbour porpoise and bottlenose dolphin. Their suitability as an MSFD indicator is improved by the fact that as yet there is no clear evidence of climate change impacts on these species. A proposed Descriptor 1 (biological diversity) indicator based on the short-beaked common dolphin, in contrast, may have to take into account distributional shifts, possibly occurring in response to climate change. Also, mammals with less specific feeding requirements (e.g. that can switch prey and feed across trophic levels) are going to be more resilient to climate change impacts on prey species.

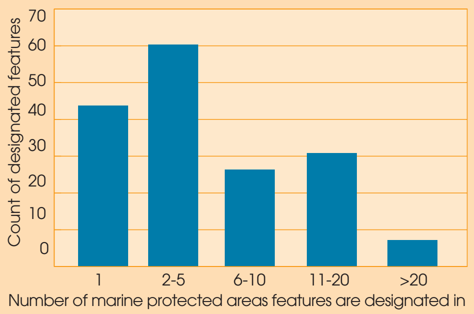
** Report of the Working Group on Biodiversity Science (WGBIODIV). 9-13 February 2015 ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/SSGEF.*

Special Topic Report Card 2015: Key issues for decision makers to consider

Although earlier marine biodiversity legislation does not refer to climate change directly there are associated secondary mechanisms through which climate change impacts can be addressed. Some recent legislation explicitly recognises the need to account for climate change in achieving its objectives. Delivering the objectives of the legislation in the face of climate change would benefit from:

- **Risk assessments for marine protected areas taking account of the impacts of climate change on their designated features.**

In contrast to the terrestrial environment, where species sensitivities to climate change are starting to be assessed, a formal analysis of the vulnerability of marine protected area features to climate change is not yet available. This could be a particular issue for features which are climate-sensitive and only designated in one marine protected area. Of the 42 features designated in only one marine protected area, a number are known to be sensitive to climate change, including long-snouted seahorses (*Hippocampus guttulatus*), black seabream (*Spondyliosoma cantharus*) and Northern sea fan and sponge communities.



The number of different marine protected areas that individual features are designated in across the UK network (right).

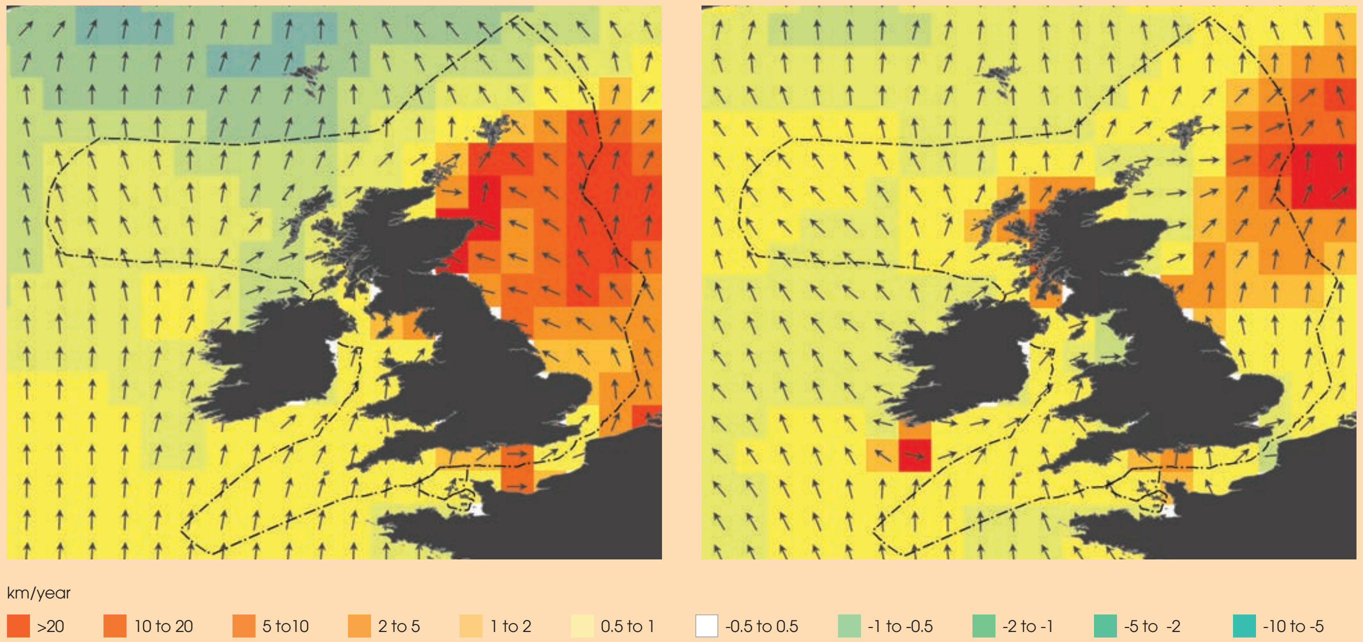
- **Knowledge of where to direct effort in terms of evidence gathering to inform management.**

The magnitude of response of those marine protected area features that are sensitive to climate change will vary temporally and geographically. Identifying where habitats and ecological communities are most, and least, likely to be affected by physical changes in the environment (e.g. temperature, salinity, dissolved oxygen and pH) will be a critical step in managing marine protected areas in the face of climate change.

One way to help prioritise where effort is directed is to use Velocity of Climate Change (VoCC) analyses as developed by the scientific community. VoCC provides a simple measure of past and likely future changes in the physical environment, such as sea surface temperature. Because VoCC gives the speed and direction of movement of areas of similar temperatures over time (in kilometres per year), it can be used to indicate how a species would need to shift its distribution to track its preferred thermal niche. In the marine environment, many species distribution shifts have been shown to follow the VoCC.

Around the UK, the VoCC for sea surface temperature was much higher off the east coast of the UK over the past 50 years (see left image) than off the west coast. This pattern is projected to continue over the next 50 years* (see right image), albeit to a lesser degree, and with highest velocities found further offshore in the North Sea. This variability in the VoCC could provide a useful indicator of the potential vulnerability of designated species and habitats across the UK marine protected area network. Where climate velocities are lower, it might be easier to manage climate change impacts on marine protected areas as species distribution shifts would be expected to be smaller.

Last 50 years **Next 50 years**



Velocity of climate change (VoCC) around the UK for sea surface temperature. The VoCC indicates how fast (colours) and in what direction (arrows) a species would need to move to track its preferred thermal niche.

**Under a comparatively high greenhouse gas emission scenario (RCP 8.5). The VoCC projection uses the mean output from a large number of climate model simulations, generated by multiple international climate models.*

Text and image based on original research by Michael Burrows and Jorge García Molinos

- **A flexible approach in responding to climate-driven changes in the distribution of features within the marine protected area network.**

- **A comprehensive review of the Marine Strategy Framework Directive biodiversity indicators and targets to assess their sensitivity to climate change.**

- **Consideration of the impacts of climate change on marine biodiversity when new legislative mechanisms are developed or existing legislation is updated.**

MCCIP Marine Climate Change Impacts Partnership

What is MCCIP?

The Marine Climate Change Impacts Partnership (MCCIP) is a partnership between scientists, government, its agencies, non-governmental organisations (NGOs) and industry. The primary aim of the MCCIP is to provide a coordinating framework, so as to be able to transfer high quality evidence on marine climate change impacts, and guidance on adaptation and related advice, to policy advisers and decision makers.

Further details and contact

The delivery of this Report Card was overseen by the MCCIP Report Card working group. The members of this group are: M. Frost (MBA/MECN); G. Bayliss-Brown (Cefas); P. Buckley (Cefas); M. Cox (Scottish Government); B. Stoker (JNCC) and N. Withers Harvey (Defra).

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For further details about the work of MCCIP go to **www.mccip.org.uk**. If you have any further enquiries, please contact us at **office@mccip.org.uk**.

2015 Report Card Knowledge Gaps

- Understanding how climate change impacts on features where human activities are absent (e.g. in highly-protected marine protected areas).
- Known and predicted range shifts for marine protected area features, and understanding the connectivity between marine protected areas and the wider environment.
- Greater understanding of the potential resilience that marine protected areas can provide to designated features in the face of climate change.
- Knowledge of the sensitivity of Marine Strategy Framework Directive biodiversity indicators to climate change.

MCCIP partners are:

Adaptation Scotland; Agri-Food and Biosciences Institute, Northern Ireland; Centre for Environment, Fisheries and Aquaculture Science; Climate UK; Department of Energy and Climate Change; Department for Environment, Food and Rural Affairs; Department of the Environment, Northern Ireland; Environment Agency; International Union for Conservation of Nature; Isle of Man Government; Joint Nature Conservation Committee; Marine Scotland; Marine Biological Association - Marine Environmental Change Network; Marine Management Organisation; National Oceanography Centre; Natural England; Natural Resources Wales; Royal Society for the Protection of Birds; Scottish Environment Protection Agency; Scottish Government; Scottish Natural Heritage; Sir Alister Hardy Foundation for Ocean Science; States of Guernsey; States of Jersey; UK Met Office; Welsh Government.

Plymouth Sound dropoff (submerged cliffline) at about 30m depth. It shows red sea fingers *Alcyonium glomeratum*, pink sea fans *Eunicella verrucosa*, a sea urchin *Echinus esculentus* and a variety of other species © Keith Hiscock