MCCIP Marine Climate Change Impacts Partnership

Marine climate change impacts

Report Card 2013

2013

The 2013 MCCIP Report Card provides the very latest updates on our understanding of how climate change is affecting UK seas. Over 150 scientists from more than 50 leading science organisations contributed to this report card covering a wide range of topics ensuring that the information is timely, accurate and comprehensive.

Lowest recorded Arctic sea-ice extent, September 2012

------- Median extent 1979-2000

Source: NSIDC

The key messages provided by this Report Card are summarised below:

Temperature records continue to show an overall upward trend despite short-term variability. For example, in the last decade, the average UK coastal sea-surface temperature was actually lower in 2008-2012 than in 2003-2007.

The seven lowest Arctic sea-ice extents in the satellite era were recorded between 2007 and 2013. The continuing downward trend is providing opportunities for the use of polar transit routes between Europe and Asia by commercial ships.

Changes to primary production are expected throughout the UK, with southern regions (e.g. Celtic Sea, English Channel) becoming up to 10% more productive and northern regions (e.g. central and northern North Sea) up to 20% less productive; with clear implications for fisheries.

There continue to be some challenges in identifying impacts of climate change. These are due to difficulties distinguishing between short-term variability and long-term trends, and between climate drivers and other pressures.

For the first time, this Report Card is also available as an e-publication at www.mccip.org.uk/arc

www.mccip.org.uk/arc

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 and industry. The principal aim is to provide a coordinating framework for the UK, 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.

Knowledge gaps and research priorities

As part of this year's submission, authors were asked to identify key knowledge gaps within their topic area. MCCIP is publishing a Research Priorities report based upon the knowledge gaps identified in the MCCIP Report Cards and supplemented by Charting Progress 2 and Climate Change Risk Assessment (CCRA). This report will be available from the MCCIP website by March 2014

IPCC 5th Assessment Report and UK Climate Projections Update

All of the reports making up the Intergovernmental Panel for Climate Change (IPCC) Fifth Assessment will have been released by the end of 2014. The UK Climate Projections will also have updates available for the marine environment in 2014.

These new projections will take time to apply to regional scale impact models of relevance to the UK.

Introduction

The 2013 Report Card provides an update on the scientific understanding of climate change impacts on our seas. As in previous report cards, changes in ocean climate set the context for evidence of impacts on the Government's vision for clean, healthy, safe, productive and biologically diverse oceans and seas.

There are some changes to the topics in the 2013 Report Card. Arctic sea-ice has been added as a new topic as it has potential to have impacts for the UK. Shipping now includes ports, and the built structures topic is split into coastal and onshore, and offshore.

The number of reported headlines provided in each theme is reduced in this report card compared with previous years. This is because many topics have shown no, or very little, change since the 2010-2011 Report Card. Across the 33 very diverse topics in this report card, one or a combination of reasons, including the following, may explain the lack of change reported:

1) there is no change in status;

2) a change in trend or status cannot be identified due to complexities in analysis and/or interpretation, e.g.:

Processing time: Collecting, preparing and analysing data over sufficient time periods to establish meaningful trends is challenging. Often findings can only be reported some time after field work has been completed.

Marine ecosystem response: The responses of organisms and large-scale processes to climate change are too subtle to provide measurable evidence of climate change impacts on a short-term basis.

3) no new data or information have become available.

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ARC online and full scientific reports

The Report Card summarises the information provided in 33 individual, peer-reviewed reports commissioned by MCCIP.

These are available at www.mccip.org.uk/arc and provide detailed supporting evidence and comprise the following sections:

- Executive summary
- What is already happening?
- What could happen?
- Knowledge gaps
- Socio-economic impacts
- Confidence assessments
- References

Scientific understanding

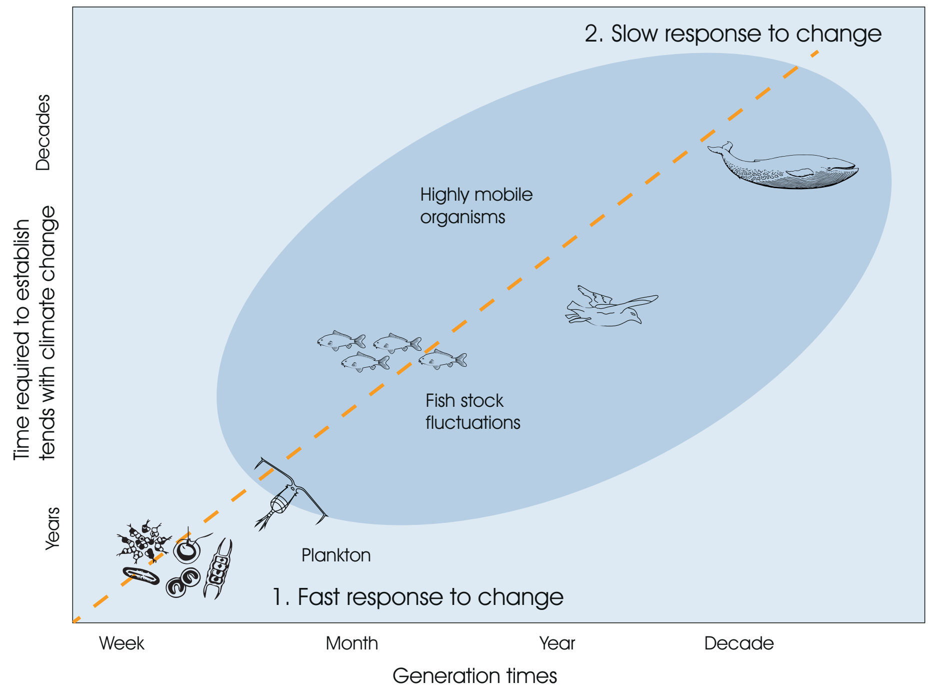
Relative time required to understand climate change driven trends in data

The time that it takes to collect data and recognise a trend varies between all of the topics covered in this card. There are also challenges with attributing these trends directly to climate change. Below we provide two illustrations highlighting some of the issues; the collation of physical time series, and species generation time.

Collation of physical time series: Identifying long-term changes can take more time for some physical processes than others. For example, because the strength of the Atlantic Heat Conveyor varies markedly on a daily basis, a relatively long time series is needed to identify any clear trends. For physical processes such as temperature, where short-term changes are less pronounced, trends can be detected from shorter time series.

© Ben Kurten, Cefas

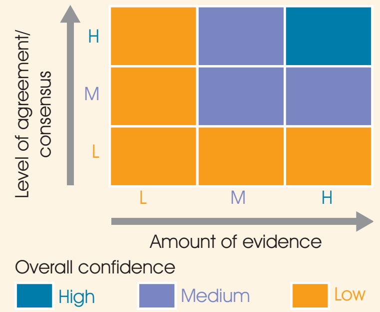
Species generation time: The ability to establish a link between climate change and trends in species numbers, distribution, etc. varies depending on a combination of factors and our understanding of the natural dynamics of the different species. For plankton species, which are short-lived and for which there is an existing long time series of data it is relatively easy. For many other organisms further up the food chain that have longer generation times and more complex interactions that need to be taken into consideration, the time required before a link between any changes and either direct or indirect climate change impacts can be confirmed is longer.



Based on Edwards *et al.* 2010.
Multi-decadal oceanic ecological datasets and their application in marine policy and management. *Trends in Ecology and Evolution*, 25: 602-610.

Confidence assessments

For all topics, confidence ratings are provided for what is already happening and what could happen. The confidence ratings of low, medium or high are based upon the amount of evidence available and the level of scientific consensus.



Changes in confidence since the 2010-2011 Report Card

Confidence may go up or down due to new data and model outputs becoming available or through changes in understanding of the science. The majority of confidence ratings have stayed the same since 2010-11; with nine of the confidence ratings increasing and two reducing.

Emissions scenarios

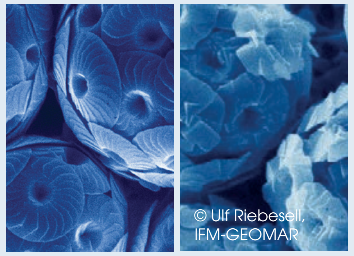
Emissions scenarios describe future releases into the atmosphere of greenhouse gases, aerosols, and other pollutants and, along with information on land use and land cover, provide inputs to climate models. They are based on assumptions about driving forces such as patterns of economic and population growth, technology developments, and other factors.

Climate of the marine environment

Understanding changes to the physical state of the marine environment particularly change in **Temperature (Air and Sea)** is critical as they ultimately result in many of the impacts described elsewhere. For most topics in this section (i.e. **Storms and Waves**; **Atlantic Heat Conveyor; Coastal Erosion**; **Salinity**; **Air-sea Exchanges of Heat and Water**; and **Air-sea Exchanges of CO_2**), there has been little change in the headline messages since the last full report card was published.

There are new headline messages for both **Arctic Sea-ice** (a new topic) and for **Ocean Acidification** that continues to be the subject of on-going research. For the remaining topics in this section, there are some more subtle changes in understanding worth noting. For **Sea Level**, an improved understanding of the key drivers (thermal expansion of water, meltwater from land-ice and changes in other terrestrial water storage) means most of the observed global average trend over recent decades can now be explained. There is now some indirect evidence of a strengthening of **Shelf Sea Stratification** beyond the normal inter-annual variability.

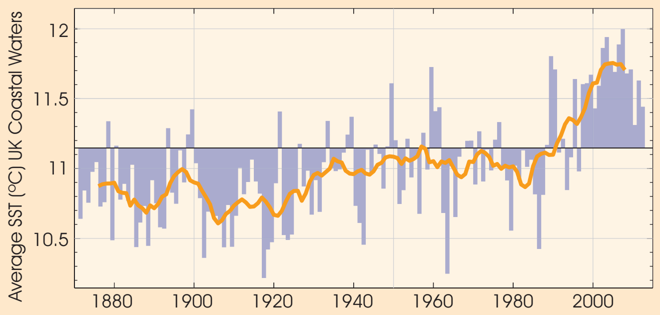
The calcifying microalga *Calcidiscus leptoporus* after experimental exposure to a CO_2 level of 700 ppm as projected for the year 2100.



Changing UK sea surface temperature: Short-term variability versus long-term trend

The long-term record of sea surface temperature around the coast shows a general warming trend. On a decade-to-decade basis, however, this overall picture is complicated by short-term natural variability. For example, in the decade, the average UK coastal sea-surface temperature was actually lower in 2008-2012 than in 2003-2007.

The UK Climate Projections (UKCP09) showed an increase of around 2.5 °C in the average annual sea-surface temperature in coastal waters by the 2080s, compared to the 1961-1990 average. This increase would lead to an average annual sea-surface temperature that is higher than the highest observations from the past.

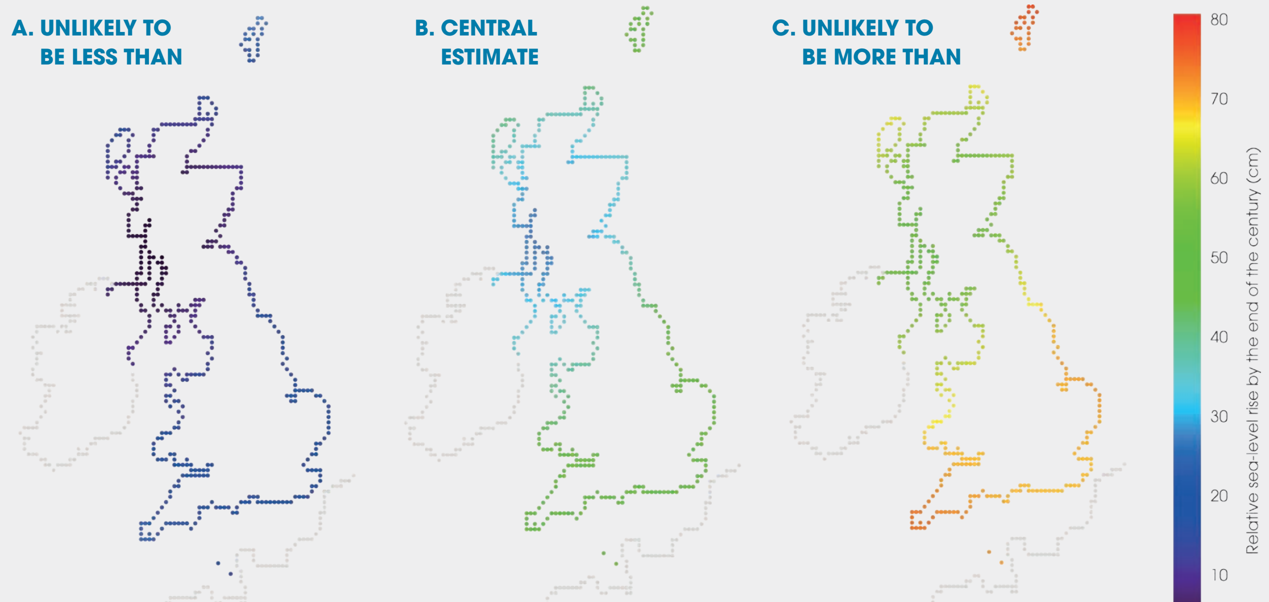


Time series of average annual sea-surface temperature in °C for UK coastal waters. The blue bars show the annual values relative to the 1971-2000 average and the smoothed orange line shows the 10-year running mean. Data are from the HadISST1.1 data set.

Projected sea-level rise by 2100

These maps provide estimates of relative sea-level rise around the UK and Channel Islands over the 21st Century.

They show the likely range of increase under a medium emission scenario (A1B under the IPCC Assessment Report 4), taking into account the relative effects of local land uplift or subsidence. Data are from UK Climate Projections 2009 courtesy of Met Office Hadley Centre.



- Each circle represents a 25km grid along the UK coastline

n.b. The greenhouse gas forcing associated with the A1B scenario reaches a level late in the 21st century similar to that of the Relative Concentration Pathway 6.0 as used in the IPCC Fifth Assessment Report.

Headlines

Arrows show change in confidence since the 2010-11 MCCIP Report Card ⬇ ⬆ ↔

	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN

Ocean Acidification

NERC; PML; MBA; Bristol University; University of Southampton; Cefas

What is already happening — High Confidence ↔

- The current rate of increase in acidity (decrease in surface layer pH) is probably more rapid now than any time in the last 300 million years.
- There is growing evidence of the importance of interactions between ocean acidification and other stressors, such as temperature.
- Recent research effort has shown the complexity of the biological effects of ocean acidification, with some species being more tolerant than others.

What could happen — Medium Confidence ↔

- Model projections indicate that by 2100 much of the North Sea could be seasonally under-saturated with respect to aragonite. Aragonite is needed by many shell-forming organisms.
- Around 70% of known cold-water coral locations are estimated to be in waters under-saturated in aragonite by the end of this century.
- The overall effect of ocean acidification on marine ecosystems and the services they provide is expected to be deleterious, with risk of substantive reductions in shellfish growth (and harvest) within 50 years. There could be benefits, however, for some macroalgal and seagrass species (due to increased CO_2 in the sea water).
- As ocean acidification continues, it may result in changes in metal toxicity and nutrient availability.

Arctic Sea-ice

CPOM; Met Office Hadley Centre; NOC; NCAS

What is already happening — Medium Confidence NEW

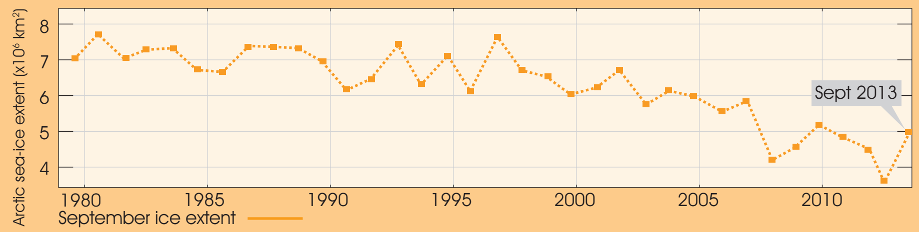
- The average monthly Arctic sea-ice extent has declined at a rate of over 4% per decade since satellite records began in 1979.
- The last seven years (2007-2013) have seen the seven lowest sea-ice extents recorded during the satellite era. Following the record low ice extent recorded in September 2012, the 2013 seasonal minimum extent was close to the linear, long-term, downward trend.
- Ice thinned at a rate of approximately 60 cm per decade over the period of 1980 to 2008, and new satellite data suggests that the equivalent rate over the period 2010-2012 is 75 cm per decade.

What could happen — Medium Confidence NEW

- Most models project the Arctic Ocean to be nearly ice free, in each late summer, by the 2030s.
- Limited modelling evidence suggests that reduced Arctic sea-ice cover could result in an increase in cold winters in the UK and northern Europe. This could partly counteract direct warming effects from climate change in these areas.
- Reduced sea-ice extent could have important socio-economic implications (e.g. shipping, fisheries and offshore mineral exploration).

Decline of Arctic sea-ice extent

Arctic sea-ice extent reaches a minimum during late summer each year, usually in September. Since records began in 1979, this minimum has shown a marked decline. Data are from the HadISST1.1 data set.



Confidence for remaining topics	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN	Authors
Temperature (Air and Sea)	High ↔	Medium ↔	Cefas; Marine Scotland; NOC; IMGL; SAMS; PML; Marine Institute; Met Office Hadley Centre; AWI
Storms and Waves	Medium ↔	Low ↔	Heriot-Watt University; NOC
Sea Level	High ↔	Medium ↔	NOC; Met Office Hadley Centre
Atlantic Heat Conveyor	Medium ↔	Medium ↔	NOC; Met Office Hadley Centre; SAMS; NCAS; Cefas
Salinity	Medium ↔	Low ↔	Cefas; NOCS; Marine Scotland; SAMS; IMGL; PML; Met Office Hadley Centre; AWI
Shelf Sea Stratification	Medium ↔	Low ↔	NOC; The University of Liverpool; Cefas
Coastal Erosion	High ↔	Medium ⬆	Plymouth University
Air-sea Exchanges of Heat and Water	Low ↔	Low ↔	NOC
Air-sea Exchanges of CO_2	Medium ⬆	Low ↔	Met Office Hadley Centre

MCCIP REPORT CARD 2013

Snapshots of marine climate change impacts

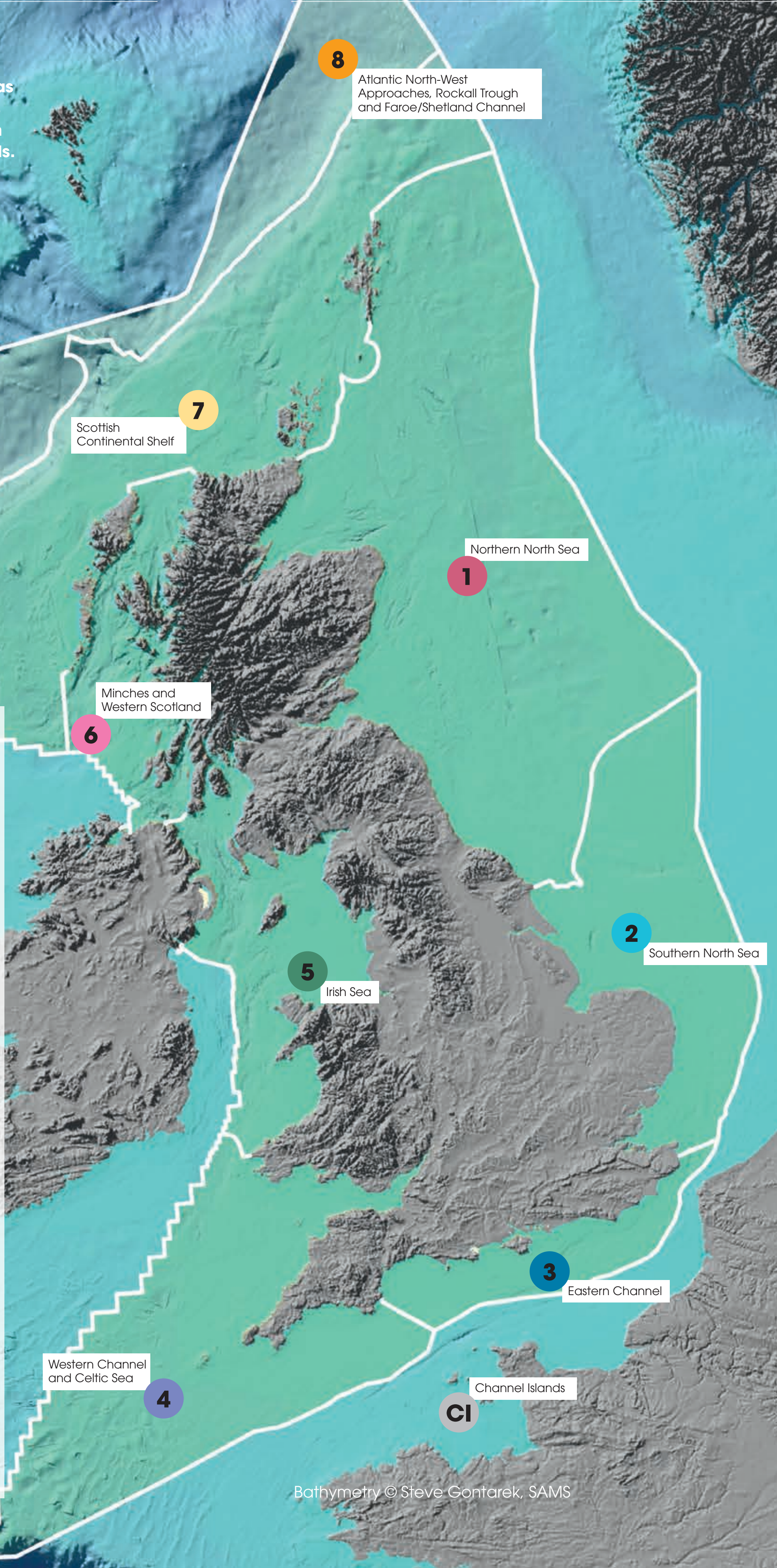
The eight regions shown are based on bio-geographical areas used for UK marine assessments and EU directives. A ninth region (CI) refers to the Channel Islands.

What is already happening

- 2 3 4 — Improved environmental conditions (i.e. summer warming) for anchovy have led to an increase in their abundance.
- 4 6 7 8 — A general northward range shift is taking Atlantic white-sided dolphins out of UK waters. At the same time, striped dolphins are moving in from the south.
- 1 6 7 — Short-beaked common dolphins are being sighted in the Northern North Sea and northernmost part of the Scottish Continental Shelf more regularly.
- 5 — Wintering numbers of little egret are increasing on estuaries in north-west England.
- 5 6 — The northwards movement of the non-native Asian club tunicate *Styela clava* has accelerated in the last decade in response to rising sea temperatures.
- 5 — The non-native Chilean oyster *Ostrea chilensis* is increasing in abundance and distribution in response to rising sea temperatures and high plankton availability coinciding with their breeding season.
- 3 4 5 — Numbers of intertidal topshells *Phorcus (Osilinus) lineatus* and *Gibbula umbilicalis* are increasing in response to rising sea temperatures.
- 4 5 — Population densities of intertidal species, e.g. the honeycomb worm *Sabellaria alveolata*, brown alga *Bifurcaria bifurcata* and limpet *Patella depressa*, are increasing in response to rising sea temperatures.
- 4 — Bristol Channel crustaceans have shown an increase in abundance of mysid shrimps *(Schistomysis spiritus, Gastrosaccus spinifer, Mesodopsis slabberi* and *Neomysis integer)* and prawns (*Crangon crangon, Pandalus montagui* and *Palaemon serratus*), in response to rising sea temperatures.
- 3 4 CI — Warm-water species are being increasingly targeted by recreational anglers, for example triggerfish on inshore wrecks.
- 2 3 5 — The timing of spawning in sole has shifted earlier at a rate of 1.5 weeks per decade since 1970.

What could happen

- 1 7 — A warmer northern North Sea will favour deeper-water, warm-water species (e.g. hake) but drive out cold-water species (e.g. haddock).
- 1 7 — White-beaked dolphin, harbour porpoise and minke whale abundances may decline.
- 2 3 4 5 6 — Warming sea temperatures will mean the non-native Pacific oyster *Crassostrea gigas* continues to expand northwards and increase in abundance, to the detriment of native oyster *Ostrea edulis* and other bivalve species.
- 1 7 8 — The melting of Arctic sea-ice will further encourage the use of polar transit routes between Europe and Asia by commercial ships.
- 1 6 7 — By the end of this century, populations of horse mackerel and anchovy are expected to increase in northern waters.
- 1 2 — Climate projections suggest fish species distribution will shift northwards at a faster rate, from a current rate of approximately 20 km per decade to an average of 27 km per decade by 2050.
- 1 2 — The highest number of properties at risk from coastal flooding is likely to be around Yorkshire and the Humber Estuary.

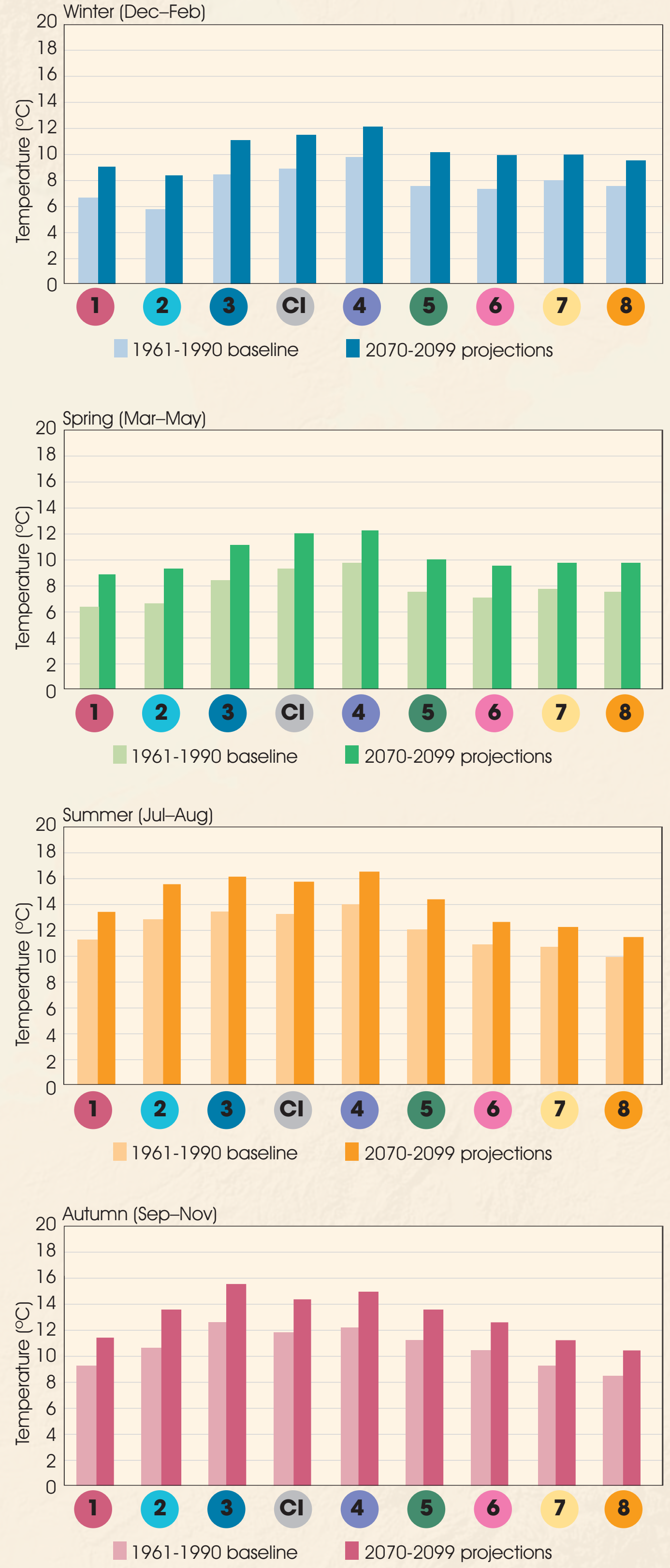


Bathymetry © Steve Gontarek, SAMS

Future sea-surface temperature

Seasonal mean sea-surface temperature projections for the 2070-2099 period (compared with a 1961-1990 baseline) for each region. Changes are based on the UK Climate Projections (UKCP09) under a medium emissions (IPCC A1B) scenario. Data courtesy of Met Office Hadley Centre.

Seasonal mean sea-surface temperature



Climate change: Impacts on our vision for a healthy and biologically diverse marine ecosystem

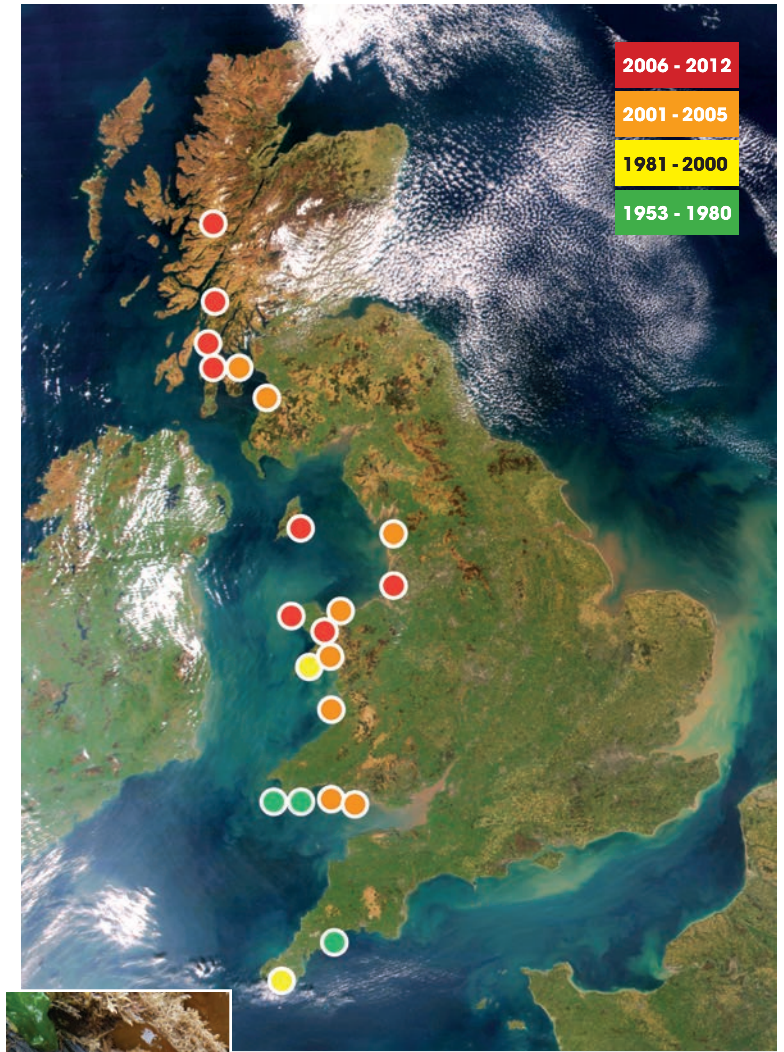
Healthy and biologically diverse seas rely on maintaining the balance between a wide range of biological, chemical and physical factors. For many topics in this theme (**Fish**; **Waterbirds**; **Non-natives**; and **Intertidal Habitats**), there is more new evidence than for the other themes due to the availability of monitoring and observational data. However, our understanding of complex interdependencies (including increasing pressure from climate change) is still in its infancy.

For a variety of reasons, there is less new information for other topics in this theme. A lack of long-term records from **Deep-sea Habitats** means that there is no baseline against which to assess climate change impacts. Whatever impact climate change has is likely to be indirect as a result of climate driven changes in surface ocean productivity. Ocean acidification also poses a potential long-term threat to deep-sea calcifying organisms.

For **Shallow and Shelf Subtidal Habitats**, climate impacts are evident in changes in distributions and abundances of various species. Previously unrecorded warm-water species have been found, especially in the south-west, but there are no new records since the last report card.

Coastal Habitats are vulnerable to a wide range of impacts; recent work suggests dune wetlands may dry out over the next 50 years and transform to dry grassland and dune, and machair vulnerability may increase as a result of erosional narrowing of beaches and dunes.

Changes in distribution and seasonal timing of some **Plankton** production, linked to climate change, are well documented. Previous MCCIP report cards have highlighted the consequences of climate change for many plankton predator species, including the larvae of many commercial fish species, as well as the effect on the breeding success of many **Seabirds**. Changes in prey abundance and distribution may affect **Marine Mammals**. The general impacts of climate change on cetaceans remain poorly understood although distributional shifts continue to be observed (see Page 6).



***Styela clava*: Observations in the UK since 1953**

A non-native species, the dots show the northward progression of Styela clava over the last 60 years and rapid expansion since 2000. Data are courtesy of NBN Gateway.

Headlines

Arrows show change in confidence since the 2010-11 MCCIP Report Card ↓ ↑ ↔

	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN
Non-natives SAMS; Bangor University; Queen's University Belfast; Marine Organism Investigations; ERI; MBA	**Medium Confidence** ↔ • Non-native species are continuing to show a northern movement as the sea temperatures provide more suitable conditions, e.g. the Asian-clubbed tunicate (*Styela clava*) has recently reached as far as Loch Carron, on the west coast of Scotland. • The Chilean oyster (*Ostrea chilensis*) introduced to the Menai Strait in the early 1960s, has experienced a rapid increase in density in this area over the last 20 years. This is as a result of the optimum spawning temperature being reached more often and favourable spring phytoplankton bloom conditions.	**Low Confidence** ↔ • Increased sea temperature will result in the expansion of the distribution of a range of non-native species including the carpet sea squirt *(Didemnum vexillum)*, Pacific oyster *(Crassostrea gigas)*, Manila clam *(Venerupis philippinarum)* and the slipper limpet *(Crepidula fornicata)*. • Individuals of the predatory veined rapa whelk *(Rapana venosa)* that have been found in the North Sea could become established with rising sea temperatures.

	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN
Fish University of Exeter; The University of Sheffield; Bristol University	**Medium Confidence** ↔ • When demersal fish communities are assessed at local scales across the UK, 36 of the 50 most common species show a response to warming: 27 warm-adapted species increased in abundance whilst nine cold-adapted species decreased. • Increasing sea temperature is affecting spawning behaviour of fish. For example, mackerel and horse mackerel are spawning earlier in the English Channel and both earlier and further north on the Porcupine Bank.	**Medium Confidence** ↔ • Changes to primary production are expected throughout the UK, with southern regions (e.g. Celtic Sea, English Channel) becoming up to 10% more productive and northern regions (e.g. central and northern North Sea) up to 20% less productive; with clear implications for fisheries. • Evidence is emerging that fish body-size is affected by climate change. For example, warm, lower-oxygen conditions favour smaller individuals, and by 2050, the average fish weight could be reduced by 14-24%. However, there are multiple drivers of changes in size distributions including the known effects of fishing.
Waterbirds BTO	**Medium Confidence** ↑ • There is increasing evidence that the overwintering distributions of many coastal waders and waterfowl have changed. In recent decades, in response to warming, their distributions have shifted north and eastwards out of the UK. This has resulted in declines in usage of the UK's east coast sites, by waders, in favour of The Netherlands. These declines may have been partly reversed by the most recent cold winters.	**Low Confidence** ↔ • Great white egret, cattle egret and glossy ibis populations are likely to become regular users of British estuaries in winter. • Potential changes in sea level will alter estuarine sediment patterns, with likely impacts on wintering waterbird communities, particularly at sites where coastal defences are maintained. • Significant warming is projected to reduce Arctic and sub-Arctic breeding ranges of waterbirds by about 50% by 2100. This suggests that despite improving conditions for wintering waterbirds in the UK, many species may decline in abundance.
Intertidal Habitats MBA; NUI; Newcastle University	**Medium Confidence** ↔ • The warm-water limpet *Patella depressa* continues to move north around the Welsh coast. In southern England and Wales, it is now more dominant than the cold-water *Patella vulgata* at many locations. • There is clear evidence of phenological (life-cycle events) shifts in warm water gastropods. Reproductive cycles of *Phorcus (Osilinus) lineatus* and *Gibbula umbilicalis* are occurring three months earlier and *P. depressa* is breeding 19 days earlier. Conversely, the cold-water *P. vulgata* is showing a delay in gonad development. • The topshell *P. (Osilinus) lineatus* range continues to extend northwards on the Welsh coast and eastwards along English south coast. *G. umbilicalis* has moved through the English Channel into the southern North Sea.	**Low Confidence** ↓ • As temperature increases, some warm-water, rocky shore species will continue to advance northwards and cold-water species will be lost from southern areas where their upper thermal tolerance levels are exceeded. • The distribution and abundance of the warm-water reef-forming polychaete *Sabellaria alveolata* is likely to increase around Scotland.

Confidence for remaining topics	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN	Authors
Plankton	Medium ↓	Medium ↔	SAHFOS; Marine Scotland; The University of Strathclyde; Cefas; NUI; PML
Seabirds	Medium ↔	Low ↔	CEH; JNCC
Marine Mammals	Low ↔	Low ↔	Sea Watch Foundation; University of Bangor; IMR
Coastal Habitats	Medium ↔	Medium ↑	CEH; University of Glasgow; SNH
Shallow and Shelf Subtidal Habitats	Low ↔	Low ↔	Cefas; Pisces Conservation Ltd.; Bangor University; MBA; Heriot-Watt University; University of Glasgow
Deep-sea Habitats	Low ↔	Low ↔	SAMS

Climate change: Impacts on our vision for clean and safe seas

Apart from **Human Health** and **Coastal Flooding**, there are no new headlines to report for this theme. This is due to the fact that despite new monitoring data being available for all the topics, the large number of influencing factors (both marine and terrestrial, anthropogenic and natural) means climate change impacts cannot be easily identified.

For **Pollution (Bathing and Shellfish)** and **Pollution (Estuarine and Coastal)**, an example of key influencing factors is the interaction between rainfall (which may be affected by climate change) and farmland management. Thus, identifying a clear climate signal is problematic.

There is concern over issues with **Harmful Algal Blooms (HABs)** such as continued blooms of *Karenia mikimotoi*. HABs can be influenced by a variety of environmental factors which may increase or reduce their occurrence and thus the impact of climate change on HABs is difficult to predict. Tracing changes in climate to impacts on **Nutrient Enrichment** is also difficult; as changes may be driven both by direct human pressures and climate mediated factors such as shelf sea stratification.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Headlines

Arrows show change in confidence since the 2010-11 MCCIP Report Card ↓ ↑ ↔

	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN
Coastal Flooding	**High Confidence** ↔	**Low Confidence** ↔
Environment Agency; NOC; University of Dundee; Marine Institute	• The approximate 14 cm rise in mean sea-level since the beginning of the 20th century, has significantly increased (as much as doubled) the risk of flooding at many locations around the coast.	• Relative sea level will continue to rise, leading to increased risk of flooding. For example, a predicted 910,000 residential properties in England and Wales will be at significant risk of tidal flooding by the 2080s.
Human Health	**Medium Confidence** ↑	**Medium Confidence** ↑
Cefas	• Recent analysis shows that there was a transition in the 1980s in the North Sea to a vibrio-dominated bacterial community, corresponding with warming in the area. • There is limited evidence of an expansion of the biogeographical ranges of the harmful warmer water phytoplankton species into higher latitudes. For example, there has been an apparent increase in *Protoceratium reticulatum* (a producer of toxins) in UK waters which can accumulate in shellfish or can be directly ingested. • There has been an apparent increase in vibriosis in Northern Europe, with outbreaks typically linked to warm weather episodes. Marine vibrio pathogens, which can cause gastro-enteritis and septicaemia, have led to disease outbreaks in Northern Europe and are now being routinely isolated from UK shellfish and bathing waters in the summer.	• Most vibrio species of human health relevance grow preferentially in warm (>15 °C) sea water. Increasing sea temperatures around the UK are anticipated to result in an increase in marine vibrio infections.

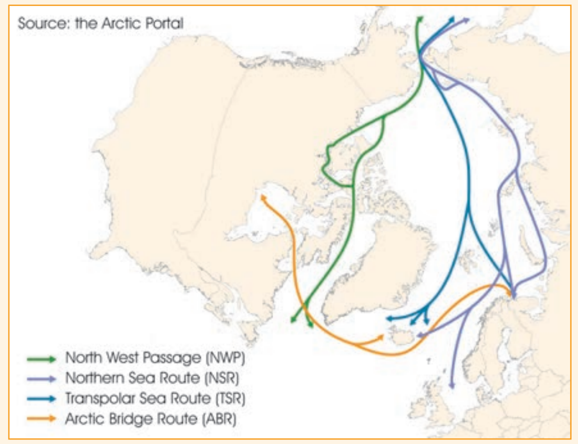
Confidence for remaining topics	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN	Authors
Nutrient Enrichment	Medium ↑	Low ↔	Cefas; Environment Agency; NOC; The University of Strathclyde; Marine Scotland; Marine Institute; DOENI; AFBI; EPA
Harmful Algal Blooms (HABs)	Low ↓	Low ↔	Marine Scotland; SAMS; SAHFOS; Cefas; AFBI; SMRU; IMGL; NUI; Marine Institute
Pollution (Estuarine and Coastal)	Medium ↔	Medium ↔	Cefas; PML; NOC; Marine Scotland; SEPA
Pollution (Bathing and Shellfish)	High ↑	Medium ↔	NOC; CREH; University of Leeds

Climate change: Impacts on our vision for commercially productive seas

The marine economy is very important in terms of food (fish and aquaculture), energy (oil, gas and renewable energy), transport, tourism and recreation. However, knowledge of current and future climate change impacts on most of the topics related to the marine economy is limited. For example, **Tourism (and Marine Recreation)**, a key economic activity, is potentially sensitive to climate change (e.g. the threats of flooding, coastal erosion and opportunities for increasing visitor numbers) but little is known about future socio-economic impacts.

The **Ports and Shipping** and the **Built Structures (Offshore)** sectors, recognise that climate change is an issue, e.g. for ports, there is a need to respond to sea-level rise, storm surges, temperature change, high winds, increased rain and snow. These sectors are keeping a watching brief rather than taking specific action as uncertainty in predictions makes it difficult to adopt more stringent design thresholds. Conversely, for **Built Structures (Onshore and Coastal)**, the effects of climate change on coastal erosion and flood risk have been routinely considered in planning, design and maintenance of new and existing structures for some time.

With respect to **Aquaculture**, evidence of impacts, that can be attributed to climate change, were presented in a major MCCIP review in 2012 and there is nothing further to report at this time. The 2012 review also considered **Fisheries** and in this case there is new evidence to report.



Arctic Shipping Routes

In 2009, the first two commercial ships used the NSR between Asia and Europe. Two years later, 34 commercial ships transited the route. The NWP and NSR could account for 2% of global traffic by 2030, and 5% by 2050.

Headlines

	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN
Fisheries	**Medium Confidence** ↔	**Low Confidence** ↔
Cefas; UEA; The University of British Columbia; PML; Marine Scotland; Marine Institute	• Commercial and recreational fishermen have responded to new opportunities in recent years, as warm-water species have appeared in greater numbers and their exploitation has become viable. Examples include boarfish, triggerfish, squid and seabass. • In 2012, 937 tonnes of seabass were landed in the UK and the Channel Islands, compared with only 142 tonnes in 1984. Recent evidence, however, suggests that their advancement northward has been slowed as a result of cold winter sea-surface temperatures between 2009 and 2012. • The timing of spawning in sole (in the Irish Sea, east-central North Sea, southern North Sea, eastern English Channel) has shifted to earlier in the year, at a rate of 1.5 weeks per decade since 1970, in response to increasing sea-surface temperatures • International commercial landings, from the north-east Atlantic, of species identified as warm-adapted (e.g. grey gurnard, red mullet, hake) have increased 250% in the last 30 years while landings of cold-adapted species (e.g. cod, haddock, whiting) have halved.	• The ability to predict the future abundance and distribution of fish species and fisheries will depend on agreeing the most appropriate modelling techniques. Much research into modelling in the last three years has so far failed to reach consensus on this. • Implications of ocean acidification on commercial fisheries remain unclear. Opinions range from wholesale degradation of marine ecosystems to negligible impacts with minimal economic consequences.

Confidence for remaining topics	WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN	Authors
Ports and Shipping	Low ↔	Low ↔	Plymouth University
Tourism (and Marine Recreation)	Medium ↔	Medium ↔	The University of Oxford
Built Structures (Onshore and Coastal)	Medium ↑	Low ↔	ABPmer; HR Wallingford
Built Structures (Offshore)	Low ↔	Low ↔	Heriot-Watt University; ABPmer
Aquaculture	Low ↔	Low ↔	Marine Scotland; University of Maine; AFBI

MCCIP Marine Climate Change Impacts Partnership

Next Special Topic Report Card

In response to the stated needs of policy and decision makers, the next MCCIP Special Topic Report Card will focus on the implications of climate change for marine protected areas and for achieving Good Environmental Status under the Marine Strategy Framework Directive (MSFD). The Card will provide timely information on how climate change will impact on biodiversity and ecosystems. This will be used to inform the implementation of key marine environmental legislation.

MCCIP partners

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

Report Card Working Group

The delivery of the MCCIP Report Card is overseen by the MCCIP Report Card Working Group: M. Frost (MBA/MECN); J. Baxter (SNH); G. Bayliss-Brown (Cefas), P. Buckley (Cefas), M. Cox (Marine Scotland) and N. Withers Harvey (Defra).

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www.mccip.org.uk

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Please cite this document as: MCCIP (2013). Marine Climate Change Impacts Report Card 2013 (Eds. Frost M, Baxter JM, Bayliss-Brown GA, Buckley PJ, Cox M, Withers Harvey N) Summary Report, MCCIP, Lowestoft, 12pp.

This report card is in memory of Katharine Giles and Seymour Laxon, the lead authors of the Arctic Sea-Ice topic.

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