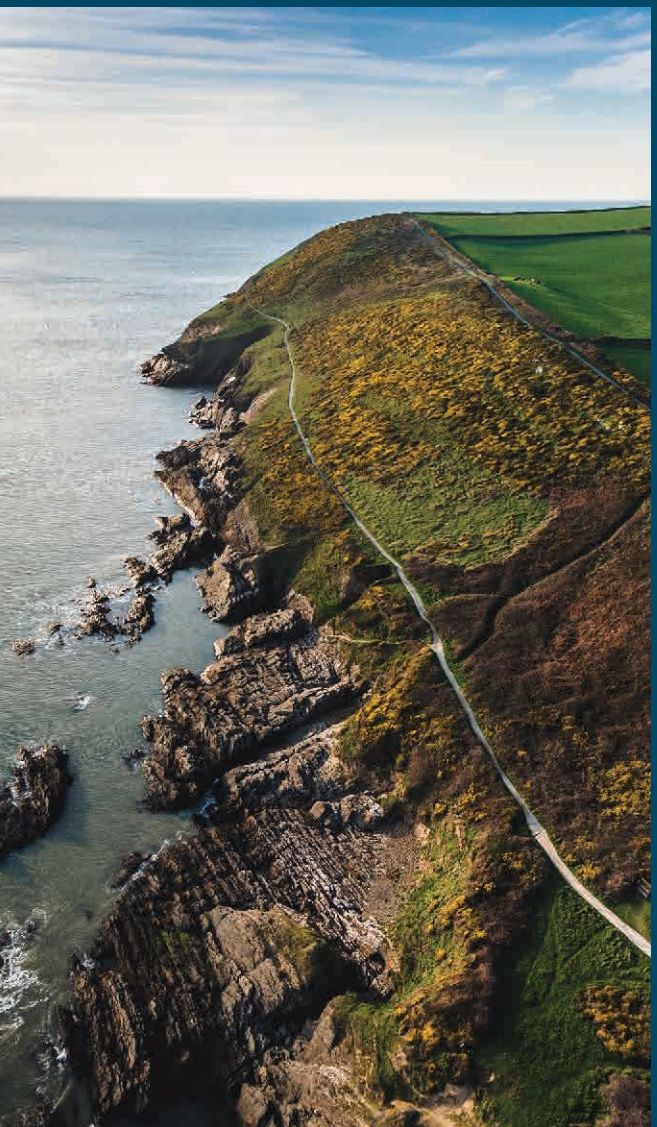
MCCIP Marine Climate Change Impacts Partnership

MARINE CLIMATE CHANGE IMPACTS

REPORT CARD 2020

THE 2020 REPORT CARD PROVIDES AN UPDATE ON SCIENTIFIC UNDERSTANDING OF CLIMATE CHANGE IMPACTS ON UK COASTS AND SEAS



KEY MESSAGES

There is clear evidence that warming seas, reduced oxygen, ocean acidification and sea-level rise are already affecting UK coasts and seas. Increasingly, these changes are having an impact on food webs, with effects seen in seabed-dwelling species, as well as plankton, fish, birds and mammals.

The upper range for the latest UK sea-level rise projections is higher than previous estimates, implying increased coastal-flood risk. The likelihood of compound effects from tidal flooding and extreme rainfall is increasing, which can greatly exacerbate flood impacts.

Oxygen concentrations in UK seas are projected to decline more than the global average, especially in the North Sea.

Fisheries productivity in some UK waters has been negatively impacted by ocean warming and historical overexploitation.

Impacts of climate change have already been observed at a range of heritage sites. Coastal assets will be subjected to enhanced rates of erosion, inundation and weathering or decay.

MORE THAN 150 SCIENTISTS FROM OVER 50 LEADING RESEARCH ORGANISATIONS HAVE CONTRIBUTED TO THIS COMPREHENSIVE, COMMUNITY VIEW ON THE RANGE AND SCALE OF PHYSICAL, ECOLOGICAL AND SOCIETAL IMPACTS OF CLIMATE CHANGE.
FOR THE FIRST TIME, MCCIP REPORTS ON THE IMPACTS OF CLIMATE CHANGE ON OXYGEN, CULTURAL HERITAGE, AND TRANSPORT AND INFRASTRUCTURE.

Changes in ocean climate provide the context for impacts on biodiversity and society.

This Report Card summarises information from 26 individual, peer-reviewed scientific reports commissioned by MCCIP. These reports provide detailed evidence of observed and projected climate change impacts which highlight emerging issues and knowledge gaps.

The scientific reports are available at: www.mccip.org.uk/impacts-report-cards/full-report-cards/2020

The evidence presented in this MCCIP Report Card reinforces the robust messages provided by the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Oceans and Cryosphere in a Changing Climate (SROCC), with warming seas, ice melt, reduced oxygen, ocean acidification and sea-level rise already affecting ecosystems and society across the globe.

EMERGING ISSUES

New research reveals the wider physical, ecological and societal impacts of marine climate change in the UK.

1

SHORT-TERM EXTREME EVENTS

There is increasing interest in the impacts of short-term events, such as marine heatwaves and storms. These may play a disproportionate role in altering species' abundances and geographical ranges, as well as driving local extinctions. The frequency, scale and impact of these events are hard to predict in a changing climate.

2

MULTIPLE STRESSORS

Multiple stressors from a changing climate, coupled with human activities, reduce the resistance and resilience of natural systems. The importance of understanding, quantifying and mitigating cumulative or synergistic impacts is highlighted across Report Card topics.

3

NORTH SEA TIPPING POINT?

A 2018 modelling study suggests that climate-driven change in the North Atlantic and Arctic oceans could reduce the transfer of oceanic water to European shelf seas. By the end of the century, this could make the North Sea more comparable to an enclosed estuary than an open-shelf sea. Salinity and oxygen levels could decrease, and temperature and shelf-sea stratification increase. Some species and habitats could be negatively affected, and pollution and eutrophication problems may increase.

4

NATURE-BASED SOLUTIONS

Management options for coastal change focus increasingly on nature-based solutions. This approach recognises that the coastline is constantly evolving, and that climate change is one of many factors that affect habitats and species, and coastal assets and communities. In response, the coastline is now managed in a variety of ways that are sympathetic to protecting the coast and helping to conserve the natural environment.

CONFIDENCE ASSESSMENTS

For each topic, confidence ratings are provided for 'What is already happening', and 'What could happen'. A rating of LOW, MEDIUM or HIGH is assigned by the respective authors for each topic, and checked by reviewers based on (1) the amount of evidence available, and (2) the level of scientific consensus.

These ratings represent a 'snapshot' at the time of writing, and are not directly comparable across topics. They are intended as a useful guide for decision makers on the current 'state of the science'. The detailed rationale supporting each rating provides a basis for further discussion of the evidence, and future needs.

CHANGING ATTITUDES

Since the publication of the last full MCCIP Report Card in 2013, there has been a substantial shift in the public and media perception of climate change, with the Extinction Rebellion and the School Strike movements acting worldwide to stage large-scale demonstrations. In April 2019, a state of Climate Emergency was officially declared by Scottish and Welsh governments, and by the UK Parliament in May 2019. UK Government and Devolved Administrations have committed to reduce greenhouse gas emissions to net zero by 2050 (2045 for Scotland).

CLIMATE OF THE MARINE ENVIRONMENT

Climate change affects the physical characteristics of UK seas, and surrounding oceans. Long-term observations show air and sea warming, sea-ice loss, ocean acidification and sea-level rise. These trends are expected to continue. For sea level, the latest UK projections show bigger changes than previously estimated, increasing the risk of coastal flooding and erosion.

Links between climate change and wind, wave and storm activity around the UK remain less clear, although there is some suggestion that the most severe storms and significant wave heights have increased in recent decades. At the broader scale, ocean and atmospheric circulation may be changing in the North Atlantic, with potential implications for UK climate and extreme weather events.

These physical changes have profound effects on marine ecosystems and people in the UK, as later sections of this Report Card explore.

AIR AND SEA TEMPERATURE

WHAT IS ALREADY HAPPENING

HIGH CONFIDENCE

UK seas show an overall warming trend. Over the past 30 years, warming has been most pronounced to the north of Scotland and in the North Sea, with sea-surface temperature increasing by up to 0.24°C per decade.

Superimposed on this long-term warming trend are short-term variations. For example, UK shelf seas were warmer in 2000–2008 than 2009–2013, but recent years have seen warmer conditions return.

UK sea-surface temperature in 2014 was the warmest on record (records go back to 1870), and eight of the ten warmest years have occurred since 2000.

WHAT COULD HAPPEN

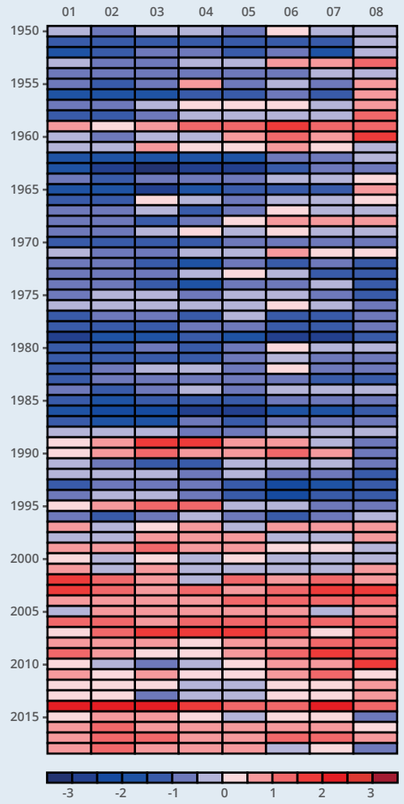
MEDIUM CONFIDENCE

Warming of UK shelf seas is projected to continue over the coming century. Most models suggest an increase of between 0.25°C and 0.4°C per decade.

There may be some regional differences. For example, warming is expected to be greatest in the English Channel and North Sea, with smaller increases in the outer UK shelf regions.

ANNUAL UK REGIONAL SEA-SURFACE TEMPERATURE (°C) ANOMALY FOR PERIOD 1950-2018

Fig 1. Sea-surface temperature anomaly (°C) for the period 1950-2018, relative to the 1981-2010 average. Red = positive (warm); Blue = negative (cool). Based on data from HADISST v1



01: NORTHERN NORTH SEA
02: SOUTHERN NORTH SEA
03: EASTERN CHANNEL
04: WESTERN CHANNEL CELTIC SEA
05: IRISH SEA
06: MINCHES WESTERN SCOTLAND
07: SCOTTISH CONTINENTAL SHELF
08: ATLANTIC NW APPROACHES

These eight regions are based on bio-geographical areas used for UK marine assessments.

OXYGEN

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

Dissolved oxygen concentrations in the global ocean have declined by 2% since the 1960s as a result of a decrease in the solubility of oxygen and increase in stratification due to increasing ocean temperature.

Some areas of UK marine waters have been identified as oxygen deficient in late summer. However, hypoxia has not been detected in UK marine waters unlike other regions in the North-west European shelf sea.

Observations from 1990 to 2010 indicate decreased oxygen concentrations and saturation in the North Sea. Reduced oxygen solubility due to ocean warming and an increase in oxygen utilisation are contributing factors to the trend.

WHAT COULD HAPPEN

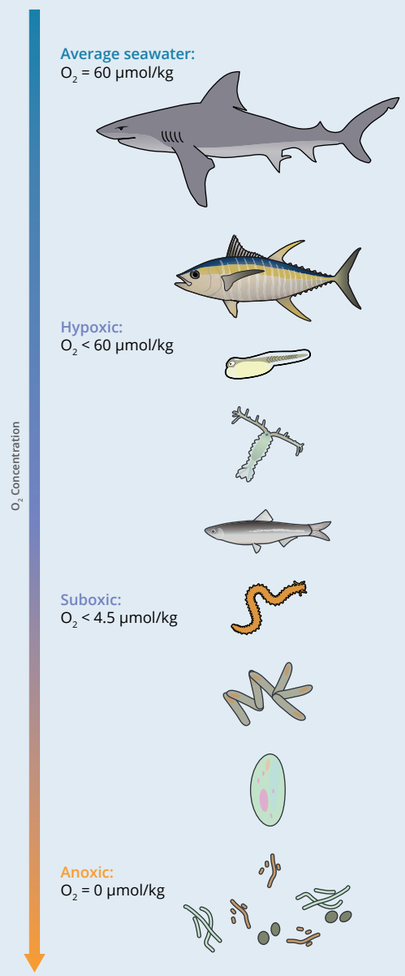
MEDIUM CONFIDENCE

Dissolved oxygen concentrations will decrease as ocean temperature increases, due to a reduction in the solubility of dissolved oxygen alongside a predicted increase in the strength and duration of stratification.

Models predict that by the end of the century, dissolved oxygen concentrations in the global ocean may decline by up to 4%, whilst concentrations in UK regional seas, such as the North Sea could decline by up to 11.5%.

CLASSIFICATION OF DISSOLVED OXYGEN LEVELS IN SEAWATER

Fig 2. Generally, larger bodied, faster moving creatures require higher oxygen concentrations. As dissolved oxygen levels decrease, the biological community becomes smaller bodied. A few larger bodied animals are adapted to deal with hypoxic waters but once waters become anoxic, bacterial communities dominate.



E.L Howes with vectors from Tracey Saxby, Integration and Application Network, Dieter Tracey, Water and Rivers Commission, Jane Thomas Integration and Application Network, Kim Kraeer, Lucy Van Essen-Fishman, Integration and Application Network, University of Maryland Center for Environmental Science

STRATIFICATION

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Thermal stratification of the UK shelf seas continues to start slightly earlier in the year, but there are no long-term trends in the strengthening of stratification.

Stratification in coastal regions influenced by freshwater inputs still show no discernible long-term trends against the background of natural variability.

WHAT COULD HAPPEN

LOW CONFIDENCE

Projections suggest that thermal stratification in UK shelf seas by 2100 will start earlier, typically by one week, and end 5–10 days later, due to changes in air temperature.

Changes in the seasonal heating cycle are projected to increase the strength of stratification in UK shelf seas.

Projected changes to shelf-sea stratification may lead to less upward mixing of nutrients and possible reductions in primary productivity and potential increases in eutrophication.

SALINITY

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

The salinity of UK shelf seas, and the adjacent Atlantic Ocean, has been highly variable on annual and decadal timescales with no clear long-term trends.

In the past five years, salinity of eastern North Atlantic waters west of the UK has dramatically decreased, probably in response to atmospheric changes in the western North Atlantic earlier this decade.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Most 21st Century projections suggest that UK shelf seas, and the adjacent Atlantic Ocean, will be less saline than present, driven by ocean-circulation changes in response to climate change.

Greater salinity decreases are projected for the North Sea, than the Irish and Celtic Seas.

OCEAN ACIDIFICATION

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

The global ocean absorbs approximately a quarter of anthropogenic carbon dioxide (CO_2) emissions annually; atmospheric CO_2 now exceeds 400 ppm and has continued to increase by approximately 2.3 ppm per year over the last decade.

The North Atlantic contains more anthropogenic CO_2 than any other ocean basin, and ocean surface measurements between 1995 and 2013 reveal a pH decline (increasing acidity) of 0.0013 units per year there.

WHAT COULD HAPPEN

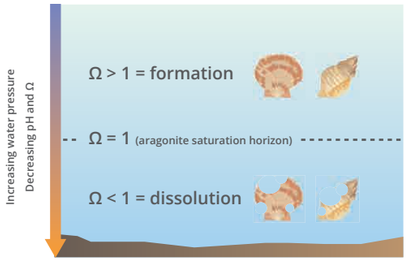
MEDIUM CONFIDENCE

High-emission scenario models project that the average continental shelf pH could drop by up to 0.366 by 2100. Spatial variability in the rate of pH decline is projected with coastal areas declining faster.

Under high-emission scenarios, it is projected that bottom waters will become corrosive to more-soluble forms of calcium carbonate (aragonite). Episodic undersaturation events are projected to begin by 2030.

By 2100, up to 20% of the North-west European shelf seas may experience undersaturation for at least one month of each year.

Fig 3. Saturation state of calcite or aragonite. As pressure (water depth) increases, pH decreases. The potential for the mineral to form or to dissolve is symbolised with Ω.



E.L Howes with vectors from Dieter Tracey, Water and Rivers Commission, Tracey Saxby, Integration and Application Network, University of Maryland Center for Environmental Science

ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

The AMOC transports heat northwards, contributing to the UK's mild climate.

Changes in the strength of the AMOC have led to multiple decades of relatively warm or cold sea-surface temperatures in the subpolar North Atlantic. These changes have affected climate in the UK (e.g. drier summers).

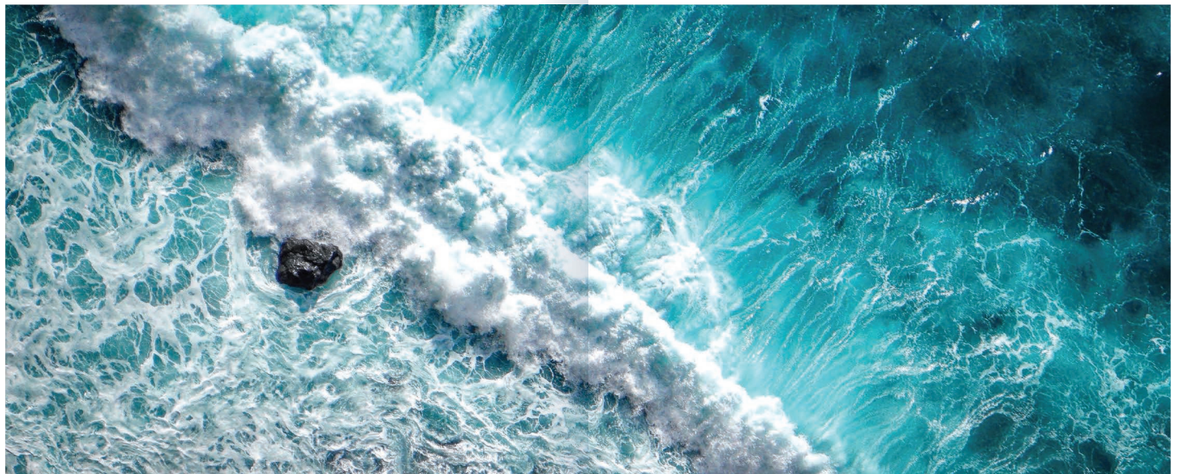
There is increasing evidence that the subpolar North Atlantic is entering a cool and fresh phase, associated with a weakened AMOC. It is unclear if this is part of a natural cycle or a long-term response to climate change.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

The AMOC is predicted to weaken in the coming century due to climate change, potentially causing large biogeographical and climatic shifts, for example contraction of blue whiting distribution off Rockall.

In general, climate models do not project an abrupt shutdown of the AMOC this century.



STORMS AND WAVES

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Models and observations show an increase in annual and winter mean significant wave heights in the North-east Atlantic since the 1950s.

Over the past 50 years, a poleward shift in mid-latitude depressions is evident during the winter. The strongest mid-latitude depressions may be increasing in intensity, but becoming less frequent.

High natural variability, and low understanding of climate change mechanisms, mean these observed trends in storms and waves cannot directly be attributed to climate change.

WHAT COULD HAPPEN

LOW CONFIDENCE

Climate change could affect storms and waves in the North Atlantic, but natural variability will continue to dominate in the near future.

Under a high-emissions scenario, there could be an overall reduction in mean significant wave height in the North Atlantic by 2100, although the most severe waves could increase in height.

The chance of severe storms reaching the UK during autumn may increase if tropical cyclones become more intense, and their region of origin expands northwards.

STORMS IN A CHANGING CLIMATE

Understanding how climate change may be affecting storm frequency and intensity in our region is important because storms can drive a great deal of energy into the sea, causing surface waves, storm surges, and vertical mixing of the water. The rainfall associated with storms can result in floodwaters entering coastal seas, changing local marine conditions.

The UK predominantly experiences storms moving eastwards from the North Atlantic Ocean. Predicting future changes to the strength, frequency and track of storms is difficult, and there is still uncertainty as to what could happen. Most model projections suggest that winters may become a little windier, but not any more than the variability in winds we currently experience. However, some models have predicted increases in storm frequency and strength, and so for some MCCIP topics the potential implications of these changes are considered.

COASTAL GEOMORPHOLOGY

WHAT IS ALREADY HAPPENING

HIGH CONFIDENCE

Coastal erosion is strongly determined by site-specific factors and usually it is these factors that determine the coastal response against a backdrop of a slowly receding coastline due to sea-level rise.

A large proportion (17%) of the UK coastline is currently affected by erosion. Other areas are either stable or accreting. These changes are partly driven by sea-level rise, with the most visible aspects of coastal change seen through extreme storm events.

In Scotland, for the first time since the last glaciation, sea-level rise is outpacing vertical land movement caused by post-glacial crustal 'rebound', increasing coastal erosion rates.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Coastal erosion rate and extent in the UK is expected to increase in the future due to a combination of relative sea-level rise, reduced nearshore sediment supply, and impacts resulting from human activities and management.

For the first time, all of Scotland's firths will be exposed to increased erosion rates due to relative sea-level rise.

SEA-LEVEL RISE

WHAT IS ALREADY HAPPENING

HIGH CONFIDENCE

Mean sea level around the UK has risen by about 12–16 cm since 1900.

When vertical land movement is included, the net rate of sea-level rise is slightly higher in the south of England and slightly lower in some parts of Scotland.

At many locations, extreme sea levels that exceed critical flood-thresholds are being experienced more frequently than in the past, due to mean sea-level rise.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

For London, the central estimate projection of sea-level rise for 2100 ranges from 0.45–0.78 m, depending on the greenhouse gas emissions scenario. Estimates for other cities are: Edinburgh 0.23–0.54 m; Cardiff 0.43–0.76 m; and Belfast 0.26–0.58 m.

Increases in future extreme sea levels and flooding will be driven by mean sea-level changes, rather than changes in storm surges.

SEA ICE

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

The extent and thickness of Arctic sea ice continues to decrease, especially in summer months (May to September) and the area of thick, multiyear ice is in significant decline.

September Arctic sea-ice extent, taken as the annual minimum, has reduced by an average of 13% per decade compared to the 1981–2010 mean.

At least half of Arctic sea-ice loss since the mid-20th Century can be directly attributed to anthropogenic warming of surface air temperature. Direct ocean warming, inflows of warm water and a reduced albedo effect, are also important factors.

A change from permanent to seasonal ice cover has the potential to affect atmospheric circulation, with possible links to seasonal UK climate (e.g. cold winters).

WHAT COULD HAPPEN

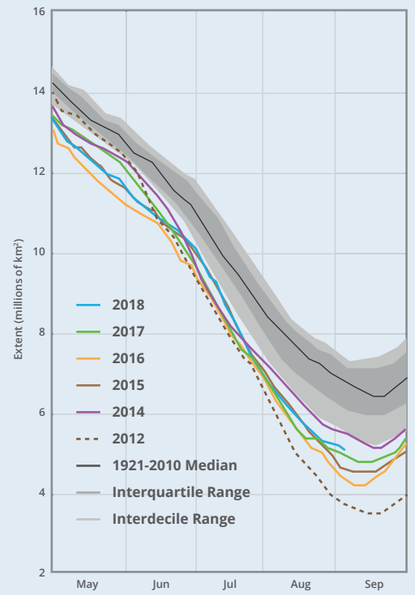
MEDIUM CONFIDENCE

Under a high-emission scenario, it is very likely that the Arctic will become seasonally ice-free before 2050.

Changes in the timing of sea-ice formation and melt is likely to cause a mismatch in demand for food and habitat for marine species, with potential impacts on Arctic fisheries.

ARCTIC SEA ICE EXTENT (AREA OF OCEAN WITH AT LEAST 15% SEA ICE)

Fig. 4: Arctic sea ice extent as of September, 4, 2018, along with daily ice extent data for four previous years and 2012, the year with record low minimum extent (from NSIDC, 2018).



SNAPSHOTS OF CLIMATE CHANGE AROUND THE UK

DECREASING pH

By 2080, summer warming may exceed the thermal tolerance of the main reef-forming cold-water coral, ***Desmophyllum pertusum***, at the Mingulay reef complex, and by 2060 about 85% of cold-water corals in the North-east Atlantic are likely to be exposed to acidified waters.

FISH ASSEMBLAGES

The structure of marine-fish assemblages has changed markedly off the west of Scotland over the past three decades, with mackerel increasingly dominant at many survey sites.

INCREASING VIBRIO SPECIES

Elevated levels of pathogenic ***Vibrio*** species from several south-west UK coastal sites coincided with record water temperatures during the 2018 heatwave. With heatwaves projected to increase in future, higher levels of pathogenic ***Vibrio*** may be recorded.

DECREASING COLD-WATER KELP

Increases in the abundance of the warm water kelp species, ***Laminaria ochroleuca***, have been observed at sites around Plymouth, the Isles of Scilly and Lundy Island. Models project that cold-water kelp species could be lost from southern England and Wales by the end of the century.

OCEAN ACIDIFICATION IN WALES

Impacts of ocean acidification on shellfish fisheries may be most pronounced in Wales, due to the importance of cockle and whelk fisheries there.

COASTAL FLOODING IN SCOTLAND

A review of climate change risks on Historic Environment Scotland properties found 31 to be at high or very high risk from coastal flooding, and 24 to be at high or very high risk from coastal erosion.

NORTHERN HAKE

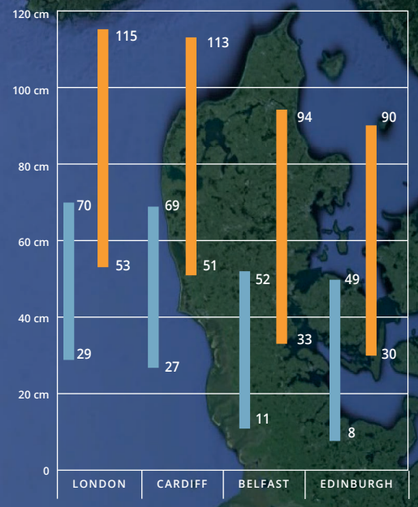
Northern hake, a warm-water species, has recolonised the northern North Sea after being largely absent for over 50 years, with implications for stock management.

TIDAL SURGES RISK PORT CAPACITY

Half of the UK's port capacity is located on the east coast, where the risk of damage from a tidal surge is greatest. This risk will be enhanced with rising sea levels.

SEA-LEVEL RISE BY 2100

Fig 5. Generally, increases will be greater in the South than in the North (figures reflect sea-level rise by 2100 relative to 1981–2000).



Adapted from UKCP18 sea-level rise figures, Crown Copyright 2018, Met Office.

THAMES BARRIER

If the Thames Barrier continues to be used for managing both river flow and tidal floods, future sea-level rise is predicted to make the number of closures unsustainable by the 2030s; if used only for tidal flooding, this is predicted to extend to around 2070.

SALINE INTRUSION

Shingle aquifers in the east and south England are likely to be at risk from saline intrusion associated with sea-level rise, combined with reduced rainfall and increased abstraction for public use.

IMPACTS OF CLIMATE CHANGE ON HEALTHY AND BIODIVERSE SEAS

Across different ecosystems, climate change is having common effects; there is evidence of shifts in both geographical distributions, species community compositions and the timing of life-cycle events. However, disentangling the effects of climate change from natural variability is complex and requires long-term datasets, especially for remote and inaccessible areas, such as the deep sea.

Human activities can have an impact on the ability of marine and coastal ecosystems to respond naturally to stressors associated with climate change, such as increasing sea temperature, ocean acidification and oxygen depletion. The resilience of marine and coastal habitats to climate change could be improved by reducing other pressures from human activities.

Evidence of altered community composition has already been observed in the North Sea, and among some intertidal / shallow subtidal habitats. These changes are likely to affect the function, goods and services provided by the ecosystem.

COASTAL HABITATS

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Evidence suggests that dune slacks in England are drying out due to changes in hydrological conditions that may be linked to climate change. There has been a 30% reduction in dune-slack extent in the largest protected sites between 1990 and 2012. Remaining dune slacks show a shift from wetter to drier plant communities.

The total extent of saltmarshes in the UK has decreased due to erosion from sea-level rise and coastal 'squeeze' from hard, built structures preventing natural roll back.

WHAT COULD HAPPEN

LOW CONFIDENCE

Sea-level rise and erosion rates are the greatest risk to coastal habitats. Sea-level rise results in deeper waters and bigger waves reaching saltmarsh, dunes, shingle and maritime cliffs, causing erosion at the seaward edge.

Changes in patterns of rainfall or temperature will affect vegetation composition of many coastal wetlands. Evapo-transpiration is likely to increase, leading to greater impact of summer droughts.

Modelling suggests that dune water tables may drop by over a metre by 2080 in some parts of the UK, resulting in potential shifts in vegetation species communities from wet to more dry tolerant flora.

INTERTIDAL HABITATS

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Warm-favouring species of rocky intertidal habitats have continued to move north along the west coast and east along the south coast of the UK (e.g. the topshell ***Phorcus lineatus***, limpet ***Patella depressa***, and barnacle ***Chthamalus stellatus***).

Regional differences in abundance trends are observed in intertidal brown macroalgae around the UK coastline, with declines in the south, but no change or increases in central and northern areas.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Warming marine temperatures are likely to result in the invasive Pacific oyster successfully being recruited annually in south-west England, Wales and Northern Ireland by 2040.

Composition of intertidal communities around the UK is likely to alter as ocean acidification increases.

Further declines in some cold-water species are expected as sea temperature increases.

SHALLOW AND SHELF HABITATS

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

North Sea infaunal species have shifted their distributions in response to changing sea temperature. Most species have been unable to keep pace with shifting temperature, meaning they are subjected to warmer conditions. These species are generally expanding their distribution northwards more quickly than they are retreating from the south.

Climate and non-climate drivers (e.g. primary productivity) are likely to interact and alter species responses to climate change, including species interactions. These outcomes are likely to be dependent on species life-history traits (e.g. small-bodied, compared to large-bodied, animals).

Changes in the abundance of a number of UK kelp species, linked to sea-temperature rise, is leading to alterations in the structure of kelp assemblages. This has implications for kelp-forest community structure and habitat resilience.

WHAT COULD HAPPEN

LOW CONFIDENCE

Modelling suggests that there will be significant shifts in range, distribution and abundance of kelp and cold-water corals across the UK, and benthic infauna and epifauna within the North Sea, leading to altered community structures.

Ocean acidification may cause corrosion of cold-water corals and maerl beds, particularly the non-living structures, which provide structural support for the living surface-layer.

DEEP SEA HABITATS

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

The aragonitic calcium carbonate saturation horizon has become shallower by 10–15 m per year in the subpolar North-east Atlantic.

Laboratory experiments have shown that cold-water corals exposed to undersaturated aragonite conditions are unable to maintain the calcification of their skeletons. Lowered pH has been found to depress feeding activity in deep-sea demosponges and increase foraging times of deep-sea echinoids.

Changes in the mean state of the North Atlantic Oscillation (NAO) has led to changes in water current strength and circulation in the North Atlantic, which has a negative impact on dispersal and settlement of the larvae of the cold-water coral ***Desmophyllum pertusum***.

WHAT COULD HAPPEN

LOW CONFIDENCE

Under a high-emissions scenario, models predict that the amount of Particulate Organic Carbon (POC) reaching the Atlantic seafloor will decrease by ≤15%, resulting in a ≤7% reduction in benthic biomass.

Under a high-emissions scenario, models predict a substantial decrease in seafloor habitat suitability for cold-water corals in the North Atlantic (~30° to 60° N), with ~85% of existing features predicted to be exposed to increasingly acidic waters by 2060.

PLANKTON

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Changes in plankton species and communities in the North Atlantic are equally driven by natural climate variability and anthropogenic ocean warming.

Plankton species with warmer-water affinities (e.g. ***Calanus helgolandicus***) have now moved northwards from the Celtic Sea to replace cold-water species (e.g. ***Calanus finmarchicus***) in most of the seas around the UK.

Over the last 50 years, total ***Calanus*** copepod biomass in the northern North Sea has declined by 70% due to regional warming, with consequences for other species.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Future warming is likely to continue to shift the geographical distribution of primary and secondary plankton production northwards. This may negatively affect ecosystem services such as oxygen production and ocean carbon storage within 20–50 years.

Warming sea temperatures in the North-east Atlantic may further decrease mean plankton community body size, with consequences for fishes, and marine mammal and seabird populations.

Ocean acidification has the potential to negatively affect calcifying organisms of the plankton community and the rate at which they sink and transport carbon to the seabed.

DECADAL ABUNDANCE MAPS

Fig 6. Decadal abundance maps for the cold-water copepod *Calanus finmarchicus* (top) and the temperate copepod *Calanus helgolandicus* (bottom) from 1960-2015. Adapted from Edwards *et al*, 2020, Data from the CPR survey.

FISH

WHAT IS ALREADY HAPPENING
MEDIUM CONFIDENCE

There have been substantial changes in fish communities in UK waters, linked to the appearance of warm-water species (e.g. European anchovy, ***Engraulis encrasicolus***) and local declines of some cold-water species (e.g. eelpout ***Zoarces viviparus***).

Warming temperatures have affected the timing of spawning among species. For example, warming has led to earlier spawning for sole, but for Raitt's sandeel, warming delays reproductive development.

Warming and associated oxygen solubility appears to be affecting the age at maturation, growth rates, and the maximum size fish can attain.

WHAT COULD HAPPEN
LOW CONFIDENCE

Experiments suggest that Atlantic cod larvae may experience higher mortality rates due to ocean acidification compared with European seabass and herring larvae.

By 2050, climate-driven changes in suitable available habitat could become a major constraint on some commercial species' distributions in the North Sea.

SEABIRDS

WHAT IS ALREADY HAPPENING
MEDIUM CONFIDENCE

Climate change is one of the primary causes of declines in UK seabird populations. Over a third of species assessed in the UK showed declines of 20% or more in breeding abundance since the 1990s.

Climate change has an impact on seabirds indirectly, by driving changes in the availability of small fish that many seabirds rely on for food.

WHAT COULD HAPPEN
LOW CONFIDENCE

Some seabirds, for example Leach's storm petrel, great skua and Arctic skua, may become extinct in the UK by 2100, while the ranges of black-legged kittiwake, Arctic tern and auks may shrink significantly northwards.

Direct impacts from changes in severe weather events and sea-level rise may increase in the future. For example, rising sea levels in the southern North Sea may have an impact on ground-nesting seabirds such as terns, which nest just above the high-water mark.

WATERBIRDS

WHAT IS ALREADY HAPPENING
MEDIUM CONFIDENCE

Evidence continues to show north-easterly shifts in the winter distributions of waterbirds in Europe, consistent with anticipated impacts of a warming climate.

Emerging evidence suggests that for some waders, breeding population declines are linked to warmer, drier summers.

Warming winter temperatures have also been associated with changes in the spring departure of wintering waterbird species to their breeding grounds.

WHAT COULD HAPPEN
LOW CONFIDENCE

Climate change is projected to have mixed impacts on the breeding and non-breeding numbers and distributions of waterbird species in the UK, with protected areas likely to continue to support internationally important populations and assemblages.

Arctic and subarctic breeding waterbirds are amongst the most vulnerable to climate change, highlighting the need for improved monitoring for these species.

MARINE MAMMALS

WHAT IS ALREADY HAPPENING
MEDIUM CONFIDENCE

The main effects of climate change on marine mammals are range shifts, loss of habitat, food-web changes, increased exposure to algal toxins and susceptibility to disease.

Warm-water species, such as striped dolphin, short-beaked common dolphin, and Cuvier's beaked whale are moving northwards and the ranges of cold-water species, such as white-beaked dolphin, are contracting.

WHAT COULD HAPPEN
LOW CONFIDENCE

Continued increases in sea temperature could result in a shift in the composition of cetacean species, with an increased presence of warm-water species.

The main influences of climate change on marine mammals are likely to be indirect via changes in prey distribution and availability, resulting in range shifts in some regional populations.

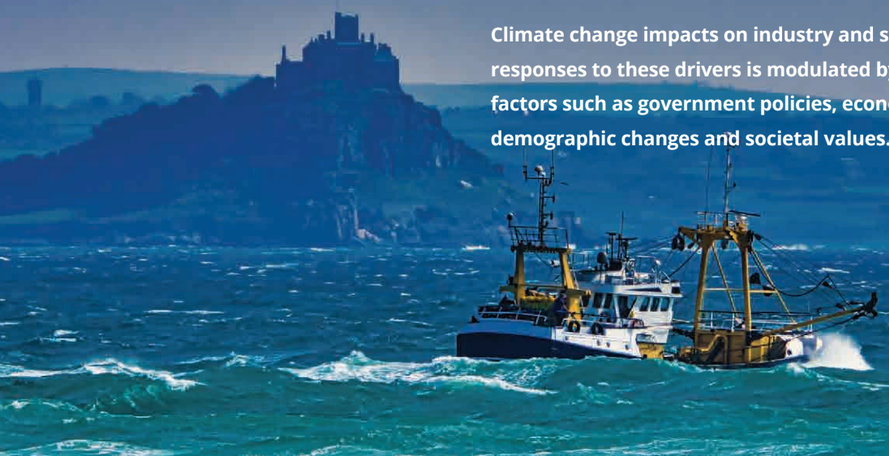
Marine mammal species that make long-distance seasonal migrations (e.g. most baleen whales) will likely arrive earlier or remain in high latitudes for longer, increasing breeding opportunities.

IMPACTS OF CLIMATE CHANGE ON SOCIETY

A wide range of economically important marine and coastal industries are being affected by climate change, with impacts on food availability, infrastructure, seasonal operating windows and the movement of goods. Coastal erosion, flooding, sea-level rise and potential changes in storminess present multiple risks to UK industries and coastal communities.

Climate change also presents risks to human health and wellbeing, such as physical impacts through flooding and disease and wider sociocultural effects such as the loss of heritage sites and changes in tourism and recreation.

Climate change impacts on industry and society and their responses to these drivers is modulated by wider external factors such as government policies, economic fluctuations, demographic changes and societal values.



FISHERIES

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Climate-driven declines in primary production and copepods in the North Sea have led to declines in fish stock recruitment for some commercial species, including cod, herring, whiting and sprat.

A global analysis of fisheries productivity highlighted that the North Sea and Celtic–Biscay Shelf are among the most negatively impacted regions as a result of ocean warming and historical overexploitation.

Increasing numbers of Atlantic bluefin tuna have been reported in UK waters by commercial and recreational fishers, which may be partly related to warming temperatures. At present, there is no quota for this species for UK vessels.

WHAT COULD HAPPEN

LOW CONFIDENCE

Projected declines in shellfish production resulting from ocean acidification may result in significant economic losses within UK fisheries.

By 2050, under a high-emissions scenario, the total maximum fisheries catch potential is projected to decrease within the UK Exclusive Economic Zone (EEZ), resulting in a 10% decrease in net present value.

Populations of incoming warm-water species (e.g. northern hake) with limited quota allocation could act to 'choke' existing mixed fisheries, such that the whole fishery must cease operation.

AQUACULTURE

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

There have been no major changes or geographical shifts in species farmed in the UK due to climate change.

However, increasing problems with invasive species, fish gill diseases, viruses and ***Vibrio*** contamination of shellfish are being linked with a changed climate.

WHAT COULD HAPPEN

LOW CONFIDENCE

Projections suggest temperatures will remain suitable for salmon farming until the end of the century and may increase growth rates. However, summer and autumn aquaculture in Northern Ireland and the south of Scotland may decline due to warming.

Ocean acidification is unlikely to affect finfish farming, but may reduce shellfish spat settlement.

Under warming conditions, problems associated with sea lice, fish disease and shellfish pathogens are expected to increase. However, some cold-water ***Vibrio*** species may become rarer.

HARMFUL SPECIES

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

The impact of climate change on Harmful Algal Blooms (HABs) is complex, and difficult to distinguish from short-term weather events or the influence of large-scale ocean currents.

Multi-decadal data from the Continuous Plankton Recorder has shown changes in the distribution of some HAB species in the North Sea as well as increases in the abundance of the harmful diatom ***Pseudo-nitzschia*** in the North-east Atlantic.

Over the past 50 years, warming in areas of the North Atlantic (including the North Sea) has coincided with an increased abundance of ***Vibrio*** bacteria.

WHAT COULD HAPPEN

LOW CONFIDENCE

Waters used for recreation and shellfish harvesting may be subject to increased norovirus loading as changes in runoff and storm surge place more pressure on the sewerage infrastructure.

Climate change has the potential to affect HAB species, for example, by extending the duration of growing seasons or changing distribution ranges; however, these impacts are difficult to predict in UK waters.

Increasing sea temperature, more heatwaves and reduced salinity are likely to increase the risk of human infection from ***Vibrio*** species.

COASTAL FLOODING

WHAT IS ALREADY HAPPENING

HIGH CONFIDENCE

Overall, the social, economic and environmental consequences of flooding have reduced slightly over time due to improvements in flood defences, advances in flood forecasting and emergency response.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Without appropriate action, the projected increases in extreme sea levels will significantly increase coastal flood risk.

In England and Wales, the length of coastal defences that are 'highly vulnerable' to failure could increase by about 70% with a 0.5 m local sea-level rise. If all these defences did fail, the number of properties affected would rise disproportionately to around 160%.

By the 2080s, expected annual damages from coastal flooding are estimated to more than double from £540m to £1.2 to £1.7b under a high sea-level rise scenario.

TRANSPORT AND INFRASTRUCTURE

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Extreme sea levels have increased over the last 150 years, but improved flood defences, advances in flood forecasting and emergency planning means there has generally not been a corresponding increase in coastal flooding.

As Arctic sea-ice declines, more voyages to explore the economic viability of trans-arctic shipping routes have taken place. Fewer than 10 were recorded in 2007, compared to around 70 in 2013.

WHAT COULD HAPPEN

LOW CONFIDENCE

Under a high-emissions scenario, the trans-Arctic shipping season could reach four to eight months by 2100; however, inter-annual variability will remain a significant factor in route availability.

The combined threat of flooding from sea-level rise and storms makes transport and energy infrastructure at the coast particularly at risk.

With the implementation of Shoreline Management Plans, an estimated 2700 properties will still be lost to coastal erosion in England over the next 50 years. Without implementation the number rises to 28,000 properties.

TOURISM AND RECREATION

WHAT IS ALREADY HAPPENING

LOW CONFIDENCE

Climate change presents both risks and opportunities for coastal tourism and recreation (e.g. risks from flooding and coastal erosion, as well as opportunities for increasing visitor numbers with a warmer, extended summer season).

Warm-water fish have been detected in the Channel Islands, including species such as the Atlantic bonito, which is popular for sea angling.

WHAT COULD HAPPEN

LOW CONFIDENCE

Warmer summers are predicted to result in more-comfortable conditions at the coast, extended tourism seasons, increased revenues, new infrastructure, and increased employment and water-sport opportunities.

However, increased visitor numbers could result in overtourism, increasing the burden on some coastal communities and infrastructure (roads, energy, waste, water, management).

The impacts of climate change on marine and coastal habitats, will affect a range of tourism and recreational activities, including angling and wildlife watching due to changes in species distributions.

CULTURAL HERITAGE

WHAT IS ALREADY HAPPENING

MEDIUM CONFIDENCE

Climate change can exacerbate the natural rates of decay. These damaging impacts of climate change have already been observed at a range of national heritage assets.

Warmer waters around the UK have facilitated the northward spread of Shipworm (***Lyrodus pedicellatus***), a wood-boring species that can cause structural damage to submerged wooden wrecks and artefacts.

Risk assessments show that many coastal heritage assets managed by English Heritage and Historic Environment Scotland are currently at risk from coastal erosion and flooding, with climate change increasing this risk. Further assessments are underway for Wales and Northern Ireland.

WHAT COULD HAPPEN

MEDIUM CONFIDENCE

Historic assets located in the coastal zone will be subjected to enhanced rates of erosion, increased flooding and changes in weathering patterns as a direct result of climate change.

Submerged sites will be adversely affected by changes in ocean pH, temperature and circulation patterns.

Future climate change impacts will result in the continued loss of many historic assets in the coastal zone. The same erosion processes will inevitably result in new discoveries being made as well.

WHAT IS MCCIP?

MCCIP is a partnership between marine scientists and sponsors from the UK and devolved governments, their agencies, NGOs, and industry.

The primary aim of the MCCIP is to provide a coordinating framework for the UK to enable the transfer of high-quality, impartial evidence on marine climate change, and to provide guidance on adaptation to policy advisors and decision-makers.

MCCIP PARTNERS

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

KNOWLEDGE GAPS

The individual scientific reports supporting this Report Card include a section on key knowledge gaps. MCCIP will use this information to produce a UK marine climate change knowledge gaps summary report in 2020.

FURTHER DETAILS AND CONTACTS

The delivery of this Report Card was overseen by the MCCIP Report Card Working Group. The members of this group are: B. Stoker (JNCC), W.R. Turrell (Marine Scotland), K.A. Robinson (NRW); E.L. Howes (Cefas), P. Buckley (Cefas) and L. Matear (JNCC).

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For further details about the work of MCCIP go to **www.mccip.org.uk**

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