2009

MCCIP Marine Climate Change Impacts Partnership

Marine climate change impacts

Exploring ecosystem linkages

Understanding the links between climate change impacts on the oceans is a critical priority for our future wellbeing. By taking a new 'bigger picture' approach, we can start to show how the interconnected nature of the marine ecosystem magnifies the many discrete impacts of climate change, documented in the MCCIP Annual Report Cards.

To support this new approach, we asked five groups of leading scientific experts on issues such as ocean acidification, Arctic sea-ice loss, seabirds and food webs, non-native species, and coastal economies to give us their views.

CO_2 and ocean acidification

In the last 200 years, ocean acidity has increased by 30% and at a rate much faster than anytime in the last 65 million years. This has serious implications for marine ecosystems and climate regulation.

Arctic sea ice

In the last decade there has been a 35% decrease in summer sea ice extent and a 15% reduction in winter sea ice, leading to changes in habitats and ecosystems.

A view from above

Climate change has already caused changes in plankton, fish distribution and species composition in the seas around the UK. Declines in some seabird populations such as black-legged kittiwakes, terns and skuas may continue as a result.

Non-native species

Most introductions of non-native species have arrived via human intervention, intentional or otherwise. The likelihood that they will establish and flourish in the UK marine environment could be greater due to climate change.

Coastal economies and people

Many of our coastal communities will face both challenges (e.g. increased flood and erosion risks, declining traditional fisheries) and opportunities (e.g. new tourism patterns, new fisheries) through climate change.

PHOTOS from top: Natural History Museum, iStockphoto.com/westphalia, Lorne Gill/SNH, Paul Newland/MarLIN, Davey Benson.

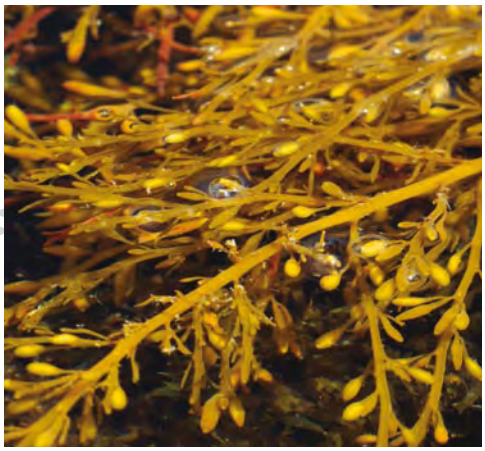
www.mccip.org.uk/elr

Introduction

The ecosystem linkages report card builds on the science of our Annual Report Cards to show how broader marine climate change impacts come together.

This report uses five topics, ranging from global to local scale issues, to demonstrate the linked relationships that you need to consider when planning for marine climate change.

By demonstrating these interactions in the marine environment, we can begin to understand why there is a need to take an 'ecosystem approach' to address the impacts of climate change at the coast and in our seas.



Topic Index	Page
CO_2 and ocean acidification: running into the buffers?	4 – 5
Arctic sea ice	6 – 7
A view from above: changing seas, seabirds and food sources	8 – 9
Non-native species	10 – 11
Coastal economies and people	12 – 13

The information provided in the five topic spreads is just a brief summary drawn from detailed peer-reviewed documents. To access these full documents go to **www.mccip.org.uk/elr**

How does this ecosystem linkages report card link to MCCIP Annual Report Cards and how is it different?

Previous MCCIP report cards have explored a wide range of topics, highlighting key impacts for individual components of the marine environment (e.g. seabirds). This report brings together these individual components, looking at how changes in one part of the marine ecosystem impact upon others (e.g. how seabirds interact with *all* levels of the marine food web).

PHOTOS from top: Lorne Gill/SNH, Murray Roberts/SAMS, Lorne Gill/SNH, Lorne Gill/SNH.

How much do we know?

Each of the topic spreads include confidence assessments to give you a better understanding of how much we know. 'Connecting' arrows or boxes are colour coded according to whether our confidence is high, medium or low.

High Confidence

Medium Confidence

Low Confidence

How are the topics linked?

The acidification of our seas has been identified relatively recently as a major global issue, affecting the world's seas and oceans, with the Arctic being particularly vulnerable. It is tempting to assume that changes occurring in the Arctic as a result of climate change are not relevant to the UK but they have local scale impacts at a UK level. This happens through various mechanisms such as the general effect of rising sea levels due to melting ice, changes to north-east Atlantic food webs, and opening of Arctic sea routes, which all have implications for non-native species and coastal economies in the UK.

Within the broader framework of climatically driven change, significant effects are being observed in the ecology of the UK marine environment. Major changes to plankton communities are having knock-on effects to fish and birds. Species new to the UK are finding a more hospitable climate in which to establish and spread. All of this has major implications for our economy involving issues such as coastal defence, aquaculture, fishing and tourism. The links between the topics are shown in more detail through the rest of the report.

Other human pressures

Whilst the focus of this report is on climate change impacts, it is important to acknowledge the role of other pressures on the marine ecosystem. These pressures can combine with climate change to magnify impacts. These include:

Coastal infrastructure; Fishing; Leisure activities; Oil, gas and mineral extraction; Pollution; Renewables; Shipping.

Where particularly relevant, these other pressures are highlighted in this report.

The UK Government has set out a vision for 'clean, healthy, safe, productive and biologically diverse seas'. As climate change and ocean acidification take hold, understanding the impacts is a key element of knowing what to do to maintain a healthy marine environment. Understanding these impacts and what their knock-on effects may be will influence how we use and value our coasts and seas both now and in the future.

PHOTOS from top: RSPB, Sea Life Surveys/Specialist Stock.

CO_2 and ocean acidification: running into the buffers?

The oceans are an enormous store of carbon, substantially greater than on land or in the atmosphere, and play a key role in the global carbon cycle, especially in helping regulate the amount of CO_2 in the atmosphere.

The oceans are important because they have taken up 27-34% of the CO_2 produced by humankind through the burning of fossil fuels, cement manufacturing and land use changes since the industrial revolution.

Whilst this has somewhat limited the historical rise of CO_2 in the atmosphere, thereby reducing the extent of greenhouse warming and climate change caused by human activities, this has come at the price of a dramatic change to ocean chemistry. In particular, and of great concern, is the measurable change in ocean pH and carbonate and bicarbonate ion concentration – 'ocean acidification'. Our understanding of the impact of CO_2 on the carbonate chemistry is such that we know with very high certainty that ocean acidification will continue.

To access the full peer-reviewed document go to www.mccip.org.uk/elr/acidification

Key linkages...

Acidification

Atmospheric CO_2 dissolves in the ocean to form a weak acid.

Atmospheric CO_2 increases.

Ocean acidity increases.

Ecosystem impacts

Ocean acidification is a serious threat to many marine organisms which may have implications for food webs and ecosystems, but these are difficult to predict as little is understood of their ability to adapt.

Impacts of Increased acidity will be evident through:

Increased physiological stress (e.g. growth, respiration and reproduction).

Reduced growth and survival of early life stages.

Reduced ability to make shells and skeletons (calcification) by marine organisms.

Potential changes to other biogeochemical processes (e.g. nitrification, C:N ratios).

Changes in nutrient chemistry and speciation.

Impacts up the food web.

Reduced buffering capacity of the ocean to take up CO_2 will increase the fraction of CO_2 retained in the atmosphere.

Ocean acidification is intimately linked to the oceans climate regulation role through its uptake of CO_2.

PHOTOS from top: Natural History Museum, Donna Roberts.

LESSONS FROM THE DEEP PAST

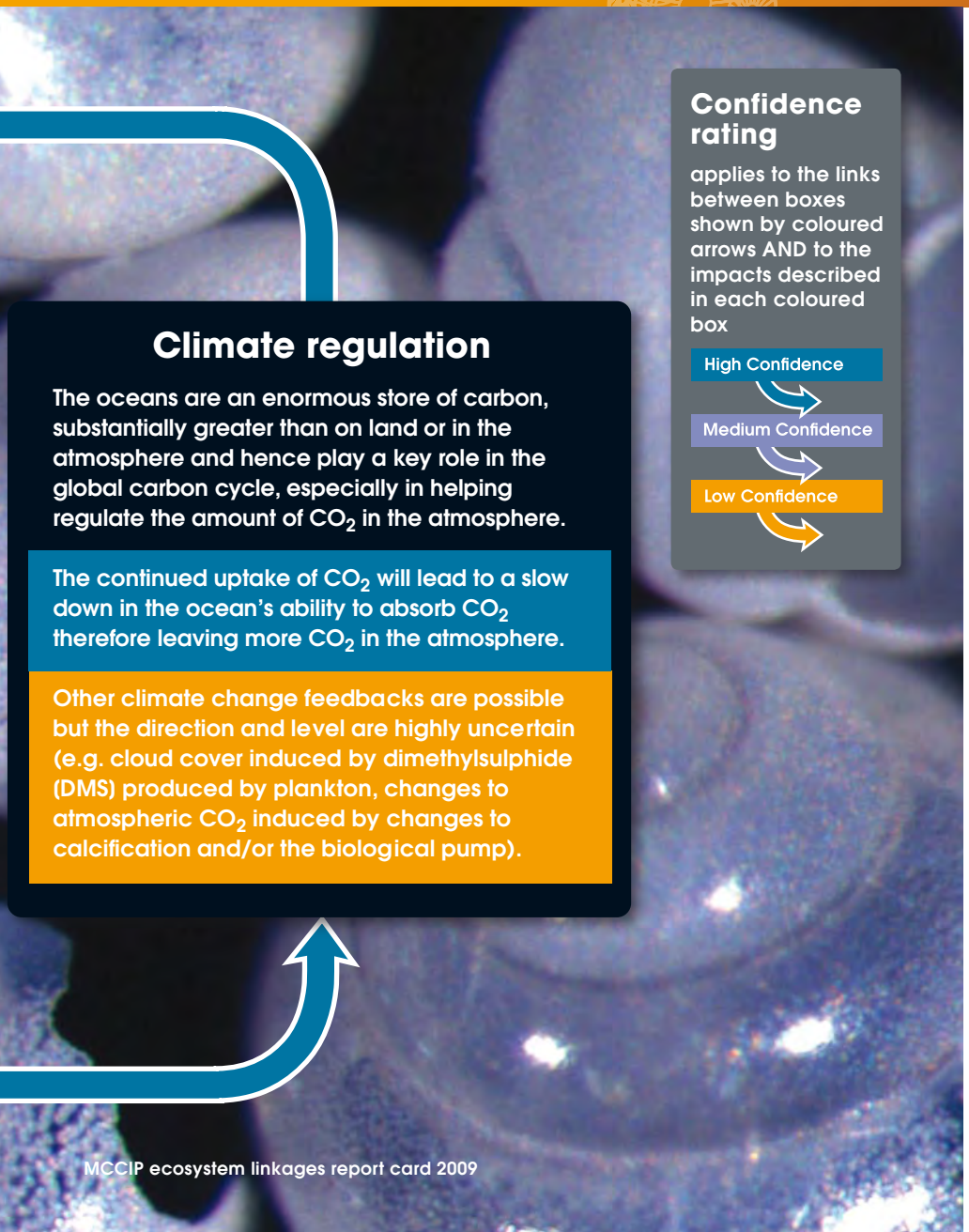
Ocean acidification events in the Earth's past may help us interpret the future of our oceans in a world of increasing CO_2 emissions.

As a result of an ocean acidification event 55.5 million years ago –

- The mass extinction of many benthic shell forming organisms may have occurred.
- Many pelagic shell forming organisms survived.
- Recovery took hundreds of thousands of years.

Today...

- Until 200 years ago atmospheric CO_2 had been constant for 650,000 years and possibly for 20 million years.
- In the last 200 years ocean acidity has increased by 30%, a rate much faster than anytime in the last 65 million years. Substantial extinctions of benthic and planktonic organisms could result.



Climate regulation

The oceans are an enormous store of carbon, substantially greater than on land or in the atmosphere and hence play a key role in the global carbon cycle, especially in helping regulate the amount of CO_2 in the atmosphere.

The continued uptake of CO_2 will lead to a slow down in the ocean's ability to absorb CO_2 therefore leaving more CO_2 in the atmosphere.

Other climate change feedbacks are possible but the direction and level are highly uncertain (e.g. cloud cover induced by dimethylsulphide (DMS) produced by plankton, changes to atmospheric CO_2 induced by changes to calcification and/or the biological pump).

Confidence rating

applies to the links between boxes shown by coloured arrows AND to the impacts described in each coloured box

High Confidence

Medium Confidence

Low Confidence

Links to Arctic sea ice...

- Winter time sea ice acts as a lid preventing CO_2 returning to the atmosphere.
- Sea ice produces brines which sink and take CO_2 with them.

Why it matters

Increasing ocean acidification has the potential to harm marine ecosystems and alter the oceans' ability to take up excess CO_2 from the atmosphere leading to a direct impact on future climate change.

Socio-economic impacts of ocean acidification are difficult to predict. However, the goods and services provided by the marine environment to the UK are important; for example, multi-million pound fisheries, fish meal and aquaculture industries employ tens of thousands of people and if impacted by ocean acidification this could have a direct economic effect. Globally, coral reefs have been valued at $30 billion and provide food, tourism and shore protection. Any threat to them will be important for the economies of some of the UK's overseas territories.

Arctic sea ice

Sea ice is formed at the surface of the Arctic Ocean during winter. Most of it melts during the summer, but some can persist to become multi-year ice. The Arctic atmosphere has warmed by about twice the global average in the last 30 years, resulting in record reductions in Arctic sea ice extent and thickness, especially in summer.

Arctic sea-ice reductions have significant impacts locally, regionally and globally through effects on climate, wildlife and humans, and indirectly on sea level. The high albedo of ice means that much of the incoming solar radiation to the Arctic region is reflected back to space without being able to warm the atmosphere, land or sea. When the coverage of sea ice reduces, more radiation is absorbed, adding to warming and loss of sea ice. Sea ice also helps to regulate the exchange of heat, gases and moisture between the ocean and atmosphere, and impacts on ocean stratification, salinity, and the global atmospheric and ocean circulation.

The Arctic will continue to warm throughout the 21st century. Arctic seas could be free of sea ice in summer within a few decades.

To access the full peer-reviewed document go to www.mccip.org.uk/elr/arctic

Key linkages...

Climate changes

Current status

Regional Arctic climate change affects the global climate system.

Sea ice reductions alter the climate system through changes in the heat fluxes to the atmosphere, ocean circulation, and albedo.

What could happen

More open ocean due to sea-ice loss is likely to lead to increased rate of CO_2 uptake and ocean acidification.

The Arctic is expected to continue to warm for the remainder of the 21st century.

Increasing precipitation and melting will lead to fresher Arctic seawater.

The Arctic is expected to be ice free in summer within the next few decades.

In addition – land ice will continue to melt increasing sea-level rise – coastal communities affected further.

Human impacts and natural resources

Current status

A warming Arctic contributes to sea-level rise.

Traditional lifestyles of indigenous peoples are impacted.

What could happen

25% of known oil and gas reserves are in the Arctic and reduced sea ice will make access to these easier.

Extension of present fishing grounds polewards. Further regime shifts in sub-Arctic ecosystems affects fisheries.

Shorter trade routes between the Atlantic and the Far East. There will be increased opportunities for ship-based tourism.

Additional shipping increases the chances of pollution and introduction of non-native species through ballast water.

PHOTO at top: iStockphoto.com/westphalia.

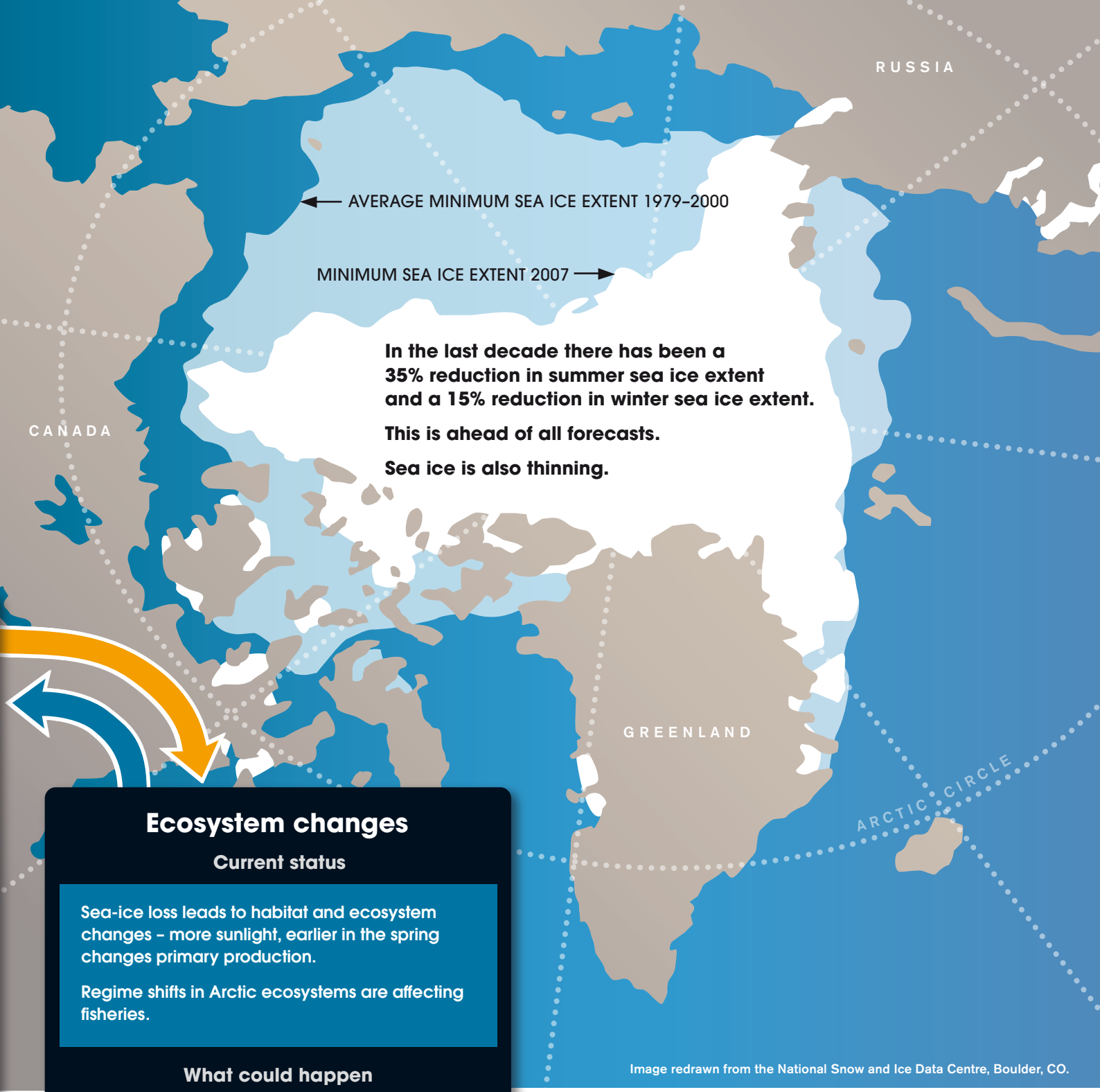


Image redrawn from the National Snow and Ice Data Centre, Boulder, CO.

Ecosystem changes

Current status

Sea-ice loss leads to habitat and ecosystem changes – more sunlight, earlier in the spring changes primary production.

Regime shifts in Arctic ecosystems are affecting fisheries.

What could happen

The Arctic will be particularly susceptible to ocean acidification, with impacts on physiology and calcification of marine organisms.

Top predators such as seals, whales, walrus and polar bears could be lost due to their reliance on sea ice for their feeding and/or breeding.

The summer feeding grounds of UK over-wintering bird populations may be disrupted.

Loss of sea ice may allow the northward migration of non-native species into the Arctic leading to impacts on the Arctic ecosystem.

Confidence rating

applies to the links between boxes shown by coloured arrows AND to the impacts described in each coloured box

High Confidence

Medium Confidence

Low Confidence

Relevance to UK

- Ease of access to oil and gas reserves.
- Shorter shipping routes to and from the Far East.
- Important changes to the climate system.
- Major changes to North Atlantic ecosystems.

A view from above: changing seas, seabirds and food sources

Seabirds sit at the top of the marine food web and hence are sensitive to human activities and changes in environmental and biological conditions which affect the whole ecosystem. There is growing evidence that the scale of marine climate change impacts around the UK is becoming sufficiently pronounced to have a noticeable effect on seabird populations.

Climate change has already caused changes in plankton and fish distribution and species compositions and, compounded by fishing, is probably involved in a marked decline in the productivity of sandeel stocks around the UK. Sandeels are the key food source of most seabirds, and the decline in sandeel availability has led to a decrease in numbers and breeding success of several species of seabirds.

In the short term (less than 5 years), the recent succession of poor breeding years caused by reduced sandeel availability are likely to propagate through the population leading to a decline in adult breeding numbers. Beyond this, changes will depend on the balance between breeding success, maturation rate and adult survival, which are difficult to predict. Much will depend on future patterns of sandeel production or whether an alternative prey species emerges which is available to seabirds.

To access the full peer-reviewed document go to www.mccip.org.uk/elr/view

Key linkages...

Primary production

Nutrient availability is affected by various climate change factors. This has direct effects on phytoplankton species and their abundance and timing of blooms. Phytoplankton are the basis of the marine food-web.

Zooplankton

Warming-related northward shifts in the distribution ranges of zooplankton in the NE Atlantic are bringing smaller, warm water species into UK waters with different seasonal patterns of production and overall abundance. A key cold water species *Calanus finmarchicus* has reduced in abundance by 70% in the last 40 years, whilst the related warm water species *Calanus helgolandicus* has increased in abundance. These two species reproduce at different times of year and the change has an impact on energy flow through the food web. Recent experimental evidence shows that acidification can also be expected to have a detrimental effect on the reproduction of some key plankton species.

Fish

The effects of climate change on fish are difficult to distinguish from the impacts of fishing. However, shifts in species distribution into deeper water and more northerly locations in the NE Atlantic, and an increase in the incidence of southern species in UK waters, are clearly related to warming. Some species also show temperature related changes in recruitment and growth.

Sandeels, a key prey species for other fish and seabirds, have declined in abundance in UK waters since about 2000, to the point where fisheries have been closed. In the southern North Sea, sandeel recruitment is negatively affected by sea temperature. Overall, it seems that the decline in sandeels is probably a consequence of the combination of fishing and climate change.

PHOTO at top: Lorne Gill/SNH.

Confidence rating

applies to the links between boxes shown by coloured arrows AND to the impacts described in each coloured box

High Confidence

Medium Confidence

Low Confidence

What could happen next?

Continued warming in UK waters could mean that –

- Southern fish and plankton species will continue to increase in UK waters, and previously dominant cold water species will retreat northwards or into deeper water.
- Black-legged kittiwakes, terns and skuas continue to decline due to low production of sandeels.

PHOTO: Patrick Stenick.

Seabird feeding success

Seabirds with different feeding habits are expected to fare differently in response to changes in prey availability. Terns, black-legged kittiwakes and skuas are considered the most sensitive due to their surface feeding behaviour. Diving birds (e.g. northern gannets) are better able to exploit deeper water fish.

Sandeels have been the key prey of most seabirds over recent decades, but their availability is now declining. Sprat might constitute an alternative food source in some areas, but elsewhere birds have been noted attempting to feed on nutritionally poor prey such as snake pipefish.

Some bird species exploit discards of fish from fishing vessels. Whilst reductions in discarding through changed legislation is generally regarded as a positive move, it may further compound the effects of declining sandeel abundance for skuas, fulmars and gulls.

Seabird populations

UK populations of black-legged kittiwakes, terns and skuas have declined in the last 10 years. More recently auks, such as guillemots and Atlantic puffins, have also declined. Declining availability of sandeels, changing weather patterns and fish distributions may all be involved.

Breeding success

Lack of availability of sandeels is causing successive years of breeding failures in a range of seabird species. Changing temperature, rainfall, wind patterns, storms and sea-level rise leading to habitat loss may have further detrimental effects.

Seabird survival offshore

Adverse weather conditions (e.g. storms preventing feeding) can lead to increased mortality of juvenile and adult birds at sea.

Non-native species

New species of fauna, flora or unicellular organisms that are not indigenous and become established in the waters around the UK are termed marine non-natives.

Some of these species can be considered to be invasive if they spread rapidly and cause economic or environmental harm, or harm to human health. Most introductions have arrived via human intervention, intentional or otherwise (e.g. aquaculture, ballast water).

More recently due to climate change some species have expanded their ranges to become established in new regions and some already introduced species have been able to take advantage of warmer conditions to become more abundant.

There is little evidence to suggest that marine non-natives in the UK have caused extinctions of native organisms. Localised impacts have included sporadic poisoning or smothering of farmed organisms in aquaculture, clogging of nets, or fouling of structures – all events of considerable concern for the aquaculture industry.

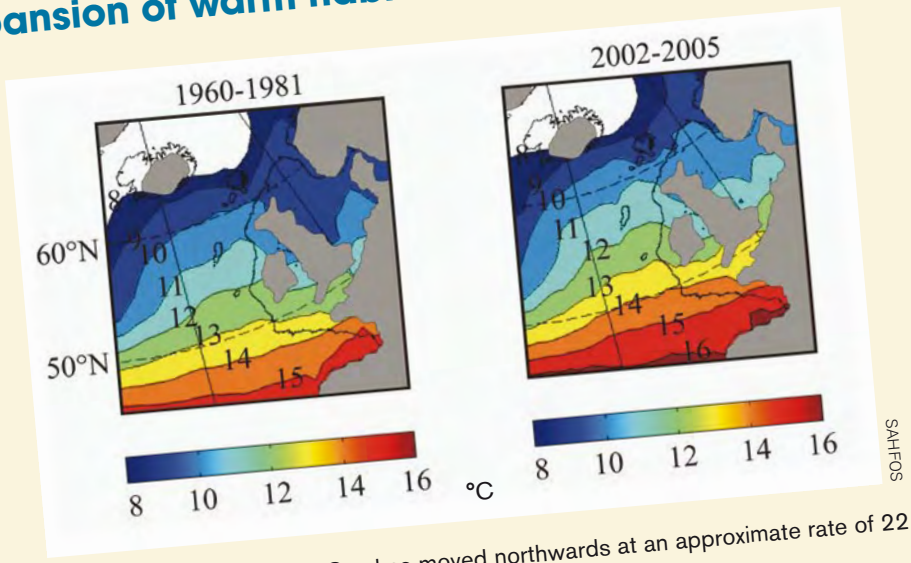
To access the full peer-reviewed document go to www.mccip.org.uk/elr/non-natives

PHOTOS from top: Paul Newland/MarLIN, Joss Wiggins.

CASE STUDY

Expansion of warm habitat

High Confidence



The 10°C isotherm in the North Sea has moved northwards at an approximate rate of 22 km per year since the 1960s.

The environment is now more suitable for warm-temperate species, which have been increasing in abundance.

It is possible that in the near future, traditional fish stocks in the North Sea (e.g. cod) will be replaced by smaller pelagic fish stocks (e.g. sardines and anchovies).

Key link to 'A view from above' through northward movement of fish stocks.

Confidence rating

applies to each case study as a whole

- High Confidence
- Medium Confidence
- Low Confidence

Regional case studies for Ireland, Scotland, Wales and England are detailed in the full review document.

©P. De Oliveira/Photolibrary.

CASE STUDY

Man-made introductions

Low Confidence

The invasive Chinese mitten crab introduced by man from Asia (found in 1935 in the Thames) lives in both estuaries and rivers in the UK and is becoming a major pest and predator on native species including young fish.

Colonisation by Chinese mitten crabs has greatly increased in the UK in recent years due to warmer temperatures.

In the case of the Chinese mitten crab, climate change did not lead to its introduction but has been implicated in its more recent rapid spread.

Key link to 'Coastal economies and people' as sea defences can act as stepping stones for non-natives moving in response to climate change.

CASE STUDY

Trans-arctic migration

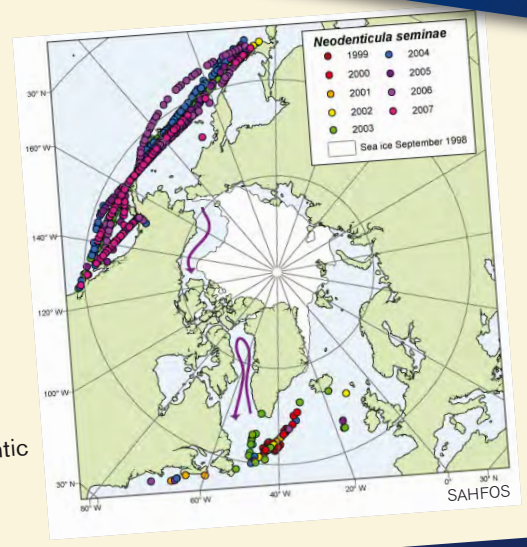
Medium Confidence

The Pacific diatom *Neodenticula seminae* arrived in the North Atlantic in 1999, after becoming locally extinct 800,000 years ago.

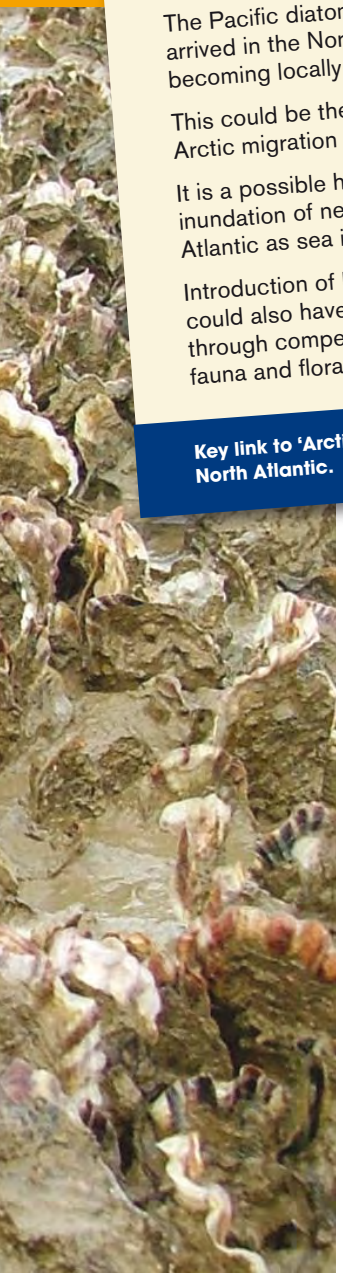
This could be the first evidence of a trans-Arctic migration in modern times.

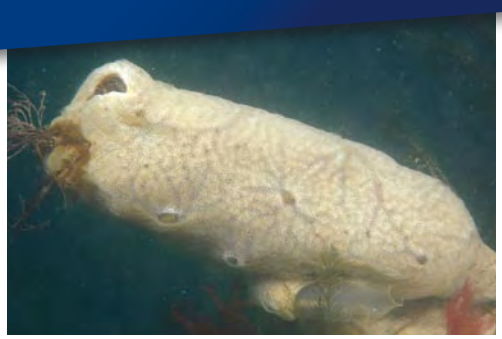
It is a possible harbinger of a potential inundation of new organisms to the North Atlantic as sea ice cover decreases.

Introduction of Pacific species to the N. Atlantic could also have an impact in the longer term through competition and hybridisation of the fauna and flora native to the UK.



Key link to 'Arctic sea ice' as reduced sea ice cover enables Pacific species to move into the North Atlantic.





Consequences and likely future changes

It is possible that in the near future traditional fish stocks in the North Sea (e.g. cod) will be replaced by smaller pelagic fish stocks (e.g. sardines and anchovies).

In the case of the Chinese mitten crab, climate change did not lead to the introduction but has been implicated in its more recent rapid spread.

Introduction of Pacific species to the N. Atlantic could also have an impact in the longer term through competition and hybridisation of the fauna and flora native to the British Isles.

Non-natives can have an economic impact on fisheries and aquaculture (e.g. the recent jellyfish bloom off Ireland, and new Harmful Algal Blooms, see the full online review for more details).

PHOTOS: Rohan Holt/CCW, Lorne Gill/SNH (lower image).

Coastal economies and people

The shape of any coast changes over time in response to changes in energy (waves, tides and currents), material (sediment type and supply), existing coastal morphology and sea level.

The potential implications of climate change, such as coastal flooding, coastal erosion and habitat change affect a diverse range of human economic activities including recreation and tourism, ports and shipping, transport and commerce.

For coastal economies and people, relative sea-level rise with increased rates and extent of coastal erosion and higher frequency of flooding are likely to be the main direct impacts.

How we respond to these challenges will directly influence environmental and socio-economic outcomes.

To access the full peer-reviewed document go to www.mccip.org.uk/elr/coasts

PHOTOS from top: Davey Benson, Lorne Gill/SNH.

Key linkages...

Climate change

- Increasing storm intensity.
- Global sea-level rise plus regional subsidence/uplift.
- Increasing global temperatures.
- Ocean acidification.

Impacts

- Flood risk increased as recurrence interval for extreme water levels shortens.
- Coastal geomorphology changes: erosion dominant over accretion but quantitative prediction of change is highly uncertain.
- Change in extent of habitat depends on adaptation strategy.
- Range shifts in distribution of commercial fish stocks and marine life.
- Impacts on shellfish growth.

Responses

- Choice of human adaptation strategy: (defend/realign/adapt) prompts different feedbacks (see full online review) and has different outcomes for society.
- Costs of meeting conservation obligations and maintaining ecosystem services.
- Commercial fishing productivity.

CASE STUDY

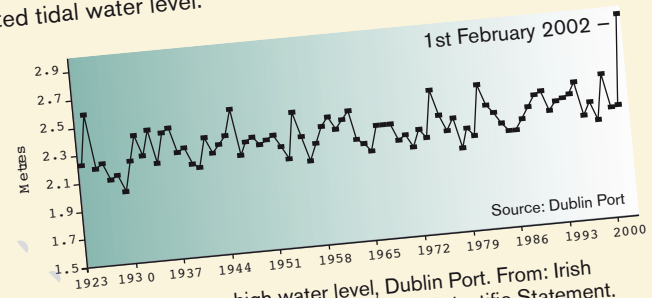
Storm surges in the Irish Sea

In February 2002, a low pressure system in the southern Irish Sea coincided with the spring tide, leading to an extreme water level (i.e. the highest water level in any given year) of 2.9 m above Mean Sea Level. This is the highest level in Dublin Port since records began in 1923. In Belfast the tide reached 1m above the predicted tidal water level.

The storm surge led to–

- Widespread flooding in Dublin and Belfast.
- Marked coastal erosion between Cork and Belfast.
- £4 million of damage on the Isle of Man and damage on the north-east English coast and the western Scottish coast.
- Ferry services across the Irish Sea were suspended.

A 0.5 m rise in sea level would mean the extreme water level of February 2002 could become an annual event. Many UK and Irish ports are on estuaries and may experience increased frequency of storm surges which would affect their operations.



Annual extreme high water level, Dublin Port. From: Irish Committee on Climate change, Third Scientific Statement. Royal Irish Academy. ©John Sweeney.

Weather chart for storm surge on Feb 1st 2002. © Crown copyright 2002, the Met Office.

and Implications

Coastal defence costs.

Landscape quality.

Property loss – annual flood losses in the UK could reach £27 billion by 2080.

The annual average erosion damage is set to increase by 3–9 times by the 2080s.

Tourism and recreation.

Public safety.

Infrastructure loss.

Social and cultural impacts on coastal communities.

Confidence rating

applies to the links between boxes shown by coloured arrows AND, where appropriate, to the impacts described in each coloured box

High Confidence

Medium Confidence

Low Confidence

Links to other topics...

CO_2 and ocean acidification

- Potential impacts on shellfish aquaculture productivity.
- Ocean acidification will be an added stressor on those fisheries that are already under pressure.

Arctic sea ice

- Ecotourism opportunities increase to the Arctic.
- Opportunities for ports and shipping through shorter trade routes.

A view from above

- Impacts on ecotourism opportunities around the UK due to changes in food-web linkages.
- Possible impacts from changes to traditional inshore fisheries.

Non-natives

- Increased growth of existing non-native species will affect aquaculture structures.
- An increase in harmful algal bloom events could affect fish farms and fisheries.
- Non-native species can extend their range by using sea defences as stepping stones.

Five key issues for decision makers to consider

1. Changes are happening now and will continue to happen. The UK Climate Projections will provide important insights into future change.
2. Ocean acidification is a critical emerging issue and the UK's Ocean Acidification Programme, along with other international research initiatives will become important sources of knowledge over the next five years.
3. The interconnected nature of marine ecosystems magnifies the many discrete impacts of climate change and this needs to be considered when making management decisions.
4. Global changes in marine ecosystems as a result of climate change will have impacts for the UK at national, regional and local levels.
5. The evidence base provided by long term data sets and specific research programmes are extremely important in understanding the impacts of climate change.

From science to policy: demonstrating excellence in the UK

In 2005, the UK Government and devolved administrations undertook a review on progress in meeting their vision for 'clean, healthy, safe, productive and biologically diverse seas' and towards making a real difference within a generation. One of the major conclusions from that work was that it was difficult to form a clear overview on the impacts of climate change on the marine environment. From this conclusion was born the Marine Climate Change Impacts Partnership (MCCIP) and the development of annual report cards.

The ecosystem linkages report card draws on the existing strengths of MCCIP in bringing together leading science and policy approaches in the UK into a unified, easy to access document on what is changing, how confident we are and why it matters. This new 'big picture approach' illustrates the world-leading role the UK is taking to best understand and communicate what is happening to our seas as a result of climate change and ocean acidification. It also illustrates the leading nature and excellence of marine science in the UK and showcases key work underway throughout the country.

It shows that although marine science is distributed across many institutions and research centres, by bringing it together we form a compelling view on marine climate change, and illustrate the quality and diversity of science that is needed to support decision making in this area. It is noticeable how a broad base of research is needed to understand both the current impacts and what may happen in the future, alongside the increasing importance of long-term datasets and earth observing systems.

Our seas also have a role to play in developing mitigation strategies and marine renewable energy is being proposed as a clean alternative to traditional energy sources and the oceans capacity for carbon storage is being investigated.

PHOTOS: Gavin Parsons, Lorne Gill/SNH.

PHOTO: Paul Kay.

MCCIP ecosystem linkages report card 2009

UK marine climate change: looking ahead

Marine bills

The UK Marine and Coastal Access Bill and the forthcoming Scottish Marine Bill and Northern Ireland Marine Bill do not contain provisions to directly tackle the effects of climate change on the marine environment. However, the proposals are intended to be sufficiently flexible to take account of changes to the marine environment whether this arises through climate change, technological development or for any other reason.

The marine policy statement and marine plans, will help to ensure the UK makes appropriate use of marine resources in the fight against climate change

Climate change legislation

The Climate Change Act requires a programme of policies and proposals which contribute to the achievement of sustainable development and set out how the UK Government will respond to the risks facing the UK as a result of climate change. It also places a duty on Welsh Ministers to lay before the National Assembly for Wales a report on the objectives, action taken and future priorities of the Welsh Ministers in relation to greenhouse gas emissions and the impact of climate change in Wales.

A Climate Change (Scotland) Bill also proposes a duty for Scottish Ministers to provide a programme of policies and proposals to address the consequences of climate change.

Developing marine climate change adaptation strategies in the UK

Our MCCIP adaptation survey and workshop demonstrated a clear need to develop integrated marine adaptation strategies bringing together nature conservation with public and private sector interests at national, regional and local scales to build adaptive capacity.

UK's Ocean Acidification Programme

The Natural Environment Research Council and the Department for Environment, Food & Rural Affairs are developing a collaborative five year research programme of approximately £12m to consider ocean acidification. The drivers and rationale for the programme are detailed in the NERC Earth System Science Theme Action Plan. The research programme will focus on the north-east Atlantic (including European shelf and slope), Antarctic and Arctic Oceans.

UK Climate Projections

The new update to UKCIP's climate projections will include a separate marine and coastal projections report for the first time. MCCIP will have an important role to play in communicating its findings.

Identifying research priorities

MCCIP is looking to develop a list of marine climate change impacts research gaps. The list will consider what we need to know and what this information is needed for.

MCCIP Annual Report Cards

MCCIP will continue to provide up-to-date information on marine climate change impacts with the next report card being prepared for 2010.

EU Marine Strategy Framework Directive

The Marine Strategy Framework Directive aims to achieve good environmental status in Europe's waters by 2020. As we develop our understanding of what good environmental status means and the measures we are going to need to put in place to achieve it, it is vital that this is influenced by our growing understanding of the impacts of climate change on the marine environment.

Online report card with full review documents

The ecosystem linkages report card is explored in much more detail in our online version where supporting evidence for each of the topics is available.

www.mccip.org.uk/elr

MCCIP Marine Climate Change Impacts Partnership

What is MCCIP?

MCCIP is a partnership between scientists, government, its agencies and NGOs. The principal aim is to develop a long-term multidisciplinary approach to understanding and communicating the implications of climate change in our seas.

Partner organisations

Agri-food and Biosciences Institute, British Energy, Cefas, Countryside Council for Wales, The Crown Estate, Defra, Department of Energy and Climate Change, Department of the Environment Northern Ireland, Environment Agency, Fisheries Research Services, Joint Nature Conservation Committee, Marine Environmental Change Network, Marine Institute Galway, Natural England, NERC 'RAPID-WATCH' programme, RSPB, Sir Alister Hardy Foundation for Ocean Science, Scottish Environment Protection Agency, Scottish Government, Scottish Natural Heritage, States of Guernsey, States of Jersey, UK Climate Impacts Programme, Welsh Assembly Government, WWF.

For more information on how to become a member of MCCIP, contact the MCCIP Secretariat at **office@mccip.org.uk**

MCCIP Annual Report Card

The 2007/2008 MCCIP Annual Report Card looked at 26 individual topics in detail. Please go to **www.mccip.org.uk/arc** to access both the summary document and the full peer reviewed reports from leading marine climate scientists.

The next MCCIP Annual Report Card is due to be published in 2010.

Further details and contacts

Further details on the work of MCCIP can be found on our website **www.mccip.org.uk**

If you have any further enquiries please contact us at **office@mccip.org.uk**

Please cite this document as: MCCIP (2009). Marine Climate Change Ecosystem Linkages Report Card 2009. (Eds. Baxter JM, Buckley PJ and Frost MT), Summary Report, MCCIP, Lowestoft, 16pp.

Your feedback

To help us understand if we are meeting your needs we need your views. Our short online questionnaire provides you with the opportunity to help shape future report cards and other MCCIP products. Go to www.mccip.org.uk/elr/survey

List of contributors

Topic leaders

CO_2 and ocean acidification: running into the buffers?
Turley C, Plymouth Marine Laboratory.

Arctic sea ice
Rodger A, British Antarctic Survey.

A view from above: changing seas, seabirds and food sources
Heath M, Fisheries Research Services.

Non-natives
Reid PC and Edwards M, Sir Alister Hardy Foundation for Ocean Science.

Coastal economies and people
Cooper JAG, University of Ulster.

Other contributing scientists

Cook EJ, The Scottish Association for Marine Science.

Findlay HS and Mangi S, Plymouth Marine Laboratory.

Furness R, University of Glasgow.

McCollin T, Fisheries Research Services.

McQuatters-Gollop A, Sir Alister Hardy Foundation for Ocean Science.

Minchin D, Marine Organism Investigations.

Pinnegar J, Cefas.

Ridgwell A and Schmidt DN, University of Bristol.

Wanless S, Centre for Ecology and Hydrology.

Quality assurance

The MCCIP report card working group commissioned the contributing scientists and identified appropriate specialists to peer-review the quality of the science.

The working group would like to thank all of the experts who kindly peer-reviewed the science behind the report card.

Designed by Ian Kirkwood design www.ik-design.co.uk Printed by JTCP02K0309