Ocean, cryosphere and climate change
Opportunities and challenges for the UK

Introduction
The Intergovernmental Panel on Climate Change (IPCC) special report on the *Ocean and Cryosphere in a Changing Climate* summarises observed and projected effects of climate change in the ocean and for the frozen parts of the Earth – including sea ice, permafrost, mountain glaciers and ice sheets. Vigorous and flexible adaptation measures can help reduce the impact of these changes, but they must be applied in parallel with the emissions reductions needed to meet the goals of the Paris Agreement. This briefing provides an overview of the key findings of the IPCC report and their implications for the UK. It identifies possible UK policy responses that would improve outcomes, both in the UK and globally.

The global perspective

**How ocean, ice and climate change are connected**
The ocean plays a major role in regulating the Earth’s temperature and carbon budget. It has absorbed about 25% of the carbon dioxide generated by fossil fuel burning and other human activity and has slowed warming by also absorbing heat.

Global warming causes melting of ice on land such as glaciers, and ice sheets in Antarctica and Greenland, adding water to the ocean, and thus raising sea level. The warming that has affected the atmosphere is also slowly penetrating the whole ocean, which causes the ocean to expand, adding to sea level rise.

By reflecting sunlight, ice and snow have a cooling effect on the climate. Removing the ice to leave darker land or ocean reduces this cooling and so amplifies climate change. Thawing permafrost releases significant amounts of greenhouse gases, causing further warming.

The ocean and cryosphere support ecosystems and the human population, both of which will be affected by impacts of climate change. As well as the many communities who depend on the sea for resources such as food, around 680 million people live less than 10 metres above sea level and many of them are therefore vulnerable to sea level rise. A similar number live in high mountain regions where changes in snow and ice cover affect their water supply.

**Where we are and where we are going**

**Ocean**
The ocean has warmed throughout its depth and is continuing to do so at an increasing rate. At the surface, marine heatwaves have doubled in frequency and become more intense. By absorbing carbon dioxide, the ocean has also become more acidic.

Marine ecosystems have been affected by warming and increased acidity, as well as by reduced oxygen content and changes in sea ice, which floats over the polar oceans. All these trends are predicted to continue, causing polar habitats to shrink and warm water species to move into previously temperate waters. Almost all warm-water coral reefs will suffer significant losses and local extinction, even under a low-emissions scenario.

Changes in ocean fish stocks and their distribution are likely to lead to significant changes in fisheries and challenges to
their governance, posing risks to nutrition in some regions. Under a high emission scenario\(^1\), there is also a risk that some marine organisms will no longer be able to build their shells because of acidification.

Ocean circulation transports large amounts of heat to the North Atlantic, warming the UK and Europe. Under the expected pattern of increasing temperatures, the circulation system known as the Atlantic Meridional Overturning Circulation (AMOC) will weaken and the impacts of this, for example on European climate and ecosystems, are hard to predict. The AMOC is very unlikely to stop completely before 2100, but this cannot be ruled out on longer timescales should greenhouse emissions remain high.

Sea level

Sea level has risen between 12 and 21 cm on a global average since 1902, as a result of ocean warming and expansion, as well as melting of land ice, with an increasing contribution from the Greenland and Antarctic Ice Sheets in recent years.

Sea level is expected to rise by 29 to 59 cm by 2100, compared to the 1986 – 2005 period, under a low emissions scenario, and by 61 to 100 cm under a high emissions scenario. It is expected to continue rising for many further centuries beyond 2100 under all emission scenarios even if the climate is stabilised.

By 2300, sea level rise is projected to reach 0.6 to 1.07 m under a low emissions scenario. Under a high emission scenario, sea level is expected to rise between 2.3 to 5.4 m, increasing at a rate of several centimetres per year across all sectors. Ice sheet loss and sea-level rise will continue even if and when emissions reach net-zero and the temperature stabilises, but the size and rate of the change will be much smaller under low emissions scenarios. Limiting the duration of any warm period would reduce likely impacts.

Sea levels around the UK have been rising compared to the global average, with somewhat higher increases in the south than the north because of concurrent rises and falls in the land surface (see figure). Sea levels are expected to continue to rise for several centuries even after the temperature stabilises, as ice sheets continue to retreat and warmth spreads through the ocean.

Rising sea levels will make the most damaging coastal flooding events more frequent, as well as increasing rates of coastal erosion. Homes, infrastructure and assets, including power plants, roads, railways, agricultural land, and ports will be subject to increased flood risk.

As an example, by 2100, sea level near London could rise between 29 and 115 cm depending on whether global emissions will be greatly reduced or not. Significant expenditure is already foreseen to enhance existing infrastructure such as the Thames Barrier that protects the Thames estuary from flood risk, and additional protection will be needed if it becomes apparent that sea level is following a path towards the higher values.

Beyond the UK itself, the UK Overseas Territories include small island states, some of which are particularly exposed to sea level change or reliant on fisheries. Other vulnerable countries include many Commonwealth nations with which the UK has close ties.

Under high emissions scenarios, many regions across the globe will suffer economic, environmental, health and trade impacts, which are likely to be felt even in nations that have themselves successfully adapted. In some cases, loss of land or livelihood could lead to conflict and migration, with important implications for the UK.

UK policy options to limit and adapt to climate change

The UK has set in law the goal of reaching net-zero emissions of greenhouse gases by 2050. This challenging commitment, if met and adopted by others worldwide, would greatly reduce the impacts on the cryosphere and oceans, including those affecting the UK.

The UK can play a substantial role in influencing other nations to commit to and reduce their emissions in a similar manner.

Even if warming is limited to a global average of well below 2°C, there will remain substantial impacts and a continuation of sea level rise. This needs to be faced...
and action taken to adapt to a wide range of possible outcomes, with the flexibility to respond to scenarios up to a 4°C rise if commitments are not met.

For UK impacts, the Committee on Climate Change has concluded that the current approach to sea level rise and coastal adaptation is unsustainable in the face of climate change and the near-certainty that adaptation to at least 1 metre of sea level rise will be needed sooner or later, perhaps before 2100. Appropriate actions vary by location but include:

• Decisions, based on technical, economic and social grounds, defining those coastal areas that can be protected against erosion and flood; those where new development should be restricted; and those where relocation and managed retreat cannot be avoided;

• Protection and restoration of coastal environments such as saltmarshes, mudflats, shingle beaches, sand dunes and sea cliffs, that can all provide natural long-term protection against waves and storm surges; and

• Greater protection for vulnerable infrastructure that cannot be relocated, such as coastal power plants and their cooling systems, and offshore wind installations.

Some impacts are hard to predict including regional changes in acidification and oxygenation, and their effects on marine ecosystems. Greater monitoring will allow decision making on issues such as sustainable fish quotas or marine protected areas to be based on the actual changes that are found to occur.

What the UK can do at international level
It is in the UK’s interest to ensure that other nations not only set ambitious targets for emissions reductions, but also adapt to inevitable changes without damaging economic and social stability. Through trade, research and aid, the UK can assist mitigation and adaptation in countries with less capacity through:

• Technology transfer and financial aid to help reduce emissions;

• Research and aid spending to support adaptation such as sea level defences, early warning of storm surges, and forecasting of water resources as glaciers retreat. Instruments such as the Newton Fund and the Global Challenges Research Fund (GCRF) can be directed to support the development of adaptation activities for this purpose;

• Providing help to devise policies and responses to sea level rise, particularly in countries where some areas may become uninhabitable;

• Offering expertise and support to ensure sustainable management of fisheries, seafood and aquaculture in regions most strongly affected by changing sea temperatures, acidification and deoxygenation; and

• Including consideration of climate (or ocean) impact in new international and commercial agreements.

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Priority actions to minimise the negative impacts of climate change on the ocean and the cryosphere and prepare for unavoidable change include:

• Achieving net-zero emissions by 2050, nationally and globally, will greatly reduce all effects of climate change, including those on the ocean and cryosphere;

• Adaptation planning for significant sea level rise and frequent storm surges;

• Establishing flexible adaptation policies to allow for various climate change scenarios;

• Supporting mitigation and adaptation around the world through trade, research and aid;

• Coordinating between all government departments to enable effective action as climate change cuts across many areas of policy.