THE ROYAL SOCIETY

25 May 2018

Submission to the Environmental Audit Committee inquiry into the Changing Arctic

Key points

- **Significant environmental changes are taking place in the Arctic:**
  - **The Greenland ice sheet has been losing about 270 billion tons of ice every year since the early 2000s, and as a result now contributes to around 25% of global mean sea level rise.**
  - **Most researchers expect that, due to climate change, the Arctic will become largely free of sea ice during the summer months sometime between 2030 and 2070, with important impacts on regional lifestyles and habitats, and on global environmental processes.**
  - **All of these factors will result in changes to important feedback loops, meaning that climate change will continue in the region and at an accelerated rate.**

- **The Royal Society is working with the other G7 scientific academies to set out a scientific vision of broad international collaboration to address the lack of scientific understanding of the Arctic marine environment. This is important because changes to the Arctic Ocean have complex and wide reaching biophysical implications for local and global environmental processes.**

- **The UK is a leading player in Arctic research, but UK research is not produced in isolation. The UK government must seek the best outcome for UK research and innovation as the UK leaves the EU, and secure the UK's ongoing role as an international scientific collaborator that is generous with our expertise to address global challenges that affect us all.**

Introduction

1. The Royal Society welcomes the opportunity to submit evidence to the Committee's inquiry into the Changing Arctic. The Society is the National Academy of Science for the UK and the Commonwealth. It is a self-governing Fellowship of many of the world's most distinguished scientists working across a broad range of disciplines in academia and industry. The Society draws on the expertise of its Fellows and Foreign Members to provide independent and authoritative scientific advice to UK, European and international decision makers.

2. This response draws on the Society's scientific expertise to address the Committee's questions about the environmental changes taking place in the Arctic and the importance of global cooperation to understand and address the challenges it presents. The response also highlights the importance of considering the impact that leaving the EU may have on UK science as a whole, including UK scientific research in the Arctic.

Environmental changes in the Arctic

3. Some of the most significant environmental changes taking place in the Arctic are highlighted below, as outlined in our recent statement 'The Global Arctic' published jointly with the G7 Academies of science (Annex A)[1].

[1] G7 Academies of science. 2018 The Global Arctic: The sustainability of communities in the context of changing ocean systems.

4. Arctic air temperature is increasing at twice the rate of the global average, equating to an approximate 2ºC increase over the course of the 20th century. Since satellite measurements began in 1979, Arctic sea ice extent has declined in all months of the year and at an astonishing rate of 13.2% per decade for the month of September (or 86,100 square kilometres per year). These changes have global consequences for ocean temperatures, salinity and water circulation. Particularly significant is the Greenland ice sheet, which has been losing about 270 billion tons of ice every year since the early 2000s, and as a result now contributes to around 25% of global mean sea level rise. Fresh water increases in the Arctic due to sea ice melting, Greenland ice mass loss, and Siberian river runoff alter Arctic ocean circulation patterns, and impact air-sea interactions and related chemical exchange processes that can have consequences on a global scale.

5. Changes to the Arctic climate system have resulted in less predictable weather patterns; sea ice formation occurring later, earlier sea ice break-up; melting of glaciers; thawing permafrost, with the potential increase of methane release; increased coastal and soil erosion. Most researchers expect that, due to climate change, the Arctic will become largely free of sea ice (i.e. less than 1 million km2 in extent) during the summer months sometime between 2030 and 2070, profoundly transforming regional and global environmental processes. All of these factors will result in profound changes to important feedback loops such as when sea ice, which reflects light, turns to open water that absorbs heat – meaning that climate change will continue in the region and at an accelerated rate. Furthermore, there will be a significant shift in the abundance of species, their seasonal occurrence and geographic distribution, thereby affecting Arctic food webs and local food security.

Changes to the climate of the Arctic have worldwide consequences

6. A changing Arctic Ocean also has major implications for global security, national sovereignty, and international trade related to: increased access to new global marine trade and transportation routes; lengthened ice-free shipping season. It is predicted that climate-related changes to the Arctic regions could stimulate investments ranging from US$ 85-265bn over the next decade, offering the potential for significant and long-term sustainability opportunities for communities and governments in the region.

7. However, with these largely climate change-induced socio-economic changes come increased potential risks such as: oil spills, shipping disasters and environmental contamination with subsequent public health risks, as well as the potential for the introduction of invasive species. There are also ramifications for search and rescue operations, human safety, mortality, and morbidity, together with impacts to infrastructure and livelihoods in the North. There are also risks related to local capacity, whereby larger global forces may overwhelm and impede locally led initiatives

Influence of decreasing Arctic sea ice on the weather in middle latitudes

8. The Royal Society has recently published the Climate Updates report[2] which outlines new evidence on key issues about climate change and its impacts since the Intergovernmental Panel on Climate Change's (IPPC) fifth Assessment Report (AR5) from 2013-2014.

9. The report highlights that it is challenging to attribute observed changes in mid-latitude weather to Arctic sea ice loss, but there are indications from observations that sea ice loss may be causally linked to changes in wintertime atmospheric circulation over Eurasia that are consistent with the cooling seen there. Despite the long-term average increase in surface temperature at high-latitudes, there has been a wintertime cooling trend both in eastern North America and in central Eurasia over the last 25 years including a number of extremely cold winters (e.g. 2009/10 in northern Eurasia and 2014 in eastern North America). This period

[2] Royal Society. 2017 Climate updates: progress since the fifth Assessment Report (AR5) of the IPCC. See https://royalsociety.org/topics-policy/publications/2017/climate-updates/ (accessed 10 May 2018).

coincides with the period of pronounced Arctic sea ice decline. Some research has suggested that warming in regions of reduced sea ice leads to a weakening westerly polar jet stream that is more likely to meander. In such meanders very cold air may reach deep into middle latitudes.

10. Recent evidence shows that the long-term decrease in Arctic sea ice extent reported in AR5 continues and the effect of ice loss on weather at mid-latitudes has become a subject of active scientific research and debate. There has been considerable use of computer models to investigate possible influences of Arctic warming on regional mid-latitude weather, and some theoretical, but conflicting, mechanisms have been proposed. If the weather systems stayed the same, enhanced Arctic warming would mean that the cold air blowing into middle latitudes from Arctic regions would be less cold. However, there is some evidence from models that regional decreases in sea ice, such as in the Barents-Kara Sea (north of Finland and western Russia), can interact with the regional weather systems to increase the likelihood of very cold winter weather in Central Asia, as has been more prevalent since 1990. The nature and strength of linkages between Arctic sea ice loss and mid-latitude weather is a focus of considerable current research.

Decrease in ice sheets of Greenland and Antarctica and the rise of global mean sea level

11. Global mean sea level will likely rise by no more than a metre by 2100, but if warming is not limited, then its effects on the ocean and ice sheets could make a rise of several metres inevitable over centuries to millennia.

12. In its fifth Assessment Report, the IPPC stated that global mean sea level rise is caused by both expansion of the ocean as it gets warmer and addition of water to the ocean due to loss of ice from glaciers and the ice sheets of Greenland and Antarctica. During the 21st century, the largest projected contribution was from thermal expansion. However, the greatest uncertainty related to the contribution from ice sheets, which could become significantly greater after 2100. Surface temperature warming passing an estimated threshold in the range 2 to 4°C above pre-industrial temperatures could lead to the complete loss of the Greenland ice sheet over a millennium or more, with a 7 m rise in global mean sea level.

13. Recent work has confirmed that observed warming of the ocean, contraction of glaciers and sea level change in the last few decades is due mainly to anthropogenic climate warming. It has also been shown that an acceleration in the rate of sea level rise since the 1990s is consistent with increasing ice mass loss particularly from the Greenland Ice Sheet, and that global mean sea level will likely rise by no more than a metre by 2100. Global sea level rise from ice loss in both Greenland and Antarctica could however increase in rate beyond 2100, and will continue for centuries under all scenarios. In a climate as warm as those projected in many models for 2100 and beyond under high emissions scenarios, large parts of both ice sheets would be lost over millennia, leaving sea level many metres higher than present.

The G7 Academies of science are working together to highlight the need to support and enhance Arctic research

14. While the Arctic marine environment sustains unique and globally important ecosystems, it remains among the least-understood basins and bodies of water in the world. This lack of scientific understanding is concerning, as changes to the Arctic Ocean have complex and wide-reaching biophysical implications for local and global environmental processes. They also have significant repercussions for the health and well-being of local communities, and they could influence the future of global maritime trade, and with it, the potential for altered global power relations.

15. The academies of science for the G7 countries have stressed the critical need to support and enhance basic Arctic research endeavours and cooperation that promote healthy and thriving coastal communities in the context of changing ocean systems. To address this need, the G7

Academies propose a vision of broad international collaboration that includes natural, social, and health sciences, engineering, humanities, and Indigenous knowledge. To achieve this, the G7 Academies make several recommendations on key areas: research cooperation, building science capacity, accessibility of information, enhanced and linked remote sensing and *in-situ* monitoring programs. The statement is included in this response as an annex and offers more details on these recommendations.

The impact of the leaving the EU on UK research and innovation

16. The UK is a leading nation in Arctic research with over 70 universities and research centres working in the area[3], but UK research is not produced in isolation. Seven EU countries are among the UK's top ten strongest collaborators[4], and 17% of the UK's research workforce comes from other EU countries[5]. Therefore, any changes to the UK's relationship with the EU will have impacts for UK science. The UK government must seek the best outcome for UK research as the UK leaves the EU. The PM's statement that the UK would like the option to fully associate ourselves with the excellence-based European science and innovation programmes – including the successor to Horizon 2020 and Euratom R&T - and recognition of the value international collaboration and mobility of researchers was welcome[6].

17. It is important that the UK's future relationship with the EU delivers on three key areas – supporting skilled people, continued close cooperation with European research and creating a regulatory environment that supports research and innovation to take place in collaboration across borders and earns public confidence. To do this the UK should seek to:

    - **People:** streamline the UK's current immigration system to demonstrate that the UK is open to international research and innovation talent.

    - **Close research cooperation:** Proactively engage in shaping Framework Programme 9 and future development of the European Research Area to send a clear message that we intend to be an ongoing partner with European research.

    - **Regulation:** put in place to ensure that the impact of any Regulations made as the UK departs from the EU are thoroughly scrutinised, supported by a transparent and thorough assessment of the possible effects on research.

18. Looking at the potential impact of any change in the UK's relationship with the EU for Arctic research specifically, we can see that UK earth, marine & environmental sciences is among the top ten disciplines that received most income from EU government bodies in 2014/15 with £34m[7].

19. Research infrastructures - facilities, resources and services used by the research community to conduct research and promote innovation – are also important for UK Arctic research. Examples of these are facilities of the NERC Arctic Office hosted at the British Antarctic Survey and the Svalbard Integrated Arctic Earth Observing System. The Natural Environment Research Council (NERC) is one of its member institutions, one of 25 institutions from 10 countries[8].

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[3] NERC Arctic Office. See https://www.arctic.ac.uk/research/ (accessed 11 May 2018).
[4] The Royal Society. 2016 UK research and the European Union: The role of the EU in international research collaboration and researcher mobility
[5] Higher Education Statistics Agency. 2017 Staff numbers and characteristics. See https://www.hesa.ac.uk/data-and-analysis/staff (accessed 14 March 2018)
[6] Theresa May. 2018 Science and modern Industrial Strategy. Jodrell Bank, 21 May 2018.
[7] Technopolis. 2017 The role of EU funding in UK research and innovation – an analysis commissioned by the UK's National Academies – The Royal Society, British Academy, Academy of Medical Sciences and Royal Academy of Engineering. See https://royalsociety.org/~/media/policy/Publications/2017/2017-05-technopolis-role-of-EU-funding-report.PDF (accessed 10 May 2018).
[8] Royal Society. 2018 A snapshot of UK research infrastructures. See https://royalsociety.org/~/media/policy/Publications/2018/snapshot-uk-research-infrastructures.pdf (accessed 10 May 2018).

20. The Society has published a statement together with the Wellcome Trust and supported by 52 UK and international organisations calling for an ambitious and close future partnership between the UK and Europe to enable excellent research and innovation to flourish across Europe, actively supporting collaboration and cooperation and avoiding introducing barriers to them[9]. To achieve this, specific issues for research will need to be addressed, either as part of the wider UK-EU relationship or through a dedicated, standalone research and innovation agreement. Achieving this is critical to ensuring research and innovation can play their central role in the future of Europe. The statement is available on https://royalsociety.org/topics-policy/projects/future-partnership-project/.

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[9] Royal Society and Wellcome Trust. 2018 Future Partnership Project. See https://royalsociety.org/topics-policy/projects/future-partnership-project/ (accessed 25 May 2018).

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Annex A – G7 Statement on the Global Arctic

THE GLOBAL ARCTIC: THE SUSTAINABILITY OF COMMUNITIES IN THE CONTEXT OF CHANGING OCEAN SYSTEMS

Executive Summary

The Arctic is being profoundly transformed by climate change. This has implications on terrestrial and marine ecosystems, affecting those who live on and from them. It is time to develop a shared scientific vision to protect these vital ecosystems as best we can, produce science for evidence-based decision-making and enhance collaborative scientific investigations of these issues. The G7 Academies propose the following:

- Research cooperation relying on augmented interdisciplinary research supported by large scale international science initiatives in combination with cooperative decision-making among Arctic nations;
- Training individuals from a diversity of fields and backgrounds, including those residing in the Arctic, to ensure the necessary scientific capacity to address global and local issues;
- Accessible, usable and timely science databases that can be shared among all stakeholders and decision makers;
- Programs on remote sensing linked with in-situ monitoring activities integrating sustained high-inclination satellite missions, new technologies for underwater measurements and regionally-integrated in-situ monitoring that incorporates local knowledge.

A Changing Arctic Ocean and Ecosystems

Arctic air temperature is increasing at twice the rate of the global average, equating to an approximate 2ºC increase over the course of the 20th century. Since satellite measurements began in 1979, Arctic sea ice extent has declined in all months of the year and at an astonishing rate of 13.2% per decade for the month of September (or 86,100 square kilometers per year). These changes have global consequences for ocean temperatures, salinity, water circulation and acidification. Particularly significant is the Greenland ice sheet, which has been losing about 270 billion tons of ice every year since the early 2000s, and as a result now contributes to around 25% of global mean sea level rise. Fresh water increases in the Arctic due to sea ice melting, Greenland ice mass loss, and Siberian river runoff alter Arctic ocean circulation patterns, and impact air-sea interactions and related chemical exchange processes that can have consequences on a global scale.

Changes to the Arctic climate system have resulted in less predictable weather patterns; sea ice formation occurring later, earlier sea ice break-up; melting of glaciers; thawing permafrost, with the potential increase of methane release; increased coastal and soil erosion. Most researchers expect that, due to climate change, the Arctic will become largely free of sea ice (i.e. less than 1 million km^2 in extent) during the summer months sometime between 2030 and 2070, profoundly transforming regional and global environmental processes. All of these factors will result in profound changes to important feedback loops such as when sea ice, which reflects light, turns to open water that absorbs heat – meaning that climate change will continue in the region and at an accelerated rate. Furthermore, there will be a significant shift in the abundance of species, their seasonal occurrence and geographic distribution, thereby affecting Arctic food webs and local food security.

Healthy Oceans, Healthy Communities, and Healthy Peoples

The Arctic is being significantly impacted by climate change. Biophysical impacts related to changing temperature, precipitation, extreme weather events, sea ice, and permafrost will have implications for terrestrial and marine ecosystems, which in turn have consequences for the health and well-being of the numerous coastal communities in the region. All communities in the Arctic will be affected as they rely on the services of healthy ecosystems for hunting, fishing, local economic enterprises, as well as for physical and mental health. The seaways enable bulk maritime re-supply with essential north/south and international economic connections that are fundamental to domestic and international trade. There is also a strong and vibrant Indigenous presence in many communities across the Arctic where cultural networks transcend national borders, where travel over water and importantly over sea ice has occurred for thousands of years, and where connections to a healthy ocean are entwined in the cultural fabric and well-being of local society.

Sovereignty, Security and Sustainability

The changing Arctic Ocean also has major implications for global security, national sovereignty, and international trade related to: increased access to new global marine trade and transportation routes; lengthened ice-free shipping seasons; and increased opportunities and pressures related to Arctic tourism, Arctic fisheries and natural resource development. It is predicted that climate-related changes to the Arctic regions could stimulate investments ranging from US$ 85-265bn over the next decade, offering the potential for significant and long-term sustainability opportunities for communities and governments in the region. However, with these largely climate change-induced socio-economic changes come increased potential risks such as: oil spills, shipping disasters and environmental

contamination with subsequent public health risks, as well as the potential for the introduction of invasive species. There are also ramifications for search and rescue operations, human safety, mortality, and morbidity, together with impacts to infrastructure and livelihoods in the North. There are also risks related to local capacity, whereby larger global forces may overwhelm and impede locally led initiatives.

While the Arctic marine environment sustains unique and globally important ecosystems, it remains among the least-understood basins and bodies of water in the world. This lack of scientific understanding is concerning, as changes to the Arctic Ocean have complex and wide-reaching biophysical implications for local and global environmental processes. They also have significant repercussions for the health and well-being of local communities, and they could influence the future of global maritime trade, and with it, the potential for altered global power relations.

Sharing a Scientific Vision for Peoples and Marine Environments

The G7 Academies stress the critical need to support and enhance basic Arctic research endeavours and cooperation that promote healthy and thriving coastal communities in the context of changing ocean systems. To address this need, the G7 Academies propose a vision of broad international collaboration that includes natural, social, and health sciences, engineering, humanities, and Indigenous knowledge in order to:

- Understand how climate change and human activities impact vital Arctic ecosystems;
- Develop innovative and interdisciplinary approaches and technologies to address these challenges;
- Use this knowledge to enable rich and robust evidence-based decision-making to inform decisions and manage and minimize environmental and sociological impacts.

The G7 Academies recommend:

1. Research Cooperation

- Funding considerably more international and interdisciplinary research, including Indigenous knowledge, in both natural and social sciences to ensure that sound scientific, environmental and societal decisions are made for future development and the well-being of all;
- Developing innovative conservation and governance approaches to support the health and well-being of Arctic ecosystems.

2. Building Science Capacity

- Training individuals from a diversity of fields and backgrounds that will ensure the necessary expertise is available internationally;
- Training those residing in the Arctic is essential: this will incorporate locally-driven science questions and foster development of circumpolar research infrastructure.

3. Accessibility of Information

- Develop interoperable and open data-sharing platforms and sample-archiving systems;

- Provide appropriate communication infrastructure that enables information sharing in a timely manner and is usable by diverse communities.

4. Enhanced and Linked Remote Sensing and in-situ Monitoring Programs

- Continue high-inclination satellite missions dedicated to monitoring long term changes in terrestrial ecosystems, as well as in ice and ocean conditions; this would also ensure safe and optimal navigation across the Arctic;
- Extend the development of research vessels, and autonomous vehicles, platforms, cabled observatories and sensors that operate in open water, under the sea ice and on the ocean floor;
- Integrate these broader scale systems with regionally-integrated in-situ monitoring programs that incorporate local knowledge.

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