Written Evidence submitted by the National Oceanography Centre

About us

The National Oceanography Centre (NOC) is the UK's leading charity for integrated coastal and deep ocean research. The NOC undertakes and facilitates world-class agenda-setting scientific research and technology development to understand the global ocean by solving challenging multidisciplinary, large scale, long-term marine science problems to underpin international and UK public policy, business and societal outcomes.

NOC operates the Royal Research Ships James Cook and Discovery and develops technology for coastal and deep ocean research. Working with its partners, NOC provides long-term marine science capability including: sustained ocean observations, mapping and surveying, data management, scientific research and advice.

Introduction

NOC welcomes the opportunity to provide written evidence to the Polar Research Sub-Committee's Inquiry into the UK and the Arctic Environment and would be delighted to meet with members of the Sub-Committee to discuss in greater detail our keen interest in understanding the Arctic Ocean, its relation to weather and climate, and how that may change in the coming years and decades. We provided evidence to the Environmental Audit Committee's inquiry into the rapid change in the Arctic in 2018.

Towards the end of the oral evidence session associated with this inquiry held on 27 March 2023, the Sub-Committee asked the Professors assembled for any specific recommendations they would suggest the British Government consider.[1] What we do not know, and where continued sustained research is needed, is exactly how Arctic warming will impact the UK's weather, climate and extremes, particularly in the medium term, and what irreversible tipping points to planetary scale Earth and ocean systems engendered by rapid changes in Arctic ecosystems might occur when.

Our responses below articulate a number of areas where greater research is required to close knowledge gaps and develop models with improved confidence levels, and highlight where NOC's involvement in current NERC funded projects such as CANARI[2] (Climate change in the Arctic – North Atlantic region and impacts on the UK) and BIOPOLE[3] (Biogeochemical processes and ecosystem function in changing polar systems and their global impacts) are facilitating knowledge creation to support policy development.

NOC's Summary Position

Our primary recommendations to UK Government are as follows:

Allocate a sustained source of funding dedicated to Arctic research, e.g. channelled through NERC's Arctic Office.

The interdisciplinary and distributed nature of UK Arctic research and expertise is a strength. UK research tends to be pan-Arctic in nature, rather than territorial based. As a non-Arctic state, we are well positioned to give credible, independent advice to global actors such as the Arctic Council based

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[1] Committees - UK Parliament, Oral evidence from Professor Terry Callaghan CMG, Professor Mark Brandon MBE, Professor Michael Bravo and Professor Helene Hewitt OBE.
[2] CANARI - NCAS
[3] BIOPOLE – Biogeochemical processes and ecosystem function in changing polar systems and their global impacts

in scientific evidence. However, a continuous source of strategic research funding for the Arctic is lacking – instead, it is project-led and reactive.

Given the importance of Arctic research to UK weather, climate and extremes, biodiversity, pollution, sea-level rise and the carbon budget, it is in our national interest to apportion a dedicated funding stream to this research.

Prioritise investment in ocean technology and future marine research infrastructure.

Marine science and its enabling research infrastructure, including autonomous marine systems, remote sensing and modelling capability, are critical to successful deliver of the UK's new Arctic Policy Framework. Technology developments in these areas will benefit sectors beyond marine science, and help us usher in advances in such fields as cleaner maritime transport and carbon capture and storage, where the UK is poised to play a global leadership role.

Issues raised in the terms of reference

1. The Arctic environment

- **What are the consequences for the UK of the observed climatic and environmental changes in the Arctic?**

[1] The short answer to this question is that we don't really know – particularly in the medium term – precisely how observed climatic and environmental changes in the Arctic will impact the UK given limitations to current models. The last IPCC report concluded that there is low confidence in the nature and strength of the connections between Arctic warming and mid-latitude weather climate.[4] Certainly there are implications for northwest European weather and climate as a consequence of observed changes in the Arctic such as severe winter weather[5] and summer heat waves[6] and droughts[7]. In addition, there is the risk of rapid, nonlinear and potentially irreversible climate change following the crossing of critical thresholds, for instance in Arctic freshwater outflow.[8] [9]

[2] Potential consequences of Arctic changes to Northwest European Shelf seas are similarly alarming. Under a low likelihood but high-impact future climate scenario, modelling suggests that changes in the strength of ocean stratification along the continental shelf edge and dynamics of the slope current, arising from future changes in larger-scale Arctic and North Atlantic Ocean circulation and salinity, may trigger a shutdown in North Sea circulation towards the end of the century.[10] The likelihood of such a dramatic event remains uncertain, but the potential ecosystem impacts include increased risks of coastal eutrophication and oxygen depletion in the southern North Sea, the disruption of larval transport pathways and increase retention of anthropogenic pollutants.

[3] The Arctic is warming faster than the rest of the planet, and as a consequence, the Arctic Ocean's covering of sea ice is reducing in thickness, concentration and extent, so that models

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4 IPCC AR6 WGI Chapter 10- Linking global to regional climate change | HimalDoc (icimod.org)
5 Divergent consensuses on Arctic amplification influence on midlatitude severe winter weather | Nature Climate Change
6 Drivers of exceptionally cold North Atlantic Ocean temperatures and their link to the 2015 European heat wave - IOPscience
7 WCDD - European summer weather linked to North Atlantic freshwater events in preceding years (copernicus.org)
8 Clement, A. C., & Peterson, L. C. (2008). Mechanisms of abrupt climate change of the last glacial period. *Reviews of Geophysics*, *46*(4).
9 Hemming, S. R. (2004). Heinrich events: Massive late Pleistocene detritus layers of the North Atlantic and their global climate imprint. *Reviews of Geophysics*, *42*(1).
10 Climate-Driven Change in the North Atlantic and Arctic Oceans Can Greatly Reduce the Circulation of the North Sea - Holt - 2018 - Geophysical Research Letters - Wiley Online Library

confidently predict the total loss of summertime sea ice in coming decades, and certainly by the end of the century. However, there is further threat to the survival of sea ice that arises from the Arctic Ocean itself related to the Ocean Conveyor Belt.

[4] Atlantic-sourced ocean waters remain relatively warm even at high latitudes – perhaps 1 or 2 ºC – not warm enough for swimming, but still warmer than the freezing point of ice, and therefore capable of melting ice. Some of this Atlantic Ocean water enters the Arctic Ocean via currents east and west of Spitzbergen, to form a layer of warm water about 1 kilometre thick below the surface. The Atlantic water is overlain by a surface layer two hundred metres thick, comprised of light, diluted seawater – as described above – and it is this layer, called the halocline, that insulates the sea ice from the heat contained in the Atlantic water.

[5] There exists a scenario whereby the heat contained in the sub-surface Atlantic water might reach the surface, and this is an active topic of research. The chain of reasoning goes like this. In past times, the Arctic Ocean was almost totally covered by sea ice all year round. When the wind blew, the force of the wind could hardly reach the ocean beneath. As a result, Arctic Ocean currents remained unusually sluggish, and the ocean itself was quiescent. In a future Arctic with much less sea ice, when the wind blows, it will be able to "grip" the ocean directly, and this will cause currents to speed up, and ocean turbulence will increase. It is this increase in turbulence that raises a concerning possibility: the sub-surface Atlantic waters may be "mixed" up to the surface, and if that happens – will it impact the survival of sea ice? Will Arctic warming accelerate further, thereby further affecting the north-south atmospheric temperature difference, with further consequences for UK climate, weather and extremes? The exotic types of ocean turbulence that would be responsible for the mixing and that are operative in high-latitude oceans are absent from the current generations of ocean and climate models, so as yet, we do not know – but are working to find out.

- **What are the observable realities of ice decline for biodiversity, air quality, sea level changes, permafrost melt and levels of methane?**

Biodiversity

[6] The Arctic Ocean is strongly affected by climate change. The combination of rapid warming, increased freshwater discharge and reduced summer sea ice has potentially a huge impact on marine hydrodynamics, microbial community structure, marine primary production and the supply of dissolved organic material into the ocean.

[7] Rising temperatures implied an increase of nutrients (i.e. nitrogen and phosphate) from glaciers, rivers and sea-ice into the marine waters. The Arctic Ocean is characterized by an imbalance of nitrogen and phosphate in the Arctic Ocean[11], with low nitrogen to phosphate ratios compared to other regions. This implies that the Arctic exports rich-phosphate waters into the Atlantic, and thus microorganisms could be limited in nitrogen. We still do not fully understand how the microorganisms currently respond to this imbalance and how they will respond in future conditions.

[8] Nitrogen and phosphate are essential to marine microorganisms, as they are needed for the production of organic carbon by photosynthesis (primary production). Previous results showed that primary production has increased during the last decade,[12] [13] but if this increase is maintained in the

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[11] Strong latitudinal patterns in the elemental ratios of marine plankton and organic matter | Nature Geoscience

[12] Secular trends in Arctic Ocean net primary production - Arrigo - 2011 - Journal of Geophysical Research: Oceans - Wiley Online Library

[13] Arrigo, Kevin Robert and Gert L. Van Dijken. "Continued increases in Arctic Ocean primary production." *Progress in Oceanography* 136 (2015): 60-70.

future is unclear. New evidence suggests that marine microorganisms able to fix atmospheric nitrogen (i.e. the nitrogen fixers), which were thought to be active in tropical waters, are also present in the Arctic[14]. Their presence in the Arctic is important as they can be considered a critical source of nitrogen, and therefore contributing to the primary production of the Arctic Ocean.

[9] The more favourable environmental conditions existing in the Arctic has benefited microorganisms, such as phytoplankton and zooplankton, which are transported by Atlantic currents into the Arctic Ocean, impacting on the structure and functioning of Arctic communities[15].

[10] Runoff from glaciers, and ice melts transport dissolved organic carbon (DOC) into the Arctic Ocean[16]. This DOC is an important source of carbon for many bacteria, which transform it back to carbon dioxide. However, a fraction of this DOC accumulates in the water column for years contributing to a large reservoir of carbon storage. It is currently unclear which factors influence the production of DOC, its transformation, and its accumulation in the Arctic waters and seafloor, and therefore we cannot assess its behaviour and the impact on sub-Arctic waters in current and future ocean conditions.

<u>Sea-level changes</u>

[11] When considering the direct contribution of Arctic ice decline to the global-mean sea-level change, it is important to distinguish between floating sea-ice and land-ice (e.g. Greenland ice sheet, glaciers, permafrost and snow pack). Roughly half of sea level rise is due to land to ocean transfer, and the other half is due to ocean expansion through warming. The Greenland ice sheet, including peripheral glaciers, contributed a quarter of total global-mean sea-level rise between 1901 and 2018.

[12] With regards to sea-ice, the direct impact of floating sea-ice melting on sea-level is very small because the volume of ice below sea-level displace the same weight of seawater as the whole weight of the ice, both above and below sea-level, following Archimedes' principle. The indirect impact of melting sea-ice on sea-level rise, however, is of great concern to scientists given that it acts as a "lid" on the ocean.

[13] Regional sea-level budgets at the scale of individual ocean basins are only now beginning to be assessed, although we are not aware of one solely for the Arctic. The Arctic poses a huge observational challenge for key properties beneath the surface of the sea-ice or ocean, such as temperature, salinity and bottom pressure, where data sparseness means that estimates of sea-level rise due to density changes (thermosteric, halosteric) and mass addition due to melting land-ice are relatively poorly constrained.

[14] Sea-level on the regional-to-local scale can be affected by dynamic changes due to both local and remote ocean circulation and density-driven processes. To convey the scientific undertaking at hand, consider the major development of atmospheric weather forecast models over recent decades, involving analogous fluid dynamics, but unlike the atmosphere, the ocean is impermeable to radar and is only observable at its surface and in a tiny fraction of its volume.

[15] These processes include the response of UK sea-level to both direct and indirect changes in the Arctic associated with melting of Arctic land-ice and sea-ice. Although the UK has developed

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[14] Home | Changing Arctic Ocean (changing-arctic-ocean.ac.uk)

[15] Footprints of climate change in the Arctic marine ecosystem - WASSMANN - 2011 - Global Change Biology - Wiley Online Library

[16] Greenland Ice Sheet exports labile organic carbon to the Arctic oceans — University of Edinburgh Research Explorer

skilful operational forecast and regional climate impact assessment models which target locally-forced sea-level changes, the adjustment of UK sea-level to remote changes over seasonal to decadal timescales is somewhat more uncertain.

[16] The IPCC found there to be only medium confidence in the understanding of ocean processes leading to dynamic sea-level change[17], therefore motivating continued research. Major projects such as CANARI will examine sea-level changes as part of its scope. However, there is a need for continued investment of research effort in dynamical adjustment of sea-level affecting the UK on intermediate timescales, which is important for planning, adaptation and impact assessment.

Permafrost melt

[17] Arctic coastal erosion poses a threat to infrastructure, coastal settlements and the wider marine environment. Arctic coastal erosion rates are an order of magnitude higher than those in the rest of the world and have been increasing for the last few decades, reaching 25-50 m per year for the hotspots in Siberia and Alaska[18] [19]. The reduction of the compact sea ice in the Arctic shelf seas allows higher waves to propagate towards the shore[20], causing coastal collapse.

[18] Arctic coastal erosion due to global warming is taking place in many different communities. The Siberian coastline is presently transitioning from a lower to a higher coastal erosion regime because of the regional sea-ice decline. The observed coastal retreat already has reached 400-1100 m over the last six decades in hot spots in the Beaufort and Laptev seas[21]. The kilometre-scale coastal retreat, observed since the 1960s near several settlements in Alaska, the Canadian Northern Territories, and Siberia, is projected to continue[22]. This, along with the averaged projected pan-Arctic coastal collapse of approximately 200 m by 2100[23], poses a serious socio-economic, safety and communication access[24] concerns for Arctic coastal communities[25]

Levels of methane

[19] Methane (CH_4) is the second most potent greenhouse gas (GHG) after Carbon Dioxide (CO_2) and has 28 times more global warming potential than CO_2. In 2020, atmospheric CH_4 concentration increased almost twice as fast as that of CO_2.[26] Anthropogenic and natural CO_2 emissions and anthropogenic CH_4 emissions are reasonably well understood, however, the magnitude, areal extent, causes and timing of natural CH_4 emissions, including those from terrestrial and marine permafrost, wetlands, freshwater, and marine gas hydrates and mega-seeps, have large uncertainties with conflicting estimates from different methods. In addition, studies on methane release from laboratory soil incubations and actual methane release from the Siberian Arctic shelves have increased rather than diminished the uncertainty when determining emissions pathways[27] [28].

[17] https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-9/#9.6.1.2#box-9.1
[18] Around one third of current Arctic Ocean primary production sustained by rivers and coastal erosion | Nature Communications
[19] Increase in Arctic coastal erosion and its sensitivity to warming in the twenty-first century | Nature Climate Change
[20] Drivers, dynamics and impacts of changing Arctic coasts | Nature Reviews Earth & Environment
[21] Grigoriev, MN (2019): Coastal retreat rates at the Laptev Sea key monitoring sites (pangaea.de)
[22] AMP12592 AMAP - CCU SPM v12 AW v2.indd
[23] Increase in Arctic coastal erosion and its sensitivity to warming in the twenty-first century | Nature Climate Change
[24] Climate change hotspots and implications for the global subsea telecommunications network - ScienceDirect
[25] State of the Cryosphere Report 2022 – ICCI – International Cryosphere Climate Initiative (iccinet.org)
[26] ESSD - The Global Methane Budget 2000–2017 (copernicus.org)
[27] Ebullition and storm-induced methane release from the East Siberian Arctic Shelf | Nature Geoscience
[28] Methane fluxes from the sea to the atmosphere across the Siberian shelf seas - Thornton - 2016 - Geophysical Research Letters - Wiley Online Library

[20] There is huge uncertainty regarding composition, inventories and functioning of different Arctic CH_4 pools. Improving knowledge of these systems and transferring this knowledge into models, so that we can make evidence-based predictions of future behaviour, is required to understand the present system and to reach a point where we can make high confidence predictions of future CH_4 emissions to the atmosphere from these key natural sources and quantify their future role in the global carbon system.

3. The UK's contribution to the Arctic through scientific research

- **What are the benefits for the UK of support for Arctic research activity?**

[21] The government's 2013 *Adapting To Change: UK policy towards the Arctic*[29] placed science at the heart of the UK's approach to the Arctic. Science underpinned all other tenants of that framework, which noted that by its nature, "science contributes directly to diplomacy, policy and our understanding of the Arctic, and is the basis of much of our co-operation with Arctic States, the Arctic Council and other actors." As "the main currency for delivering many of the UK's objectives," high quality, independent science is an area in which the UK is rightly deserves an international reputation for excellence.

[22] British participation in Arctic research activity supports the UK's soft power advantage as a science and technology superpower, and directly contributes to the global knowledge base about the critical relationship between climate change and the Arctic.

[23] As noted above, NOC has an interest in marine autonomy and net zero oceanographic capability[30], both of which are driving rapid engineering and technological innovations of relevance to shipping and the maritime sector. Ocean technology is a key enabler of Arctic research activity, and NOC hosts the world's second-largest fleet of Marine Autonomous Vehicles and the largest of any research organisation globally. NOC's National Marine Equipment Pool (NMEP) is the largest centralised marine scientific equipment pool in Europe.

[24] Autonomous Unwater Vehicles (AUVs) are robot submarines which are used to explore the Ocean without a pilot or any tether. Robot submarines are able to travel under ice, and have recently contributed to scientific missions in in the Antarctic, including The Thwaites-Amundson Regional Survey and Network (TARSAN)[31] where Autosub Long Range (ALR, also known as Boaty McBoatface[32]) successfully gathered data more than 40km under the Dotson Ice Shelf.[33] Marine Autonomous Systems are scheduled to participate in several funded studies in polar environments in the coming months, and hold great potential for unlocking access to key scientific information about Arctic glaciers, sea-ice and ocean currents.

[25] Finally, it is important that the UK support Arctic research activities given the strong link between the Arctic and the Atlantic via water masses and air systems. For example, greenhouse emissions from lower latitudes are causing the Arctic to warm faster than the global average. In addition, Arctic sea ice reduction in autumn is related to the increase of cold extremes in sub-Arctic areas. Supporting Arctic research activity will help us to better understand and improve our predictions of the effects of the increasing temperatures in marine organisms, in Arctic and subarctic regions such as the UK. Better knowledge about the Arctic will in turn contribute to making more

[29] Adapting_To_Change_UK_policy_towards_the_Arctic.pdf (publishing.service.gov.uk)
[30] Net Zero Oceanographic Capability | National Oceanography Centre (noc.ac.uk)
[31] ITGC Thwaites Glacier
[32] Boaty McBoatface | National Oceanography Centre (noc.ac.uk)
[33] Boaty McBoatface returns from Thwaites Glacier | National Oceanography Centre (noc.ac.uk)

informed decisions about investments in UK coastal defences as well as infrastructure to support threats to property and human security resulting from extreme weather events.

- **What more could the UK do to improve or increase its contribution to Arctic science?**

[26] The UK would improve its contribution to Arctic science with a sustained source of strategic research funding. The interdisciplinary and distributed nature of UK Arctic research and expertise is a strength, and we currently punch well above our weight in terms of published articles and citations related to Arctic science. As a non-Arctic nation, we are well positioned to provide independent, disinterested scientific evidence to inform global policy discussions. However, we are limited by a research funding model which is largely reactive and project-based, rather than strategic and long-term.

[27] Given the importance of Arctic research to UK weather, climate and extremes, biodiversity, pollution, sea-level rise and the carbon budget, it is in our national interest to apportion a dedicated funding stream to this research.

[28] The UK would also increase its contribution to Arctic science with continued investments in ocean technology and marine research infrastructure, given the centrality of ocean science to Arctic environmental dynamics. Marine research infrastructure includes crewed ships, which will continue to play a critical role in supporting Arctic research. However, emerging ocean technologies such as marine autonomous robotics systems[34] and autonomous underwater vehicles[35] will play an increasingly prominent role in conducting Arctic research, and developments in the field of ocean technology such as in-situ sensors[36] capable of withstanding harsh polar environments have strategic benefits in sectors outside of pure scientific research. Investments in ocean technology will also enhance our ocean modelling capacities, where the UK is a global-leader.

[29] Investment in the next generation of ocean technology spanning marine autonomous systems, remote sensors and modelling capability will both increase our knowledge of the Arctic and support UK's interests in the Arctic region.

- **How do the findings of scientific research into the Arctic's climate and environment inform the UK's Arctic policy?**

[30] As we are not an Arctic State, findings from our scientific research into the Arctic's climate and environment come from a disinterested perspective. This is an asset from the perspective of transparency and integrity. We would therefore be well positioned to make impartial, scientifically-informed recommendations to bodies such as the International Arctic Science Committee and the Arctic Council on such topics as mercury and plastic pollution in Arctic ecosystems.

[31] Changes in the Arctic marine, atmospheric and hydrological terrestrial environment alter pathways of contaminants through the system ecosystems, wildlife, and humans. The full-scale impact is unknown, although recent studies show cause for concern, and the Arctic Monitoring & Assessment Programme (AMAP), a working group of the Arctic Council has added marine plastics and mercury to the list of threats to the Arctic.[37] In fact, the Arctic Ocean already contains higher microplastics concentrations that other world oceans.[38] Pollution in Arctic environments can only be

[34] Marine Autonomous Robotic Systems | National Oceanography Centre (noc.ac.uk)
[35] Autonomous Vehicles | National Oceanography Centre (noc.ac.uk)
[36] Instruments and Sensors | National Oceanography Centre (noc.ac.uk)
[37] Arctic Monitoring and Assessment Programme | Arctic Council (arctic-council.org)
[38] Desktop_Study_on_marine_litter.pdf (pame.is)

expected to increase as a consequence of development initiatives, and the UK is well placed to play a leadership role in delivering evidence-based policy solutions to address this problem.

- **What are the implications for UK Arctic research of the UK Government's new Arctic policy framework?**

[32] The new framework brings together all policies and strategies of relevance to the Arctic into a single structure, with a "whole-of-government" approach to the Arctic. It also affirms the UK Government's intention to "continue to be a leading producer of Arctic science and an active partner in international research collaborations" including those which contribute to a global understanding of climate change. A more coordinated approach is welcome from the perspective of UK Arctic research interests, as it signals an interest in providing a more strategic approach to this key area, which we hope will be met with a continuous and focused funding source to achieve the ambition required to close the knowledge gaps that exist with regards to the changing Arctic. The emphasis on strong bilateral relationships with our Arctic partners and Allies is also welcome from a research perspective.

- **How can future Arctic research in UK institutions be supported so as to maintain and enhance the UK's leadership in Arctic science?**

[33] As noted in our 2022 response to the House of Lords Science and Technology inquiry into delivery of a science and technology strategy[39], the UK research and development funding model prioritises delivery of project-based science undertaken by academics at universities. Longer-term funding models designed to support large-scale research and technological innovation outside of the higher education sector will be key to enhancing the UK's leadership in Arctic Science. Research institutes like the National Oceanography Centre are a vital part of the RDI landscape which depend on large infrastructures, long-lead-time technological innovation and a critical mass of scientific and technical capabilities. Yet, compared with other science superpowers, the UK has increasingly turned away from providing non-university independent research institutes with the stable, predictable funding required for effective collaboration with industry and international partners.

[34] UK Arctic science has never been centralised, even though our participation in this field dates back to the 18th century (e.g. William Scoresby)[40]. It is powerful in part because it is distributed across a variety of institutions and driven by curiosity. But the approach of having universities, independent research organisations and public research institutions compete against each other for a limited pool of project-based funds is a losing proposition. A long-term strategic programme of funding for Arctic research which enables cooperation across actors in the UK's diverse research ecosystem would enhance our leadership in Arctic science.

- **What factors govern the commissioning of Arctic research programmes in UK scientific institutions, and to what extent are the outputs of such programmes used in contributions to multilateral scientific assessments such as the IPCC?**

[35] As articulated in our answer above and in our introduction, UK funding for Arctic research tends to be reactive and project-based. This is not to say that it is not excellent. The UK punches above our weight in terms of the number of published research articles and citations, ranking number four in the world of the number of published research articles on the Arctic, with papers cited around twice as often as the global average.[41] Furthermore, as the 2023 Arctic Policy

[39] Delivering a UK science and technology strategy - Written evidence - Committees - UK Parliament (STS0025)
[40] William Scoresby - Wikipedia

Framework points out NERC provides national capacity funding to research centres who are all active in conducting natural science research in the Arctic. What is lacking is a continuous and focused source of funding for strategic Arctic research.

- **What research activities concerning the climate and environment ought to be eligible for UK support through the NERC?**

[36] All of the directly UK relevant research priorities identified above would benefit from a continuous, focused and sustained source of funding in Arctic research, including weather, climate and extremes, biodiversity, pollution, sea-level rise and the carbon budget.

[37] NERC's 2022-2025 Strategic Delivery Plan rightly allocates significant funds to the Antarctic Infrastructure Modernisation Programme to modernise polar science. The 2023 Arctic Policy Framework notes that in 2021 the UK's Arctic Research Station at Ny-Ålesund, Svalbard saw significant new investment in logistics and science equipment, as well as in the fabric of the Station itself. However, this is no substitute for the scale of investment the UK should be making into Arctic research, particularly given our position as a long-standing observer status in the Arctic Council, our Presidency of the International Arctic Science Committee (IASC) Executive Committee and our position as the northernmost near-Arctic non-Arctic state.

[38] Furthermore, NERC's Living Action Plan sets out what NERC will do to boost diversity and inclusion. Increasing the participation of local and Indigenous groups in scientific research in Arctic communities would further this goal and should be supported.

- **Has the UK's departure from the EU had an impact on UK research in the Arctic? Has there been any impact on agreements on international cooperation, joint research projects and access to funding streams such as Horizon Europe?**

[39] It is unfortunate that the protocol on UK association with Horizon Europe has yet to be formally adopted. The interim funding guarantee procedure adds an additional layer of uncertainty that does not contribute to effective scientific collaboration. Changed regulations for non-UK EU nationals coming to the UK to work as a researcher or academic leader are also unhelpful, given that the Arctic research network is particularly spread thin throughout Europe.

[40] The Arctic Research Icebreaker Consortium[42] will continue, which is fortunate, and scientific data exchange and sharing protocols between UK and EU scientists appears largely unaffected.

[41] NOC joins the Royal Society in welcoming the Government's restated intention to deliver UK association with Horizon Europe.[43] The uncertainty with regards to our association with Horizon Europe inhibits active collaboration with major research partners across Europe.

Response submitted by Alice Kloker with input provided by Professor Sheldon Bacon and NOC scientists including Dr Yevgeny Aksenov, Dr Phil Bagley, Professor Angus Best, Dr Elena García-Martín, Dr Joanne Hopkins, Dr Marilena Oltmanns, Roland Rogers and Dr Chris Wilson.

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[41] arctic-research-publication-trends-august-2016.pdf (uarctic.org)
[42] Arctic Research Icebreaker Consortium: A strategy for meeting the needs for marine-based research in the Arctic | ARICE Project | Fact Sheet | H2020 | CORDIS | European Commission (europa.eu)
[43] Royal Society responds to the announcement of the Pioneer prospectus plan | Royal Society