Introduction

1. The British Antarctic Survey (BAS) is a component institute of the Natural Environment Research Council (NERC). BAS undertakes a programme of world-leading interdisciplinary research in both polar regions that advances our understanding of Earth, and which will benefit society. Through its extensive logistic capability and polar know-how, coupled with its expert scientific support staff, BAS also provides access to the Polar Regions for the UK science community and its international collaborators. BAS has a commitment to excellence in science and to safe and efficient operations which helps it sustain a leading position for the UK in Antarctic affairs. BAS would welcome the opportunity to provide similar support to the UK in the Arctic. (For more information about BAS visit www.antarctica.ac.uk).

2. BAS welcomes the opportunity to respond to this Call for Evidence on its own behalf. BAS does share views that have been submitted elsewhere, particularly in the responses from NERC and NERC’s Arctic Office.

Background

3. Since its establishment in 1962, BAS has been a leader in Antarctic science. In initiating our current science programme in 2009, “Polar Science for Planet Earth”, BAS began to develop a portfolio of research in the Arctic. Some of these activities complement those undertaken in the Antarctic, while others address purely Arctic issues.

At present many of our Arctic activities are collaborative, however, we have a growing impetus to lead specific science programmes and to help coordinate sections of the science community. Our growing position in the Arctic stems from the expertise gained over many years of operation in the Antarctic. For example:

- BAS led a consortium of 24 institutes from 16 countries in a European Union (EU) funded programme, which led to reductions in uncertainty about the contribution of glaciers (including the Greenland ice sheet and Arctic glaciers) to future sea-level rise. (www.ice2sea.eu);
- BAS has deployed a suite of atmospheric monitoring instruments mounted on one of its Twin Otter aircraft to investigate cloud formation in the Arctic; cloud formation has been identified as an issue limiting the performance of climate models in Europe;
- BAS is currently leading a flagship, multi-national programme funded by the EU on sea-ice change in the Arctic, coupled with physical, social and economic impacts (www.ice-arc.eu).

BAS is currently redefining its science strategy and in so doing intends to enhance elements of Arctic science. The BAS science and logistic platforms (ships and aircraft) are available for

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1 Submitted by Director of Science, Prof. David Vaughan on behalf of BAS – 4th July, 2014. Prepared by Prof. D. G. Vaughan, Dr. E. Shuckburgh, Dr. P. Trathan, Prof. J. Francis., Dr B. Schlarb-Ridley.
use wherever needed, including in the Arctic. Where such activities are outside the
Antarctic, and in order to meet Government budgetary requirements, BAS must recover
costs of deploying these platforms in science support roles and on commercial charters.

Since 1991, BAS has operated the UK’s only Arctic science station on Svalbard on behalf of
NERC. This station exists within the international science facility at Ny-Ålesund, which is
managed by the King’s Bay Company. This station receives specific funding of around £150k
per year from NERC and provides a key resource for the UK Arctic science community,
providing cost-effective access to the polar environment for studies in terrestrial and coastal
biology, glaciology and geology.

Question 1. What are the main issues arising from recent and expected changes in the
Arctic region? How will these changes impact upon the Arctic, and what is the impact for
the UK?

noted that “multiple lines of evidence support very substantial Arctic warming since the
mid-20th century”. This warming significantly exceeded the global average. Over the last two
decades, accelerating ice-loss from the Greenland ice sheet has been documented, and
Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in
extent. There is also high confidence that permafrost temperatures have increased in most
Arctic regions since the early 1980s. There is some evidence of an increase in precipitation
in most pan-Arctic land areas over the past few decades.

5. In coming decades, it is considered very likely that Arctic sea ice cover will continue to
shrink and thin and that Northern Hemisphere snow cover and near-surface permafrost will
be reduced in extent over the 21st century. Projections indicate that by the mid-century
there are likely to be substantial changes in other climate parameters, such as storm tracks
and precipitation, throughout the Arctic. The impact of these Arctic changes is likely to be
felt further afield and even in the UK and Europe.

6. The impact of climate change has already been observed in the ecology and hydrology of
Arctic lakes, and terrestrial and marine ecosystems. Future changes including increased
atmosphere and ocean temperatures, reduced sea ice cover, ocean acidification, thawing
permafrost and changed precipitation patterns have the potential to further impact these
ecosystems, to affect infrastructure and related services in the Arctic, and to exacerbate
existing vulnerabilities of the populations living in the region.

7. Changes in the Arctic have the potential to impact the UK through their influence on the
persistent patterns of atmospheric circulation across the northern hemisphere (e.g., the
North Atlantic Oscillation), loss of glacier ice contributing to global sea-level rise, and
through changes to the ocean circulation in the Atlantic Ocean (e.g., Meridional Overturning
Circulation). Each of these processes will impact the UK directly, and each is an area of
active and urgent research. Changes in the Arctic are also associated with possible abrupt or
irreversible events that would impact global climate, such as the melting of the Greenland
ice sheet, changes to the Meridional Overturning Circulation in the Atlantic Ocean, release of greenhouse gases (methane and carbon dioxide) from permafrost, and from terrestrial and marine sediments (clathrates). Such events are, however, generally considered to be unlikely to occur during the 21st century.

8. In recent years, the UK science community has played an important role in observing climate change and its impacts in the Arctic. The task for science in future years will be to address squarely, key scientific questions around improving projections of future change and its impacts. Improving these projections will inform options for adaptation and increase resilience, and reduce risks to Arctic communities and commercial activities. However, to fully achieve the potential benefits will require a coordinated and strategic approach.

Question 2. Will changes in the Arctic lead to new economic and commercial opportunities? What are these opportunities, and how might they be delivered? What should be the role of the UK Government, of British businesses and of other sections of civil society?

9. The changes will likely lead to new opportunities in a variety of commercial sectors: in particular: shipping, mineral and hydrocarbon extraction, tourism and fisheries. The degree to which these opportunities will arise as a result of climate changes, and the degree to which they arise as a result of other factors (e.g., improved technology, widening of commercial awareness of Arctic opportunities) cannot be fully disentangled. Similarly, how these economic opportunities are taken up by commercial interests will depend upon national and international policies and regulation.

10. Taking a lead from NERC’s strategy “Business of the Environment”, BAS acknowledges its responsibility to undertake science that underpins responsible development of Arctic resources, reduces risk and enables sound stewardship of the Arctic region. BAS will also seek to provide balanced and timely advice to UK Government on issues of Arctic management and governance, and underpin evidence-based policy-making.

Question 3. How should economic development be balanced with environmental protection in the Arctic? Are appropriate systems in place to ensure the correct balance is found and maintained? How should the UK be involved in establishing this balance?

11. See paragraph 10 above.

12. There is an urgent need for baseline studies of Arctic marine ecosystems, and these need to be initiated before direct human impacts begin to make understanding of the pre-exploitation state impossible. Such studies may eventually allow the underlying causes of changes in these ecosystems to be ascribed. For example, changes in marine mammal or seabird populations could potentially result from:

- A local expression of global climate change (e.g., through temperature rise or sea-ice retreat) affecting local food-webs;
• Specific local activities (e.g., increased shipping, or initiation of mineral extraction activities) that pollute or cause disturbance to critical habitats or food-webs;
• Global biogeochemical changes (e.g., ocean acidification) affecting critical life-history stages of prey species in local food-webs;
• Regional ecosystem disturbance (e.g., from fisheries) leading to by-catch of animals, or resulting in competition for prey.

For over 30 years, BAS has carried out sustained research in support of the ecosystem-based framework used to manage Antarctic fisheries. Through the Polar Regions Department of the FCO, BAS provides scientific information and advice to the international Commission for the Conservation of Antarctic Marine Living Resources. CCAMLR currently manages three important fisheries, including Antarctic krill, a species that is also important in the diet of many marine mammals and seabirds.

**Question 4. What are the human aspects of the expected climatic and economic changes in terms of local populations, current and future?**

13. Climate change and associated changes to the marine and terrestrial environment of the Arctic will probably affect local populations through impacts on social and economic factors such as food security, access to resources, and infrastructure. The rapid rate of change projected for the region is likely to make adapting to environmental change particularly challenging.

**Question 5. Are there sufficient data on the Arctic to make informed policy decisions? If not, where are the gaps and how should they be remedied?**

14. There are many areas where improved data would provide greater certainty on the magnitude, pattern and severity of current changes and increase confidence in projections.

15. For several key parameters (e.g., sea ice extent, atmospheric temperatures, glacial contribution to sea-level change) current data series acquired over several decades are adequate for measuring and mapping change but are too short to quantify natural variability on timescales of centuries to millennia. Improved use of climate proxies (e.g., from ice and marine sediment cores) would be valuable in improving understanding about the interaction of natural variability and human-induced climate change, and thus improving confidence in projections.

16. As noted above (12), the assessment of the structure and function of Arctic marine ecosystems is not well developed and may, in the future, severely limit our ability to assess change, and determine the cause of those changes.

17. For sea ice, good records of changes in ice extent exist for more than 30 years, but detailed and specific parameters required by shipping companies to assess risk and evaluate business opportunities are much more poorly known. Ice-thickness, for example, has only been comprehensively measured for a matter of a few years, while other parameters (snow-cover, ridge characteristics, etc) are still not monitored on a pan-Arctic basis.
18. The quantification of methane in near-surface terrestrial permafrost and marine sediments (as clathrates) is only poorly assessed. The hypothesis that warming of the atmosphere, permafrost and/or coastal seas could release considerable quantities of this potent greenhouse gas, which would constitute a strong positive feedback amplifying climate change, will not be tested until more data on the distribution and release of methane has been acquired.

19. Monitoring of the current state and emerging changes in ocean circulation in the Arctic and the characteristics (temperature and salinity) of Arctic water masses is urgently required.

20. Both Arctic glaciers and the Greenland ice sheet require ongoing monitoring to determine their future contribution to sea-level rise, and to identify patterns of change that can be used to test and thus improve projections of change.

**Question 6. Are there climate change mitigation and adaptation strategies local to the Arctic that should be deployed or tested? What contribution can the UK make?**

12. No response.

**Question 7. Are current international governance and security arrangements appropriate for dealing with anticipated challenges in the Arctic? How should the UK support the Arctic states in their stewardship of the region?**

13. The geo-political environments of the two polar regions are quite dissimilar. However, the UK has a significant voice in each.

In Antarctica, the UK was one of the original signatories to the Antarctic Treaty, and through vigorous diplomacy and scientific leadership continues to maintain a considerable voice in the Treaty system. Similarly, the UK was one of the original signatories to other legal instruments operating in the Antarctic and Southern Ocean, including both CCAMLR and the Agreement on the Conservation of Albatrosses and Petrels.

As one of the nearest neighbours to the Arctic, the UK has a unique non-sovereign role and one in which science could provide an important pillar. Through the UK’s observer status at the Arctic Council, our non-sovereign status means that UK science is well positioned to provide unbiased advice particularly on issues of stewardship. This, coupled with existing UK skills and knowledge about accessing remote and hostile environments to address globally important scientific questions, as well as UK experience in managing multi-national scientific collaborations, means the UK science community could provide strong support to influence Arctic affairs.

**Question 8. How effectively does the UK interact with Arctic governance structures? Is the UK Government’s approach, as set out in the Arctic Policy Framework, proportionate and appropriate?**

14. No response.