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071-18/NH

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RE: The case for UK Associate Member status to the Arctic Regional Hydrographic Commission (ARHC)

The United Kingdom (UK) would like to thank Arctic Regional Hydrographic Commission (ARHC) Member States for the opportunity to outline our commitment to the domain of MSI, hydrographic surveying, marine cartography, nautical information, MSDI and scientific research in the Arctic region, to support our application to become an Associate Member.

The United Kingdom Hydrographic Office (UKHO) is keen to support its near neighbours in the Arctic region by contributing to the development of spatial data management, and by providing a central point of contact for access to data collected in the Arctic region by UK research organisations.

The UK government recognises that the Arctic region is of fundamental importance, not only to the people who live and work there but also to the health of the planet. 20 years ago, the UK became one of four original observers to the newly formed Arctic Council. We remain as committed as ever to the Arctic States and the indigenous peoples of the Arctic and to securing a sustainable future for them that benefits us all.

The attached paper outlines the UK's case for Associate Member status to the ARHC by describing the resources, expertise, knowledge and data that the UK can contribute to the work of the ARHC.

Yes indeed

The case for UK Associate Member status to the Arctic Regional Hydrographic Commission (ARHC)

UK's Arctic Region Responsibility and Collaboration

This application for ARHC Associate Membership Status mainly describes the UK's current and future contribution to technical and scientific activities, in the domain of hydrographic surveying, marine cartography and nautical information in the Arctic region, as defined by its Statutes as being of interest to the ARHC. However, before providing details of these activities, it is important to recognise that the United Kingdom Hydrographic Office (UKHO) is the NAVAREA I co-ordinator for the International Maritime Organisation (IMO) and International Hydrographic Organization (IHO) Worldwide Navigational Warning Service (WWNWS). This area extends to 75° N as shown in Figure 1 below. As such, although UK is not an Arctic State, UK has responsibility for Maritime Safety Information (MSI) within Arctic waters, and therefore, that the UK already contributes to regional coordination of information, and regional collaboration, on matters of interest to the IHO, in line with Article 4 of the Statutes of the ARHC (Objectives of the Commission). Furthermore, within the domain of MSI, UK chairs the IMO NAVTEX Coordinating Panel and attends the IHO WWNWS sub-committee.

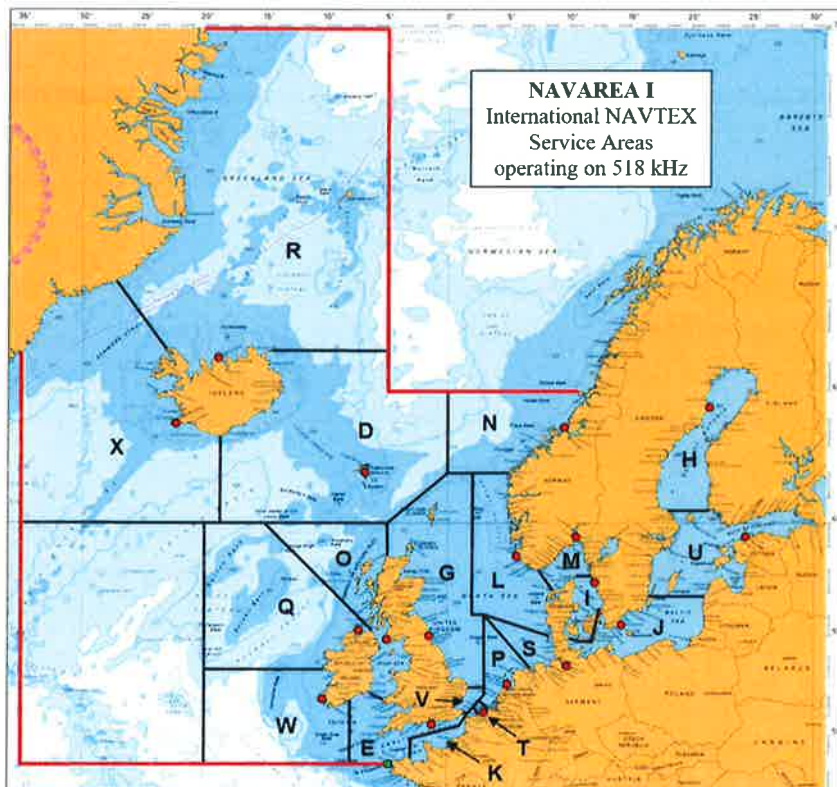


Fig. 1. Limits of NAVAREA I

Marine Geospatial Information Management

UKHO is developing geospatial capability to support wider uses of marine data. Development of a data engine is well advanced, that will change UKHO from a product based organisation, with duplicated data stores for separate products, to one that will store data once, for multiple uses. This enhanced data management will provide flexibility and improved agility to answer geospatial queries. Recognising our existing and future geospatial expertise, we are one of six core bodies working towards setting up the UK Government's Geospatial Commission. Exploring opportunities to exploit geospatial technology is central to UKHO's strategy, thus we are active in the IHO MSDIWG¹, OGC's² Marine Domain Working Group (being a co-chair), and have been appointed as the UK's lead organisation for the Marine Geospatial Information working group of the UN-GGIM³.

As the host of the UK MEDIN⁴ Bathymetry Data Archive Centre (DAC), bathymetric data for UK waters is made available for a multiplicity of uses, satisfying the EU INSPIRE directive. In the same way, UKHO is establishing a central repository of bathymetric data collected by UK scientific expeditions in the Arctic region. Until recently this data has been held by its originators, such as:

- British Antarctic Survey⁵;
- Scott Polar Research Institute, University of Cambridge;
- Scottish Association for Marine Science⁶;
- British Oceanographic Data Centre.

Figure 2 provides an example of the coverage of bathymetric data collected by UK Arctic Research. By bringing such data into a central repository, UKHO provides improved search and retrieval capabilities, thus making Arctic bathymetric data held within the UK more accessible.

UKHO also works closely with the UK Maritime Administration, the Maritime and Coastguard Agency (MCA), to establish the national approach to the IMO e-navigation agenda. We have participated in the IMO/IHO Harmonization Group on Data Modelling with interests in delivering international clarity about future e-navigation maritime services, some of which may be of significance to future Arctic navigation.

With a view to delivering future information requirements in new formats and structures, UKHO is active within the IHO Nautical Information Provision Working Group (as Vice-

¹ Marine Spatial Data Infrastructure Working Group

² Open Geospatial Consortium

³ United Nations Committee of Experts on Global Geospatial Information Management

⁴ Marine Environmental Data and Information Network

⁵ UK's role in Arctic research is managed by the Arctic Office at British Antarctic Survey, which supports the Arctic science community in the UK

⁶ An independent non-profit organisation to promote the study of Marine Science through research and education, with an active Arctic research programme.

chair). This is focused on using the IHO S-100 standard to meet evolving e-navigation requirements.

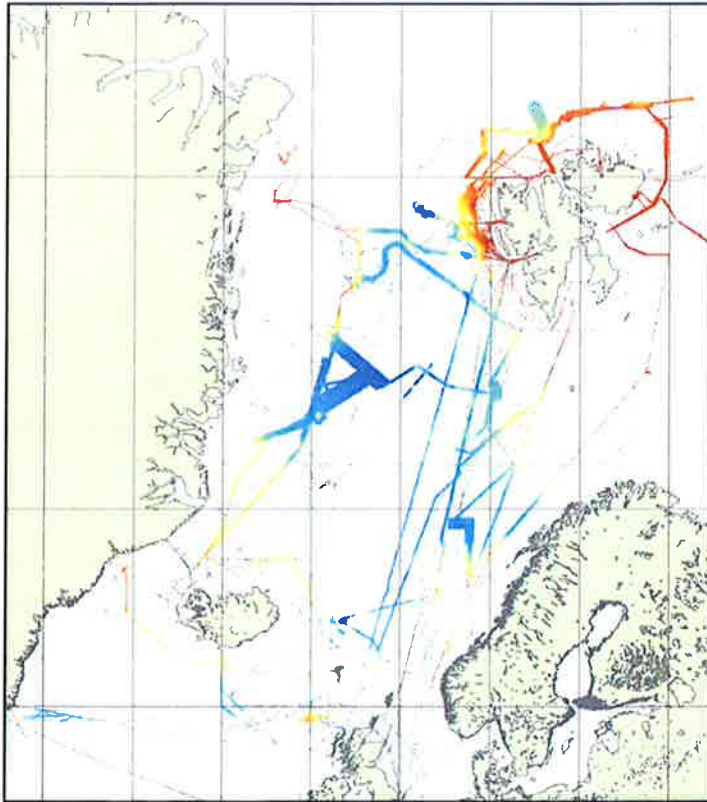


Fig. 2. Example of bathymetric data collected by UK Arctic research

All of the above demonstrate UKHO's enthusiasm for contributing to the development of future access to marine information beyond existing navigational use. We would be pleased to contribute to ARHC's consideration of how to best exploit geospatial technology to support the region, and to contribute to the development of an Arctic regional marine spatial data infrastructure through the ARMSDIWG⁷.

UK's Arctic Research Activities

The UK government is committed to supporting top scientists and their international collaboration on the Arctic – particularly as the new Agreement on Enhancing Scientific Cooperation in the Arctic is implemented. The UK Government is investing both manpower and finance in pioneering Arctic research. £16 million in the 5-year Changing Arctic Ocean Programme and a further £2.3 million for UK-based scientists to take part in the MOSAiC international study of the Arctic climate.

Due to this growing interest in the Arctic Ocean, and responding to the UK government's concerns about global climate change impacts on the Arctic, the UKHO and UK scientific

⁷ Arctic Regional Marine Spatial Data Infrastructure Working Group

community contributes to, and often leads on, a number of areas of prominent research addressing a variety of scientific topics relating to the Arctic. The leaders of the two main UK research bodies in the Arctic are Dame Prof. Jane Francis (British Antarctic Survey) and Prof. Julian Dowdeswell (Scott Polar Research Institute, University of Cambridge) with coordination from the Natural Environment Research Council, Arctic Office, Cambridge, led by Dr. Henry Burgess.

Mapping the Arctic seafloor: Introduction and Background

The UK has a long record of mapping the seafloor and coastline of the Arctic, stretching back to early Royal Navy expeditions in the 19th Century to explore the Northwest Passage. Since 1994, the UK's ice strengthened research vessel, RRS James Clark Ross (JCR) (Figure 3), has undertaken annual cruises of 30-40 days each year to the Arctic seas. Since 2000, when fitted with a Kongsberg EM12/120 deep-water multibeam system, seafloor bathymetric data have been collected. A new UK ice-strengthened ship, RRS Sir David Attenborough (Figure 3), will be available for Arctic expeditions in 2019. In addition, scientists frequently go to sea as part of collaborative research projects with other nations, and utilize bathymetric datasets acquired from those ships. More detailed information on the Polar Research Vessels, RRS James Clark Ross and RRS Sir David Attenborough is available at Annex A.

Products of this Arctic work include maps and charts of the Arctic seafloor and scientific papers that explain the shape of the seafloor to aid our understanding of submarine processes and landforms. For example, UK bathymetric data from the JCR formed an important contribution to the 2012 GEBCO-supported International Bathymetric Chart of the Arctic Ocean (IBCAO), and the associated paper was co-authored by a UK scientist who also sits on the IBCAO Steering Committee. In addition, a UK scientist was lead editor of the 2016 "Atlas of Submarine Glacial Landforms", a 600-page benchmark publication with several hundred examples of the imprint of past glaciers on the high-latitude seafloor.



Fig. 3. UK's ice-strengthened polar research ships: RRS James Clark Ross and RRS Sir David Attenborough.

Mapping the Arctic seafloor: UK programmes in Arctic waters

The UK's Natural Environment Research Council (NERC) has funded regular scientific expeditions of the JCR to Arctic waters over the past 23 years. These have been both individual science projects and parts of large-scale national programmes, for example:

- Arctic Ice and Environmental Change Programme of 2000-2006 (£6M),
- Autosub under Ice Programme of 2008-12 (£7M)
- NERC Arctic Research Programmes of 2010-2016 (£15M)
The overarching aim was "to improve our capability to predict changes in the Arctic, particularly over timescales of months to decades, including regional impacts and the potential for feedbacks on the global Earth System".
- NERC Arctic Research Programmes of 2017-22 (£16M).
The over-arching goal is "to understand how change in the physical environment (ice and ocean) will affect the large-scale ecosystem structure and biogeochemical functioning of the Arctic Ocean, the potential major impacts and provide projections for future ecosystem services".

These science projects and programmes demonstrate the long-term commitment of the UK to the acquisition of environmental data from the Arctic seas, of which swath-bathymetric mapping for hydrographic purposes is an important component. The £200m cost of the building the RRS Sir David Attenborough represents the UK Government's largest capital investment in polar science since the 1980s and is further evidence of UK's ongoing commitment to the Polar Regions.

Substantial seafloor mapping contributed to the following Arctic cruises of the JCR:

- Arctic methane hydrates and climate change (Principal Investigator [PI]: Minschull, Southampton)
- Will climate change in the Arctic increase the landslide tsunami risk? (PI: Talling, Southampton)
- Slope stability on Europe's passive continental margins (PI: Dowdeswell, Cambridge)
- Marine geophysical and geological investigations of past flow and stability of a major West Greenland ice stream through Quaternary glacial-interglacial cycles (PIs: O'Cofaigh, Durham; Dowdeswell, Cambridge).
- Marine geological processes and sediments beneath floating ice shelves in Greenland and Antarctica: investigations using the Autosub AUV (PIs: Dowdeswell, Cambridge; Larter, BAS; Griffiths, Southampton).

Maps of the ship tracks of two of these cruises, to West Greenland (Figure 4) and Svalbard waters (Figure 5), give examples of the scope of these 30-40 day research projects. Bathymetric data from these contributed to version 3 of IBCAO. Detail of part of the multibeam dataset acquired the West Greenland cruise is shown in Figure 6.

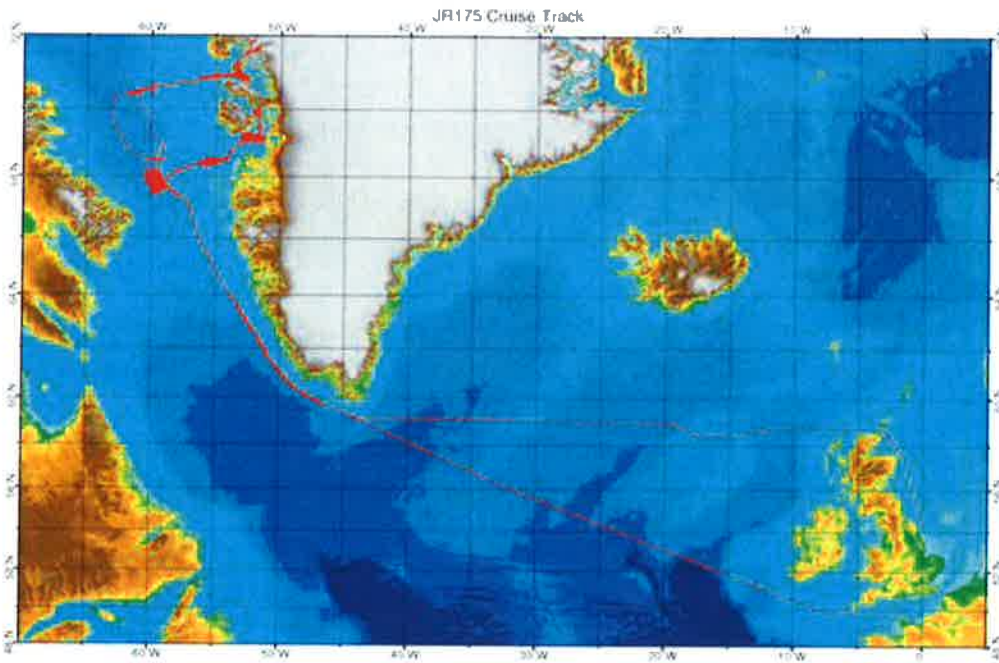


Fig. 4. Cruise of the UK's RRS James Clark Ross to West Greenland waters. Swath bathymetric data were collected throughout. Detailed swath bathymetry from Ummannaq fjord and shelf is shown in Figure 6.

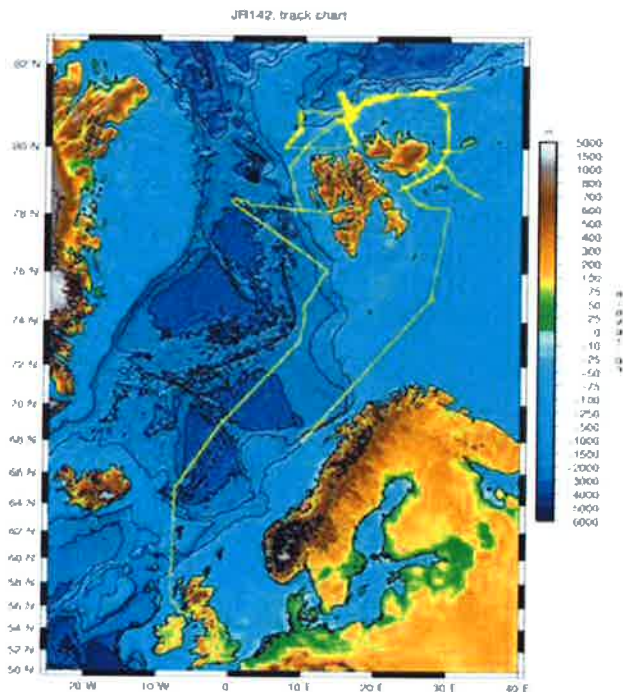


Fig. 5. Cruise of the UK's RRS James Clark Ross to Svalbard waters. Swath bathymetric data were collected throughout.

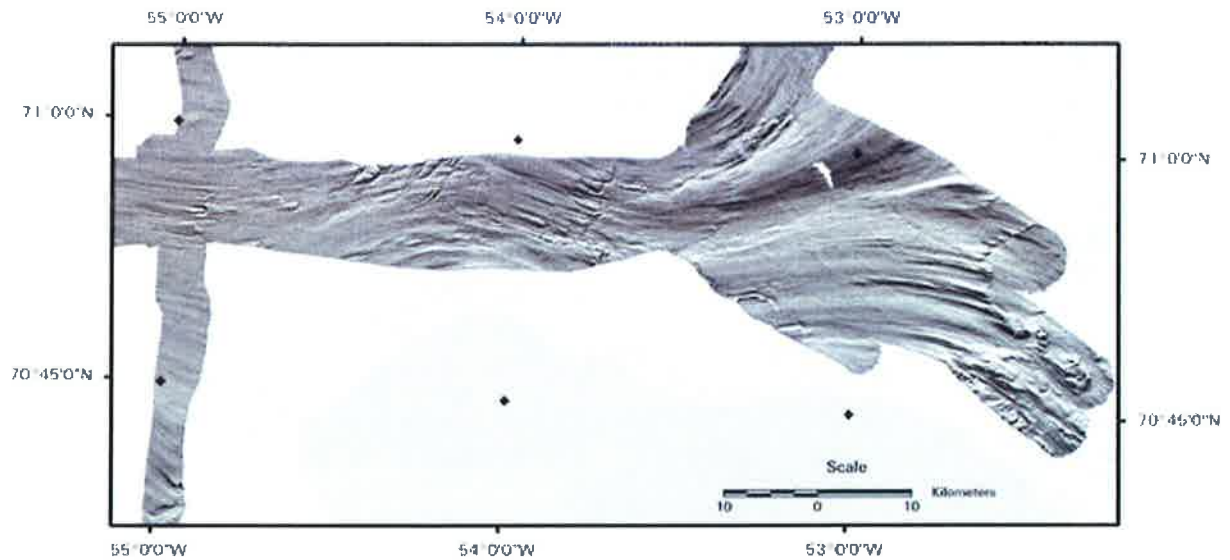


Fig. 6. A 100 km-long section of swath-bathymetric data collected from the Ummannaq Shelf offshore of West Greenland during a cruise of the RRS James Clark Ross. Note the streamlined glacial landforms on the seafloor.

Mapping the Arctic seafloor: A comprehensive Atlas of Submarine Glacial Landforms for Polar waters

In the past two decades there have been several developments that make the production of an Atlas of Submarine Glacial Landforms timely. First is the development of high-resolution imaging technologies: multi-beam echo-sounding that allows the detailed mapping of the sea floor at water depths of tens to thousands of metres, and 3-D seismic methods that enable the visualisation of palaeo-shelves in Quaternary sediments and ancient palaeo-glacial rocks. A second technological development is that of ice-breaking or ice-strengthened ships that can penetrate deep into ice-infested waters, to deploy the multibeam systems. A third component is recognition that the Polar Regions, and especially the Arctic, are particularly sensitive parts of the global environmental system, and are likely to become easier to navigate in the coming decades. An enhanced understanding of the bathymetry sediments and landforms of these fjord-shelf-slope systems is, therefore, of increasing importance to both academics and commerce.

The “Atlas of Submarine Glacial Landforms” (Dowdeswell et al., 2016) (Figures 7 & 8), edited by UK, Spanish, Swedish and Canadian scientists, presents a comprehensive series of contributions that describe, discuss and illustrate features on the high-latitude, glacier-influenced seafloor. Several hundred examples of such submarine landforms have been compiled in this 600-page Geological Society Memoir, published in late 2016. Many contributions include bathymetric data obtained from the UK’s JCR in Arctic waters (Figures 6 & 8). Over 180 papers from over 200 authors are organised in two ways: first, by position on a continental margin – from fjords, through continental shelves to the continental slope and rise; secondly, by scale – as individual landforms and assemblages of landforms. A final

section includes discussion of integrated fjord-shelf-slope systems. The resolution of these marine-geophysical data is from a few to tens of metres in the horizontal and about 1 m in the vertical. The UK-led Atlas project represents the most comprehensive attempt to bring together bathymetric data from many sources to better understand the forms and processes operating on the Arctic seafloor.

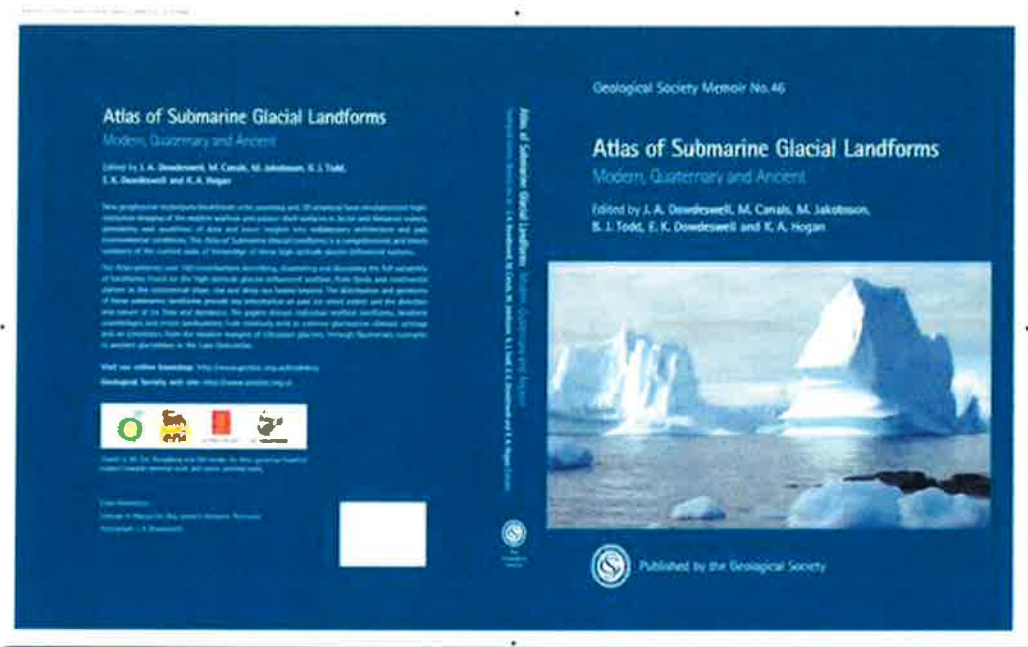


Fig. 7. Cover of the “Atlas of Submarine Glacial Landforms”, a 600-page UK led initiative in collaboration with co-editors from Spain, Sweden and Canada, to produce a comprehensive survey of the floor in the polar seas.

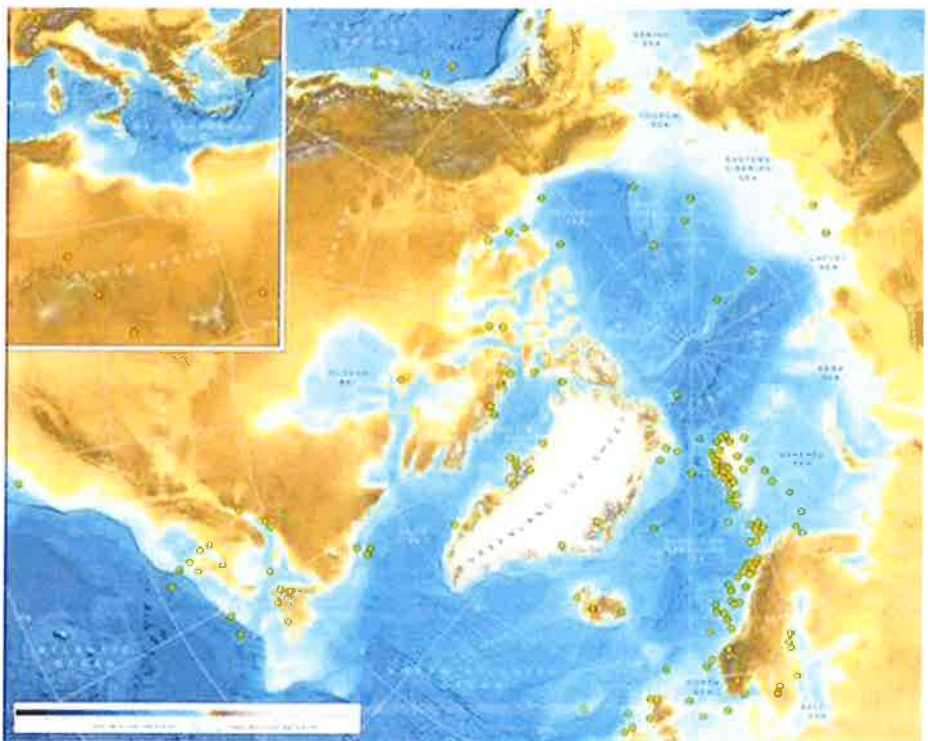


Fig. 8. The Arctic contributions to the “Atlas of Submarine Glacial Landforms” (shown by yellow dots). Each represents detailed swath-bathymetric imagery of specific submarine glacial landforms in Arctic waters.

Nautical Cartography and Marine Information Activities

The UK has a prominent role in the Arctic region, not just with scientific research but also as a leading maritime nation through the role of the UKHO, which continues to be involved in the development of hydrographic services in the region. The increased access to both the Northwest Passage (through the waters north of Canada and Alaska) and the Northern Sea Route (through the waters north of Russia) offers significantly shorter travelling distances between Europe and Asia and will increase shipping traffic in Arctic waters, especially during the summer months. It is widely considered that the use of ice-free Arctic sea lanes could be quicker and cheaper than using traditional shipping routes through the Suez Canal or round the Cape of Good Hope. To support maritime trade, the UKHO produces a global series of navigational charts and supporting publications. These products are designed for the international mariner and are supplied to end users through a global network of distributors. The UKHO recognizes increasing importance of Arctic issues because receding ice is exposing sea areas, about which, little or nothing, is known, but which also opens up opportunities for trans Arctic Ocean navigation. A large proportion of vessels heading for the Northern Sea Route are likely to transit through UK waters. It is therefore important for the UK to monitor and understand any significant increase in cross polar traffic to ensure that navigational support and infrastructure is suitably addressed.

The UKHO maintains a portfolio of charts and publications covering the Arctic region. More recently, Admiralty coverage of the Arctic Ocean has been improved through agreement with Norway on a Bilateral Arrangement for a chart adoption programme, which has improved coverage of Svalbard. The UKHO also plans to rationalise and improve charting coverage within the Barents Sea and Kara Sea following a comprehensive chart-by-chart review of the area. The aim is to produce modern metric coverage that will incorporate the latest hydrographic information available to link the Kara and Barents Seas with our metric North Coast of Norway and Russian White Sea series.

As a global chart producer, the UKHO continually develops its chart, publication and information services portfolio to take account of changing shipping patterns and new trading routes to serve the needs of the international mariner. The UKHO is also mindful of recent IMO guidance for ships operating in Polar Waters and the newly established IMO mandatory ship reporting system in the Barents Sea. There is potential benefit for UK and ARHC Members to work closer together to develop regional cooperation in the light of UKHO's global experience.

As operator of IC-ENC, UKHO is responsible for delivering RENC services including Arctic coverage. This again demonstrates UK's commitment to international collaboration to improve navigational safety. ENC coverage of the Arctic is not well developed at present, but with any increased sea traffic in the region there will be more demands and expectations to provide suitable coverage. UK will continue to support this through RENC services.

General Maritime Interests

The UK is not an Arctic State, but is the Arctic's nearest neighbour. The UK Government's 2018 Policy Framework document on the Arctic (Beyond the Ice - UK policy towards the Arctic [www.gov.uk]) sets out the detail of the UK's interests in the Arctic, how we will work with Arctic States and the wider international community, and what expertise the UK can offer to help meet some of the long-term challenges facing the region.

UKHO's contribution to the UK Government's Arctic policy is recognized in 'Beyond the Ice' which states:

"The UK played an active and influential role in the development of the Polar Code and as Arctic shipping routes become more open we continue to advocate for the highest possible shipping standards and adherence to the Polar Code.

"The UK Hydrographic Office, as a global leader in producing charts and publication services to support international maritime navigation, continually develops its publications to take account of changing shipping patterns, new trading routes. To do so, UKHO maintains strong links with Arctic nations to ensure access to the best available data to serve the needs of the international mariner. Furthermore, the UKHO is developing marine capability in geospatial information management to support the UK's Arctic interests. Such capability will ensure that UK expertise, scientific research, hydrographic surveying, marine cartography and nautical information is suitably integrated to provide comprehensive and efficient information management."

Additionally, the UK engages in Arctic shipping issues through the Arctic Council and specifically its "Protecting the Arctic Marine Environment (PAME) Working Group", and of course other international bodies in which the UK plays a strong role.

Conclusion

The UK government recognises that the Arctic region is of fundamental importance, not only to the people who live and work there but also to the health of the planet. 20 years ago, the UK became one of four original observers to the newly formed Arctic Council. We remain as committed as ever to the Arctic States and the indigenous peoples of the Arctic and to securing a sustainable future for them that benefits us all.

The UKHO is keen to support its near neighbours in the Arctic region by contributing to the development of spatial data management, and by providing a central point of contact for access to data collected in the Arctic region by UK research organisations. The UK is a well-qualified and closely engaged Arctic stakeholder with expertise and knowledge in the fields of science, maritime assurance and commercial governance. The Arctic is a dynamic and hazardous area of the world which requires cooperative effort to meet the international navigational and environmental challenges of the region. Increased shipping in the Arctic has ramifications for navigational safety and environmental protection. Those operating in the

Arctic environment are exposed to many unique risks such as sea ice and icebergs, and extreme weather conditions. The relative lack of comprehensive and modern charts, very restricted Search and Rescue capabilities and the lack of shore infrastructure and other navigational aids, pose additional challenges for mariners. Navigation in Arctic latitudes will continue to be hazardous and uncertain, and great care must be taken by Arctic Stakeholders to ensure navigational safety and environmental protection in the region.

The ARHC Statutes align their objectives (Article 4) to the work and key objectives of the IHO. UK is a major contributing IHO Member State with global (and polar) hydrographic experience and expertise. The UKHO has similar goals of improving regional coordination through participation at IHO Committees, Working Groups and Regional Hydrographic Commission meetings, enhancing the exchange of information and fostering training and technical assistance, in pursuance of the objectives, resolutions and recommendations of the IHO. This contribution to the area facilitates the exchange of hydrographic and marine information and regional cooperation.

This application for ARHC Associate Membership Status describes the UK's current and future contribution to regional collaboration, and scientific research as required by the Statutes. The UK's Arctic interests, expertise, research, hydrographic surveying, nautical cartography and marine MSDI information capabilities, compellingly demonstrate the technical benefits of our work, which would benefit the ARHC in their endeavours for collaboration in the Arctic region.

The UKHO is the central access point for hydrographic data collected in the Arctic region by other UK Government organisations such as the UK National Oceanography Centre (NOC), the British Oceanographic Data Centre, British Antarctic Survey (BAS) and the Scott Polar Research Institute. We have agreements with NOC and BAS to ensure that inter-Government cooperation and exchange of marine and maritime information is efficient and effective. UKHO's involvement in the development of the UK Government's Geospatial Commission indicates our central role in geospatial information management within the UK. We are keen to share our experiences to the benefit of regional partners.

The UK's contributions to the work of the ARHC will be to participate in discussions on the development of MSDI and to highlight current and future UK scientific expeditions to Arctic waters. The UK's attendance at the ARHC Ilulissat Maritime Workshop in 2017 included Professor Julian Dowdeswell (Scott Polar Research Institute, University of Cambridge), who gave a presentation on Mapping the Arctic seafloor: An Atlas of Submarine Glacial Landforms. The UK would be pleased to provide reports/updates on our NERC 2017-22 Arctic Research Programme, and other relevant activities in the Arctic region, to the ARHC on a yearly basis as a further contribution to studying these remote regions.

Mapping the Arctic seafloor: References:

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Jakobsson, M., Mayer, L., Coakley, B., Dowdeswell, J.A., Forbes, S, Fridman, B., Hodnesdal, H., Noormets, R., Pedersen, R., Rebesco, M., Schenke, H.-W., Zarayskaya, Y., Accettella, D., Armstrong, A., Anderson, R.S., Bienhoff, P., Camerlenghi, A., Church, I., Edwards, M., Gardner, J.V., Hall, J.K., Hell, B., Hestvik, O., Kristoffersen, Y., Marcussen, C., Mohammad, R., Mosher, D., Nghiem, S.V., Travaglini, P.G. and Weatherall, P., 2012. The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0.

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Polar research vessels

Royal Research Ship (RRS) James Clark Ross

RRS James Clark Ross contains some of UK's most advanced facilities for oceanographic research. The ship is equipped for geophysical studies, with a compressor bank to power a seismic air gun array, and large aft and starboard decks for scientific equipment deployed by aft and mid-ships gantries. The ship is designed with an extremely low noise signature to allow sensitive underwater acoustic equipment to operate effectively.

RRS Sir David Attenborough

Construction is progressing on the RRS Sir David Attenborough – one of the most advanced polar research vessels in the world. From 2019 onwards scientists researching oceans, ice and atmosphere will have access to state-of-the-art facilities on this floating multidisciplinary research platform.

This new research platform will transform how ship-borne science is conducted in the Polar Regions. The commissioning of the RRS Sir David Attenborough is part of a major Government polar infrastructure investment programme designed to keep Britain at the forefront of world-leading research in Antarctica and the Arctic. This £200m commitment represents the UK Government's largest investment in polar science since the 1980s.

With greater fuel efficiency and an ability to use remotely operated and robotic technologies, the ship is expected to reduce the environmental impact of ship-borne science and save more than £100m in operating costs over its 25-year lifespan.

The RRS Sir David Attenborough's design optimises her ability to support science in extreme environments. A wide range of specialist scientific facilities, instruments and laboratories will enable scientists to conduct a wide range of multi-disciplinary sciences to study the ocean, seafloor and atmosphere. Data from the deep ocean and under-ice inaccessible locations will be captured using robotic and remotely operated devices.

While the ship will have a number of laboratories on board, the increased space for containerised laboratories from RRS James Clark Ross introduces a new level of flexibility in science support. As technologies and techniques change the containers can be reconfigured to ensure research teams have what they need to conduct world-leading science.

See: <https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/rrs-sir-david-attenborough/>

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