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A strategy for meeting the needs for marine-based research in the Arctic

Deliverable 1.4. Identification report on contribution of a coordinated PRV fleet to fulfilling EU member states' research interests in the Arctic Ocean

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Abstract

The study of the Arctic Ocean has become a priority area of research and innovation in Europe during the past two decades. This report reviews a series of recent national and pan-European Arctic research policies. It illustrates national and international research priorities, the urgent knowledge and data gaps as well as restrictions in accessing research. It then explains how a coordinated PRV fleet would contribute to fulfilling the common European research goals in the Arctic Ocean. The societal impact of this coordination action would be significant as the benefits include improved forecasting and climate projections, contribution to the development of mitigation strategies for the local and global effects of the changing cryosphere and better tools for ecosystem-based management of the Arctic.

1. Introduction

ARICE is a European Union Horizon 2020 integration action for starting communities. Its aim is to improve the use of existing Polar Research Vessel (PRV) capacity at European and international level by improving their coordination and avoiding duplication of efforts and by working towards an International Arctic Research Icebreaker Consortium.

ARICE Work Package 1 (WP1) "Towards an Arctic Research Icebreaker Consortium" contributes towards these efforts by organizing of workshops, conducting desktop analyses, providing guidelines and suggestions and Terms of References, as well as by linking researchers and PRV operators.

This deliverable is the third desktop analysis out of the total of five deliverables in WP1 that together present a coherent global picture of the resources and potential of enhanced collaboration between PRV fleet operators as a basis for the further multinational co-operation.

The previously conducted desktop analysis, Deliverable 1.2. *Guidelines on the conditions to access European PRVs* reviewed the status of the European Arctic Research Vessel fleet and their accessibility (ARICE 2019a). Deliverable 1.3. *Map of potential beneficiaries of a coordinated PRV fleet* identified four overarching categories of beneficiaries and explained how bettering European coordination of PRVs would require significant, but mutually beneficial to all these four groups, changes in the ways the funding of research on and access to PRVs is organized (ARICE 2019b). This report European research priorities in the Arctic Ocean and explains how the better coordination of PRVs would contribute to fulfilling them.

The materials used in this report include individual European Union (EU) countries' policies. The focus is, however, on the following four common European policy papers, statements and studies:

1) European Commission's Joint Communication (2016/21) to the European Parliament and Council, "An integrated European Union policy for the Arctic."
2) Report of the 2nd Arctic Science Ministerial, CO-OPERATION IN ARCTIC SCIENCE – CHALLENGES AND JOINT ACTIONS. 25–26 October 2018. Berlin, Germany.
3) EU-PolarNet (2016) Deliverable 2. 1 Report on prioritised objectives in Polar Research.
4) EU-PolarNet (2019b), The EU-PolarNet White Papers.

2. European states' research interests in the Arctic Ocean

The changes in the environment and climate of the Arctic region and their couplings to lower latitudes have become a high priority research area in national research and development strategies

of both Arctic and non-Arctic European states. The reasons for this are geographic, strategic and economic.

Of the eight Arctic Council member states, three are also member states in the European Union (EU)(the Kingdom of Denmark, Finland, and Sweden), and two (Iceland and Norway) are members of the European Economic Area (EEA). Of the non-Arctic European states some, such as Germany and United Kingdome, operate PRVs and maintain devoted world leading polar research institutes. Others, such as France, Switzerland, Portugal, Spain, Italy and Poland have not invested PRVs in the Arctic but have built strong polar research programmes and research stations in the Arctic.

The research interests of both the Arctic and non-Arctic states evolve around the new challenges and opportunities associated with climate change. France for example summarizes to have scientific, economic, ecological ethics, political and defence interests in the Arctic (Ministére des affaires étrangéres et du développement international 2016, 57). Germany identifies three pillars as the basis for its Arctic engagement: Arctic research activities; sustainable realization of economic opportunities; and protection of the Arctic environment and fight against climate change (Arctic Institute, 2019). Sweden's Arctic policy priorities are likewise threefold: climate and the environment; economic development; and the human dimension (Government offices of Sweden, 2011.)

Next to these new developments in national traditions of investing into Arctic research, the EU has formulated a common Arctic research and innovation policy and has expressed interest in playing a key strategic role in the development of the Arctic region (JOINT, 2016/21; European Commission 2018).

Because Arctic research is intrinsically linked to the use of research icebreakers and polar research vessels in adjacent areas, its coordination, both at European and international level, are crucial to fulfil the needs in Arctic research.

2.1. European Union's Arctic Policy

In JOINT (2016/21) the European Commission (EC) explains the need for an integrated European Union to the Arctic region by referring to how a "safe, stable, sustainable and prosperous Arctic is important not just for the region itself, but for the European Union (EU) and for the world." The reasons for this regional and global importance of the Arctic are explained to be principally connected to the predicted impacts of climate change in the Arctic region and their connections to lower latitudes, the role of Arctic in global geopolitics and the new economic opportunities connected to these changes.

EC acknowledges that the Arctic states have primary right for deciding how to tackle issues within their sovereign territories. However, many of the issues affecting the Arctic region such as long-range transportation of air pollutants and persistent organic pollutants originate from lower latitudes and can be only addressed through regional and multilateral cooperation.

JOINT (2016/21) identifies the following three priority areas for EU's engagement with the Arctic and the eight Arctic states:

i) Climate Change and Safeguarding the Arctic Environment

ii) Sustainable Development in and around the Arctic

iii) International Cooperation on Arctic Issues

In the description of the suggested common actions to be taken in all three areas, importance is placed on research, science and innovation, especially in fulfilling the following goals and solving the following problems:

- basic understanding of the Arctic systems, their functions and possible responses to various climate drivers are still largely unknown
- to better assimilate Europe's scientific and operational capabilities in the Polar regions the EU should continue to promote and facilitate effective international scientific cooperation through supporting transnational access to research infrastructure
- The EU should promote establishing marine protected areas (MPA) in the Arctic
- There is need to obtain more information on ecosystems in the Arctic Ocean before opening up this region to commercial fishing
- To fill gaps in the available marine data about the seabed in the seas and oceans around Europe and the life they support

These specifications reflect the prioritized research areas in the national Arctic policies of European Union member states.

2.2. Polar Research Priorities in Europe

EU-PolarNet is a HORIZON 2020 Coordination and Support Action that takes place between 2015 and 2020. One of its main achievements has been that it has brought together the world's largest consortium of expertise and infrastructure for polar research that has been aimed at developing and delivering as "strategic framework and mechanisms to prioritise science, optimise the use of polar infrastructure, and broker new partnerships that will lead to the co-design of polar research projects that deliver tangible benefits for society" (Eu-PolarNet 2019a).

To further its goals, in 2016 Eu-PolarNet conducted a comprehensive desktop study on EU, national and organizational recommendations and priorities for Arctic research and how they connect to Arctic and European social needs and benefits. The study was followed by the compilation of five whitepapers that identified "research topics of most relevance to society and timeliness for their delivery" (EU-PolarNet 2019b, 2).

The desktop study and the whitepapers identify ten overarching, common prioritized themes in European polar research. Of these ten themes, four are particularly dependent on data from the Arctic Ocean that can only be retrieved by PRVs in Polar Code's Category A (ARICE 2019a). They and their societal relevance are as follows:

1. Polar Climate System

The research of polar climate and its couplings to global climate conditions has progressed rapidly during the past decade especially in the numerical development of individual model components of polar systems such as atmosphere, ocean and ice. However, the complex interfaces between different natural physical processes necessary for forecasting and climate projections remain poorly understood.

The focal point for improving the basic understanding of the couplings is the empirical study of the physical and chemical processes in the Arctic Ocean. Here access to ice-covered parts of the Arctic Ocean year-round is vital to capture Arctic specific processes, especially atmosphere-ocean-ice interactions. This research is only possible by means of icebreakers in Polar code category A (Polar

Class 1 to 5), i.e. vessels that can operate year-round it at least medium first year ice with inclusions of older ice.

Because of the central role of the Arctic in climate change the improved understanding of the region specific processes will improve predictability of global coupled climate models benefit the societies environmental policy, ecosystem management, and businesses locally and well beyond the Polar Regions (EU-PolarNet 2019b, 6-7: EU-PolarNet 2016)

2. Cryosphere

In order to create good mitigation strategies for the global and local effects of the changing cryosphere as a result of global warming, it is urgent to know "how polar ice sheets will react to the warming, how much and how fast the global sea level will rise and how the global circulation (and consequently the latitudinal heat transfer and precipitation) will change." (EU-PolarNet 2019b, 8) Another set of commonly prioritized questions for cryosphere research and monitoring in Europe include measuring and modelling the risk associated with greenhouse gas emissions from thawing sub-sea permafrost (EU-PolarNet 2016, 13). All these research topics warrant the use of PRVs and have significant societal implications. Ocean-ice sheet interactions will contribute to sea level rise requiring work in challenging conditions at the ocean – land/ice interface. Thawing sub-sea permafrost may affect marine infrastructures and preparing for both is essential to manage the risks to coastal communities, precious coastal ecosystems and major capital assets both locally and globally (Eu-PolarNet 2016, 18).

3. Palaeoclimate and Palaeoenvironment

To project the future, we need to know the past. In many cases, the lack of direct observational data from the Arctic necessary for improving future climatic projections can be addressed by gathering data using paleoclimate proxies in ice and sediment strata such as composition of air bubbles and dust trapped into ice layers, or of the fossils and minerals contained in sediments. These proxies tell about environmental and climatic changes such as precipitation/accumulation rates, sea ice covered or open waters. (Eu-PolarNet 2019b, 12) To gather these records of environmental (physical, biochemical and ecosystems) conditions before the collection of modern instrumental records requires PRVs with sediment coring capacity are of vital importance because only they can provide the infrastructure needed for the collection of marine sediment cores in challenging sea-ice conditions (Eu-PolarNet 2019b, 8, 22-23).

4. Polar Biology, Ecology and Biodiversity

Data from the ice-covered parts of the polar oceans is missing, especially when it comes to biogeochemistry and ecology. Polar ecosystems are vulnerable to rapid environmental changes, ocean acidification one of the most imminent threats in the Arctic Ocean. While there are prospects that unidentified polar marine species can provide for new biotechnology and biomedical applications, and the polar marine food web has been recognized as crucial for harvesting of living resources (fisheries, hunting, etc.), threats to this ecosystem will directly affect Arctic residents but also commercial fisheries. Thus, there is a great need for fundamental exploration of the polar marine ecosystem, especially in ice-covered waters, before these ecosystems irreversibly change. (Eu-PolarNet 2019b, 20-27)

In addition to the above four priority themes that can make most benefit from PRV based operations, also several other research areas that require PRV based operations in the Arctic Ocean are mentioned in the Eu-PolarNet materials. These include the study of pollutants/contaminants in the

ocean, increased exposure to ultraviolet radiation in the ocean (due to less ice and ozone depletion), sustainable fisheries, and exploitation of Arctic oil and gas reserves (Eu-PolarNet 2016. 12,21).

Coordinated European PRV fleet would contribute to fulfilling the common European research needs in the Arctic Ocean in these four areas through the development of common solutions to gaps in capacity, coordination and knowledge.

3. European Arctic Ocean research: capacity, gaps and challenges

The European PRV fleet used to study these regions is small compared to the scientific demand for research vessels in ice-covered parts of the Arctic and in Antarctica (EMB 2019). ARICE (2019a) illustrated how the actual capacity for Arctic research operations is limited not only by the low number of PRVs available to do research in ice covered waters, but as well by the logistical supply/icebreaking duties these few European PRVs are used for. As a result, there are many areas in both the Antarctic and the Arctic margin and Ocean, which are still unexplored because they are too remote to be accessed considering the budget and the logistic needs of national projects (Dañobeitia et al. 2015, 9).

The 2nd Arctic Science Ministerial referred to this high cost and future return of common investments by highlighting how "research and observations are essential for predicting the evolution of changes in the Arctic and their impacts on regional to global scales." (*Report of the 2nd Arctic science Ministerial 2018*, 13). Observations and research require costly infrastructures. No single nation can tackle the operational and logistical requirements for fulfilling all the common goals, scientific demand for conducting research in Arctic in all seasons. This is especially true when it comes to the study of the Arctic Ocean.

The available European research fleet of PRVs with Polar code category A (Polar Class 1 to 5), i.e. vessels that can operate year-round it at least medium first year ice with inclusions of older ice is limited and aging. There are currently only three heavy icebreakers (capacity of operate year-around in ice with multi-year ice inclusions) in operation in the EEA: PRV Polarstern (Germany), IB Oden (Sweden) and PRV Kronprins Haakon (Norway). There are currently also three vessels in the Polar Code Category A (Polar Class 4 and 5), which can operate year-round in ice dominated by first-year ice. Two of them are in the United Kingdome (RRS James Clark Ross and RRS Sir David Attenborough, both PC4) and RV Astrolabe (France). However, RRS James Clark Ross will be decommissioned in 2020 and replaced by the new RRS Sir David Attenborough. RV Astrolabe is used exclusively in the Antarctic. (EMB 2019)

ARICE (2019a) explained how access to these PRVs is almost completely limited to national research programs. However, as mentioned above, several EU nations that have strong polar programs, do not operate their own PRVs, which limits accessibility and hinders the full use of EU's intellectual capital and capacity.

4. Benefits of a coordinated fleet to fulfilling EU member states' priorities in the Arctic Ocean

The four polar research priority areas in Europe underline how there is a pressing need to collect scientific data from previously inaccessible areas in the Arctic Ocean especially during the winter season. The summary of these areas also highted how there are specific gaps in the study of marine food webs, particularly in the coastal, deep sea and under-ice environments in the Arctic Ocean. It is also not only polar ecology but also the study of climate, cryosphere and paleoenvironment that

require this geographical and temporal data. To gain this data requires access to PRVs (year-round or at least in winter) in the Arctic Ocean.

As mentioned in ASM2 these monitoring and research efforts in the Arctic Ocean are beyond the capacity of a single nation. To meet the demands and requirements of research in the region there is a need for increased and improved cooperation among countries, research institutions and communities, and in the joint and coordinated use of expensive infrastructure, including research vessels. Having an umbrella of European research priorities to guide at least part of the PRV research ship time allocation and scheduling at the European level would especially help those countries that have strong polar programmes but not their own PRVs to implement their polar research in a collaborative way. Better coordination of European PRVS would, hence, fulfil these research needs while also fulfilling EC's objective on increased **international cooperation on Arctic issues.**

Next to enforcing cooperation in the Arctic, better coordination between the countries with PRVs would allow more efficient use of the existing PRV fleet (ARICE 2019b, 9). As many vessels work in both polar regions, this coordination would increase the ship-time available for research in both the Arctic and Antarctica. Furthermore, research vessels also typically carry sophisticated bottom sounders, that can provide lacking information to improved bathymetric charts and thus for future safe operations in Arctic waters (Arctic Council 2009). Together with the research in climate, ecology, paleoenvironment and biodiversity in the Arctic Ocean this data provides the bases for fulfilling EC's second goal of **sustainable development in and around the Arctic.** It is not only improved logistics and observations but also research capacity that would increase through the better coordination of PRVs.

As mentioned above, not all countries with polar research programmes have their own PRVs in the Arctic. Coordinated fleet would, thus, not only allow for the placement of the right vessel at the right place but also the right scientist in the right vessel. This would contribute to the full use of EU's intellectual capital and capacity, which would significantly contribute to better understanding, mitigation and preparedness for Eu's third priority area in its Arctic policy: **climate change and safeguarding the Arctic environment**.

5. Conclusion:

The study of the Arctic Ocean has become a priority area of research and innovation in Europe during the past two decades. The reasons for this are geographic, strategic and economic. On the one hand, the changes in the cryosphere of the Arctic Ocean are seen to open new economic opportunities reaching from bioprospecting to shipping and increased mineral resource use. On the other hand, the impacts of these changes to existing economies, societies and ecosystems services are uncertain.

The European Commission's Arctic policy document highlights how research and innovation are the corner stones in harnessing these opportunities and responding these challenges by fulfilling objectives in three priority areas: i) Climate Change and Safeguarding the Arctic Environment, ii) Sustainable Development in and around the Arctic, and iii) International Cooperation on Arctic Issues. Advances in all require increased access to the Arctic Ocean. More specifically, in responding to the common, European research interest in climate systems, cryosphere, palaeoenvironment and polar ecology have highlighted how access to the Arctic Ocean, especially in the wintertime, is a prerequisite to responding the new societal needs and challenges of the changing Arctic.

Resent collaborations in Arctic science and policy have highlighted how monitoring and research in the Arctic are beyond the capacity of single nation. Getting to the sites where gaps in knowledge are the greatest in the Arctic Ocean would require increased and improved cooperation among countries, research institutions and communities, and the joint and coordinated use of expensive infrastructure such as PRVs. Because of the key role of the Arctic in earth system sciences and the lack of previous data this coordination in research and innovation that would lead to high returns in collaboration, research and innovation. These returns in Europe would be further amplified as the capacity and infrastructure of the European Polar fleet is currently insufficient to even fulfil the needs of the national research communities of countries operating PRVs.

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