The Research Council of Norway

Norwegian Polar Research

An Evaluation

Evaluation
Division for Energy, Resources and the Environment

Content

Preface

Polar research receives increasing interest internationally due to the large environmental changes occurring in polar regions, the role polar regions play in shaping global climate processes, and the large impacts and opportunities the changes may have on society. The unprecedented change and speed in Arctic environmental change, with Arctic temperatures increasing 2-3 times the global average, the possible tipping points and state shifts in the climate system, and the global impacts of unstable Antarctic ice shelves, call for urgent implementation of integrated monitoring programmes and coordinated national and international research and funding policies and programmes.

Polar research is a high priority in Norway with public funding partly from Ministries, the Research Council of Norway (RCN) and the EU. Some large private companies also contribute with research funding of relevance to polar areas. The mapping of Norwegian polar research in 2015 (NIFU report Norsk Polarforsking – forskning på Svalbard), gives a comprehensive overview of resources and publication output, in an international perspective. According to the report, Norway ranks as the world's fifth-largest polar research nation in terms of publication volume. In the Arctic, Norway is on the third place, only out-numbered by US and Canadian papers.

The mapping exercise did not assess organisation and prioritisation of Norwegian polar research, nor does it propose recommendations to the structure and levels of national funding instruments and coordination. The Research Council therefore with this evaluation report presents the first full thematic evaluation of Norwegian polar research. The evaluation provides a critical review of Norwegian polar research in an international perspective and is tasked to recommend measures to enhance the quality, efficiency and relevance of future polar research. The evaluation reviews the landscape of polar research in Norway, not single institutions. It also gives special attention and recommendation to help improve the quality and impact of Svalbard research, responding to the requirements put forward in the recent White Paper on Svalbard (Meld.St. 32 2015-2016 - Svalbard).

We expect that this evaluation gives helpful advice to the Research Council, to relevant Ministries and also directly to the research institutions and communities, providing measures to further develop Norwegian polar research, and the research in Svalbard. The work has been carried out effectively and efficiently by the members of the evaluation committee and the secretariat SALT. We are grateful to all and would especially like to thank David Carlson for leading the work. We would also like to thank all participating research units for their time spent on contributions to facts and information, as well as interviews with selected major units. We appreciate this support which has been fundamentally important for the committee in compiling a comprehensive and reliable report.

Oslo, Norway, June 2017

Fridtjof Unander
Executive Director
Division for Energy, Resources and the Environment
The Research Council of Norway

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Executive Summary

In late 2016 the Research Council of Norway (RCN) initiated an evaluation of Norwegian polar research with a relatively broad mandate:

> *"The evaluation is to assess research quality, impact, effectiveness, national and international cooperation, relevance, and make recommendations on future Norwegian polar research. The evaluation shall direct particular attention towards the role played by the RCN and give advice on how Norwegian polar research organisation, funding and coordination could be improved. The evaluation shall also give advice how Svalbard as research platform can be developed in order to increase the quality and impact of national and international research."*

The Research Council of Norway recruited a chair and nine distinguished polar scientists to serve as an expert review team. Collectively the Evaluation Committee come from eight countries and represent a broad range of scientific specialities.

We worked relatively rapidly through a large assemblage of information. We reviewed the written RCN mandate to this Committee and heard detailed presentations from RCN. We focused on the document "Norwegian polar research - Research policy 2014-2023" (RCN 2013). We looked carefully at prior bibliometric analysis of Svalbard publications and advised NIFU on plans for subsequent bibliometric analyses covering the full range of Norwegian polar research. We evaluated the RCN-sponsored evaluation of Norwegian climate research ("Norwegian Climate Research, An Evaluation" RCN 2012) and its impacts. We worked with our Secretariat, SALT, to set an overall workplan and schedule.

Our tasks included:

- Compiling existing strategies and goals for Norwegian polar research
- Establishing a backdrop for the analysis
- Collecting information from the community of Norwegian Polar Research
- Preparing an overview of Norwegian Polar Research in an international context
- Evaluating the relevance of Norwegian polar research in relation to societal challenges
- Writing and submitting an evaluation report

We relied on the SALT workplan and Secretariat and on prior connections to and databases of polar organizations compiled by RCN. We met face-to-face three times - including substantial time devoted to in-person interviews with polar researchers conducted in both Oslo and Tromsø - and by teleconferences approximately monthly, over 6 months.

We used four primary data sources:

- A prior mapping of polar research (Norsk polarforskning - forskning på Svalbard, Aksnes 2015) and the databases that enabled and supported that study.
- A fresh bibliometric analysis of Norwegian Polar Research publications (Norwegian Polar Research & Svalbard Research Publication Analysis, Aksnes 2017) covering the period 2010-2014. We added a small additional step based on research publications nominated by polar organizations.
- Self-evaluation materials received from 38 organizations.
- A series of 13 dialogue meetings.

We conducted interviews with top-level management of key polar organizations. We looked at additional information including plans related specifically to Svalbard and Ny-Ålesund.

As we evaluated this large volume of material over a relatively short time period, we addressed critical questions about the validity of our information:

- Do bibliometric analyses represent a fair and valid basis for internal assessment and external comparison?
- Did we, through self-evaluation surveys, receive an appropriate response from leading polar research organizations of Norway?
- Can we, from frank and enthusiastic face-to-face interviews, identify consistent topics and concerns so that we base our findings and recommendations on persistent issues identified by multiple sources?

We made extensive but cautious use of bibliometric analyses, based on recognition that published scientific papers in indexed peer-reviewed scientific journals may not represent the preferred outcome for all of Norway's polar research efforts. We received evaluation materials from all of the ten largest polar research organizations in Norway. Through our dialogue meetings, we spoke directly with scientific and administrative representatives of all responsive major players in Norwegian polar research. In general, each issue addressed in the evaluation arose from at least two separate interviews heard by at least two of our three interview teams. Our schedule allowed no time for follow-up.

From the wide variety of ideas and topics presented by Norway's polar organizations we extract several pervasive and compelling themes:

- *Arctic climate system*: Changes in Arctic sea ice extent and snow cover impact and respond to oceanic and atmospheric circulations. Changes within the Arctic Ocean affect circulation, heat content and marine productivity. Norway, proximal to the North Atlantic Arctic gateway and with Svalbard as an Arctic doorstep, has opportunity, urgent national need, and an international role to understand and predict the future Arctic and its interactions with global climate.
- *Arctic ecosystems*: Norway sits in exactly the crucial geographic, scientific and economic position to understand how marine organisms and ecosystems will adapt, evolve and survive in a changing acidifying Arctic.
- *The Arctic biogeochemical environment*: Local- and externally-produced contaminants and pollutants accumulate in the Arctic. The role of Arctic marine and terrestrial ecosystems as carbon sources or sinks remains unclear. A coherent Arctic environment program would meet national and international needs.
- *The commercial and industrial Arctic*: As commercialization accelerates, Norway needs forecasting tools necessary to assure safe operations, useful knowledge on polar engineering, and better understanding of how humans can and should work in cold environments. Effective solutions emerging from Norwegian research partnerships will resonate and propagate throughout the Arctic.

Norwegian researchers likewise identify scientific urgencies related to glacier and ice-sheet dynamics on the Antarctic continent and on Southern Ocean ecosystems. They express a need for research on outer atmosphere physics and seafloor geophysics. They encourage increased attention to substantial issues related to indigenous and local livelihoods and culture in the context of rapid Arctic change.

To meet these challenges, the Norwegian polar community calls for:

- Norway to take a leading role in scientific and political affairs relevant to both the Arctic and Antarctic.
- Recognition of and funding strategies responsive to the high costs of polar research, infrastructure and facilities.
- Stronger, clearer national priorities for polar research.
- Greater overall coordination of polar research, including better and more transparent coordination of polar research facilities and infrastructure.
- Re-definition of Norway's Arctic geographic boundaries to facilitate effective integrated Arctic research.

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Our findings

We identify many strengths within Norway's polar research programs. We identify clear and compelling directions that could emerge from and engage the research community. We see cold-region technology and engineering as a strong component of Norway's polar research. We applaud Norway's initiative on the new ship and recognize a positive contribution from the Nansen Legacy project. The Norwegian research community makes very good use of Svalbard for research and education. We identify strong justification for continued Antarctic research. We find no major deficiencies in the number or quality of publications by Norwegian researchers. We detect very strong political commitments by Norway to national and international polar research.

We likewise identify key weaknesses. Polar research across Norway involves a large number of universities, organizations, institutions and companies without clear processes for coordination and collaboration. This relative fragmentation imposes barriers to focus, to assembling critical mass, and to communication. The present funding model tends to deter rather than encourage collaboration. Recruitment and retention of young researchers represents a serious challenge. Government funding for polar research occurs through multiple routes often with disparate priorities. Norway takes prominent geopolitical roles for Svalbard and Antarctica but Norway's polar research community remains uncertain and uncoordinated in developing and implementing science and infrastructure plans for either region.

Our recommendations

We recommend that Norway take advantage of the opportunity represented by new ships, new projects and strong political support to undertake a serious revision of how it coordinates and funds polar research.

1. Norway should **enhance quality and impact of its polar research** by:
   a. Developing and implementing a plan for recruitment and retention of a diverse next generation of polar researchers;
   b. Continuing and strengthening the combinations of environmental monitoring with fundamental research and the focus on safe clean polar operations;
   c. Developing community coordination mechanisms to focus on priority areas where Norway can excel; and
   d. Establishing and promoting a national open data policy and culture.

2. Norway should:
   a. open a much **larger fraction of polar research funds to open competition**; and
   b. establish mechanisms, incentives and practices that develop and encourage a sense of collaboration and opportunity among national researchers.

3. Norway should establish a clear accessible **national coordination function for polar research infrastructure**, including ships, field stations, and major instrumentation.

4. Norway should:
   a. Promptly implement a clear focused plan for polar research and education at Svalbard, with particular attention to the roles of UNIS and Ny-Ålesund;
   b. Provide clear information about access policies and procedures to national and international researchers; and
   c. Ensure that all activities enhance the environment of Svalbard.

5. Norway should establish a clear focused basis for effective Antarctic research.

Overall summary

We identify a strong and effective group of polar researchers whose work covers a wide range of topics relevant to Norway and to urgent changes in polar environments. We confirm that Norway's polar researchers publish at about the same quality level and in approximately the same quantity as polar researchers from other major research nations. We perceive a very strong political interest and investment by Norway in polar research. At the same time we detect a persistent sense that Norway's polar research could and should achieve a higher level of performance and coherence. We get a sense of polar research remaining a half-step behind rapid changes in, and the rapid commercialisation of, polar environments. We affirm that Norway's polar research community has the talent and resources to take serious steps forward.

We recommend organisational and behavioural changes that will encourage bottom-up inclusive setting of priority research areas for Norway's polar science and ensure abundant and open opportunities for participation in those research activities. We call for enhanced community-based priority setting combined with inclusive and transparent options for participation. Future polar research will require multi-author, multi-institutional, multidisciplinary and multinational processes and products. By making substantial changes to its polar research programs, Norway can favour and encourage its own polar researchers while setting a positive international example. ❖

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The Evaluation Committee

Secretariat (SALT Lofoten AS)

1 Introduction

Research Council of Norway assembled a Committee of eminent polar scientists to evaluate polar research across Norway. We evaluated publication records, solicited written evaluations from the polar organizations, and interviewed polar researchers.

In late 2016 the Research Council of Norway (RCN) initiated an evaluation of Norwegian polar research. The RCN framework for that evaluation provided a relatively broad mandate:

> *"The evaluation is to assess research quality, impact, effectiveness, national and international cooperation, relevance, and make recommendations on future Norwegian polar research. The evaluation shall direct particular attention towards the role played by the RCN and give advice on how Norwegian polar research organisation, funding and coordination could be improved. The evaluation shall also give advice how Svalbard as research platform can be developed in order to increase the quality and impact of national and international research."*

The present evaluation occurs relatively soon after the production (by RCN) of a Research policy for Norwegian polar research (RCN 2013) which specifies Norway's objectives for polar research:

> *"The objective of polar research is to enable Norway to fulfil its special responsibility for acquiring the knowledge needed to implement policy, management and economic activity in the polar regions."*

That policy document also highlighted an additional reason for evaluation:

> *"The most recent mapping (referring then to NIFU report 3-2012) of polar research activities shows that researchers in Norway lag behind researchers in leading nations with regard to citation frequency."*

That motivation, to understand apparent deficiencies in the fundamental quality of Norwegian polar research, persisted through a subsequent study focused on Svalbard (Aksnes 2015) and emerged again in prominent place in the mandate for this study. We undertake an extensive and careful evaluation of that issue in this report.

This report appears ten years after the global stimulus of the International Polar Year 2007-2008. It appears as Norway places a new vessel, FF Kronprins Haakon, into service for polar research, at the onset of the large multi-institutional Nansen Legacy project within Norway, and almost simultaneous with the release of the latest iteration of the Snow, Water, Ice, and Permafrost in the Arctic assessment produced by the Arctic Monitoring and Assessment Program of the Arctic Council (AMAP 2017). Polar research, acccompanied by effective messages from the polar research community, added to the motivation and momentum for the Paris climate agreement. Polar research will play an increasing role as countries confirm their commitments to the Paris agreement and to Sustainable Development Goals, and as the UNFCCC initiates a series of global stocktakes.

Side bars
Review committees such as ours often recommend ideal 'solutions' that have proven impractical or unpopular elsewhere. We insert these boxes in the report to indicate fresh or even radical changes that could push Norwegian polar research in interesting directions.

Separate from paper agreements, the scientific need for exploration, analysis and prediction of polar regions remains emphatic. Ice sheet contributions to sea level rise, impacts of ice-derived freshwater on ocean circulation, impacts of sea ice retreat and snow cover loss on northern hemisphere atmospheric circulations and on marine and terrestrial ecosystems, the impacts of Southern Ocean and northern permafrost on global carbon cycles - any list of urgent climate issues requires polar research at almost every turn. Issues faced by polar communities - food security, water resources, migration pressures, economic interdependencies - already resonate globally. Social, political and economic interest in and pressure on the north will only grow. In this context Norway must attend to its polar research portfolio.

1.1 The Evaluation Committee and the Evaluation Process

The Research Council of Norway initiated this review process by soliciting Dr D Carlson to serve as chair for an evaluation »

Committee. Next, RCN, in consultation with the Committee chair, recruited nine distinguished polar scientists to serve as an expert review team (pictures on page 6). Collectively we come from eight countries and represent a broad range of scientific specialities. Many of us knew each other from our participation in the International Polar Year. To accomplish this evaluation we worked very effectively by Skype, through shared on-line documents and in three face-to-face meetings. As detailed below, we worked relatively rapidly through a large assemblage of information.

We share concern for the health and well-being of our planet and its inhabitants and an understanding that the present health of this planet depends acutely on processes occurring in polar regions. We do not, and do not expect to, find ourselves in full agreement on details and aspects. Our report represents a majority rather than consensus view. We view a degree of disagreement as a positive indication of the scientific breadth and deep competence of the Committee and as a clear indication of our serious respectful approach to this important and demanding task.

1.2 The Evaluation Tasks

We started by reviewing the written RCN mandate (Appendix 1) to this Committee and hearing a detailed presentation from RCN. We focused on the recent RCN document "Norwegian polar research - Research policy 2014-2023" (RCN 2013).

We looked carefully at prior bibliometric analysis of Svalbard publications and heard from Dr Aksnes about his plans for subsequent bibliometric analyses covering the full range of Norwegian polar research. We evaluated the recent RCN-sponsored international evaluation of Norwegian climate research ("Norwegian Climate Research, An Evaluation" RCN 2012) and heard from RCN their assessment of that process and impact of that report. We worked with our Secretariat, SALT, to set an overall workplan (Appendix 2) and schedule. Our projected tasks included:

- Compiling existing strategies and goals for Norwegian polar research
- Establishing a backdrop for the analysis
- Collecting information from the community of Norwegian Polar Research
- Preparing an overview of Norwegian Polar Research in an international context
- Evaluating the relevance of Norwegian polar research in relation to societal challenges
- Writing and submitting this evaluation report

In accomplishing these tasks we relied heavily on the SALT workplan and Secretariat and on prior databases of polar institutions compiled by RCN. We met face-to-face three times - including substantial time devoted to in-person interviews with polar institutions conducted in both Oslo and Tromsø - and by teleconference approximately monthly, all in the course of 6 months.

1.3 Data sources

We used four primary data sources.

1.3.1 Previous mapping of polar research

A prior effort - Norsk polarforskning - forskning på Svalbard (Aksnes 2015) - and the NIFU and RCN databases that enabled and supported that study served as important background material and as a natural starting point for this evaluation. We note from the summaries of hours worked in that analysis that polar institutions in Norway reported more than 20% of their efforts devoted to "Technology". Institutions reported another 2% or so of work hours devoted to "Social Sciences and Humanities". Those research topics, particularly the substantial efforts in polar technology, emerge again in this report.

1.3.2 Bibliometric Analysis

At RCN instigation, NIFU conducted a fresh bibliometric analysis of Norwegian Polar Research publications - "Norwegian Polar Research & Svalbard Research Publication Analysis" (Aksnes 2017) - primarily covering the period 2010-2014, to support the work of this Committee.

NIFU conducted the present analysis based on publicly available publication data. They specifically analysed publications containing polar research content indexed in the Thomson Reuters ISI Web of Science database. Web of Science indexes most core disciplinary and geographically-specific Journals, with sufficient detail to allow application of geographic search terms and keywords related to Arctic and Antarctic research. This study focused on Norwegian polar research generally for the years 2010 to 2014 but also included a specific focus on Svalbard research and on information that allowed us to explore Norwegian publication performances over time and in comparison to information from other countries. This primary evaluation considered, to the extent possible, all research publications involving Norwegian polar researchers as retrievable from the Web of Science database, with the following important caveats. Researchers in engineering, social sciences and the humanities often publish in journals and formats (e.g. conference proceedings, books or book chapters) not presently covered by the Web of Science database. Also, the Web of Science database very likely does not cover outcomes from long-term monitoring programmes which often appear as technical reports or databases.

Our Committee added a small additional step. In the self-evaluations we invited each responding institution to list up to five research publications that they considered as best representing the capabilities of their researchers and the impacts of their programs. We received 139 publications


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from 29 institutions, covering the time period 2006 to 2017. We extracted a subset of those publications, 54 in all (we inadvertently included one duplicate), whose publication dates matched the time period covered by the Aksnes 2017 analysis, and submitted those separately to NIFU as an independent institution-generated alternative to the Web of Science searches. For reasons described below we feel confident that this subset of publications covered the activities of top polar research organisations within Norway.

The second smaller analysis provided two important validation features for the larger report. First, 86% of the publications submitted on behalf of the polar institutions also turned up in the larger automated analysis. A few of the articles submitted by institutions did not contain 'polar' identification words in their title, which might have made the correspondence even higher. We conclude that the overall NIFU analysis had a very high correspondence to actual publications produced by Norwegian researchers. Second, half of the publications regarded as prominent by institutions rated, by citation, in the top 10% of journal articles in that particular research field in the Web of Science database. In other words, bibliometric analyses confirmed that many papers considered prominent by polar institutions also showed high citation rates in high impact journals. These initial conclusions serve to increase confidence in the larger analysis.

We provide many useful and appropriate details of the specific bibliometric analysis in Section 4 and list some cautions below (Section 1.4.1).

1.3.3 Self-evaluations

We solicited institutional self-evaluations over the time period March and April 2017. Working from the evaluation form and recipient list used in the Svalbard 2015 analysis, we produced a shorter evaluation form in a more quantitative format (Appendix 3) and distributed that request to the same 175 recipients targeted in the earlier Svalbard study. These recipients represent most of the Norwegian institutions that are involved in polar research. The institutions had roughly six weeks to complete the form and provide information. We received self-evaluation material from 38 institutions (Appendix 4). Many of them provided extensive and informative responses but many of them also noted - correctly - the very short time allotted to them for those responses. We compiled quantitative information (e.g. on staffing or partnerships, reflected in figures throughout this report) and narrative (free text) content for this report. »

1.3.4 Dialogue meetings with polar research institutions

Based on invitations to all institutions that submitted self-evaluations, we conducted a series of 13 dialogue meetings (Appendix 4) involving - in most cases - three-member teams of our Committee and three to five individuals representing the polar institution. We conducted these meetings, of roughly two hours duration, over one day in Oslo and two days in Tromsø (including connections via Skype when necessary). For universities, where several separate departments might have submitted independent self-evaluation materials, we encouraged collective and coordinated interviews by institution rather than by department. We conducted all the dialogue sessions based on standardized questions and Chatham House rules. Our teams reported impressions and outcomes to the full Committee immediately following each interview and recorded extensive notes for later analysis and referral.

1.3.5 Other information sources

In additional to substantial fresh information from new bibliometric analyses, from project-specific self-evaluations and from face-to-face interviews, we conducted several telephone interviews with top-level management of key polar institutions using a structured question approach and Chatham House rules. In addition, we looked at a variety of additional informal information sources including institutional strategy plans, prior and parallel products related to Svalbard including the Ny-Ålesund Science Plan, and similar analyses conducted in other countries.

1.4 Data limitations

Evaluating the quality and impact of any research program in a field of science necessarily involves a mixture of objective and subjective assessments. We evaluated a large volume of material in a relatively short time period. We confronted three questions:

- Do bibliometric analyses represent a fair and valid basis for internal assessment and external comparison?
- Did we, through self-evaluation surveys, receive an appropriate response from leading polar research institutions of Norway?
- Can we, from frank and enthusiastic face-to-face interviews, identify consistent topics and concerns so that we base our findings and recommendations on persistent issues identified by multiple sources?

1.4.1 Bibliometric analysis

We made very extensive use of the bibliometric analyses, always with caution based in part on recognition that the basic raw materials of bibliometric analysis - published scientific reports in indexed peer-reviewed scientific journals - may not present a favored or useful outcome for some fraction of Norway's polar research efforts. In research efforts on what we categorize as 'resources and technology', for example, journal publications often do not represent a primary outcome. We emphasize that no single metric, bibliometric or otherwise, can provide an accurate assessment of quality or productivity across the range

Photo: © Leif Anderson

of research expectations and outcomes represented by Norway's broad polar research program.

Nevertheless, we focus on bibliometric analyses because:

- Norway has invested substantial resources in producing such analyses for this effort;
- RCN has used such analyses as a prominent basis for prior and other external evaluations;
- The bibliometric analysis team have documented their work very clearly;
- These types of bibliometric analyses represent one of the most-used tools for assessing individual careers and institutional impacts; and
- Such analyses with, as in this case, careful documentation can serve a valid data for comparison with other programs or areas of science, within and across nations.

1.4.2 Self-evaluation surveys

As mentioned, we received 38 responses. Based on comparison of the list of responding institutions with similar lists of top research institutions identified by numbers of publications, relatively high citation rates and prominence in national and international partnerships in the bibliometric analyses, we conclude that we received evaluation materials from all of the ten largest polar research institutions in Norway. We note in particular that partner institutions in the Nansen Legacy project often appear at the top of most of these lists, from self-evaluations and from bibliometric analyses.

1.4.3 Face-to-face interviews

The face-to-face dialogue meetings provided this Committee a chance to hear concerns and ideas directly from polar researchers. Working from prior RCN lists and our list of institutions that provided self-evaluations, we ensured that we spoke directly with scientific and administrative representatives of all responsive major players in Norwegian polar research. Although we worked from a consistent set of structured questions and had, in most cases, read relevant self-evaluation materials beforehand, these interviews provided intensely valuable elements of spontaneity and enthusiasm. Our challenge in digesting and reporting information from those sessions lies in identifying consistent and coherent messages. In our report we have avoided all comments that arose from single responses or single interviews. We applied with some flexibility a requirement that each issue that we discuss arose from at least two separate interviews heard by at least two of our three interview teams. We recognize in all cases that we had little or no time for follow-up with those interviewees or to external sources based on information brought forward from the interviews. ❖

Photo: © Geir Wing Gabrielsen/Norsk Polarinstitutt

2 Context

Norway occupies a prominent position in polar research. Internally, researchers in universities, national institutes, and companies constitute a strong polar research community. Research funding occurs through several mechanisms with diverse outcomes. Norway's polar research priorities fit very well with national needs and international directions.

By geographic, historic, cultural and economic definitions Norway qualifies as a prominent polar nation. Cape Nordkinn, the northernmost point of mainland Norway and of the European continent lies more than 4° north of the Arctic Circle. The northernmost part of Norway, Svalbard, serves as a prominent node of regular human activity in the Arctic, including an international research-focused community at Ny-Ålesund at almost 79° north. Norway also operates one of the few inland all-year research stations in Antarctica, at Troll Station.

Polar enthusiasts around the world know the names of Amundsen and Nansen who opened the polar regions to exploration and discovery. Norway manages a successful fishery in the Barents Sea. From 2010 to 2014, Norway represented the largest national harvester of Antarctic krill (see www.ccamlr.org). By technological and economic standards Norway plays a leading role in exploration for and exploitation of Arctic petroleum resources. Norway advertises itself to international tourists as one of the best destinations for viewing the aurora borealis.

Norway served as a founding member of both the Arctic Council and the Antarctic Treaty. A strong investment by Norway in the International Polar Year (IPY, 2007-2008) set a positive and stimulatory example for the international science community; an urgent message from students in Oslo at the start of IPY - 'give us back our winter' - echoed in classrooms worldwide. In this context, a vibrant programme of polar research represents an essential part of Norway's past, present and future.

The Research Council of Norway, in its document defining national polar research policy (RCN 2013) for the period 2014-2023, emphasizes Norway's particular role in polar research: "The objective of polar research is to enable Norway to fulfil its special responsibility for acquiring the knowledge needed to implement policy, management and economic activity in the polar regions".

The RCN national polar research policy responds to a mandated goal to set directions for polar research in Norway. This policy states: "Norway must engage in comprehensive international collaboration and promote fruitful interaction between the national and international polar research communities. New and existing infrastructure must be optimally utilized and new generations of polar researchers must be recruited. Norway must also promote effective coordination of research activities in Svalbard and enhance the capacity and quality of Antarctic research." We evaluated, discussed, formulated, reported and made our recommendations consistent with these RCN goals.

2.1 Research Landscape within Norway

This Committee evaluated polar research according to geographic boundaries specified in RCN's Polar Research Policy Document reproduced below. We adopt the familiar practice of delimiting Antarctic research on the basis of features of the Southern Ocean. However, the boundaries identified for Norwegian polar research in the Arctic seem peculiar to say the least. We note, for example, that research boundaries apparently include land ecosystems and human communities across Canada and Russia but not in Norway, glaciers in Greenland but not Norway, and ocean currents extending the full length of Greenland but, apparently, none of the ocean currents along Norway's coast. We accept that these Arctic boundaries derive from prior decisions but confront the issue in this evaluation of assessing a polar research community that artificially excludes terrestrial and social researchers. Researchers from several polar organizations echoed this odd confusion arising from the 'official' Norwegian definition of "Arctic". The bibliometric analysis discussed below also noted that this geographic restriction on the definition of Arctic research, by excluding publications (often of high quality) in terrestrial ecology or sociology, reduces substantially the numbers of research publications credited to Norway.

2.1.1 Organizations

At least 30 separate Norwegian organizations identify a role in polar research. These include, among the 38 separate research units that responded to our inquires, at least six universities often with three or four discipline-based departments within those universities, at least four national research centres, three or four consortium organizations, and two or three private research companies. In annual budget and numbers of staff these units range from one or two polar researchers within a university department to some of the largest organizations in Norwegian science. Their funding (below) comes from a variety of sources with a variety of expected deliverables. Individual researchers at these organizations perform under a wide range of professional requirements for research, education, partnerships, annual reporting and outreach. From our surveys we identify at least 1000 people engaged full-time in polar research across these 38 research units.

Polar research at these different organizations has variable objectives and differing success criteria. Universities evaluate the performance of their research staff by numbers of publications in peer reviewed journals. A researcher at a national polar laboratory may need to demonstrate a similar publication record but also notable contributions to mission-related reports or information for tasks mandated by ministry directives. For researchers within a contract-based service industry, indicators represent products or outcomes delivered to the terms of those contracts and, where outcomes remain confidential, the number of subsequent contracts . No single metric, bibliometric or otherwise, can provide an accurate assessment of quality or productivity across this range of research expectations and outcomes.

Of the 38 Norwegian organizations that responded to our survey (full list in Appendix 4), we identify a group of 10 with significant staff efforts devoted to polar research (figure 2.2). This list corresponds very closely, in both organizations involved and magnitude of effort, to organizations identified in prior surveys by RCN. We conclude that this evaluation covers the major players in Norwegian polar research.

These organizations identify substantial contributions to predicting future changes in polar systems as a result of climate change and to understanding polar ecosystem processes. Many of them report significant contribution to global conventions and assessments. Their research guides and supports improved monitoring and forecasting for safe Arctic operations. They convey with pride their ability to attract and support students, their development of new technologies, and the positive impacts of their work - in addition to and beyond scientific publications - for Norway and for specific users including the Governor of Svalbard, various ministries and agencies (e.g. the Norwegian Environment Agency or the Ministry of Climate and Environment) and industry. They should and do take pride in

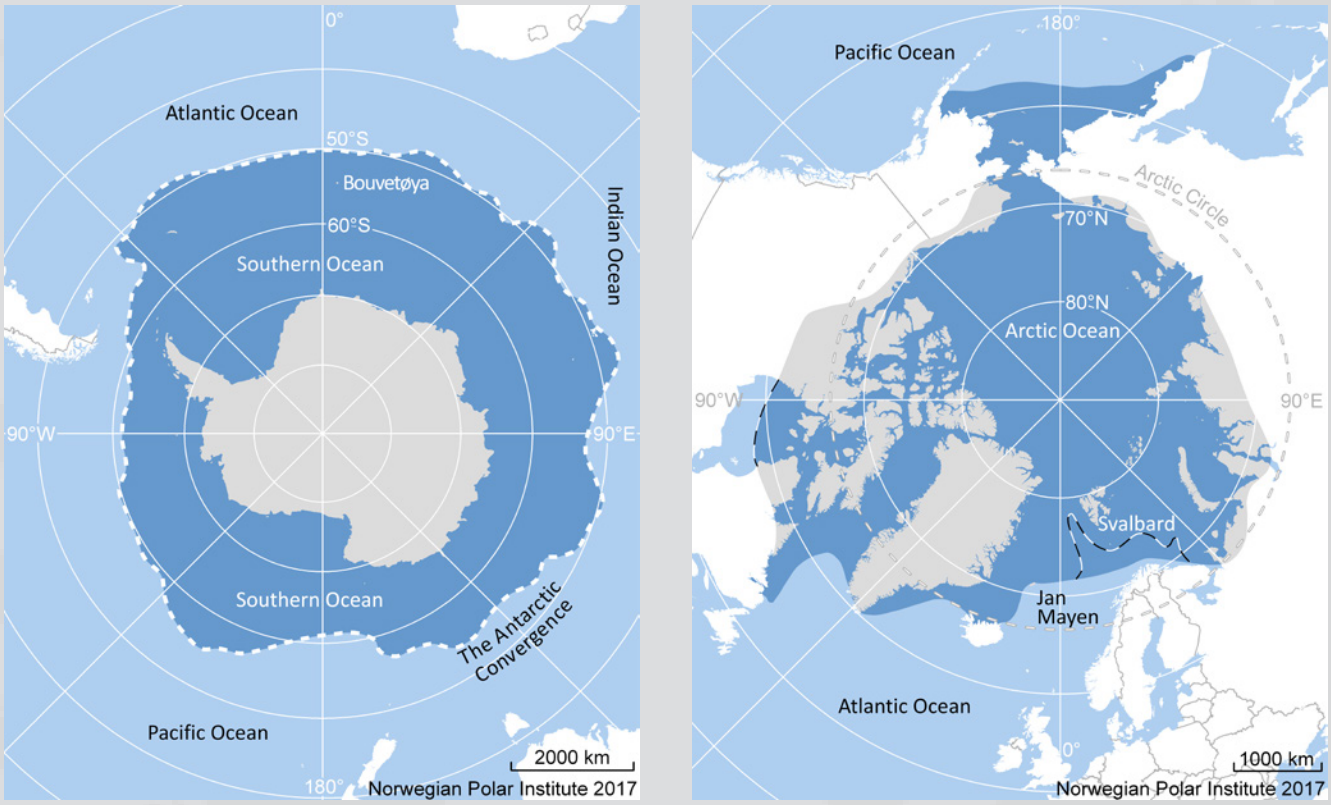

Figure 2.1. Effective boundaries for the evaluation and analysis conducted by this committee. This evaluation covers the area south of the Antarctic Convergence, while in the Arctic the shaded (dark blue and grey) area is covered (source: The Research Council of Norway, 2013, page 6).

their new infrastructure (see below), their multidisciplinary and integrated approaches, their efficient administration and IT-support functions and in maintaining positive research environments in which innovations such as new discoveries about winter biology can emerge.

Amidst this array of polar organizations, the Norwegian Polar Institute (NPI), because of its specific government mandates and its role as infrastructure provider and manager, and the Institute of Marine Research (IMR), because of its role providing the research and monitoring basis for managing high-value marine resources of the Barents Sea, play unique roles in Norway's polar research landscape. The wider polar research community necessarily pays very close attention to NPI's funding, staffing, science directions and policies. IMR serves as a prominent representative of and advocate for the polar community as it conducts research of high relevance to several Norwegian ministries. NPI's and IMR's shared role in the Nansen Legacy project and their partnership with University of Tromsø (UiT) on the new ship FF Kronprins Haakon draw careful and somewhat anxious attention. This evaluation recognizes that changes or improvements in polar research across Norway, for the purpose of improved quality or impact, must start with and engage NPI and IMR.

We also note the existence of a Norwegian Scientific Academy for Polar Research (NVP, hosted in Longyearbyen), an international membership organisation of scientists and administrators with attention on the Arctic. Since 2011 NVP, with many of the Norwegian organizations described here as partners, have hosted multiple summer schools focused on Arctic and Svalbard issues under the impact of a changing climate. Their 2017 summer school focuses on marginal ice zones in the Arctic, likewise the focus (in the Barents Sea) of the Nansen Legacy project. The NVP promotes international scientific cooperation but does not represent itself as a coordination body for polar research.

2.1.2 Funding practices and options

Funding for polar research in Norway occurs through several ministries, within a wide range of programs and funding instruments, and not necessarily or primarily through RCN. This Committee heard repeatedly that RCN funding accounts for less than 20% of total annual polar research funding. From the Svalbard report for 2014 we identified a total of 1 800 million kroner for polar research of which 340 million kroner (19%) came from RCN. The remaining 80% passes by multiple routes from several ministries for a variety of research missions and polar infrastructures, primarily but not exclusively to NPI and IMR. As a positive signal, this directed funding with its associated mandates demonstrates enduring political interest and relevance of polar research in Norway, reflecting Norway's scientific and technical capabilities and its territorial interests in both the Arctic and the Antarctic. This Committee recognizes that the dual mandates - scientific excellence and national »

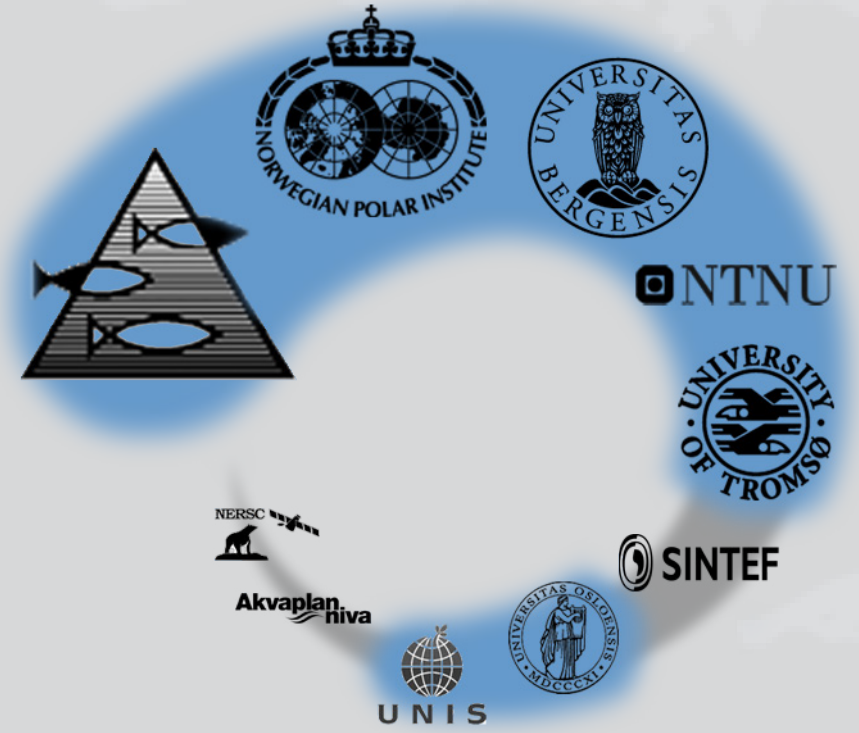

Figure 2.2. Norwegian organisations with significant staff efforts devoted to polar research (source: Self-Evaluation Survey). Those organisations marked in blue represent the instigating members of the Nansen Legacy project (for description, see Section 2.1.2).

relevance - arise exactly from these two national needs: effective management of national resources and scientific prominence. Ideally, polar science in Norway achieves excellence simultaneous with relevance. In reality and of necessity, these needs occasionally diverge. We address quality and relevance issues in more detail in Section 4.

From the view of Norwegian polar research organizations, particularly universities, the primary issue with the RCN fraction of polar research funding remains the very low success rate of proposals, below 10% by most accounts. Even assuming that half of submitted proposals should fail due to fundamental quality issues (a very high fraction by most international standards), remaining proposals of acceptable quality still have only a 20% probability of success. One reads a consistent message of frustration with this system and this success rate across the self-evaluations submitted to this Committee. Some organizations estimate the benefit to cost ratios for proposal submission as simply prohibitive. Amidst this tightly constrained funding situation, concerns about fairness and differential access inevitably arise. Several organizations see the high levels of competition as detrimental to the collaborations and partnerships they espouse.

A second issue, of almost equal concern, has to do with the short-term nature of proposal-based funding. The polar research organizations surveyed here confront substantial challenges in instrument development, infrastructure maintenance, team building, and sustained progress on urgent topics through mechanisms of short-term proposals With more than 40% of present polar research workforce (450 of 1055 total in our surveys) on time-specific contract funding, we heard very clear concern about both the viability of longer-term programmes and individual careers.

Against these perennial funding pressures and concerns, the successful funding and anticipated availability of the new polar ship FF Kronprins Haakon stands out as a remarkable achievement and strong vote of confidence to Norway's polar research community (see infrastructure discussion below).

2.1.3 Nansen Legacy

The Nansen Legacy represents an initiative by seven leading polar research organizations to establish a research priority and secure incremental funds. Building on the investment in the new ship and matching that with a challenging and highly relevant new research programme, UiT, NPI, IMR and five other partners (4 listed in figure 2.2 plus Met.No) have instigated the Nansen Legacy project (Arven etter Nansen) to: "provide the integrated scientific knowledge base required for the sustainable management of the environment and marine resources of the Barents Sea and adjacent Arctic Basin through the 21st century".

The Nansen Legacy thus represents a fresh internally-generated example of the clear priority and long-term focus called for by many polar organizations in Norway. It represents a polar-focused SAK initiative (Norwegian acronym for cooperation, task division and concentration), built on the requirement of 50% resource commitments from participating organizations. It earned external endorsement through an international review. At a total (6-year) cost of more than 700 million kroner and at an average yearly investment of 130 million kroner (2017 through 2021), it represents the largest recent and anticipated incremental investment in Norway's polar research, a rare (by international standards) success of matching new science funding to a new infrastructure acquisition.

2.1.4 Infrastructure

Norwegian polar researchers operate, maintain and have access to an extensive array of infrastructure. A list from self-evaluation surveys conveys the geographic and scientific breadth of this infrastructure:

- **APN**: Barents Laboratory for Arctic ecotoxicology, Kraknes full-scale aquaculture research facility, benthic identification and sorting laboratory, chemical analysis laboratory, technology for environmental monitoring and modeling.
- **IMR**: research vessels, Argo floats, gliders, mooring arrays; data centre (NMDC).
- **NILU**: measurements at Zeppelin (Svalbard) and Trollhaugen (Antarctica); EBAS-database (http://ebas.nilu.no).
- **NORSAR**: 9-element seismic array SPITS on Spitsbergen, seismic station Troll in Antarctica, radionuclide station on Platåberget (Longyearbyen).
- **NPI**: Svalbard Research Park (Longyearbyen), Sverdrup Station and Zeppelin Observatory (Ny-Ålesund), Troll Research Station and associated satellite field stations (Antarctica), Norwegia Station (Bouvetøya), research vessels RV Lance and FF Kronprins Haakon (from 2018), ice-lab, instrumentation (e.g. EM bird, ocean moorings, AURAL networks, COAT-Svalbard); NPI's Polar Data Centre, Quantarctica.
- **NTNU**: Applied Underwater Robotics Laboratory (NTNU AUR-Lab, 4 ROV´s, 3 AUV´s), optical and acoustic sensors, ice laboratories.
- **SINTEF**: Svea/Van Mijen Fjord, in-door laboratory called Svalbard Arctic Research Infrastructure (SARI), technological laboratories (Trondheim).
- **UiB**: European Plate Observing System (EPOS, Norwegian node), Earth Surface Sediment Laboratory (EARTHLAB), Facility for advanced isotopic research and monitoring of weather, climate, and biogeochemical cycling (FARLAB), Norwegian Marine Robotics Facility (NORMAR).
- **UiO**: Automatic weather stations, mass balance measurement (Austfonna, Nordaustlandet, Svalbard),

GNSS/GPS-stations (Svalbard), permafrost observation stations (Northern Norway), all-sky imaging systems and GNSS scintillation and TEC receivers (Ny-Ålesund, Longyearbyen), EISCAT Svalbard Radar, and SVALRAK (Ny-Ålesund).

- **UIT**: RV Helmer Hansen, laboratory facilities, fresh and sea-water aquaculture station with infection lab and climate control (Kårvika research station), field station at Svalbard, research facilities and laboratory for arctic animals, small boats, SIMBA bouys including underwater hyperspectral imager, K-Landers-Seafloor observatories.

- **UNIS** (Svalbard Science Centre, Longyearbyen): laboratory facilities, sea-water laboratory, growth culture/climate laboratory, research vessel Viking Explorer and smaller boats, Kjell Henriksen Observatory, SuperDARN radar antennas, bedrock cores, permafrost boreholes, drilling equipment, CO_2 test field, mooring arrays, automatic weather stations.

A more detailed list would itemize various instrumentation, sensors, and support services for all of the above!

2.2 External Research Landscape

The urgencies of polar science require multinational and international dialogue, planning and collaboration. Documenting, understanding and predicting the future evolution of freshwater accumulation in the Arctic Ocean, for example, demands attention at least from the peripheral Arctic coast nations if not from oceanographic researchers worldwide. The onset, quantity and composition of carbon release from permafrost as it thaws likewise demands multinational and international attention. Understanding relatively warm ocean eroding Antarctic ice shelves from below requires the attention and effort of ships and investigators of all major research nations. Unlike global organizations attending to climate (e.g. WCRP, IPCC, etc.), no single international organisation attempts to provide planning, oversight or coordination for polar research. Two multinational science bodies, the Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC) provide coordination roles for their respective poles. Within those international consensus frameworks, national polar programmes develop their own specific implementation plans. »

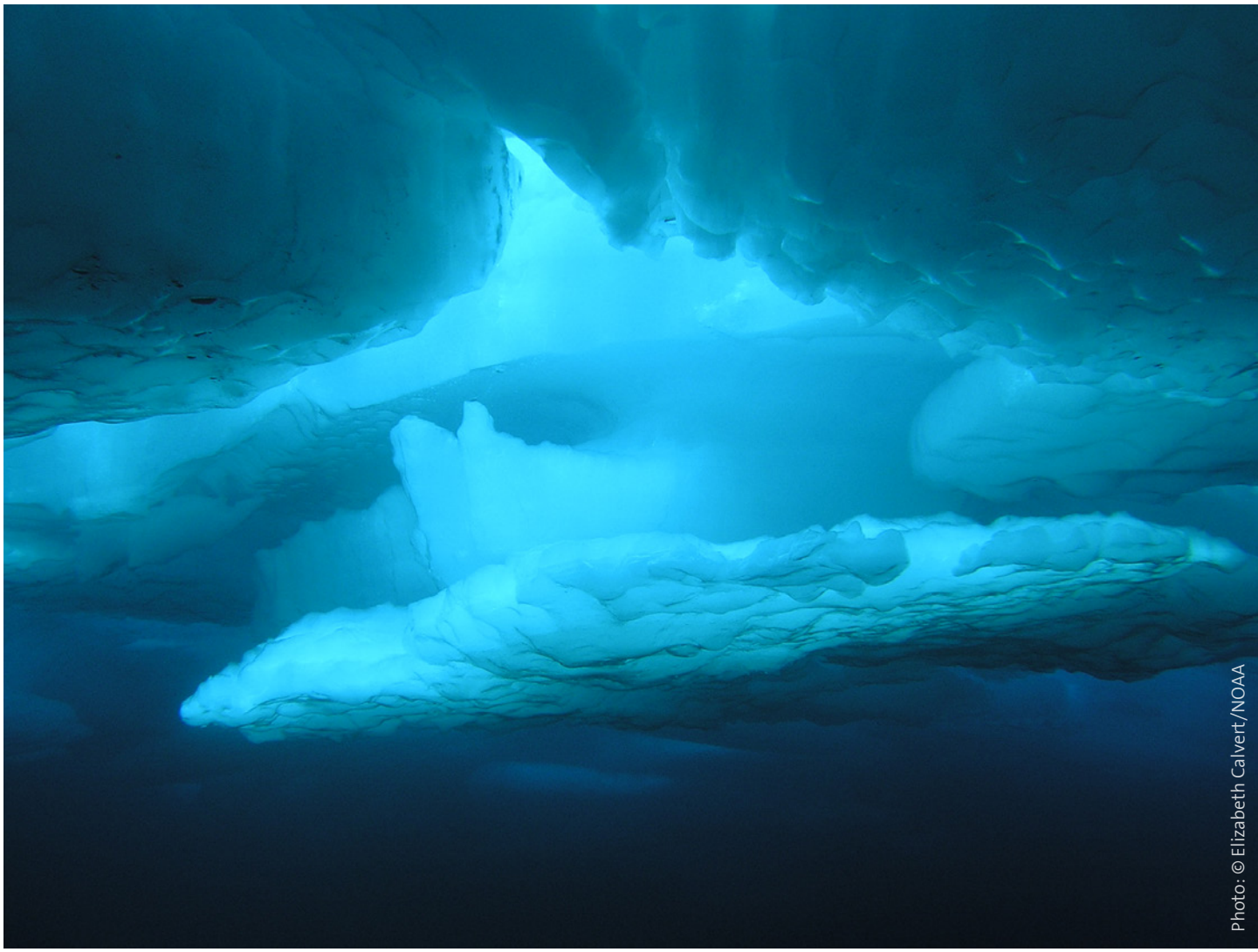

Photo: © Elizabeth Calvert/NOAA

2.2.1 International cooperation and participation in bilateral, Nordic, European and global programs

Figure 2.3 documents the most important international partnerships identified by Norwegian polar organizations. Norwegian cooperation with the top four countries on that list (Germany, USA, UK and Russia) occurs in both Arctic and Antarctic settings. Cooperation with other countries on the list (Denmark, Finland, Canada) occurs primarily in an Arctic context.

Several Norwegian organizations list collaborations with Russia among their priorities for research partnerships. A few responses listed enhanced collaboration with Russia among their challenges and needs. Through mutual interests in fisheries, space weather, permafrost and Arctic oceanography, Norwegian researchers have provided effective links to Russian researchers and research organizations.

Norway manages an array of cooperation agreements relevant to polar research. These take the form of (many) governmental/state to state bilateral agreements, research council to research council agreements and institutional agreements/MoUs. At the research council level these include RCN agreements with Italy (Consiglio Nazionale delle Ricerche), USA (National Science Foundation), India (Ministry of Earth Sciences), and Russia (Russian Foundation for Basic Research). Norwegian polar organizations maintain specific agreements with counterpart organizations in, for example, Germany, Canada, Japan and China. Figure 2.3 indicates a substantial number of positive ad hoc interactions at researcher to researcher levels.

Several Norwegian polar research organizations compete for EU funding. Many Norwegian researchers joined a large EU FP7 project, DAMOCLES, focused on Arctic system science. The Nansen Center leads the EU H2020 Integrated Arctic Observation System (INTAROS, 2016-2021) project that includes nearly 50 research partners (7 from Norway) from 20 countries; INTAROS proposes to extend, improve and unifying observing systems in different regions of the Arctic. NILU participates in the EU H2020 project ENVRIplus, an activity to link and coordinate environmental research infrastructure, including the proposed Svalbard Integrated Arctic Earth Observing System (SIOS), across Europe.

Norwegian researchers contribute to all the Arctic Council scientific working groups (e.g. AMAP, CAFF, PAME, SDWG, etc.). The very recent Snow, Water, Ice and Permafrost in the Arctic assessment (SWIPA) produced by AMAP included several Norwegian researchers as contributors and lead authors; three separate Norwegian polar organizations listed contributions to SWIPA as primary outcomes. Likewise, three Norwegian organizations listed contributions to the State of Arctic Marine Biodiversity Report just released by CAFF among their high impact assessment activities.

To assess the overall correspondence of Norwegian polar research priorities as represented by the Polar Research Policy Document to international polar research priorities we matched specific programme areas from the Policy Document to:

- SCAR (Strategic Plan and 20-year Horizon Scan)

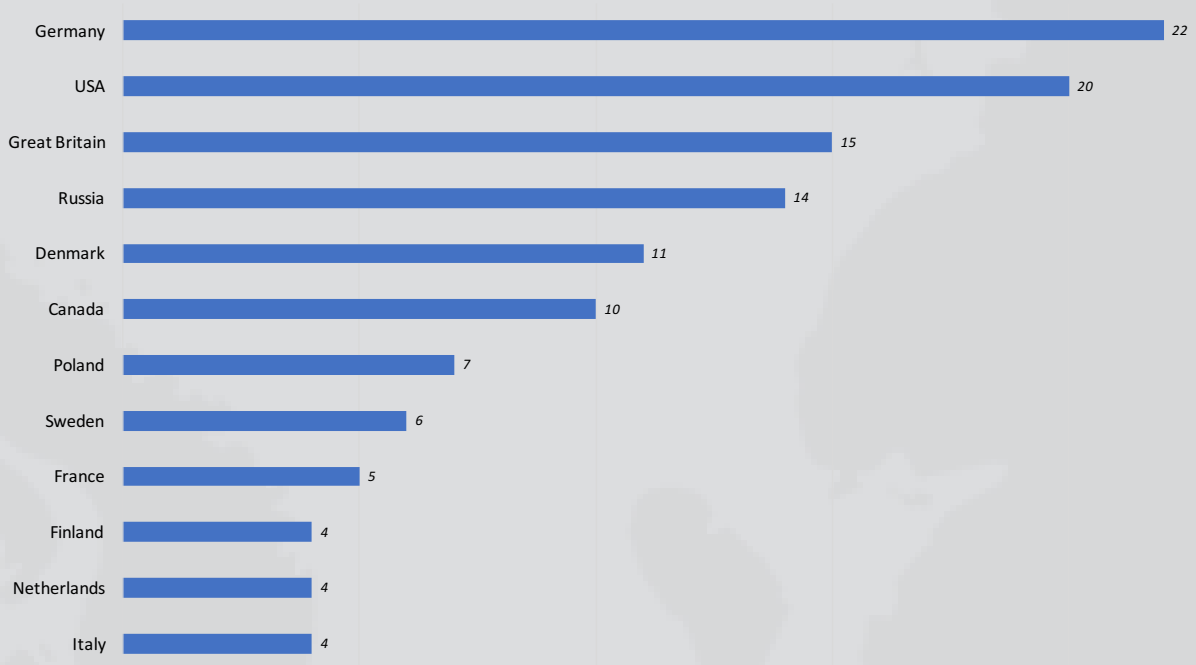

Figure 2.3. Data from question 3 b) in the self evaluation survey - «top 5 international polar research partnerships», sorted on which country the partners are situated in.

- IASC (ICARP III, Working Groups) plans
- EU (Polar Board, H2020 Arctic Proposal) initiatives
- WCRP 'Melting Ice' Grand Challenge priorities
- AWI priority areas
- UK (Antarctic, Arctic and British Antarctic Survey) plans
- Canada (ArcticNet and Sentinel North) plans
- USA (NSF, NOAA, NASA, Arctic Research Consortium, Arctic Research Priorities) plans

Our analysis (appendix 5) confirms a very close and strong coherence of polar research in Norway with a wide array of external national and international planning documents (table 2.1). Working from the level of 'Priority Research Topics' listed in the RCN Research Policy document, we identify strongly similar priorities in virtually all external plans. Specific topics under the general category of 'Changing Climate and Environment Under Pressure' from the Norwegian plans show up again and again in plans of other countries. Table 2.1 includes a clear Arctic bias but several topics (links to global climate, polar ecosystems) emerge as strong priorities in both the Arctic and Antarctic.

Assessing similarly the specific topics under the Norwegian category «Natural Resources and Industrial Activity» - which we might consider more a national (e.g. Norwegian, Russian, Canadian) than international priority - we find good coherence (with primarily an Arctic focus) with other international and national plans, particularly for marine resources (fishing) and marine environment (transport and shipping)(table 2.2).

In these particular analyses we rely entirely on existing national or international planning documents. We did not survey external organizations to determine their specific interests in or connections to Norwegian plans. Identifying a substantial degree of agreement thus represents a very clear indication that polar research plans as expressed by RCN on behalf of Norway resonate strongly with international priorities, particularly in the two general areas of changing climate and managing resources.

The larger matrix (appendix 5) demonstrates some additional coherence between Norwegian and international research priorities in the areas of governance and management and mutual interest in infrastructure, capacity building and data and communication issues.

2.2.2 Utilisation of research data, databases and data infrastructure

We find substantial data access and data sharing efforts supported by the Norwegian polar research community for use by Norway and other polar researchers. For resource reasons, data centers with larger holdings and better access tools tend to occur at the larger polar organizations. Working from information provided by those organizations we identify several data centers that serve or intend to serve Norway's polar research community, including:

Table 2.1. Priority Research Topics listed in the RCN Research Policy document under the "Changing Climate and Environment" category compared to external national and international planning documents (colour indicates coherence).

From Norway	SCAR	IASC	EU	WCRP	AWI	UK	Canada	USA
Polar processes in earth system models								
Polar climate system & links to global climate								
Polar ecosystems								
Changes in ocean circulation								
Long-range & local pollution								
Impacts on Arctic communities								

- At IMR, the Norway Marine Data Centre (NMDC) (http://www.imr.no/forskning/forskningsdata/en)
- At NILU, the EBAS-database (http://ebas.nilu.no)
- At NPI, the Norwegian Polar Data Centre (NPDC) (https://data.npolar.no/home/)
- At NERSC, the Arctic-ROOS portal, (http://www.arctic-roos.org)
- At NERSC, the Norwegian Satellite Earth Observation Database for Marine and Polar Research (NORMAP) (https://normap.nersc.no/)
- At Met.no, the Norwegian Scientific Data Network, (https://nordatanet.metsis.met.no)
- At NORSAR, seismic data for earthquakes and nuclear explosions (https://www.norsar.no)

These data centers tend to have good to excellent web-based services. Some have plans and intentions more than actual operations and services. They espouse open access policies and open access licenses (typically Creative Commons CC BY) but most also allow researchers to restrict access through use of proprietary access periods typically extending two years. Most of them publish clear guidance for appropriate citation and acknowledgement for use of their data.

Some of the Norwegian data centers have yet to support digital object identifiers. None currently serves as a direct open data repository used by data publication journals, although the Geological Survey of Norway did host the initial published NORPERM (Norwegian Permafrost Database) (access to later versions has moved to Pangaea) and EBAS at NILU serves as the repository for data published by the German Ultrafine Aerosol Network (http://wiki.tropos.de/index.php/GUAN). As one might expect for this range of data, data formats vary widely, even within the holdings of any one data center. Several of the data centers include necessary links to open access or proprietary GIS tools; NPI hosts a specific open-access GIS portal for Antarctica maps and data (http://quantarctica.npolar.no). NORSAR, as the Norwegian National (seismic) Data Centre, provides access to national and global seismic data for research and for verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

The Norwegian Polar Data Centre (NPDC) at NPI serves a very wide variety of information covering datasets, maps, and information about publications, expeditions, and projects including real-time cruise data and one-click browse capability for a variety of time series data sets. Arctic-ROOS, on the other hand, focuses specifically on analysis and display tools for satellite-based measurements of Arctic sea ice. Several of the Norwegian data centers link to each other (e.g. Arctic-ROOS links back to IMR for in situ data) and NPDC provides data links to other international repositories (e.g. Pangaea).

IMR, EBAS and Arctic-ROOS all serve as nodes in European data networks: Copernicus Climate Change Service, European Monitoring and Evaluation Programme, and EuroGOOS, respectively. Through these European nodes the Norwegian data holdings also serve larger international conventions (e.g. the Convention on Long-range Transboundary Air Pollution for EBAS data). EBAS hosts two World Data Centres under

Table 2.2. Specific topics under the Norwegian category «Natural Resources and Industrial Activity» compared to external national and international planning documents (colour indicates coherence).

From Norway	SCAR	IASC	EU	UK	Canada	USA
Knowledge basis for petroleum extraction						
Improved ice, atmosphere & weather forecasts						
Environmentally sound fisheries						
Research basis for mineral extraction						
Land & sea infrastructure						
Manage environmental impacts						

the auspices of WMO-Global Atmosphere Watch: Aerosols (www.gaw-wdcs.org) and Reactive Gases (www.gawwdcrg.org). NILU operates an official data centre for atmospheric measurements under the Arctic Monitoring and Assessment Program (www.amap.no). NERSC, IMR and Met.No share responsibility for the EU Copernicus Marine Environment Monitoring Service - Arctic Marine Forecasting Centre (CMEMS AMFC) providing forecasts of sea ice and ocean information/products for the Arctic Ocean.

Looking at polar data from the open access publication end (e.g in ESSD or Scientific Data) we find publications on permafrost initially supported by Geological Survey of Norway but presently hosted by Pangaea (Germany) and Northern Circumpolar Soils Data Center (Sweden, for permafrost carbon), extensive meteorological data from Svalbard published by AWI and hosted at Pangaea, Southern Ocean chlorophyll data (from marine mammals) at the British Ocean Data Center, and recent data on permafrost lakes again hosted by Pangaea. Other than the NORPERM product, in general these recent openly-published sources of polar data include very few Norwegian researchers. In common with other polar data centers and with data centers in general, many of these Norwegian polar data centers suffer the symptoms of general inattention given to data: lack of priority in science or infrastructure funding, difficulty to recruit and maintain long-term skilled staff, increasing demands for access, interoperability and services on flat or declining budgets. ❖

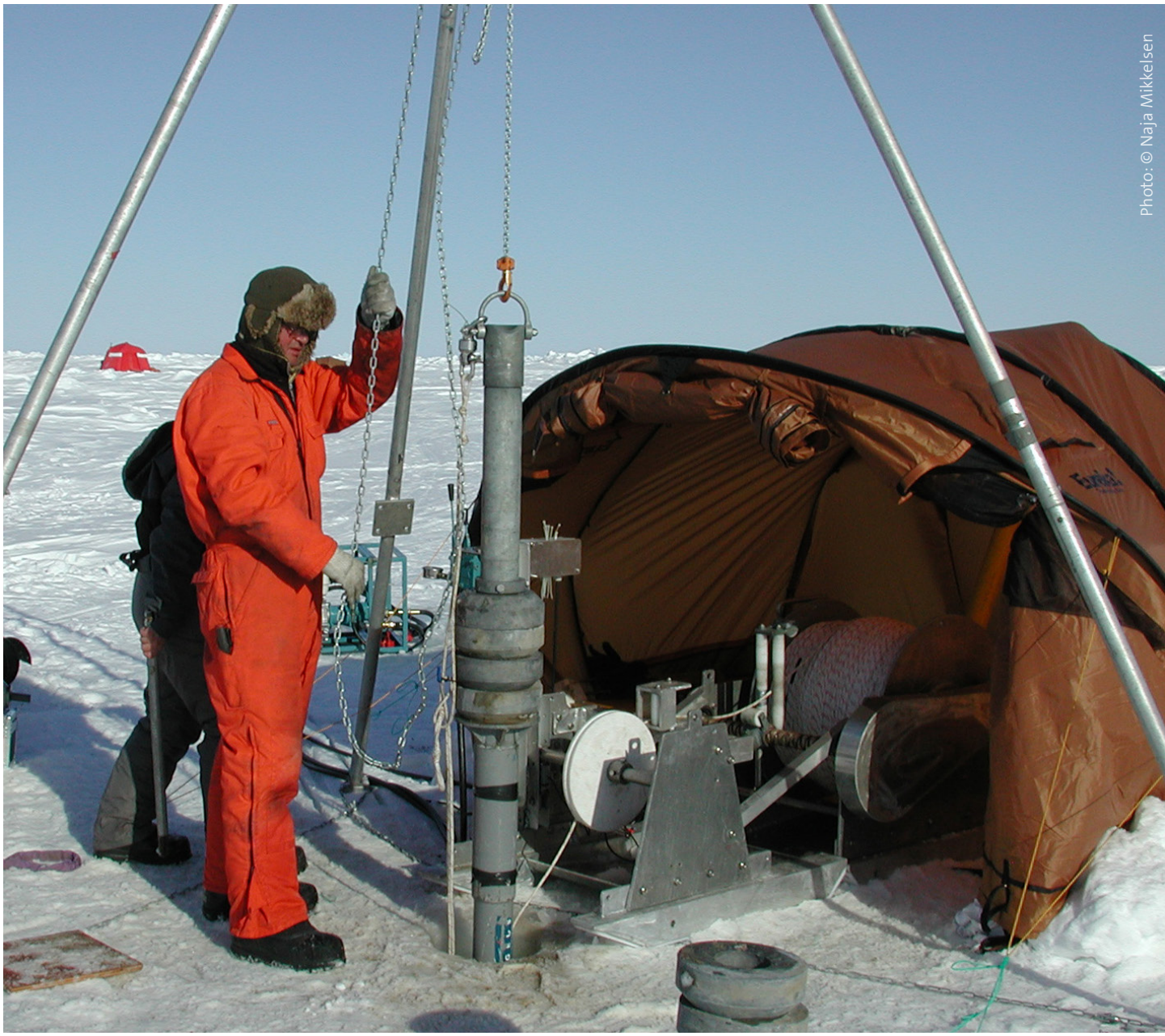

Photo: © Naja Mikkelsen

Photo: © Leif Anderson

3 Focus Areas of Norwegian Polar Research

We identify 'climate and environment' and 'technology and resource management' as prominent and urgent topics for polar research in Norway.

The polar research community within Norway conducts a very wide range of research activities covering, vertically, from the deep sea floor and below to the high aurora and beyond. Clear areas of strength emerge for the topics of interactions of polar processes with the global climate system, understanding and preservation of polar environments and health of polar ecosystems. Norway also maintains strong research programs to understand and manage polar natural resources, design and support polar monitoring systems, and understand and safely operate a wide range of commercial and industrial activities in polar regions. The bibliometric analyses (Aksnes, 2017) discussed below emphasize this strength in biological, oceanographic and climate-related research but very likely missed many products and outcomes of the engineering and operations-related research. Norwegian polar research includes smaller but substantial activities in sea floor and space geophysics and in economic, historic and legal aspects of governance, risk management and international administration. In general terms this broad portfolio of polar research matches Norway's needs and interests.

As an overall description, the RCN document Norwegian Polar Research, Research Policy 2014-2023 (RCN 2013) provides a useful and mostly-inclusive guide to Norway's polar research programs. For purposes of this Committee, and consistent with many comments from the self-evaluations and the interviews, we regard the document as necessary but not sufficient. It starts, as already noted, with the odd geographic definition of Arctic research. As a consequence, although it includes social science fields focussing on geopolitical issues and regimes for management of resources and an explicit priority on People and Cultural heritage, it tends to exclude many strengths and priorities of polar terrestrial and social science on the basis of geography. It provides an overall description but does not attempt to provide the long-term integrated priorities or directions that guide polar research organisations. Fundamentally, the Policy lacks connection to and implementation via funding resources. As confirmed by interviews with the management of several polar organizations, for many of them the RCN Policy does not represent a determining factor in their planning or activities.

3.1 Norway's contribution to advancing the research front

We asked each Norwegian polar organization to list their own top-five research priorities; 28 organizations provided responses. Sorted into the overarching categories from the RCN policy document, those priorities emerge in table 3.1. »

Photo: © Naja Mikkelsen


Photo: © Jan-Ola Olofsson

Two strengths of Norwegian polar research, which we might characterise very generally as 'climate and environment' and 'resources and technology', emerge very clearly from these organizational priority lists. This Committee notes positive opportunities represented by promotion, extension and intersection of these dominant themes coupled with a need for Norway to identify particular priorities and strengths.

In detailed comments recorded in the self-evaluations, the polar community elaborates on these perceived strengths. We learn that the Norwegian polar research community addresses a full range of scientific and technical issues. They study meteorology, atmospheric contaminants, sea-ice, oceanography, microbiology, glaciology, geology, biodiversity, and ecotoxicology, all in a climate context. In these areas they apply physics, mathematics, data assimilation, geo- and bio-statistics, remote sensing, information technology and computer science. They combine careful observations with advanced numerical models. To advance ocean research and technology, they develop remote and autonomous vehicles and sensors, explore engineering and technical issues related to ice and ice mechanics, and develop predictive models of environmental loads and hazards which will affect operations and infrastructures in the Arctic. Their research on Arctic operations includes applied physiology, to better understand how humans adapt to extreme environments. They often work at interesting and challenging boundaries of biology with geology, of processes connecting marine, freshwater and terrestrial systems, of molecular genetics with large scale ecosystems, and of hydrology with microbiology in determining composition and amounts of terrestrial carbon release.

As a separate indication of both focus and breadth, a wordle (Figure 3.1) demonstrates the prominent words and topics extracted from titles of five best research papers solicited from each polar research organisation (130 publications listed by 29 organizations, detailed discussion in Section 4).

'Arctic' and 'Svalbard' obviously emerge as frequent topics from the publications but one also gains a clear sense of marine biology, oceanography, ice, glaciers, and many climate connotations. We believe this figure very well reproduces the topics in the general category 'climate and environment'. Because of this particular information source - research

Table 3.1. Data from question 4.b. in the self evaluation survey - «Top-five research priorities» (with number of responses).

International Interactions	Changing climate & environment under pressure	Natural resources & industrial activity	Other
Governance (4)	Arctic ecosystems (13)	Impacts of industrial activities (10)	Geophysics (5)
Arctic Council (3)	Contaminants (7)	New monitoring technology (12)	Paleoclimate (2)
Decision support	Polar night (2)	Harvestable marine resources (10)	Recruitment
Risk management (2)	Sea ice (4)	Shipping (11)	Space (4)
Svalbard management	Climate connections (13)	Sea floor activities (4)	Bioprospecting
International agreements	Antarctic ecosystems	Marine technology (6)	
	Biodiversity, evolution (3)	Arctic geohazards (4)	
12	**43**	**57**	**13**

publications nominated by the responding organization - we understand that marine technology and many resource management outcomes, which do not result in indexed journal publications, might not appear in this graphic. The recurring themes of "Svalbard", "Atlantic" and "Barents" probably distinguish Norway's interests from those which would emerge from a comparable analysis of other Arctic-focused national research programs.

Given Norway's location and resources, the polar research community has developed systematic approaches to marine ecosystems, to ice-ocean-atmosphere interactions, to polar-climate connections, and to local impacts of large scale processes (such as long-range atmospheric transport of contaminants). Their research supports important and unique global fisheries, resource exploration in the deep ocean, international regulations on pollutants, space weather forecasts, and maritime operations. The Norwegian research program also provides important contributions in polar law and polar history.

This polar community provides and supports a unique set of long-term term data records, necessary and useful in a disciplinary context but essential for understanding climate changes. These long-term time series data sets include marine ecosystem survey data for the Barents Sea, measurements of meteorology, greenhouse gases and atmospheric contaminants at Ny-Ålesund, stratospheric and mesospheric composition measurements from interior Antarctica, continuous records of seismic data, libraries of ice and rock cores, and oceanographic records at coastal, North Atlantic and Arctic locations.

Interdisciplinary approaches within and across polar organisations of Norway encourage the system approaches listed above and the development of next-generation models of sea ice, of marine ecosystems, of coupled ocean-atmosphere-ice systems, of marine microbial dynamics and ocean energy transfer, and of evolution of the combined physical and ecology system of the Arctic ocean under climate forcing. In many ways Norwegian researchers lead the international community with their focus on dynamics and trophic interactions of Arctic marine ecosystems.

Although we address the issue of research related to and conducted from Svalbard later in this report, we note here the strong enthusiasm and clear advantages of Svalbard as expressed by many of Norway's polar research organizations: "unique location ... ideal for research in biology", "flagship programs", "unique location to study the upper polar atmosphere", "year-round presence ... innovative studies of most Arctic habitats", access to "the polar night", "harsh environment ... unique challenge for ... instruments and technologies", and "best location to measure aurora activity". ❖

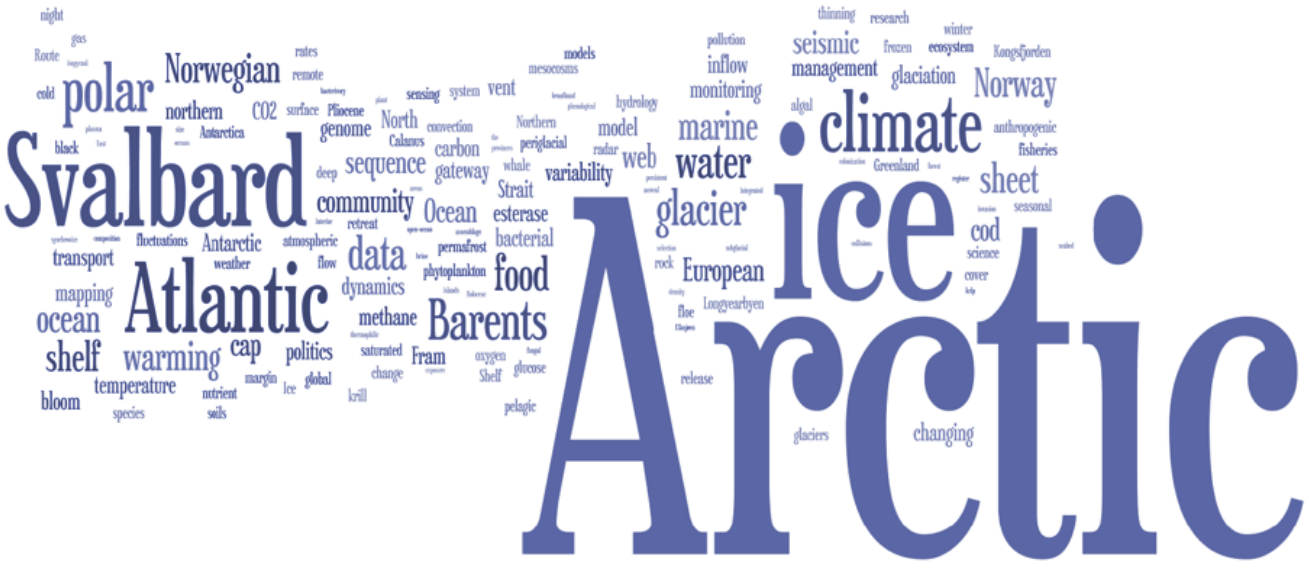

Figure 3.1. Wordle figure with the most prominent words and topics extracted from the titles of the five best research papers solicited from each polar research organization (from question 2 g) of the self evaluation survey).

Photo: © Jon Aars/Norsk Polarinstitutt

4 Quality, Impact and Capacity

Applying careful analysis to a variety of bibliometric and self-evaluation information, we assess the patterns, appropriate comparisons and limitations of factors used to describe products and outcomes of Norway's polar research. We determine that Norway's polar research, including research from or about Svalbard, meets and often exceeds international expectations and standards for quality and impact.

4.1 Quality of Norwegian research in an international context

The bibliometric analysis confirms that, for the time period analysed, Norwegian polar researchers play a prominent role in international polar research. For overall number of polar research papers Norway rates 5th among all countries, behind (in order), USA, UK, Canada and Germany (figure 4.1).

The number of publications by Norwegian polar researchers increased substantially over the time period 2005 to 2014, by more than 80% according to the detailed metric (figure 4.2). Only China showed a larger publication increase over that time period.

The fields of biology and geoscience (including oceanography and much of climate in the Web of Science journal listings) dominate Norway's publication output (at 37% and 47%, respectively, figure 4.3) with no other specialty areas showing more than a 5% contribution to total publications.

We note, as do the authors of the bibliometric analysis, that Web of Science does not represent an effective index of social sciences. In evaluating the list of publications by institution (figure 4.4), we find the top ten Norwegian polar institutions by publication very consistent with what we identified based on staffing (figure 2.2).

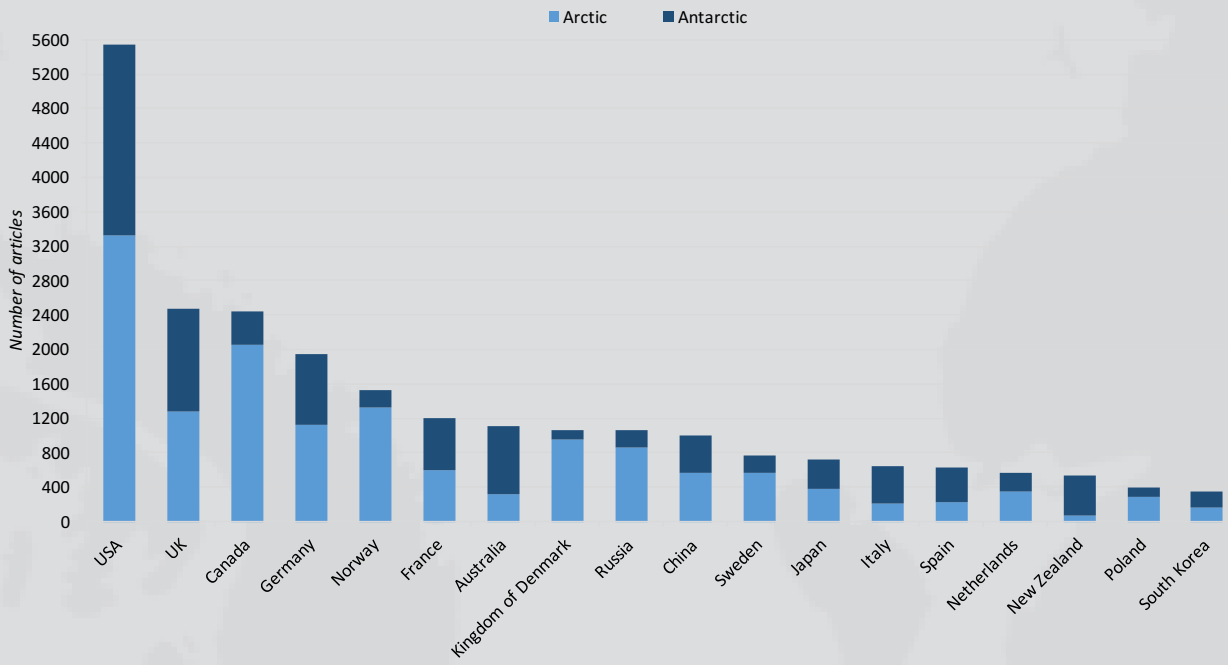

Figure 4.1. Number of polar research articles by country and geographical area, 2012-2014 (source: figure 3.1 in Aksnes, 2017).

Nearly 75% of Norwegian polar publications for the time period 2012 to 2014 involved international co-authors (figure 4.5). Over that time period most other countries had international co-authorship percentages in the range 50 to 90%. Prominent countries for co-authorship with Norwegian researchers included USA, Canada, UK, Germany, Russia, Denmark, France: basically the same countries listed in the self-evaluation data as prominent partners. The same countries, with the addition of Sweden and China, maintained substantial co-authorship with Norway. In general, international co-authorship in polar research publications increased from 2009-2011 to 2012-2014. Roughly one third to one half of all polar research publications by Norwegian researchers involved both national (other institution) and international co-authors.

In terms of relative citation index, one plausible measure of quality and impact, Norway's polar research publications rated clearly above the international average, but at a relative rating of number 12 out of 24 top-publishing countries (figure 4.6). Countries such as USA, UK, Canada and Germany had higher relative citation indices while countries such as New Zealand, Japan and Russia had lower citation indices. Of the seven largest polar research countries by total publications (including Norway) all but Canada saw an increase in relative citation rates from 2005-2009 to 2010-2013.

In addressing the journal profile for publications by Norwegian polar researchers, the NIFU bibliometric analysis concludes:

> *"The fact that the journal profile of Norway is below the one of the leading countries in terms of citation rate may have different possible explanations: a) Norwegian polar research has a distinctive scientific profile which means that it less often is suitable for being published in the most prestigious journals, b) Norwegian polar researchers are not sufficiently ambitious when they select journals for their publications, c) the scientific quality of part of Norwegian polar research is too low for getting into the most prestigious journals. It is not within the scope of the present report to assess the likeliness of the various explanations. However, we will conclude by arguing that there are good reasons for attempting to increase the proportion of Norwegian polar research in the leading or high impact scientific journals." (Aksnes 2017, p. 47).*

We echo point (a) above: a broad research program tailored to meet national needs for Norway or any other country will not, by definition, result in maximum number of publications in a relatively few highly-ranked science journals. We contend that, given its geographic location and scientific prominence, Norway needs a broad research program that includes ecology, technology and sociology, even as research publications on those topics and scientific journals that publish those papers may not - for reasons outside of national control - score at the highest end of citation counts and impact factors. With this dual goal of quality and relevance in mind, this Committee takes a somewhat cautious view of the comparative outcomes of bibliometric analysis, particularly related to international comparisons. We agree with the general rating of Norwegian polar research with respect to other countries but also recognize that many other factors (choice of journal, international collaborations, choice of research location, scientific specialty and institutional preferences and expectations consistent with Norway's specific polar mission) will influence citation records for individual researchers and for research institutions. As part of our recommendations, we suggest that in future evaluations Norway should include comparisons to countries with more similar, and therefore directly comparable, missions and resources.

4.1.1 Arctic

Norway's research publications focus predominantly on Arctic science: in 2014 roughly 450 of 510 publications by Norwegian polar researchers focused on Arctic science. In terms of volume of publications related to the Arctic, Norway rates 3rd, behind USA and Canada (figure 4.1). The number of publications by Norwegian researchers on Arctic science have increased steadily from 2005 to 2014 (figure 4.2).

The prominent co-authorship of research papers between Norwegian researchers and colleagues from Canada, Russia and Denmark indicates Norway's strong collaborative role and reputation in Arctic research. We note the leading role - by staff, resources, publications - of organisations like UiT or IMR that make strong contributions to Arctic research. 14 out of 18 of the highest impact papers identified from the bibliometric analysis treat Arctic issues. 80% of the self-nominated papers explicitly treated Arctic research.

By all information extractable from the bibliometric analysis, Norway has a strong and prominent program of Arctic research. In view of the fact that this analysis did not consider many of Norway's Arctic research activities in mainland terrestrial ecology, resource management, marine technology, and human and social science - and that publication metrics may not represent valid indicators of productivity in several of these fields - we believe that full accounting, including e.g. reports, patents, regulations, etc., of Norway's Arctic research would show even greater quantity, quality and impact.

4.1.2 Antarctica

By bibliometric analysis, Norwegian researchers produced 230 publications concerning Antarctica and the surrounding Southern Ocean during the period 2010-2014. Most related to ice and ocean, or krill in the case of biology. Fewer than 20 of those publications referenced Troll Station in the titles or abstracts. As one example of international research that takes advantage of special conditions at Troll Station, NTNU and UK researchers used a BAS radiometer at Troll to obtain unique measurements of mesospheric CO (ESSD).

Figure 4.7 shows the distribution of Norwegian Antarctic publications by topic. Cryosphere and oceanography

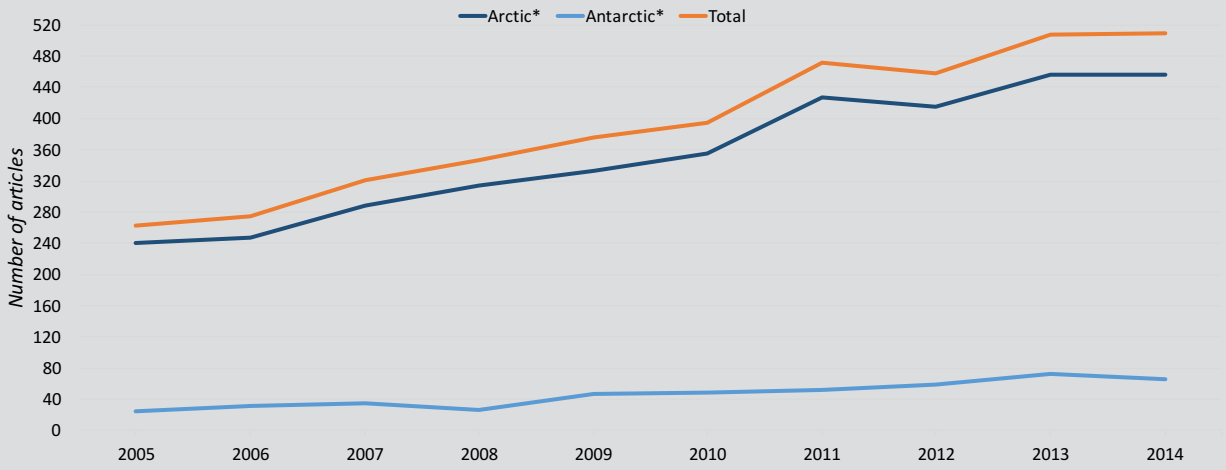

Figure 4.2. Number of polar research articles, Norway, by geographical area, 2005-2014 (source: figure 3.2 in Aksnes, 2017).

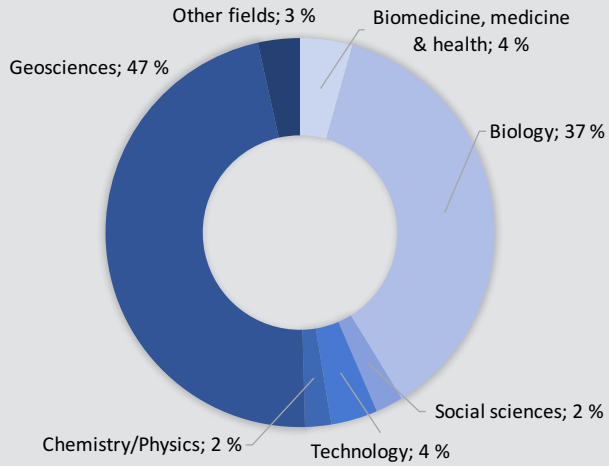

Figure 4.3. Relative distribution of polar research articles by fields, Norway 2012-2014 (source: figure 3.3 in Aksnes, 2017).

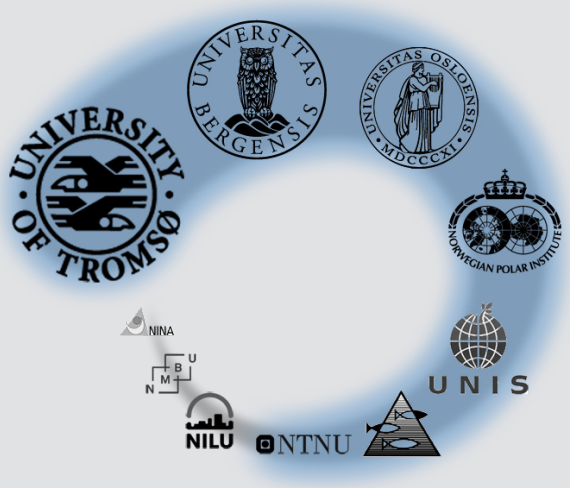

Figure 4.4. Top ten Norwegian research institutions by number of polar publications indexed in Web of Science. Blue indicates partnership in the Nansen Legacy project.

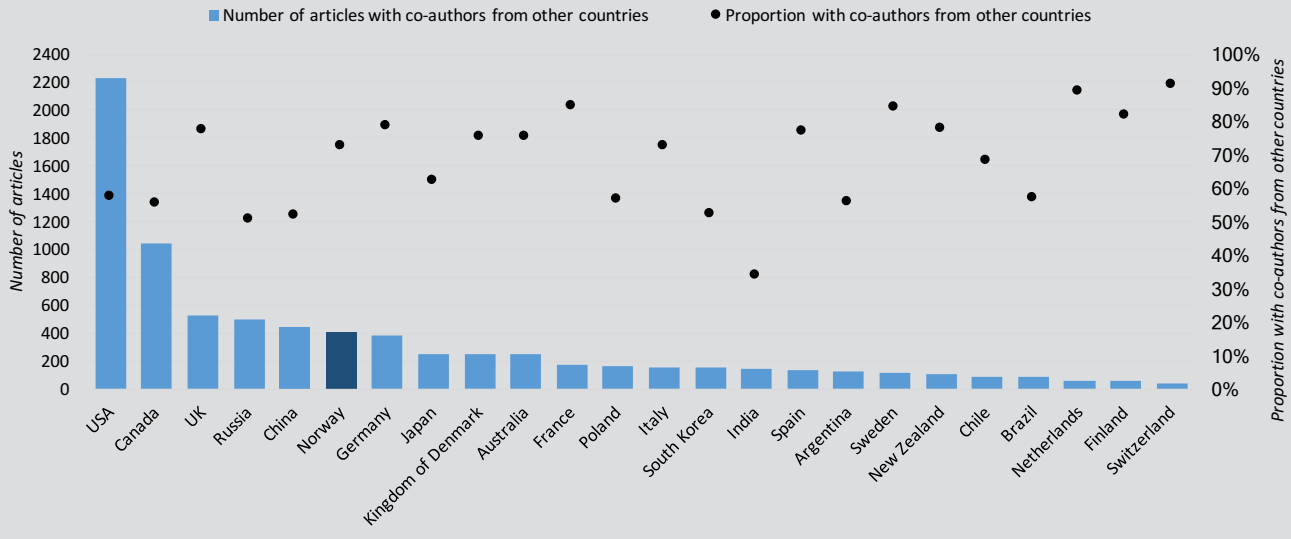

Figure 4.5. International collaboration in polar research (total). Number and percentage of articles with international co-authorship by country, 2012-2014 (source: figure 3.5 in Aksnes, 2017).

dominate, with fisheries and marine biology a much smaller fraction than in Norway's Arctic research programs. More than 20% of Antarctic publications derive from NPI but researchers from at least 8 other universities and institutions, including UNIS and IMR, participated in Antarctic research.

Norwegian publications on Antarctic science increased in number and in proportion from 2005 to 2014. Although these publications represent a small fraction of the total Norwegian polar program, the bibliometric analysis indicates that Norway's Antarctic publications have at least an equal citation rate and publication impact relative to the total Norwegian program.

4.1.3 Technology

According to the bibliometric analysis, publications in polar technology represent only 4% of Norway's total polar publications (figure 4.3). At least recently, publications in the area of polar technology elicited a lower citation rate than those in biology or geoscience. We note that only one distinctly technology-focused journal, Cold Regions Science and Technology (with a low impact factor by comparative standards), appears on the list of journals most frequently used by Norway's polar research community (table 4.1).
For reasons already mentioned, including preferred use of conference proceedings (not indexed by Web of Science) by engineering communities, the Committee consider that the bibliometric analysis understates the quantity, quality and impact of Norway's research programs in polar technology.

4.1.4 Analysis of self-selected papers

Our Committee provided to NIFU a list of publications extracted from the self-evaluation forms submitted by polar institutions as most prominent and relevant to their mission.

NIFU conducted a brief analysis of these publications. We submitted 54 articles (one duplicate). The NIFU analysis found 48 of these articles (89%) indexed in Web of Science. Of these 48 articles 38 were included in the larger bibliometric analysis of polar research. The 'precision' (correspondence between NIFU machine analysis and self-selection) rate was greater than 80% (excluding articles which deliberately have been left out), probably even higher as two or three articles submitted would probably not be counted as polar research given the definition used. This relatively high correspondence seems to confirm a mutual assessment of quality between bibliometric analysis and institutional self-evaluations. We note however that none of the publications selected by the polar institutions appear in Table 3.10, most cited articles, in the bibliometric analysis (Aksnes, 2017). On average, each self-nominated paper had 7 authors. Researchers affiliated with Norwegian institutions were first authors on 42 of the articles (89%). These data indicate that institutions reported publications where they, or at least Norwegians, had been major contributors.
The self-selected articles had collectively been cited 1600 times by 01.01.2017 (from Web of Science core journals). Half of these articles were among the 10 percent most cited within their fields. Three articles had more than 100 citations (same criteria used to identify highest impact publications

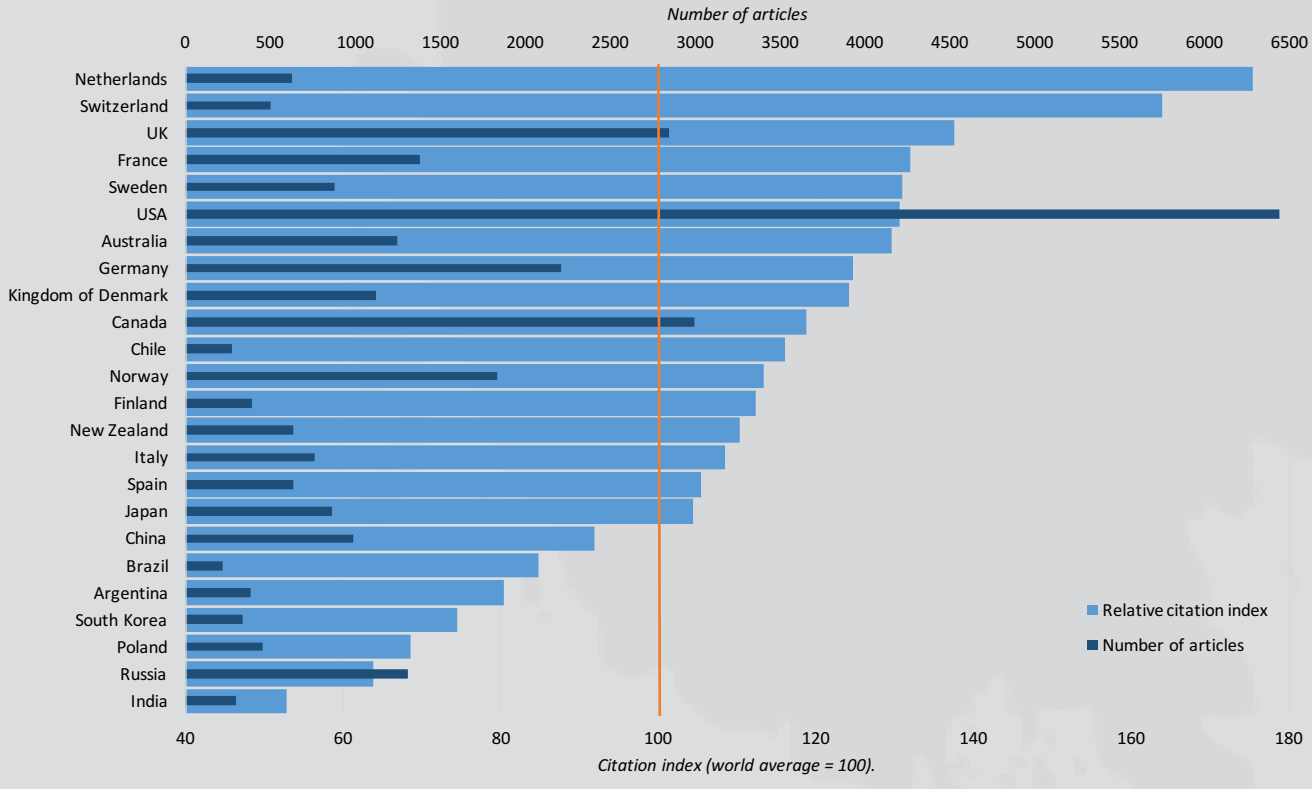

Figure 4.6. Relative citation index and the number of articles of the 24 largest polar research nations, 2010-2013 (source: figure 3.8 in Aksnes, 2017).

in the full analysis). On the other hand, 9 of 41 articles (22%) published in the period 2011-2014 (and excluding editorials) were cited less than 10 times; these often represented technical reports or opinion pieces judged by the institutions to have high importance but not widely cited. The average relative citation index for the articles was 266, significantly above Norway's national average of polar research (113). The articles were on average published in journals with impact factors significantly above the field average (index 173). Thus, perhaps not surprisingly, the self-selected articles on average were also highly cited and published in high impact journals according to bibliometric analysis.

4.2 Publication activity and scores on research impact indicators

We consider here one of the indications from the NIFU bibliometric analysis that, by publication metrics, Norway's polar research programs fall below expectations with respect to polar research programs in other countries. We specifically address this summary statement from the NIFU report (page 55 in Aksnes, 2017):

> *"The analysis shows that impact of Norwegian polar research in terms of citation rates is lower than for several other major polar research nations."*

The NIFU report mentioned several factors that might contribute to this apparent deficiency as follows:

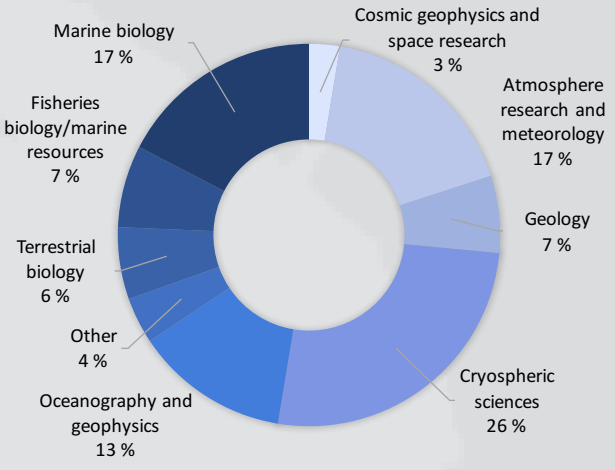

Figure 4.7. Relative distribution of Norwegian Antarctic research articles by fields, 2010-2014 (source: figure 3.30 in Aksnes, 2017).

- Publication in journals with relatively low impact factors
- Publishing research from single locations, specifically Svalbard
- Publishing across a wide range of disciplines some of which have inherently low citation rates and journal impact factors
- A range of publication expectations and practices within and across Norwegian polar research institutions
- An apparent correlation of higher publication impact with higher international collaboration

We mentioned above our reasons for expecting that some research products essential to Norway will not appear in highest-impact journals. We consider location issues (and Svalbard specifically, in a later section), discipline disparities, and international collaborations in more detail in this Section. We start this discussion with two important quotes:

- ***"Norway ranks higher than many other countries and has a score above the world average on several indicators."*** (page 55 in Aksnes, 2017)
- ***"There is no reason to conclude that Norwegian polar research is poorly cited."*** (page 55 in Aksnes, 2017)

The indications and conclusions in this and previous sections derive almost entirely (and necessarily) from automated bibliometric analyses of standardized databases. We follow guidance from the bibliometric report (Aksnes 2017) itself: "In order to evaluate scientific quality and the content of the research, examinations by peers are required. Possibly, peers may arrive at other conclusions than what is suggested by citation measures. This is not only due to the limitations of citation indicators, but also because a peer-evaluation may involve assessments of factors besides scientific quality or factors that are not likely to be reflected through citation counts." This Committee, serving as peers, accepts as our »

Figure 4.8. Wordle figure with the most frequently appearing words in the Norwegian Antarctic publication titles, 2010-2014 (source: figure 3.28 in Aksnes, 2017).

Table 4.1. Journal profile of Norwegian polar research, 2010-2013. Number of articles and relative journal citation index, ranked by publication frequency (source: table 3.7 in Aksnes, 2017).

Journal	Number of Norwegian polar articles	Relative journal citation index (all articles)*	Relative citation index (Norwegian polar articles)
Polar Biology	81	66	81
Atmospheric Chemistry And Physics	52	183	166
Journal Of Geophysical Research-Oceans	39	140	115
Quaternary Science Reviews	39	184	174
Journal Of Geophysical Research-Atmospheres	37	125	85
Polar Research	37	54	47
Marine Ecology Progress Series	34	106	111
Cryosphere	29	209	262
Plos One	27	64	44
Science Of The Total Environment	27	130	265
Annals Of Glaciology	26	88	82
Norwegian Journal Of Geology	26	94	68
Geophysical Research Letters	25	166	151
Journal Of Geophysical Research-Space Physics	23	64	20
Ices Journal Of Marine Science	21	120	141
Journal Of Glaciology	19	120	127
Marine Biology Research	17	64	126
Palaeogeography Palaeoclimatology Palaeoecology	16	127	121
Progress In Oceanography	16	211	172
Biogeosciences	15	154	200
Environmental Science & Technology	15	165	118
Ambio	14	101	104
Boreas	14	103	78
Climate Dynamics	14	162	123
Cold Regions Science And Technology	14	60	45
Geology	14	222	181
International Journal Of Circumpolar Health	14	45	71
Journal Of Marine Systems	14	132	109
Canadian Journal Of Fisheries And Aquatic Sciences	13	131	97
Marine And Petroleum Geology	13	113	101
Tectonophysics	13	114	99
Marine Pollution Bulletin	12	106	53
Deep-Sea Research Part I-Oceanographic Res Paper	11	130	121
Geophysical Journal International	11	108	86
Global Change Biology	11	282	320
Journal Of Geophysical Research-Earth Surface	11	149	86
Polar Record	11	21	13
Proceed Of The National Academy Of Sciences Of Usa	11	182	156
Quarterly Journal Of Royal Meteorological Soc	10	194	26

**) Weighted by number of articles and year (Norwegian). Source: NIFU / Web of Science.*

task and responsibility to provide additional knowledgeable assessment, motivated by a genuine desire to identify opportunities for improvement.

The NIFU analysis showed that, for polar researchers of any country, focus on a single location increased the probability of lower-impact publications. We find the location distinction less than helpful. Uncertainty about impact of location on quality applies to all countries, not exclusively to Norway. We note, as does NIFU, that single location studies represent by far the largest fraction of geographically-delineated publications analysed and that, by a large margin, single location studies included more high-impact publications than multiple-location or general area studies. Multiple-location and general area studies also had substantial fractions of low-impact studies. We also note that singular events tend to have specific locations so that publication about an Icelandic volcano, of high- or low-impact depending on timing with respect to eruption, might reference a single location but have hemispheric impact. Alternately, publications carrying in their title the phrase 'rapid mass loss' might have very high impact for the single location of Greenland but less so for the single location of Svalbard even if, from the Svalbard study, one learned more about glacier dynamics. In that case the magnitude of possible impact outweighs any single location limitation. Because the Web of Science database contains only titles and abstracts, but not full text with maps or methods sections, a high-impact publication on Arctic haze, for example, would appear as a general area topic until one learned in the methods section that the measurements came from the Zeppelin facility. Around the circumpolar Arctic with relatively few locations to support hiqh-quality measurements, we contend that a quality or impact distinction between single and multiple locations lacks generality and credibility.

For the purposes of Norwegian polar research we expect two 'single' locations - Svalbard and the Barents Sea - to draw substantial research attention based on national mandates applicable in both locations. In both cases we anticipate location inaccuracies from the Web of Science database: 'Atlantic' cod as a research topic in the Barents Sea or, as already mentioned, 'Arctic' haze measured from Svalbard. That Norwegian researchers might focus on Svalbard or the Barents Sea seems quite logical to us. We see no particular factor in either case that would preclude high-impact publications but we also understand that high-impact publication might not represent the only or preferred outcome of such research. As these examples illustrate, high impact papers could result from publications that include Norwegian locations in a global analysis, for example of fisheries or air quality, but - without distinct polar keywords in title or abstract - those global perspectives would not emerge in a polar-focused analysis.

The NIFU analysis also suggests that disciplinary breadth, specifically the inclusion of publications in lower-cited specialties such as (by Web of Science metrics) medical or technical vs higher-cited specialties such as geoscience or biology, might contribute to lower publication impacts. We applaud the disciplinary breadth of Norway's polar research; we see that breadth as appropriate and necessary regardless of publication impact. A closer comparison with Canada opens the possibility that national funding policies and national professional expectations may play a larger role than disciplinary factors. We find the research portfolio of Canada very similar to that of Norway: terrestrial, marine, social, cryospheric, economic, etc. Although Canadian researchers produce nearly twice as many polar publications as the Norwegian polar community, by all other bibliometric data Canada and Norway seem very similar. For purposes of comparing any two countries, we adopt a plus/minus 10% uncertainty.

We note that Canada and Norway share an Arctic focus. Both countries value and practice international cooperation. Despite disparity in number of publications, the two countries have nearly identical: relative citation rates; percentage of publications with first authorship; percentage of publications with exclusively national authorship; proportion of publications in upper 10% and lowest 20% categories; etc. Because Canada represents a similar situation to Norway, any citation quality 'penalty' that derives from a multidisciplinary portfolio should impact citation indicators for Canada's polar research similar to Norway's polar research. Comparisons of Norway with countries that maintain disproportionately large Antarctic programs, such as USA, UK or Germany, seem less relevant.

We accept the general contention that polar science productivity rises with degree of international collaboration: internationally co-authored papers tend to have higher average citation rates. We feel less confident that the quality of polar research, as measured by citation rates or impact factors, rises directly as a consequence of international interaction. We see evidence that quantity of publications increases with degree of international interaction, but in those comparisons - for reasons stated above - we consider comparisons of Norway with USA or UK - nations with large well-funded Antarctic programs - as inappropriate.

In summary, we feel that bibliometric analyses provide useful information. We certainly accept the proposition that Norway (like many other countries) could improve its publication-based performance. We suspect that the location, disciplinary and international factors invoked by NIFU as possible limitations play a smaller or less clear role than national and institutional expectations and policies. Even as we echo the fundamental NIFU conclusion already cited - "Norway ranks higher than many other countries and has a score above the world average on several indicators" - we recommend in section 8 some changes in metrics that could enhance the overall profile of Norwegian polar research and the impact of research publications.

4.3 Basic and applied research, multi- and interdisciplinary research

The Norwegian polar research portfolio, as presented, includes a wide range of priorities and activities (e.g. Aksnes, 2017, Figures 3.30 and 4.5) . Most of these defy easy categorization as basic or applied or as disciplinary or multi- (or inter-) disciplinary. The polar programs of Norway share strong affinity with environmental science generally in that assignment as basic or multidisciplinary often depends on context and local implementation. In polar science, particularly in Norway's programs, we find many research connections that meet Norway's needs by drawing from multiple disciplines and producing simultaneous basic and applied outcomes.

In Table 3.1 above, working from research priorities of the polar institutions, we identify two predominant research threads in what we have labeled 'climate and ecology' and 'resources and technology'. While the former might include science defined as basic and the later science defined as applied, we see many cross connections that demonstrate interdisciplinarity and broad relevance. We identify fundamental biology and resource management, both quite disciplinary, combined to stimulate an interdisciplinary research focussed on very basic and very applied questions for Barents Sea ecosystems. Likewise, we recognize sea-ice physics (basic, disciplinary) converging with marine transport (disciplinary) into research on new shipping technologies and regulations for the future Arctic - a highly interdisciplinary and applied program.

Question 4c in the self-evaluation survey invited respondents to list interdisciplinary activities; 27 institutions did. We find many valid responses - nearly 100 in all - related to institutional priorities and specialties but identify a predominant reference (particularly if the institution listed only one activity) to climate and climate change. A large majority of institutions identified the interdisciplinary challenges inherent in understanding polar ecosystem links to climate change. The themes of resource management and shipping, also listed among interdisciplinary challenges, also occur with frequent reference to changing climate. At least one institution mentioned the Nansen Legacy project as a specific interdisciplinary priority.

Titles of the self-nominated research publications confirm this overall pattern of research in a climate context. In many of those publications researchers describe their own work with reference to external oceanographic or meteorological records of environmental change. We also note that geographic boundaries applied here will have hidden interdisciplinary research about, for example, how changes in offshore fisheries impact local communities and economies and how changes in precipitation impact terrestrial ecosystems or reindeer husbandry.

In summary, we confirm from all evidence that Norway's polar research simultaneously achieves basic and applied goals via disciplinary or interdisciplinary approaches as appropriate. We recognize continuing tension within the Norwegian polar research community reflected in simultaneous advocacy for more open competition and more focus. Advocates tend to identify open competition with basic and disciplinary research while also expressing concern that Norway's polar research programmes lack coordination, focus and shared direction - which might portend more interdisciplinarity and more attention to applications.

4.4 Capacity and efficient use of infrastructure

As listed in Section 2.3, Norwegian polar researchers develop, support and exploit a wide range of high quality infrastructure. The list above (Section

2.1.3) centers on ships and ship-based instrumentation but extends to land-based instruments, field stations, ocean moorings, etc. This Committee heard and resonates with concerns about overall support levels for that infrastructure and about equitable access to the facilities, but we feel confident in the overall quality of systems and services. We address systems and services on Svalbard separately, below.

Despite the apparent abundance and variety of infrastructure listed above, access to and long-term reliable support of this infrastructure remains a pervasive concern across the Norwegian polar research community. Access to and support for research vessels (ships) represent the most prominent and potentially the most limiting facility concerns but many concerns related to ships apply to other infrastructure as well.

Norway with its long history of sailing has a reputation for efficient operation of research vessels with an excellent working atmosphere between crew and scientists. Norway's ocean-going polar researchers want and deserve a continuation of this tradition. Concern remains, however, over access, possible preferential access, and cost of access to the new ship (FF Kronprins Haakon), about impact of the new ship on overall availability of ship resources, and about the connection of ship allocation to scientific priority. To some extent the new ship stimulates these concerns although in many cases the concerns derive from past experience.

For all infrastructure, for both operators and users, concern remains high about long-term access to and capabilities of these facilities. In many cases, even with only small increases in operational costs, the expense of using polar research sites and instruments remains very high and difficult to justify or obtain as access to general research funds decreases. Access to individual sites or instruments remains apparently quite ad hoc, based in large part on word-of-mouth between colleagues. Even for a single location, e.g. Longyearbyen, the absence of a systematic and comprehensive list of facilities, with availability schedules and access and use policies, remains a barrier to many polar researchers. For heavily-subscribed facilities access knowledge within a small user community may prove sufficient, but an overall open and efficient usage system matched to science priorities seems desirable. Many Norwegian-operated facilities represent important nodes in global networks, but that knowledge, and how it should drive support decisions, remains very much within institutions and disciplines.

Many polar institutions express a desire to contribute ideas and planning to an overall research infrastructure development plan, within polar research or for the wider Norwegian science community. Such a plan could include proposal-based access to substantial facility-development funds; facilities proposed under these mechanisms would need to demonstrate national access plans. Polar research in Norway apparently offers several good examples of industry partnerships on laboratories and equipment. An inclusive facility development and support plan for polar research could identify and stimulate additional partnerships.

The bibliometric analysis did not 'drill in' on issues of facilities or sensor technology. For reasons already mentioned (access only to titles and abstracts), Web of Science database would often not reveal information about specific instruments or measurement platforms. We know from institutional descriptions and titles of self-selected publications that Norwegian researchers use a range of tools and facilities from genomics to superDARN radars.

The issue of long-term support for development and operation for observing facilities raises the science question of monitoring versus research. In a stable climate we might consider some observations (of ocean sea surface temperatures, for example) as examples of useful long-term monitoring, but with climate change impinging strongly on snow, ice and polar ecosystems, distinction between monitoring and research tends to dissipate. The nearly 40- »

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year record of satellite-based measurements of Arctic sea ice extent demonstrates this intimate connection of monitoring and research: the sustained 'monitoring' record remains a vital aspect of and resource for contemporary 'research'. Long-term IMR data on Barents Sea ecosystems provide a similar long-term basis for urgent present-day investigation. In both cases the Norwegian research community articulates a clear motivation for sustained monitoring. Long-term records produced and shared by Norwegian researchers represent a research asset of undeniable value and quality, while continued support for systems and operations that produce those records represents one of the highest research priorities. A community-wide facilities planning effort within the Norwegian polar research community, as the new ship enters into operations, seems highly desirable.

4.5 Data management

As listed in section 2.2.2, data services within specific components of the Norwegian polar research community seem good to excellent. We note leading Norwegian roles for the EU/ESA Copernicus services for the Arctic Monitoring and Forecasting Center (AMFC) and for H2020 INTAROS (section 2.2.1 above).

Overall, polar science within Norway appears to honor a general policy of open access to public but access as practiced seems quite variable. In particular the explicit allowance of data restriction proprietary periods, while not unusual in comparison to policies of other nations, remains somewhat out of step with the larger trends toward full open access. Collaboration or even communication among the larger polar data centers seems limited. We did not find much evidence for connections of the polar data centers with other environmental data centers across Norway (e.g. the intended Norwegian Scientific Data Network of Met.No seems to not provide much access to polar research data).

In general, Norway's polar data centers seem relatively quiet on the international data scene, especially in view of a gradual international move toward full open access and data publication. NPI and perhaps IMR lead in these directions. Nonetheless, many Norwegian data sets do not carry permanent identifiers. NILU/EBAS appears as the only current Norwegian open access participant in the community of nearly 40 data centers from 13 countries supporting open data publication in ESSD and Scientific Data. We identify a relative degree of insularity in Norway's polar data community.

Data access and data services emerged frequently in the self-evaluations, particularly as concerns and particularly as bottlenecks or challenges. Some of these concerns had to do with specific data sets or with restrictive data practices by key groups. Our Committee could not and did not look into specific data access issues. We do, however, recognize a general concern about timely access, about funding and staffing for data services, about the lack of clear data policies, and about general data availability both for public policy and as a clear mechanism to enhance research.

4.6 Svalbard research in general

If the archipelago of Svalbard did not exist, Norway, with its impressive deep water engineering skills, would probably have had to build a research facility in roughly the same location. Svalbard sits farther north than all continental land masses and than most islands. It sits approximately equidistant from northern Norway and northern Greenland, at the boundary between a broad continental shelf and deeper channels, where surface and deep ocean currents connect the North Atlantic and Arctic Oceans, and where sea ice rapidly retreats. It offers a range of geologic, ecologic and cryospheric features and habitats. Svalbard and its research station at Ny-Ålesund offer Norwegian as well as international researchers outstanding access and infrastructure for Arctic research.

Our particular evaluation effort grew from an earlier assessment that highlighted Svalbard-based research programs (Asknes 2015). We know that RCN has at least one separate evaluation of Svalbard research and education underway simultaneous with our work. Amidst this profusion of information it became easy for our Committee to hear and record concerns about specific services or activities in Longyearbyen or Ny-Ålesund. However, in this report we take a wider, longer look at the general role of Svalbard in Norwegian polar research and attempt to provide a thoughtful assessment of issues of quality related to Svalbard research.

Many polar research organisations of Norway, in written responses to our questions, identified Svalbard, including the locations of Longyearbyen and Ny-Ålesund and the institution of UNIS, as a strength and opportunity of Norwegian polar research. A Ny-Ålesund Science Plan seeks to confirm and enhance Ny-Ålesunds international role as an "outstanding observatory, laboratory, and field base for Arctic research". Several institutions mentioned their role in SIOS - Svalbard Integrated Observing System - as both a positive contribution and as a need for the future. Education opportunities represented by UNIS also received strong attention from many institutions. International participation in Ny-Ålesund research confirms its scientific potential and particularly its political importance.

If Svalbard represents a very good place for Arctic research, it does not represent the only place and measurements from Svalbard (or any other single perimeter station around the Arctic) can not represent the full Arctic environment. In both self-evaluations and interviews we heard a concern that policies and funding that tend to direct research toward Svalbard might somehow restrain research that might take a wider pan-Arctic view. A similar concern applies to the Barents Sea, where intensive local data gathering and fisheries research might occur in competition with or at the expense of research on broader issues of Arctic marine

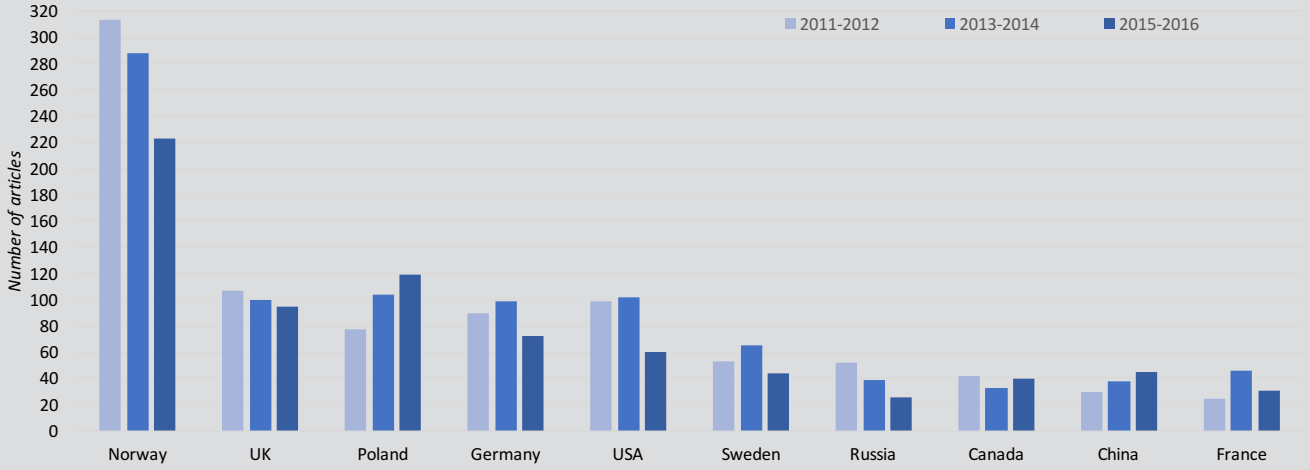

Figure 4.9. Number of Svalbard articles, by country per two year periods, 2011-2016 (source: figure 4.2 in Aksnes, 2017).

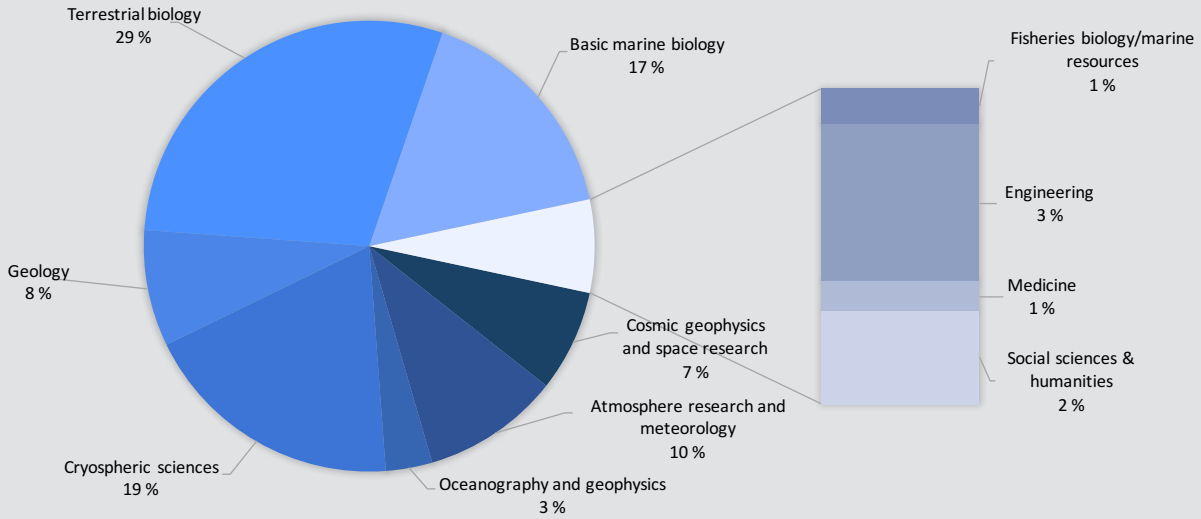

Figure 4.10. Distribution of the Norwegian Svalbard-articles 2010-2014 by field (source: figure 4.5 in Aksnes, 2017).

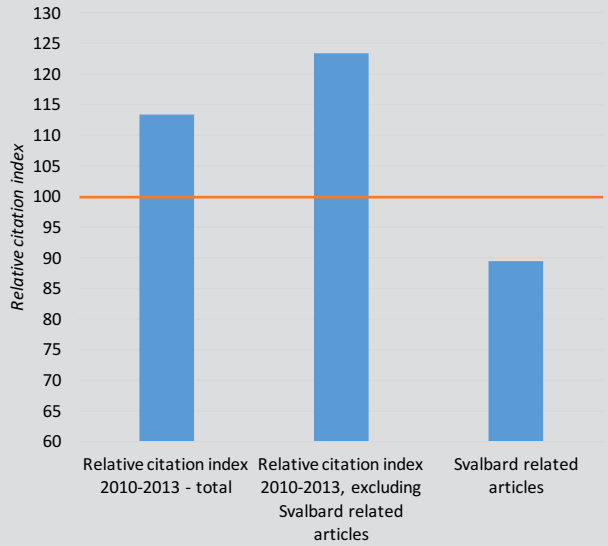

Figure 4.11. Relative citation index for Norwegian polar articles, total, Svalbard related, and total excluding Svalbard related, 2010-2013 (source: figure 3.16 in Aksnes, 2017).

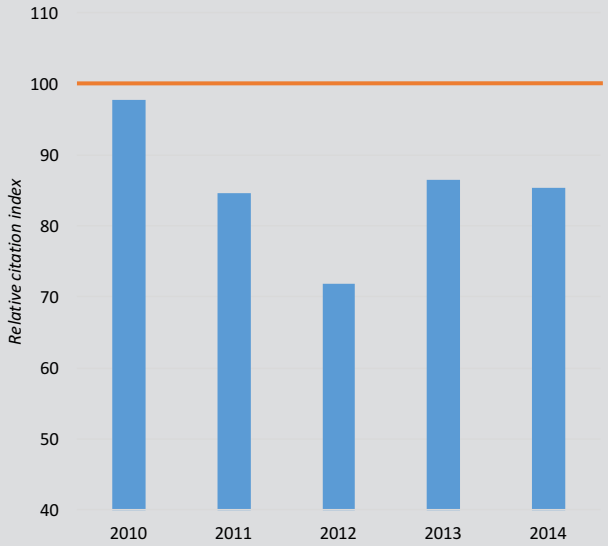

Figure 4.12. Relative citation index for Svalbard related articles, total (all countries) 2010-2014 (saource: figure 4.9 in Aksnes, 2017).

ecosystems. A local focus on Svalbard may impact research quality (see below) and may also represent a facet of the larger relevance vs quality discussion. Concerns about quality and impact of Svalbard research raise a longer-term planning issue: does Norway have a long term vision for Svalbard that builds on its role as a unique research outpost in a rapidly-changing but fragile environment?

With commercial eyes, especially from Europe, turning toward the Arctic, with internal and external research and education interest (and need for research and education infrastructure) growing, and as snow and winter become more attractive to tourists, we anticipate greater pressure on Svalbard and particularly on Ny-Ålesund. Several institutions reported observations of too many visitors and too large a human footprint in Ny-Ålesund and on Svalbard generally.

4.6.1 Characteristics of high and low impact Svalbard publications

The bibliometric analysis confirms that Svalbard plays a key role in Norwegian polar research and that many Norwegian polar research articles relate to Svalbard. Norway produces twice as many research publications on Svalbard as any other nation (figure 4.9), although Norway's own number of Svalbard publications seem to have decreased over the time period 2011 to 2016.

Norwegian research on Svalbard covers primarily the fields of terrestrial ecology and biology, cryospheric sciences, marine biology and Arctic technology with smaller efforts in atmospheric research and meteorology, geology and cosmic geophysics, space studies, oceanography and marine geophysics (figure 4.10).

International research on Svalbard follows very much these same disciplinary patterns, with Norway contributing roughly 25% to 30% of the total international research efforts in terrestrial ecology and biology, cryospheric sciences and marine biology. Climate forms a very large component of both the Norwegian and the international research programs. Research by UNIS, UiT and NPI accounts for approximately half of all Norwegian Svalbard-related publications (table 4.2). Approximately 70% of Norwegian publications about Svalbard included international co-authorship, very similar to levels of collaboration for all of Norway's polar research.

Based on citation rates, the bibliometric analysis suggested a lower quality or impact of research published on Svalbard: removal of the Svalbard-associated papers raised the overall citation rate for Norway's polar research (figure 4.11). Further analysis reveals that Svalbard publications from all countries, not only those of Norway, have lower than average relative citation rates (figure 4.12).

Norwegian Svalbard research publications (including those publications with lead authorship by Norwegian researchers) - like those of UK, Germany and France for example - reach the median value for international polar research (figure 4.13), although with a relative citation rate very slightly lower than for Norway's overall polar research (Asknes 2017 and see figure 4.15 below).

Additional analysis shows that Norway's most highly cited polar scientists generally have a sizeable contribution of Svalbard work in their portfolios (figure 4.14). Norwegian and almost all international researchers tend to publish Svalbard work in journals of slightly lower impact (figure 4.15). Across »

Table 4.2. Number and proportion of Svalbard articles by institution/ institute/sector, 2010-2016 (source: table 4.1 in Aksnes, 2017).

	Institution/institute/sector	Number of articles	Proportion
HE sector	University Centre in Svalbard	346	19%
	The Arctic University of Norway	278	15%
	University of Oslo	222	12%
	University of Bergen	127	7%
	Norwegian University of Science & Technology	90	5%
	Norwegian University of Life Sciences	54	3%
	Other HE-institutions	30	2%
Institute sector	Norwegian Polar Institute	262	14%
	Akvaplan Niva	63	3%
	Norwegian Institute for Nature Research	57	3%
	Norwegian Institute for Air Research	51	3%
	Other institute sector	159	9%
	Other	32	2%
	Business sector	53	3%

*) Only units with more than 50 articles are shown separately in the table. Articles with contributions from several institutions/institutes will be included in more than one category. (Source: NIFU / Web of Science)

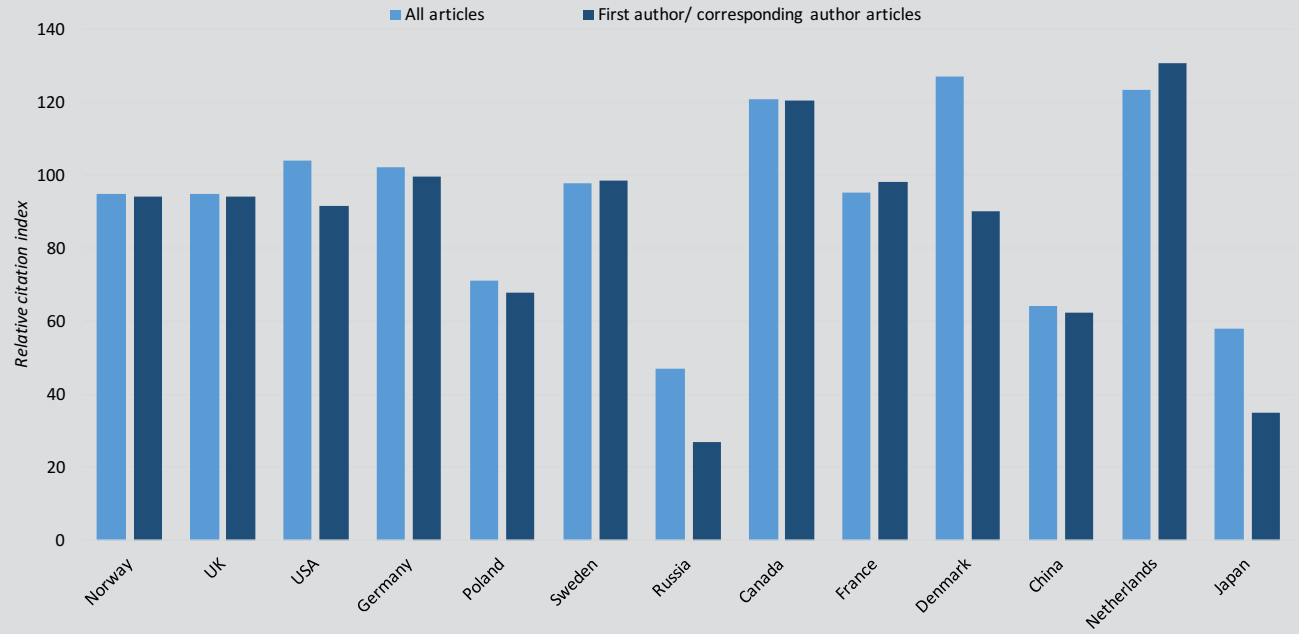

Figure 4.13. Relative citation index for Svalbard related articles, by country and authorship, 2010- 2014 (source: figure 4.10 in Aksnes, 2017).

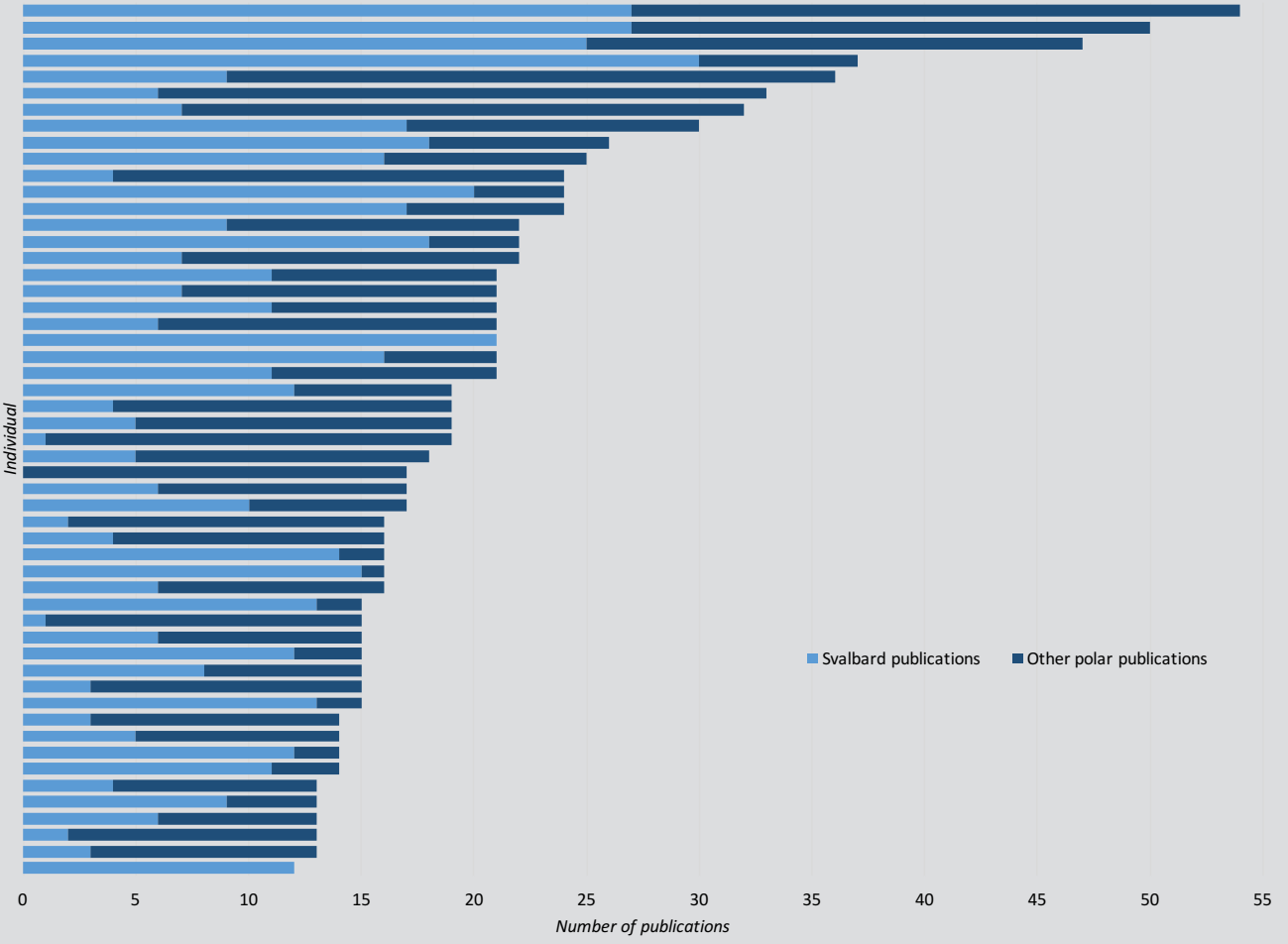

Figure 4.14. Overview of the most prolific Norwegian polar researchers (N=53), distribution of Svalbard publications and other polar publications, 2010-2013 (source: figure 4.19 in Aksnes, 2017).

all countries, citation rates for cosmic geosciences and space research - a small but significant fraction Svalbard research due to its unique geomagnetic location - fall well below the citation impact of other disciplines such as terrestrial ecology or marine biology.

Taking all factors together, Norwegian Svalbard publications have small but positive citation impacts for all disciplines relative to all countries (figure 4.16). Likewise, single location publications related to Svalbard had a lower citation impact than publications from multiple locations, but within this pattern Norway's publication citation rates exceeded the average for all countries (figure 4.17).

In summary, we conclude that Svalbard research can and does result in world-class publications but that in many disciplines, for all countries, Svalbard research often falls short of this standard. In some specialties, Svalbard research may focus on single sites which have little influence outside of that geographical location and, hence, a lower rate of citation. Unique conditions on Svalbard may favor some specialities (e.g. ionospheric geophysics) that themselves have lower citation rates. Purely local investigations on Svalbard that do not offer comparative analysis may lead to publications of limited relevance to a wider community. We see no evidence that Norwegian research differs from most other international Svalbard research with respect to quality and, for geographic and bibliometric reasons discussed, we recognize limitations that constrain our ability to assess the impact of Svalbard research in the context of global assessments.

We also note, and the bibliometric analysis confirms, that Svalbard offers a valuable means to train Norwegian and international polar scientists (next section).

4.7 Human capacity

Through their written responses and in-person interviews, members of Norway's polar research community conveyed a shared sense of purpose and urgency, awareness of national and international impact of their work, and overall enthusiasm for their roles and tasks as polar researchers. Notwithstanding the talent and energy of the present polar research workforce, we identify several concerns related to overall recruitment and retention.

We read and heard about the difficulty of assembling a critical mass of expertise on crucial issues or projects. We believe that a very wide range of topics covered by Norwegian polar research and relative fragmentation among many institutions combine to allow these periodic shortages. Absence of a clear long-term plan and the nature of short-term funding may also hinder efforts to assemble effective research teams. We also heard and read about the need for continued and perhaps enhanced recruitment of young scientists, engineers and technicians into polar science. Again, absence of a clear long-term national plan »

Photo: © Ann Kristin Balto/Norsk Polarinstitutt

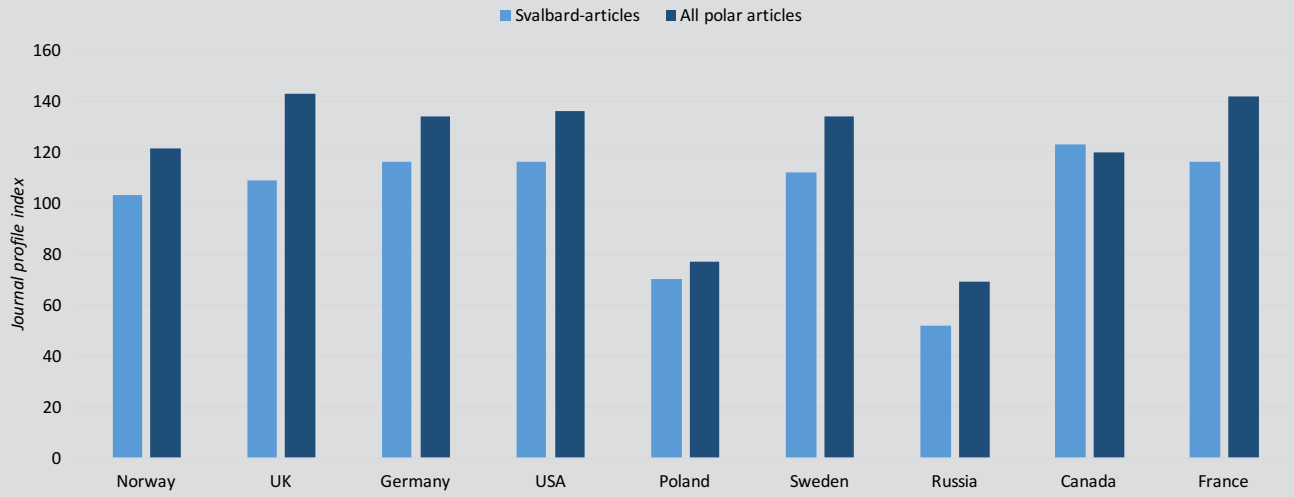

Figure 4.15. Journal profile (the relative citation index for the journals used) Svalbard-articles and all polar research articles, 2010-2013 (source: figure 4.12 in Aksnes, 2017).

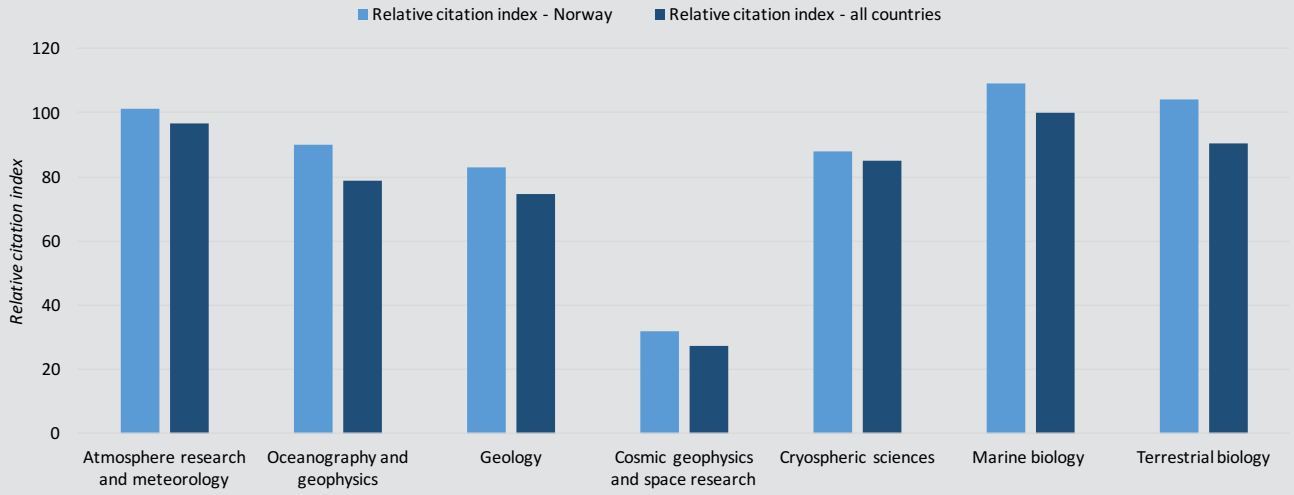

Figure 4.16. Relative citation index for Svalbard articles, by field, total all countries and Norway, 2010-2014 (source: figure 4.14 in Aksnes, 2017).

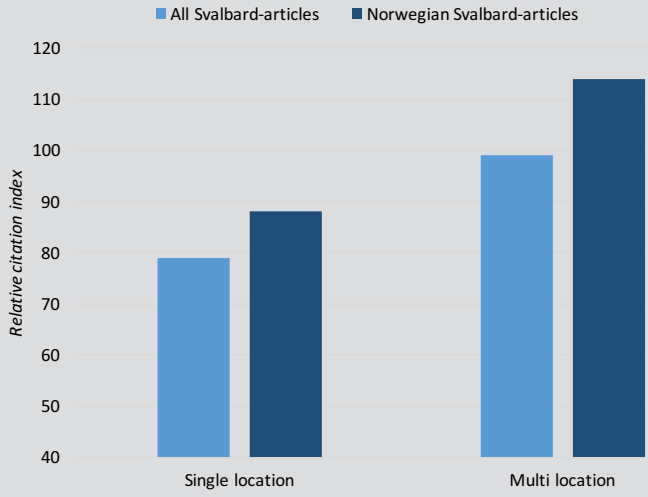

Figure 4.17. Relative citation index for Svalbard articles by geographical type, Norway and all countries, 2010-2014 (source: figure 4.16 in Aksnes, 2017).

and reliance on short-term funding may represent deterrents when polar science itself, with its planetary relevance and abundant challenges, should offer inducements. A clear national message, implemented via RCN, on the importance of fundamental polar research to Norway - perhaps as one outcome of this review - could prove useful for polar science.

In science generally, and within the relatively small community of polar science particularly, a vigorous international exchange of students, post-docs and faculty has proven both necessary and strongly beneficial. We confronted some evidence that Norway, perceived as a good place to do polar science, lacks enticements and expectations at student levels and incentives at the faculty level to ensure this exchange. If most student funding for polar science derives from RCN, we might expect that RCN would work from an overall science workforce development plan that gave particular attention to the needs of polar science.

We heard about but did not evaluate gender issues. We expect, for Norway at least, that gender bias or gender restrictions in polar research occur no more often than in research generally, and that Norway maintains a pro-active gender-diverse recruitment and retention policy for science and engineering. We also heard (partly, we admit, in form of rumors) about differences in staff recruitment, evaluation and compensation policies - perhaps inevitable for ship-going and field-going researchers from multiple institutions - that raised unhelpful issues of unfairness and inequity within the polar research community.

Related to recruitment and communication, the polar research community of Norway clearly recognizes strong education advantages with Svalbard as a location and with UNIS as an institution. A majority of institutions, not only the universities, listed substantial advantages for research, testing, demonstration and evaluation, and education at Svalbard and with UNIS among both strengths and needs.

UNIS promotes research- and field-based education, with research integrated into education and students involved directly in research. Norway's polar research community seems to recognize and accept one or the other of the research and education roles depending on the user's interests. Few within UNIS or within the polar research community understand clearly how those roles fit together or what plans UNIS has to expand or enhance its education or research roles within overall national directions and priorities for polar research. UNIS seems often mentioned, frequently used, well known, but not really understood. UNIS as an institution together with its science departments play an active role in the on-going strategic planning process for research and higher education in Svalbard (scheduled for release in autumn 2017).

NIFU's bibliometric analysis showed a clear impact of Svalbard in its education role as an effective training ground for PhD students in polar research. In the time period 2001-2011 and using data from three institutions (UNIS, NPI, biology department at UiT) with polar research at the core of their mission (a broader sample would have provided larger numbers), the NIFU analysis tracked 71 students starting their PhD projects in Svalbard. Of these, 68% had a foreign (non-Norwegian) citizenship, 73% completed their studies by 2015, and 50% continued their research as a postdoc on Svalbard (figure 4.18).

Of the Norwegian Svalbard-related publications in 2013, 58% included PhD students (figure 4.19). These analyses confirm that Svalbard plays an important role in the education of Norwegian and international polar researchers. ❖

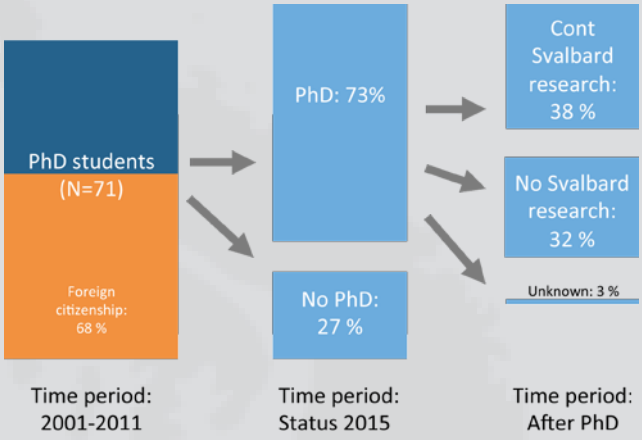

Figure 4.18. Career of individuals with PhD projects in Svalbard (source: figure 4.20 in Aksnes, 2017).

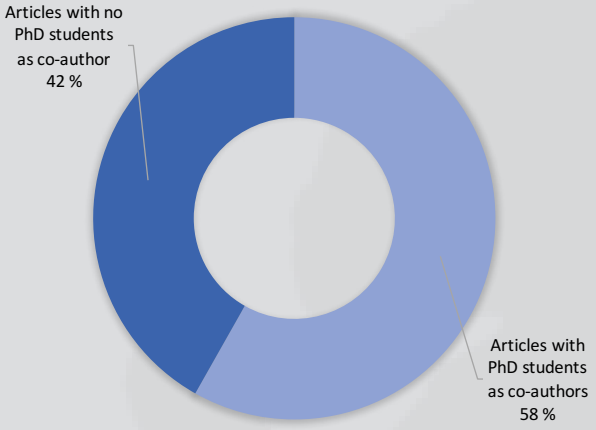

Figure 4.19. Proportion of Norwegian Svalbard articles with and without PhD students as co-authors, 2013 (source: figure 4.21 in Aksnes, 2017).

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Photo: © Leif Anderson

5 Research Partnerships

Norway's polar researchers maintain a vigorous set of internal partnerships, particularly among and from organizations involved in the Nansen Legacy. We also identify strong external (international) partnerships necessary and appropriate for addressing key topics in polar research.

As documented in Section 2.2, the challenges and urgencies of polar science require national and international partnerships, dialogue, planning and collaboration.

5.1 Internal

Norwegian polar research organizations perceive a need for clear long-term prioritization for Norway's polar research. They express concern about the absence of long-term funding (particularly for instrumentation and databases), about opportunities and success rates for proposals generally (especially for proposals on fundamental science), and about their ability to assemble and sustain critical masses of talent for urgent tasks. Many of them recognize an emerging national deficiency in the overall training of the next generation of Norwegian polar scientists and an associated impact on national partnerships as scientists from other countries working in Norway find it beneficial to maintain research contacts with external colleagues. These organizations all confront continuing high costs of access to polar regions and conflicts inherent in meeting simultaneous mandates for national relevance and scientific quality.

We encountered oral statements to the effect that communication among these partners, including across departments within a single university, needed improvement. Written contributions from the organizations themselves did not identify communication within or among organizations as a limiting factor. Several of the organizations did note, again in interviews, that they sometimes found it easier to collaborate with international partners than with other national organizations.

Through their self-evaluations, Norwegian polar organizations identified key national partners. Bibliometric analysis of publications co-authored by researchers from multiple national organizations tends to confirm those partnerships. Figure 5.1 shows the lists of partners identified in the self-evaluation surveys. »

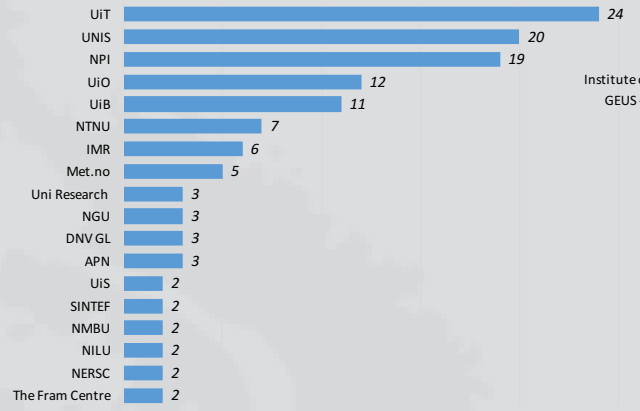

Figure 5.1. Data from question 3 a) in the self evaluation survey - «top 5 national polar research partnerships». Only partners mentioned more than one single time are included.

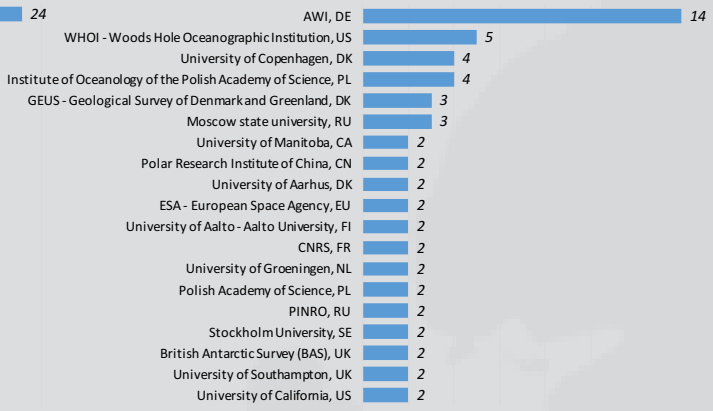

Figure 5.2. Data from question 3 b) in the self evaluation survey - «top 5 international polar research partnerships». Numbers indicate how many of the Norwegian institutions presented them as important partners (only partners referenced by more than one institution is included).

Photo: © Bjørn Anders Nymoen

Taking the top seven organizations from this table (not surprisingly, the Nansen Legacy partners), and including three other organizations with significant co-authorship with the Nansen seven, and then extracting additional information from a more complete table in the bibliometric analysis, we observe that co-authored publication rates among these organizations confirm the frequency of research partnerships reported in the self-evaluations: the top seven organizations identified by their partner organizations also produce a relatively frequent number of co-authored publications. We note subtle patterns of symmetry and asymmetry (Table 5.1). Nansen Legacy organizations tend to have reciprocal research relationships: 14 occasions where researchers from the 'lead' institution publish often (>10%) with the co-author organizations matched by 9 occasions where researchers from the co-author organization publish with the original lead organization. A different pattern emerges for non-Nansen organizations: 13 occasions where their researchers publish frequently with Nansen partners while researchers from the Nansen partners relatively rarely (only 4 occasions) publish with the non-Nansen organizations. Together, table 5.1 and figure 5.1 confirm national partnerships and indicate the relative strength of collaborations among and with Nansen Legacy partners.

The Nansen Legacy, arising from the Norwegian SAK process, highlights a difficult issue: the contradictory desire across the Norwegian polar community for clearer focus and at the same time more opportunities (and resources) for open competitive research through RCN based on proposal ideas and initiatives. This tension between large long-term 'top-

Table 5.1. Co-authorship of Norwegian polar research articles, 2010 to 2014. Lead author (top row) with co-authors (left column). Green indicates 2 to 5% of publications, other progressively warmer colors indicate 10-19%, 20-29%, >30% (source: Table 3.6 in Aksnes, 2017).

	UiT	UNIS	NPI	UiO	UiB	NTNU	IMR	UMB	NILU	NINA
UiT		31	27			15	13	20	15	31
UNIS	17		11	15	12			24		
NPI	19	13		13		20		26	16	31
UiO		20	15		13	10	17	17	15	
UiB		17		14		11	30	11		
NTNU			10					12	13	24
IMR				15						
UMB									10	10
NILU								11		
NINA			10			16		11		

down' science programmes and small open competitive idea-driven 'bottom-up' science driven by individual proposals exists across science and beyond Norwegian science.

Nansen Legacy was consistently regarded by those involved (and others) as an exemplar of coordinated planning and implementation. Advocates note that Nansen Legacy improves access to facilities and strengthens collaborations. Many believe it will have a large impact on Norwegian polar research, enabling a more active and coordinated profile in marine ecosystem research. Even non-participants regarded it as an appropriate funding structure to address important questions, a positive example for other areas of polar and general research. Not infrequently, non-initiating organizations listed participation in Nansen Legacy as one of their research goals. Even cautious voices accepted that Nansen Legacy initiative process and outcome deserved careful assessment as a model in which a collection of organizations set science priorities and influence science funding.

Against this optimistic view, we heard a variety of criticisms of Nansen Legacy. Most criticisms came from organizations that identified themselves as outside or excluded from the initiative. Several organizations felt themselves excluded by cost share requirements. Other organizations felt uninvited. Organizations worried about Nansen Legacy research dominating ship time in competition with their own needs. Others decried the apparent disproportionate influence of nationally-funded laboratories or expressed preference for open competitive funding calls.

This Committee regards Nansen as a positive development in polar research for Norway, but one that could and should serve as a catalyst for stronger and broader cooperation. We observe that neither the Norwegian polar research community nor RCN have resolved, or have a consensus plan to resolve, issues raised by Nansen Legacy.

5.2 External

Norwegian polar researchers maintain a vigorous array of international partnerships and strong participation in international assessments. On paper, Norwegian polar research priorities as conveyed by RCN resonate strongly with external priorities. We, along with polar researchers in Norway, do not see how Norway adheres to or implements these priorities internally, nor how, as a country, it expresses and promotes these plans and priorities in international fora. Frequent comments in the self-evaluation surveys suggest that institutional and individual members of the Norwegian polar research community do not understand how and by whom external communication takes place. Many organizations understand and expect a central role by NPI but do not understand a process for developing a consensus view that NPI then conveys. Other organizations, including RCN itself, wonder about RCN's role in this regard. »

Table 5.2. The extent of co-authorship with international partners (source: Table 3.4 in Aksnes, 2017).

	Institution/institute	Publications with internal* authorship only	Publications with national co-authorship	Publications with international co-authorship	Publications with national and international co-authorship	N- Total number of publica-tions
HE sector	The Arctic University of Norway	13%	57%	62%	33%	565
	University of Bergen	6%	60%	74%	39%	468
	University of Oslo	8%	63%	68%	39%	427
	University Centre in Svalbard	1%	72%	75%	48%	316
	Norwegian University of Science & Technology	12%	71%	54%	37%	191
	Norwegian University of Life Sciences	8%	75%	65%	48%	114
	Other HE-institutions	6%	61%	70%	37%	79
Institute sector	Norwegian Polar Institute	2%	64%	78%	45%	403
	Institute of Marine Research	11%	69%	55%	34%	208
	Norwegian Institute for Air Research	2%	50%	84%	36%	130
	Norwegian Institute for Nature Research	6%	78%	58%	42%	111
	UNI Research	0%	88%	71%	59%	99
	Other institute sector	10%	67%	59%	37%	482
	Business sector	3%	80%	57%	41%	209
	Other	3%	74%	66%	44%	94

*) Colleagues from same institution (Source: NIFU / Web of Science)

As shown in figure 5.2, the Alfred Wegener Institute (AWI) in Germany is by far the most important external research partner. AWI has access to significant funding, important infrastructure and an icebreaker. The next highest-ranking collaborator was WHOI from the USA. GEUS and University of Copenhagen, both in Denmark, are also frequent collaborators. Overall, the self-evaluations indicate a generally high level of European and international collaboration. Participation in Nordic and EU funded projects will have simulated many of these collaborations, particularly in geophysical science and marine research.

Research collaboration at the Nordic level is relatively extensive as reflected in self-evaluation surveys and in bibliometric analysis. Nordic collaboration – with Denmark and Sweden ranked high among Norwegian partnerships – reflects multilateral Arctic collaboration, neighbor with neighbor interactions, similar organizational frameworks across the Nordic countries, and enhancement by access to Nordic funding (NordForsk or Nordic Council of Ministers).

Bibliometric analysis of publications co-authored by researchers from international organizations tend to confirm the extent of international partnerships listed in self-evaluations. Table 5.2 shows that researchers from Norwegian polar organizations publish with international partners at least as often as with national partners. Data in table 5.3 indicate that the USA and the UK are important partners for Norwegian researchers, with Germany, Denmark and Canada close behind. Figure 4.5, taken from the bibliometric analysis, also conveyed the level of Norwegian collaboration relative to that of other countries. In that figure, while US and Canadian researchers produce relatively high numbers of publications, the top 10 countries by numbers of publications all had percentages of international co-authors in the range 50% to 70%.

In addition to publishing as co-authors, Norwegian polar researchers contribute to a wide range of international initiatives, programmes, and committees etc, including for research initiatives: CNARC, IMBER, Arctic Council working groups of CAFF and AMAP, H2020, EU-PolarNet, GoNorth, MOSAiC, ERA-NET, SCAR, NordForsk Arctic programme, IPY. Likewise for global change programmes - SAON, IPCC, Future Earth, WMO, WCRP, PAGES, CEDAR, (note that only a small fraction of the surveyed organizations provided answers to this section).

Norwegian polar researchers also sustain important international interactions in polar technology and marine operations, research areas not typically covered by bibliometric analyses. These partnerships - involving major Arctic 'players' such as Denmark, Canada, Iceland, Russia, Sweden, Finland and the United States - focus on building knowledge and developing tools to minimize the impacts of industrial and other activities in the Arctic region in the context of emerging regulations and changing climate. ❖

Table 5.3. Collaboration by institution/institute. Percentage of articles with co-authorship from various countries, 2012-2014 (source: Table 3.5 in Aksnes, 2017).

	Institution/institute	USA	UK	Germany	Kingdom of Denmark	Canada	Sweden	France	Russia
HE sector	The Arctic University of Norway	13%	13%	10%	9%	10%	7%	5%	8%
	University of Bergen	21%	23%	20%	10%	8%	8%	8%	7%
	University of Oslo	28%	17%	11%	10%	10%	9%	9%	8%
	University Centre in Svalbard	22%	25%	11%	17%	8%	11%	3%	9%
	Norwegian University of Science & Technology	15%	12%	6%	12%	13%	9%	9%	7%
	Norwegian University of Life Sciences	11%	12%	11%	20%	17%	21%	4%	4%
	Other HE-institutions	25%	22%	8%	23%	5%	9%	3%	5%
Institute sector	Norwegian Polar Institute	26%	15%	18%	13%	20%	12%	10%	6%
	Institute of Marine Research	12%	14%	10%	9%	11%	6%	4%	14%
	Norwegian Institute for Air Research	33%	18%	25%	9%	18%	18%	22%	8%
	Norwegian Institute for Nature Research	6%	19%	4%	11%	14%	14%	17%	4%
	UNI Research	24%	29%	21%	6%	2%	6%	13%	6%
	Other institute sector	14%	14%	14%	10%	8%	7%	7%	5%
	Business sector	15%	11%	11%	9%	7%	4%	3%	7%

(Source: NIFU / Web of Science)

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6 Relevance and Communication

The outcomes and products of Norway's polar research community address key national and global issues. In addition to research publications, the polar research community serves and communicates to stakeholders and the public through a wide variety of services and mechanisms.

In Section 2.2 we documented a very good correspondence of Norway's priority areas for polar research, as expressed in the RCN Polar Policy document, with national and international plans and strategies. In this section we explore how those activities meet the needs of a wide range of users and how the polar researchers across Norway communicate the importance and outcomes of their work.

6.1 Participation and collaboration with users of research based knowledge

In its Research Policy for Norwegian Polar Research (RCN 2013, page 4), RCN specifies that Norwegian polar research must "fulfil its special responsibility for acquiring the knowledge need to implement policy, management and economic activity in the polar regions". We find that many aspects of Norwegian polar research develop in collaboration with commercial and industrial users and many outcomes provide direct information and benefit to specific user communities and to the general public. Norwegian polar researchers attempt to understand, cooperate and meet the needs of fisheries, marine transport and safety, ecosystem and environmental monitoring, operational forecasting, geohazards, seafloor mapping, and policy-makers addressing climate changes.

Norwegian researchers carefully monitor polar fisheries in large part through cooperation with the fishing industry and the Norwegian Coast Guard. Based on these data, and first-hand understanding of industry needs, the IMR has developed advanced model-based methods to quantify composition from commercial catches. Researchers from IMR and other organizations have established effective bilateral partnerships with fisheries management bodies (Ministry of Fisheries, the International Council for the Exploration of the Seas), fishing companies and environmental NGOs. Close collaborations between IMR and PINRO, to provide fisheries management advice through ICES, ensure appropriate feedback to help identify knowledge gaps and formulate research questions.

A variety of polar organizations focus their research on operational and safety issues, working on topics such as navigation, high-latitude communication, seabed mapping, coastal and offshore infrastructure and operations, and human physiology and medicine in cold environments. The Nansen Center, in cooperation with the Meteorological Institute and IMR, leads a project of the EU's Copernicus Marine Environment Monitoring Service to deliver weekly ocean and sea ice forecasts for the Arctic. NILU leads national and international efforts to improve air quality in Europe as well as in the Arctic. One can identify clear industry partnerships and social benefits in all of these activities.

Many Norwegian polar researchers give special attention to Svalbard and particularly Longyearbyen. Through close collaboration with local managers and the Longyearbyen community, polar researchers build an effective local knowledge basis for conservation and management decisions relevant to tourism, geohazards, community water and power supplies, and operational safety on land and water. Research stimulated through the Longyearbyen CO_2 lab helped build a better understanding of Carbon Capture and Storage (CCS) and the development of Norway's CCS policy (http://co2-ccs.unis.no).

Research on ice sheet and glacier contributions to sea level rise, and on permafrost structural changes and atmospheric carbon emissions, have clear social relevance, nationally and globally. Within Norway, the strong threads of ecosystem and operational / technology research represent a potent combination and contribution to environmental monitoring and preservation, efficient and safe polar operations, and management and governance of polar environments and resources. Research into resource economics and legal bases and options for regulations help make the management and governance tasks more effective.

6.2 Dissemination of knowledge

Too few of the participating organizations addressed knowledge dissemination as part of their self-evaluations. Many organizations did however address communication issues in their comments about the relevance and impact of their work. We conclude that Norwegian polar research organizations often use a variety of mechanisms for dissemination of knowledge to stakeholders, the ministries, public administration, industry players and society at large but that no organisation tracks or documents the cumulative or collective impact of Norway's polar activities.

We addressed earlier (Section 2) the substantial contributions by Norwegian polar researchers to international scientific assessments. We also highlighted the polar information services represented by several of Norway's polar data centers (Section 2.2.2). In general we conclude that exchange of scientific information and products occurs with reasonable frequency and impact within Norway's polar research community, although often in an ad hoc manner and perhaps more effectively externally than internally.

Publication of research results - a valued and often mandated activity - represents a primary form of knowledge dissemination with the research community. Many individuals and the government-funded polar institutes interact with stakeholders and convey their findings through a wide variety of workshops, conferences, newsletters,

user forums, social media, web sites, visitor programmes, educational materials, television programs, etc. The discoveries and excitement about the polar night, shared through broadcast and social media, represent a good recent example of successful communication and outreach by the Norwegian polar research community.

Several of Norway's polar organizations sustain direct on-going partnership with 'information' organisations, including NGOs such as WWF and IUCN. Very often these partnerships include products specific to the partnership - e.g. maps or survey results - that also stimulate public interest. The polar research community contributes positively and effectively to public discussions about marine protected areas, Svalbard environmental issues, and Arctic marine safety. Often one can follow operations on one of Norway's polar research vessels through daily social media reports and occasional real-time broadcasts.

From self-evaluations and interviews we gain a relatively clear and positive picture of the Norwegian polar research community actively engaged with sponsor, stakeholders and the public on import issues of effective management of Arctic resources as sea ice retreats and human activity increases. We do not, however, have a clear sense of the overall impact or effectiveness of these communication and outreach activities. ❖

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7 Challenges and Opportunities

Clear opportunities for collaboration on urgent Arctic and Antarctic topics ideas emerge from ideas and priorities conveyed by Norway's polar research community. The new ship Kronprins Haakon represents a prominent asset. Lack of coordination and relative fragmentation emerge as substantial barriers.

7.1 National Coordination

In their written evaluations and through face-to-face interviews, the Norwegian polar research community provided extensive and enthusiastic views of opportunities and challenges ahead in polar research. On many administrative issues this community remains divided, however. Some advocate for more large (multi-organizational) thematically-focused programs. Others prefer expansion of general calls for smaller self-motivated research projects. A substantial group wants both long-term strategic direction and individual flexibility. Implicitly and explicitly, we hear and emphasise a clear sense that Norway's polar research - on all topics and in whatever configuration - falls behind the rate of change in polar systems. Relative disorganization and lack of funding exacerbate the inability of the polar research community to keep pace with environmental change and commercial development. Even with improved organization and funding, Norway's polar research programs need clear focus and direction and stronger collective efforts to meet national and international needs. From amidst the wide variety of ideas and topics proposed by Norway's polar organizations we extract pervasive and compelling themes.

7.1.1 Arctic climate system

Through external and global forcing, a warming climate imposes large and rapid changes on Arctic systems and on the Arctic Ocean. Increasingly, Arctic changes, particularly in sea ice extent and snow cover, feedback into global oceanic and northern hemisphere atmospheric circulations. Within the Arctic Ocean changes in circulation and mixing affect air-sea interaction, ocean heat content and marine productivity. Anticipating these changes and building observational and forecasting capabilities for this new more challenging Arctic requires focus and resources. Norway, with eminent scientific and technical capabilities and with Svalbard located at the center of the gateway between Atlantic and Arctic Oceans, has opportunity, an urgent national need and an international role to understand and predict the future of the Arctic. Norway's Arctic climate effort must involve innovative technologies, sustained observations, and advanced open data collection , modelling and distribution systems. Ships, particularly the new ship FF Kronprins Haakon, and the research station at Ny-Ålesund, must play key roles in this coordinated effort. Meeting this research challenge will require recruitment of the best new scientists and heightened integration across, and collaboration within, an ice-ocean-atmosphere-ecosystem observing and modelling framework.

7.1.2 Arctic ecosystems

Norway's successful management of Barents Sea fisheries sets a notable global example, but climate changes outlined above combined with exacerbated ocean acidification in cold polar waters make this successful fishery also one of the most vulnerable to local and large-scale ecosystem changes. Arctic species distributions will change. New species will migrate and invade, new predators may displace seabirds and cetaceans, ice-adapted species will recede. The newly-discovered richness of the polar night may take on a more prominent role. Commercial exploitation of Barents Sea and Arctic marine resources will often develop faster than monitoring and understanding of the exploited ecosystems. Norway, based on location, eminence in research and technology, and commercial imperatives, sits in exactly the crucial geographic, scientific and economic position to carry forward a vigorous program to understand how marine organisms and ecosystems will adapt, evolve and survive in the changing and acidifying Arctic Ocean. The Nansen Legacy project represents an important first step, around which to build greater understanding of ecosystem services including transfer or biodegradation of contaminants and changes in carbon sequestration. This research effort will require and should attract a new generation of scientists from molecular geneticists to ecosystem modellers to resource economists.

7.1.3 The Arctic biogeochemical environment

The Arctic remains, unfortunately, an accumulation and deposition zone for a variety of local- and externally-produced contaminants and pollutants, including plastics of all sizes. The role of Arctic marine and terrestrial ecosystems as carbon sources or carbon sinks remains

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unclear. Hydrological and biogeochemical effects of thawing (terrestrial and sub-marine) permafrost, gas exchanges and ecosystem effects, and natural and enhanced biodegradation of contaminants represent large residual uncertainties in budgets and fates of carbon and contaminants. Development of appropriate monitoring tools, reliable prediction capabilities, and bioremediation methods represent urgent tasks. Norwegian researchers represent major contributors and vital collaborators in this interdisciplinary biogeochemical challenge. A coherent and better-resourced Arctic environment program would meet clear and urgent national and international needs.

7.1.4 The commercial and industrial Arctic

Norwegian polar research needs to rapidly catch up with and address the consequences of increased marine transport, polar tourism, fisheries, offshore oil and gas exploitation, mineral production, offshore wind energy harvesting, coastal and offshore aquaculture, wildlife conservation, and the governance and policy-making frameworks needed to guide and regulate those activities. An aggressive and disparate commercial and industrial sector will, for the most part, move rapidly ahead with or without knowledge and guidance from the polar research community. An enhanced multidisciplinary research and technology effort by the science community must take as its core focus the predictive capabilities and forecasting tools necessary to assure and assist safe and economically-effective commercial and industrial operations and the effective communication of knowledge and guidance on environmental issues, biodiversity, and systems ecology. It must generate useful knowledge on polar engineering and on how humans can and should work in cold environments. In a Norwegian context, this focus on environmentally sound information and operations must address concerns and issues of the Svalbard treaty and of present and future Barents Sea operations. This operational research focus must anticipate the speed of developments in polar regions and establish effective collaborations with industrial partners. Good examples and effective solutions emerging from Norwegian research partnerships will resonate and propagate throughout the Arctic.

7.1.5 Antarctic research

In extracting four plausible and coherent themes from among the wide array of topics described by Norway's polar research community, we have deliberately and (in our view) appropriately focused on the Arctic. At the same time we recognise scientific urgencies coupled with political mandates for Antarctic research, particularly warming effects on glacier and ice-cover dynamics on the Antarctic continent and on Southern Ocean ecosystems. We submit that, with better coordination and enhanced infrastructure support, Norway can and should further-develop and maintain a substantial high-quality program of Antarctic research.

7.1.6 Geophysical and socio-economic research

We appreciate that, in our focus on climate, environment and resources - extracted with high fidelity from the abundant ideas and concerns of the Norwegian polar research community - we have minimised smaller research programs on outer atmosphere physics and space weather and on seafloor geophysics. The overwhelming attention of Norway's polar research community on the present and future Arctic should not preclude important geophysical research activities. We have also, based on assigned geographic boundaries, necessarily devoted insufficient attention to substantial issues related to indigenous and local livelihoods and culture in the context of rapid Arctic change. We advocate for relaxation of those artificial boundaries and for an inclusive physical-ecological-economic-social organizational and funding approach to Arctic research.

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7.2 Community needs

Assuming we have understood and properly conveyed directions and priorities emerging from the Norwegian polar community, how should the multiple ministerial and research council sponsors and administrators of polar research respond? The polar community has offered a varied but often divergent set of recommendations for this Committee's consideration. Anticipating formal recommendations to follow (Section 8, below), we report a general community consensus on several themes.

- While meeting its own needs and building on its own national strengths, Norway should take a leading role in international scientific and political affairs relevant to both the Arctic and Antarctic. In some cases this effective international voice may require more coherence and more coordination of internal advice and opinions.

- Sponsors of Norwegian polar research must recognise and adopt funding strategies and policies to the inevitable high costs of polar research, infrastructure and facilities. The community wishes for greater clarity in facility allocation, resource competitions targeted at instrumentation and infrastructure (in which polar research can compete), and a coordinated national strategy for overall polar research infrastructure, particularly for sufficient and additional ship time.

- Overall, the community observes a need for stronger and clearer national priorities for polar research. Initiating partners of the Nansen Legacy project see their efforts as a very positive step forward for polar research (and some other disciplines advocate for their own equivalents of the Nansen Legacy) but other organizations, and perhaps RCN in particular, need to develop plans and practical mechanisms to allow additional researchers to join these large coordinated activities. Our Committee regards the Nansen Legacy project as an effective coordination mechanism and urgent research direction for the polar research community, a central effort that a larger community can and should respond to and build upon. However, with its focus on the Barents Sea ecosystem, the Nansen Legacy project advances only one of the four research challenges identified above. We agree with the polar community that the present RCN polar research policy document lacks specificity, connection to funding priorities, and a useful implementation strategy in light of the broader array of Norway's polar research activities and of specific initiatives such as the Nansen Legacy project.

- Despite good intentions and despite good efforts by RCN to develop the polar research priority document as an inclusive community-wide product, the Norwegian polar community perceives a clear need for greater overall coordination of polar research, including (as mentioned above) better and more transparent coordination of polar research facilities and infrastructure. This national coordination effort should specifically address recruitment, education and retention of the next generation of polar scientists and technologists and serve as mechanism among and across various sponsors of polar research to develop a more practical and useful balance of short-term vs long-term funding options.

- As mentioned above, the polar research community also advocates for relaxation of the artificial Norwegian definition of Arctic geographic boundaries as those represent unhelpful barriers to effective, necessary and integrated Arctic research.

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8 Assessment

We offer five concise recommendations addressing quality, coordination, infrastructure, Svalbard and Antarctica. Taken together, our recommendations constitute a substantial revision of how Norway coordinates and funds polar research. We include a list of opportunities related primarily to international assessments and a series of implementation steps including improved performance metrics.

This committee identifies many accomplishments, strengths and positive directions from and within the Norwegian polar research community. We also identify barriers - related to funding mechanisms, lack of transparency and fragmentation - that, once remedied, would allow the efforts of individual Norwegian researchers and of Norway's collective polar research community to have greater impact and gain greater recognition. We believe Norway can and should set a leading example of coordinated polar research for the global research community as we seek to understand and predict rapid environmental and societal changes underway in polar regions.

8.1 Findings

We identify many strengths. Each member of this Committee, from various scientific viewpoints, identifies prominent research programmes and valued colleagues within Norway's polar research programs. We identify several clear and compelling directions emerging from the research community's priorities (Section 7). We very much like the inclusion of cold-region technology and engineering as a component of Norway's polar research. We applaud Norway's initiative on the new ship and recognize a positive and necessary contribution from Nansen Legacy project. The Norwegian research community makes very good use of Svalbard for research and education. We easily identify strong scientific justification for continued Antarctic research. We find no deficiencies in the number or quality of publications by Norwegian researchers. We detect very strong political commitments by Norway to national and international polar research and we believe that Norway's polar research programs justify that investment. We find ourselves impressed by strong polar ambition from a relatively small country.

We likewise identify key weaknesses. Polar research across Norway involves a large number of universities, organizations, institutions and companies but without clear processes for internal coordination and collaboration. This relative fragmentation imposes challenges and barriers to focus, to assembling critical mass on urgent issues, and to communication. The present funding model tends to deter rather than encourage collaboration. Recruitment and retention of young researchers represents a serious challenge. Government interest in, and funding for, polar research occurs through multiple routes often with disparate priorities. Norway takes prominent and essential geopolitical roles for Svalbard and Antarctica but Norway's polar research community remains uncertain and uncoordinated in developing and implementing science and infrastructure plans for either region.

8.2 Recommendations

We recommend that Norway take advantage of the opportunity represented by new ships, new projects, new leadership and strong political support to undertake a serious revision of how it coordinates and funds polar research.

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Norway should establish, at a high inter-ministerial level, an interim Polar Research Enhancement group, with the charge to:

a. implement our recommendations below;
b. identify the resource impacts of recommended changes;
c. engage the Norwegian polar research community in the development of additional productivity metrics that can serve as appropriate and reliable long-term indicators of quality and impact; and
d. put itself out of business in two years by establishing appropriate efficient on-going coordination and oversight mechanisms.

8.2.1 Quality and Impact

Norway should enhance quality and impact of its polar research by:

a. Developing and implementing a plan for recruitment and retention of a diverse next generation of polar researchers;

b. Continuing and strengthening the combinations of environmental monitoring with fundamental research and the focus on safe clean polar operations;

c. Developing community coordination mechanisms to focus on priority areas where Norway can excel; and

d. Establishing and promoting a national open data policy and culture.

Although this report often focuses on publications and citations we believe that quality of output and impact depends fundamentally on quality of researchers and on their practices and behaviors. Norway's distinguished tradition as a male-dominated ocean-going polar community should not deter it from continued efforts to achieve gender-neutrality within its community of polar researchers. We believe that a gender-neutral educational and research environment will require a nationally-coordinated effort with local implementation. We also believe that Norway should continue its support for long term environmental and ecological monitoring as the much-needed basis for fundamental research, particularly in polar research where attribution requires careful high-quality long-term climate records. We believe Norway can and should play a leading role in researching, developing and implementing humanly-safe and environmentally-friendly polar technology and operations. We provide detailed recommendations on focus areas below but consider that the coordination necessary to develop those focus areas itself represents a step forward for quality and impact. Multiple studies document the positive impact of open access to data on research collaboration: polar research within Norway and in collaboration with international partners will strongly benefit from improvements in Norway's data access policies and data sharing practices.

Polar research communities - operating in separate departments across university campuses or as parts of diverse institutions - require explicit coordination and collaboration mechanisms in many countries. One positive response to these challenges - with impact that required sustained efforts over several years - occurs in the UK: annual joint meeting of UK polar researchers and facility providers (https://ukaapartnership.org). Successful examples exist in other countries as well.

8.2.2 Coordination and Funding

Norway should:

a. open a much larger fraction of polar research funds to open competition; and

b. establish mechanisms, incentives and practices that develop and encourage a sense of collaboration and opportunity among national researchers.

A change in funding practice may necessitate corresponding changes in funding processes. We identify several potential changes as follows:

a. relaxation or elimination of many labels and categories that serve as fences in the present national funding portfolio;

b. possible use of pre-proposals to refine the proposal submittal process particularly for big proposals; and

c. greater coordination among and across ministries on research priorities and funding processes.

We see this open competition and greater coordination as inextricably linked. Open competition will not result in better proposals and better science unless and until the polar community develops mechanisms and practices for coordination on research, infrastructure and human capital. The polar community will see little motivation for engaging in greater collaboration unless they perceive tangible funding opportunities. By open, we mean open to polar researchers from universities, national institutions and private companies. We intend these changes to encourage greater participation by the research community in setting national priorities (e.g. on urgent challenges emerging from our evaluation process in Section 7) and greater coordination across Ministries in funding those priority activities. Nansen Legacy represents a premier example of large-scale, coordinated efforts that would and could emerge from greater participation and coordination.

8.2.3 Infrastructure and Facilities

Norway should establish a clear accessible national coordination function for polar research infrastructure, including ships, field stations, and major instrumentation.

This coordination function should address inventory and capabilities, overall access and scheduling, and data policies. Through this coordination function the polar research community should develop priorities and plans for major infrastructure procurements and collaborative proposals to various RCN or other national infrastructure funding opportunities. Norway supports a good array of polar research infrastructure but lacks the national information and access tools to best allocate and deploy those assets. Norway's future allocation processes for polar facilities should focus on scientific quality and equitable access.

8.2.4 Svalbard

Norway should:

a. Promptly implement a clear focused plan for polar research and education at Svalbard, with particular attention to the roles of UNIS and Ny-Ålesund;

b. Provide clear information about access policies and procedures to national and international researchers; and

c. Ensure that all activities enhance the environment of Svalbard.

Our committee discovered and recognizes an abundance of plans and planning documents related to research and education at Svalbard. We saw notes of a parallel RCN assessment and we read a 'Ny-Ålesund science plan 2015 – 2020'. We admire efforts such as the Research in Svalbard (RIS) portal and the Svalbard Science Forum. In general, however, we observe much evaluation (including this document) and planning but little evidence of implementation. In view of rapid changes in sea ice, ocean ecosystems and commercial fishing and tourism operations, and with the essential research and monitoring efforts at Ny-Ålesund so important to a global community of researchers, we believe that further study or more delay will allow commercial developments by default. We strongly recommend continued and strengthened research operations - including marine technology testing and evaluation - at Svalbard as the basis for effective and environmentally-sound management. Marine research in the waters close to Svalbard would strongly benefit by a permanent location of a small research vessel in Longyearbyen.

Our thinking resonates with that of many Norwegian researchers who advocate a 'science national park' for Svalbard. We find this idea attractive because:

a. national parks have a long history of managing the impacts of increasing tourism on scientific fieldwork and environmental protection;
b. research operations at Ny-Ålesund seem particularly vulnerable to commercial pressures; and
c. the idea of a research 'Center of Excellence' at UNIS focused on polar tourism seems timely, appropriate and attractive.

8.2.5 Antarctica

Norway should establish a clear focused basis for effective Antarctic research.

We recommend that Norway continue its leadership in geopolitical affairs related to Antarctica but at the same time develop a much clearer focus for its Antarctic research priorities. The international Antarctic research community, represented by SCAR, has updated international research priorities. With the new Norwegian ship likely to work in Antarctica in some years and some seasons, we see a pressing need for a revised and inclusive Norwegian Antarctic research plan. We easily identify urgent scientific questions: sea level rise from vulnerable marine margins of the ice sheets (in particular in West Antarctica), and ecosystem changes in the Southern Ocean for two examples. At the same time we see a lack of coordinated planning and limited access to ship time as disincentives for researchers to propose new Antarctic research. This recommendation fits closely with the recommendations on Coordination and Funding above: transparency about facility availability for Antarctica will motivate and stimulate emergence of good science proposals. The steps forward will require interlinked improvements in both the resource base (deployment funds and facilities in this case) and in the opportunities for scientific collaboration

8.3 Relevant international connections and opportunities

As it undertakes the revisions and enhancements of polar research advocated here, we strongly recommend that Norway consider how best to maximize the relevance of its current and future polar research programs to the anticipated opportunities, requirements and schedules of external assessments. Thinking particularly of Arctic issues and events, we believe that Norway science managers and researchers should anticipate and understand processes and products of the Arctic Monitoring and Assessment Program (AMAP), the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report (including perhaps the IPCC's Special Report on Ice and Ocean, occurring very soon), and the upcoming although as yet undefined UNFCCC Global Stocktake. Norway's polar research programs can and should provide notable and nationally-recognized contributions to those and other international assessments.

In the publication and citation analysis produced for this report, the NIFU authors maintained a broad approach that considered all polar research countries. We understand the basis for and necessity of that approach. We also understand many reasons why Norway might adopt a similar approach for other or subsequent evaluations. We suggest, however, that Norway add an additional category for these types of assessments, a category we might call 'nearest neighbors'. 'Nearest' in this case represents geographic neighbors as well as countries with similar funding levels in polar research. »

A short exploration of polar research in Canada highlights several issues that Norway might consider as it evaluates its own programs as follows:

- Canada operates its polar research mostly through Universities.
- Federal Canada funds (through open national competitions) a series of large national-priority 5- and 10-year programs. Two polar programmes (ArcticNet, Sentinel North) have received research funds but also a mandate and funding to provide a layer of overall direction and coordination.
- Canada operates national infrastructure grants (in which the Canadian icebreaker competes for instrumentation funds) and competitive research chair positions for the Universities that often go to leading polar researchers.
- In the past, at least, Canada has supported research on marine fisheries through it Department of Fisheries and Oceans, with perhaps similar responsibilities to IMR.

For these neighbors we recommend that Norway recalibrate its external comparisons, focusing more on countries like Canada for example (with its similar Arctic focus and mixture of fundamental research with applied engineering and technology), or on Germany, France or Australia (with roughly similar levels of publications), and on Scandinavian partners with whom Norway maintains many positive collaborations. At several points during this evaluation we found comparisons with nearest neighbors more appropriate than comparisons with countries (e.g. USA, UK) that maintain massive logistic operations and expenditures in Antarctica.

Personal collaborations of Norwegian polar researchers with Russian counterparts have very often proven both essential and beneficial. Several institutions mentioned Russian partnerships as important on institutional and national levels as well. We know that Norway-Russia bilateral coordination often extends scientific benefit to researchers from third party countries. This Committee recommends that Norway seek to continue polar research collaboration with Russia whenever and wherever possible.

8.4 Implementation and next steps

For lack of better or alternative information, this evaluation focused largely on bibliometric analyses of publications and citations. For many reasons outlined above we recognize deficiencies in such an approach. We frequently noted the mis-match of those widely-used bibliometric tools to the specific types of research outcomes produced by Norway's polar 'technology' community and additional weaknesses of those tools as applied to social science and humanities research. As a first implementation step, the implementation team (perhaps our 'Polar Research Enhancement' group as proposed) should establish a small set of additional quantitative or qualitative indicators to cover areas and outcomes of polar research not covered by bibliometric analyses. Development of these indicators must occur by a process of co-design with appropriate partners. An initial agreement and assessment of these indicators now, as an immediate outcome of this report, will put them in place for a subsequent analysis in a manner that allows and encourages consistent and accurate representation of the full quality and impact of Norwegian polar research.

We heard, almost as a reflex in many cases, frequent calls for re-establishment of a Polar Coordination Committee. A few of us served on that Committee. We understand some of the motivation for re-establishing such a coordination group but believe that an interim group with a fresh and specific mandate, working to a relatively short deadline, represents a much better option (and offers a much better chance) to achieve the substantial changes described here. In particular, although such a group - and such changes - need to deeply engage with NPI and IMR, for reasons of transparency and neutrality the implementation group should not operate within NPI or IMR nor allow the perception of control by NPI or IMR. We see the Polar Research Enhancement activity as a mechanism to establish or reestablish the trust of Norway's polar research community in RCN as the instigator and driver for a comprehensive national polar research strategy

We strongly recommend a re-thinking of the geographic boundaries that artificially separate Arctic from High North in RCN's thinking and management. We find those boundaries unhelpful, not scientifically valid, and unlikely to encourage the kinds of coordination, collaboration and interdisciplinarity that we envision as the cornerstones of future Norwegian polar research.

Although we find and appreciate many notable outreach and education products and services instigated and supported by Norwegian polar researchers and research institutions, we also note the absence of an integrated communication strategy and of metrics to assess the impacts of that strategy on Norwegian audiences.

Although we welcome RCN efforts to announce and promote this report, we believe that what happens next outweighs the importance of what we announce. The schedule as planned (completion June, announcement September) should allow RCN to develop practical responses and actions to accompany the report announcement. We understand summer holidays and national budget cycles but feel that RCN should nevertheless have worked with appropriate ministries to at least identify next steps by September. At a minimum the announcement process should have those next steps or at least the likely partners for those next steps in mind and on site. We believe that a substantial outreach event from RCN for the large polar community in Tromsø should occur as an important part of these initial steps. ❖

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9 Conclusions

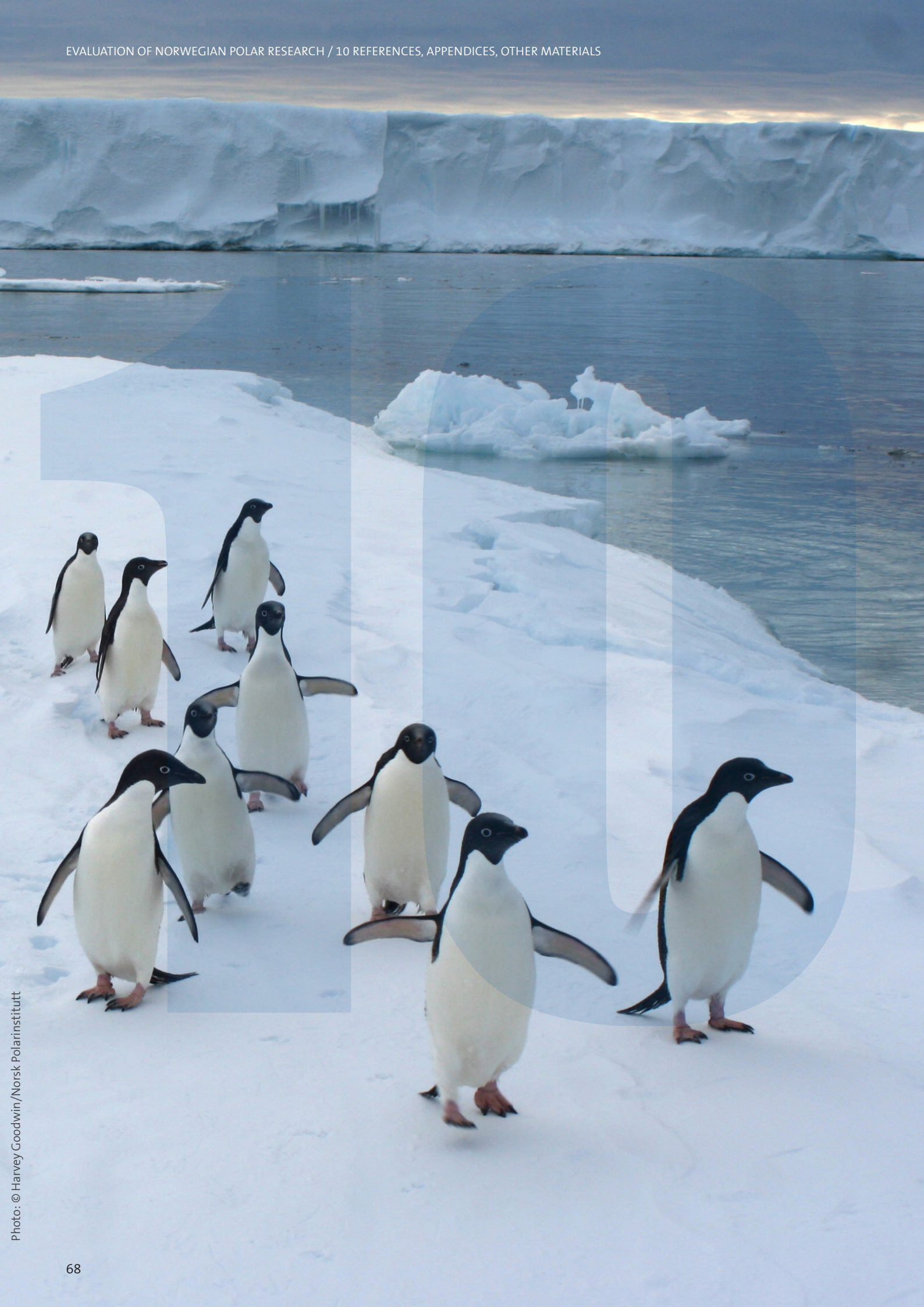
Based on present talent, infrastructure and resources, the polar research community within Norway has very strong national and international potential. We detect and endorse a clear sense that this community could and should enhance its coherence and impact.

We identify across Norway a strong and effective group of polar researchers. Their work covers a wide range of topics relevant to Norway and to urgent changes in polar environments. Norway's polar researchers and engineers convey the outcomes of their activities by a variety of mechanisms including conference presentations, public and corporate reports, and scientific publications. By systematic evaluation of those publications we confirm that Norway's polar researchers publish at about the same quality level and in approximately the same quantity as polar researchers from other major research nations. We perceive a very strong political interest and investment by Norway in polar research, with the new ship FF Kronprins Haakon as one tangible example. We find abundant evidence of polar researchers enthusiastic about their work and knowledgeable about their contributions to Norwegian and global issues.

At the same time we detect a persistent sense that Norway's polar research could and should achieve a higher level of performance and coherence. Part of this desire for improvement arises directly from researchers who face daunting challenges to secure funding and gain access to infrastructure; many of them bemoan the absence of clear priorities. Norway's polar institutions and organizations likewise confront dual challenges of conducting and supporting excellent research while meeting political and geographic mandates. Members of our Committee, as we review proposals and papers from Norwegian researchers, often wish that we had seen stronger products from the Norwegian polar research community. Perhaps most importantly, for Norway and for the global polar research community, we get a sense of polar research remaining a half-step behind rapid changes in, and the rapid commercialisation of, polar environments. We affirm that Norway's polar research community has the talent and resources to take serious steps forward.

These improvements require coupled changes in researcher behaviour and research funding mechanisms. Behaviour changes will not succeed without funding incentives while funding alone will not guarantee fresh cooperation or collaboration in the absence of behavioural changes. We predict that a coherent and effective polar research programme by Norway will - over the long term - require additional resources. In the shorter term, however, we believe that issues of fragmentation, transparency and cooperation represent serious immediate obstacles to the effective use of present funds and resources. We deliberately confront the issue of open competition. We recognise and agree that Norway can not build a coherent polar research program from tens or even hundreds of independent proposals; the present proposal system appears to encourage competition at the expense of collaboration. We also contend, however, that priority areas of polar research need a larger degree of community buy-in at the conception stage and a greater degree of fair and open competition at the implementation phase.

We recommend organisational and behavioural changes that will encourage bottom-up inclusive setting of priority research areas for Norway's polar science and ensure abundant and open opportunities for participation in those research activities. We call for enhanced community-based priority setting combined with inclusive and transparent options for participation. Future polar research will require multi-author, multi-institutional, multidisciplinary and multinational processes and products. By making substantial changes to its polar research programs, Norway can favour and encourage its own polar researchers while setting a positive international example. ❖



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10.2 Appendices

Appendix 1 Mandate and framework for the evaluation

Appendix 2 Work Plan / Work Packages

Appendix 3 Self-Evaluation Survey form

Appendix 4 List of units participating in interviews and self-evaluation

Appendix 5 Norway polar external scan

Appendix 6 Composition of the Polar Evaluation Committee

Appendix 1 - Mandate and framework for the evaluation

Mandate and framework for the evaluation of Norwegian polar research

The Research Council of Norway, 31.08.2016

This mandate may receive minor revisions in order to meet specific needs and instructions received from the Ministry of Education and Research, as follow up of the Governmental White paper on Svalbard (Meld.St. 32 2015-2016 - Svalbard).

Background

Polar research receives increasing interest internationally due to the large environmental changes occurring in polar regions, the role polar regions play in shaping global climate processes, and the large impacts and opportunities the changes may have on society. Polar research is a high priority in Norway with public funding partly from Ministries, the Research Council of Norway (RCN) and the EU. Some large private companies also contribute with research funding of relevance to polar areas. The landscape of polar research in Norway is changing with new investments in research infrastructure, establishment of new research consortia and centers through different funding mechanisms, etc. On the international scene, priorities in polar research are formulated by international committees and networks. Many countries and the European Commission are formulating their polar strategies, and the funding of Arctic research under Horizon 2020 is increasing with the establishment of new large research projects and consortia.

The RCN initiated in 2015 a mapping of Norwegian polar research, providing information about the resources (finance and personnel) invested in Norwegian polar research for the year 2014. Similar mapping activities were performed in 2002, 2006 and 2010. A bibliometric survey was also performed as part of the mapping activity, giving information about the level of publication, citation rates and cooperation in Norwegian polar research, in an international context. Special emphasis was put on the research activities and infrastructure in Svalbard. The Nordic Institute for Studies in Innovation, Research and Education (NIFU), carried out the mapping *(NIFU Report 2015:37 – Norsk Polarforsking – forskning på Svalbard)*.

According to the report, Norwegian polar research seems healthy and strong. Norway has maintained its ranking as the world's fifth-largest polar research nation in terms of publication volume. In the Arctic, Norway is on the third place, only out-numbered by US and Canadian papers. Norwegian polar researchers have extensive publication collaboration with researchers from other countries. In the period 2012–2014, three out of four "Norwegian" scientific papers on polar research included a co-author from other countries, with US and UK colleagues as our main research collaborators. Norwegian polar research papers are cited more frequently than the world average for polar research in general. Nonetheless, the impact of Norwegian polar research (in terms of citation index) is lower than the research carried out by other major polar research nations. Norway is the largest research nation by far in Svalbard, in terms of scientific publications. However, Svalbard-related research is in general less frequently cited than the world average for polar research.

The recent White paper on Svalbard (*Meld.St. 32 2015-2016 - Svalbard)* points out that there is a need to improve the quality and develop the position of Norwegian research in Svalbard. In order to improve the quality of our research, collaboration with the best international research communities should be a high priority. Norwegian leadership need to

build on disciplines where we have the best researchers and expertise, infrastructure and opportunities, and in research fields that require multidisciplinary approach.

Definitions and delimitations

The evaluation is to assess Norwegian polar research in relation to research quality and capacity, strategic focus, communication and interaction, and relevance to society, and it is to provide external views on the performance of Norwegian polar research on the areas where Norway has special interests and needs. The evaluation shall also provide advice on the strengths, weaknesses, opportunities and threats in how Norwegian polar research is funded, organised and coordinated, with respect to the goals and priorities given in the White paper on Svalbard and the RCN's Policy for Norwegian Polar Research.

Norwegian polar research encompasses activities ranging from basic research to applied and industry-oriented research in and on the polar parts of the Arctic and Antarctic. Polar research includes thematic areas such as climate, the environment, geology, natural resources, the societal and industrial challenges, geopolitics and culture, and is thus not a separate discipline. The term “industrial challenges” does not include all industry-relevant research in polar areas, but focuses on the particular problems that arise as a result of natural conditions in polar regions. Geographically, Norwegian Arctic research refers to the polar part of the Arctic and does not include Norwegian mainland. The delimitation definition is given in the Norwegian Polar Research Policy (2014-2023).

The evaluation need to relate to contemporary priorities in polar research formulated in national and international strategies and policies, and shall focus on those geographical and thematic areas that are especially relevant for Norway, i.e. areas in which Norway has particular expertise, a long-standing tradition, favourable conditions, needs, responsibility, or the potential for value creation. Larger coordinated research projects, groups, institutes or centres, are of particular interest. The evaluation shall focus on polar research conducted in the past 10 years, with special emphasis on the last part of this period. National and international Svalbard research is of particular interest, and should be addressed separately.

Aim of the evaluation

The evaluation is to assess research quality, impact, effectiveness, national and international cooperation, relevance, and make recommendations on future Norwegian polar research. The evaluation shall direct particular attention towards the role played by the RCN and give advice on how Norwegian polar research organisation, funding and coordination could be improved. The evaluation shall also give advice how Svalbard as research platform can be developed in order to increase the quality and impact of national and international research.

The evaluation shall provide a critical review of Norwegian polar research in an international perspective, and give recommendations on measures to enhance the quality, impact and relevance of future polar research activities in Norway, with special emphasis on Svalbard. It shall also provide alternative pathways of organizing coordination, research communities and funding channels, in order to increase the level and quality of Norwegian polar research. It is especially important that the evaluation also gives attention to multidisciplinary needs and the synergies that can be achieved when bringing new disciplines together. The evaluation will include a more detailed bibliometric analysis looking specifically on Svalbard publications.

The evaluation is to assess Norwegian polar research, with special attention to the following parameters:

1. Research quality, impact and capacity
- Norway's contribution to advancing the research front;
- The quality of Norwegian research groups in an international context;
- Publication activity and scores on research quality indicators;
- Basic and applied research, multi- and interdisciplinary research[1];
- Capacity and efficient use related to recruitment, infrastructure, investment, etc.;
- Characteristics of high and low impact Svalbard publications;
- Svalbard research in general.

2. Organisation, funding, strategy and coordination
- Interaction and coordination between national players, such as the RCN, government ministries, agencies, directorates and research groups.
- Organisation and coordination of Norwegian polar research seen against a backdrop of how research is organised in other large polar research countries;
- Distribution of tasks, interaction and coordination between national instruments for polar research, both within and outside of the RCN (large-scale programmes, action-oriented programmes, research infrastructures, research institutes and centres, centres of Excellence (SFF), Centres for Research Based Innovation (SFI), large coordinated projects, Svalbard Integrated Earth Observing System (SIOS), Svalbard Science Forum (SSF), etc.);
- Interaction between Norwegian and international instruments for polar research, e.g. in the Arctic Council countries, the Nordic countries, EU, ASIA, North America.

3. The players involved in polar research – national and international cooperation
- National cooperation and participation in bilateral, Nordic, European and global programs; relevant players that need mobilisation;
- Utilisation of research data, databases and infrastructure;
- Pathways to develop Norwegian leading fields and Norway's contribution to international polar research.

4. Relevance to the challenges to society
- Relevance of Norwegian polar research to the international polar research priorities as identified by for example SCAR Horizon Scan, ICARP and EU-PolarNet;
- Degree of participation and collaboration with business and industry and other users of research based knowledge;
- Dissemination of knowledge to the ministries, public administration, industry players and participants in society at large;
- Impact of the research on societal, industrial and policy development.

Use of the evaluation

This will be Norway's first evaluation of polar research. The evaluation may give research communities, stakeholders and funding institutions the necessary basis on which to decide the right measures to develop the quality and relevance of the research. The evaluation shall offer guidance on research-related issues to the RCN, the research institutions, and the authorities.

[1] For the purpose of this evaluation we understand the term interdisciplinary as collaboration and interactions between natural and social sciences.

In addition, the White Paper on Svalbard presented by the government in May 2016, reveals that two strategies will be developed, one for research and higher education in Svalbard and one for research in Ny Ålesund. Furthermore, the work programme for the RCN's Polar Research Programme (POLARPROG) will be revised in 2017. For these processes the evaluation will serve as a central knowledge base.

Data material

The evaluation will build on a number of existing relevant mapping and evaluation reports, as well as relate its findings to the priorities given in the White paper on Svalbard and the RCN's Policy for Norwegian Polar Research (2014-2023). The data used in the evaluation may include:

- Mapping and bibliometric analysis of Norwegian Polar Research in 2014 (NIFU 2015:37).
- Evaluation of Norwegian Climate Research (2012)
- Evaluation of basic science in biology and geophysics (2011)
- Evaluation of Environmental Research Institutes (2015)
- Evaluation of basic and long-term research within technology (2014)
- Background data on the overall participation of players involved in polar research and the research groups under evaluation
- In-depth bibliometric analysis of national and international Svalbard publications
- Self-assessments by the research groups, including selected scientific publications
- Interview data compiled from meetings between the research leaders and researcher groups and members of the evaluation committee.
- The Office of the Auditor General's investigation of the utilisation of research infrastructure in Norwegian Arctic areas (Document 3:13 (2013-2014))
- Consultations with the Polar Forum, both at an initial stage and before the finalisations of the report

Composition of the evaluation committee

The committee will consist of 8-10 people with the following competences (some people may cover more than one of the competencies below):

- A chairperson with broad-based experience in the area of polar research and research strategy, as well as good knowledge of the international polar research system;
- Members with expertise in
  - The natural science disciplines geosciences and biology, including multidisciplinary climate research and ecosystem studies related to processes in the atmosphere, cryosphere, land and ocean, and earth system science perspective;
  - The role of polar areas in global processes and global climate change, teleconnections;
  - Social sciences and humanities, i.e. international politics, northern studies, economic development and cultural heritage;
  - Cold climate technology and the impacts of climate change on polar infrastructure;
  - Environment and resource management;
  - Research in business/industry;
  - International polar research planning, funding and management.

The evaluation committee must be independent and have an international membership. Some members should be affiliated with key international organisations for polar research,

such as IASC, SCAR, WMO and funding agencies, and all of the members should have international experience and an international orientation

Secretariat and external support

The RCN will provide a point of contact to the secretariat and evaluation committee and assist with preparing the background material and other relevant information. The committee's working language will be English, although a number of relevant documents will be in Norwegian.

An external secretariat will be established on contract with the RCN. The staff of the secretariat shall have good written and oral language skills in both Norwegian and English. The secretariat will assist the evaluation committee with the following tasks:

1. Research secretary

The secretary will provide assistance to the evaluation committee and facilitate all its activities as agreed on with the chairperson of the committee and the RCN. In cooperation with the committee, the secretary will e.g. draw up a progress plan for the committee's activities; plan, prepare and summarise the meetings of the committee; prepare the data collection, provide the data needed, and adapt the data for use by the committee; draw up an outline for the evaluation report, write the first draft, incorporate the contributions of the committee members, and finalise the report.

2. Background data on and overview of the structural framework for polar research

In order to provide a framework for the evaluation, the secretariat will provide necessary background data as listed above under the *Data material* paragraph and synthesise conclusions and recommendations from existing evaluations, giving the evaluation committee a good overview of Norwegian polar research.

The secretariat will compile a synthesis report on relevant data collected from research institutions through existing evaluations and mappings. This will form the basis for the committee's development of data collection instruments for e.g. research groups' self-assessments and interviews between members of the evaluation committee and the research leaders and researcher groups.

The secretariat will also provide an updated overview of polar research funding, funding instruments, coordination bodies, players in Norwegian polar research etc.

3. Bibliometric analysis

A bibliometric analysis was performed under the polar research mapping (NIFU Report 2015:37). A more detailed bibliometric analysis, with the aim to characterize publications with low and high impact (citations), will be carried out. The study will have special focus on national and international Svalbard publications.

Cooperation with the RCN

The RCN is responsible for the content of the mandate and the framework conditions for the activities in connection with the evaluation, and the RCN point of contact may be consulted on an ongoing basis by the committee and secretariat regarding the fundamental and practical aspects of the mandate, activities, limitations and other matters requiring clarification during the process.

The RCN will assist in providing relevant background material and helping to organise meetings. Travels must be planned in cooperation with the RCN, and expenses will be reimbursed according to established government rates.

Timetable

The evaluation will be launched after the appointment of the evaluation committee during autumn 2016, and is expected that the final report can be concluded in June 2017. The progress plan for implementation will be prepared by the evaluation committee and the secretariat in cooperation with the RCN.

Appendix 2 - Work Plan / Work Packages

WP 1: Compile strategies and goals for Norwegian polar research

- Use the established objectives for Norwegian polar research, as they are defined
  - Nationally by among others RCN and in relevant proposals to the Storting
  - Internationally as defined by SCAR Horizon Scan, ICARP and the EU-PolarNet.
- This will give the evaluation Committee a tool to evaluate to what degree and on which topics the Norwegian polar research lives up to the defined objectives, and to identify gaps between set objectives and reality.

WP 2: Establish a backdrop for the analysis

Preparations before the Committee's collection of data

- *2A. Divide the work area into thematic fields*
  - Geographic (Arctic, Antarctica, Svalbard)
  - Topics/disciplines
  - Thematic division, across disciplines
- *2B. Prepare an overview of relevant existing evaluations, mappings and analyses*
  - The Secretariat will prepare an overview of data, results and recommendations from existing evaluations, mappings and analyses of relevance to Norwegian polar research (based on the mandate).
- *2C. Prepare a description of the players involved in Norwegian polar research, including their organisation and division of labour between them.*
  - The Secretariat will prepare an overview of the various players involved in Norwegian polar research, including funds, departments, directorates, research institutes, groups of scientists, private research institutes and corporations.
- *2D. Prepare a description of international players of relevance to Norwegian polar research*
  - The Secretariat will prepare an overview of the most important international funds, foreign research councils, international partner organisations and major international/foreign research groups.

WP 3: Collect information from the community of Norwegian Polar Research

The Secretariat will assist the Committee in the collection of information from Norwegian research communities, through self-evaluation schemes and dialog meetings between scientists and Committee members. The bibliometric depth analysis on Norwegian polar research also constitutes a big part of the data collection.

- *3A. Design self-evaluation scheme*
  - The self-evaluation scheme will be designed by the Secretariat, based on instructions from the Chair and the Committee.

- *3B. Execution of self-evaluation scheme*
  - The self-evaluation scheme will be conducted by the Secretariat after the initial meeting of the Committee. The Secretariat will deliver a summary of the self-evaluation to the Committee.

- *3C. Prepare an overview of funding, publishing, quality of publishing, cooperation axis's and communication from Norwegian polar research groups*
  - Two central data sources in this work are the bibliometric depth analysis (separate project to be delivered by external contractor by 31.03.17) and the self-evaluation scheme (WP 3A and 3B).

- *3D. Collect depth information on focus, structure and framework of Norwegian research environments*
  - The Secretariat will assist the Committee to conduct dialogue meetings between Norwegian research groups that are active in polar research and the Committee.
  - We suggest arranging such meetings back to back with the first two Committee meetings, or as separate meetings between representatives of the Committee and the research groups at other times during the evaluation period.

WP 4: Present an overview of the organisation of Norwegian Polar Research in an international context

The Secretariat proposes to present an overview of the organisation of Norwegian polar research in an international context. The Secretariat will assist the Committee in this work upon request.

- *4A. Compare the organisation of Norwegian polar research against the organisation in other countries*
  - Including models for funding, organisation in strong research communities, access to research infrastructure, etc.

- *4B. Examine the interactions between national and international instruments for funding of polar research*
  - Based on information collected as part of 2C, 2D, 3A and 3B, examine:
    - to what extent national research funds are channelled through national channels
    - to what extent Norwegian funds are matched with the funds of other countries
    - to what extent Norwegian funds are channelled through international systems for funding
  - Examine to what extent Norwegian polar research is funded:
    - through POLARPROG
    - by international funds
    - by other research programmes

- *4C. Examine the effect of strategic priorities ("store satsinger")*
  - Based on information collected as part of 2C, 2D, 3A and 3B, examine the effect of strategic priorities, such as "The international polar year", other targeted funding arrangements and the focus on SFFs, SFIs and similar.

- *4D. Examine the degree of Norwegian participation in international cooperation*
  - Based on information collected through 3A, analyse the degree of participation in international cooperation.

WP 5: Evaluate the relevance of Norwegian polar research in relation to societal challenges

The Secretariat proposes to investigate how Norwegian polar research answers societal challenges and to what extent the results of the research is communicated to decision makers and a broader audience. The Secretariat will assist the Committee in its work upon request.

- *5A. Examine the contribution from Norwegian polar research to solve or understand major societal challenges*
    - Based on information collected through 3A and 3B, analyse the proportion of research funding that is used to respond to societal challenges.
        - Climate change affects the polar areas faster than other areas, and we suggest to evaluate to what extent Norwegian polar research contributes to increase knowledge about climate change and contribute to climate adaptation in society.
        - Other threats, such as ocean acidification, marine littering and transboundary pollution, may also be relevant to look at.

- *5B. Examine the contribution from Norwegian polar research to business development*
    - Based on information collected through 3A and 3B, evaluate:
        - to what extent Norwegian polar research contribute to developing new and existing business activity.
        - the degree of cooperation between private players and polar research.
    - The role of Norwegian polar research for development of business on Svalbard may be of special interest.

- *5C. Examine the dissemination of Norwegian polar research*
    - Based on information collected through 3A and 3B, evaluate whether Norwegian polar research is adequately communicated to relevant decision-makers and to a wider audience.

WP 6: Write report

The report is the main product of the project. The draft report will be made available to all members through Google documents, and everyone will write their contribution in the same document.

- *6A. Draft outline of report*
    - The Chair, in cooperation with the Secretariat, will draft a first outline of the report.

- *6B. Contribution from members of the committee*
    - The major part of the report will be written collectively and collaboratively by the Committee.

- *6C. Streamlining and finalization of report*
    - The Secretariat, in cooperation with the Chair, will make sure that the text is coherent throughout and will add administrative parts of the report.

- *6D. Final report*
    - The Committee will read through and correct the final draft report and make changes as required before approving the report and delivery to RCN.

Appendix 3 - Self-Evaluation Survey form

Self-Evaluation Survey
Evaluation of Norwegian Polar Research 2017

Self-Evaluation

of academic departments and research institutes

The Research Council of Norway (RCN) has appointed an international committee to evaluate the quality and impact of Norwegian polar research. This self-evaluation survey for the academic departments and research institutes will provide essential information for the Evaluation Committee. The survey is intended to give relevant information about the participating university departments and research institutes, focusing both on past and present strengths and future challenges.

The deadline for submitting this survey is March 6, 2017

Send your reply, according to the procedure below, on email to:

erlend@salt.nu

With subject: "Self-evaluation of academic departments and research institutes"

(Please note that the two last letters in the address is not .no but .nu)

Procedure

All academic department/research institutes that responded to the 2015 mapping survey of Norwegian polar research (NIFU Report 2015:37) are invited to participate in this self-evaluation survey. We have particularly high expectations that all responding entities in all sectors with more than 10 person-years of polar research per year take part. Smaller units, e.g. from humanities and social sciences, may submit the survey with a more restricted scope. Please respond at the same department/institute level as for the mapping survey *(see «Vedlegg 2. Enheter som inngår i datagrunnlaget 2014» at page 120 of NIFU report 2015:37 for an overview of department/institute levels)*.

Please submit the survey electronically as one single PDF-file, according to the template given below. All text must be searchable. Please also submit the completed Word-document.

English is the working language for the evaluation. This means that all text must be in English.

We recommend that you read the mandate for the Evaluation Committee before you fill in the survey. For the purpose of this evaluation, polar research is defined as follows:

> *Norwegian polar research encompasses activities ranging from basic research to applied and industry-oriented research in and on the polar parts of the Arctic and Antarctic. Polar research includes thematic areas such as climate, the environment, geology, natural resources, the societal and industrial challenges, geopolitics and culture, and is thus not a separate discipline. The term «industrial challenges» does not include all industry-relevant research in polar areas, but focuses on the particular problems that arise as a result of natural conditions in polar regions. Geographically, Norwegian Arctic research refers to the polar part of the Arctic and does not include Norwegian mainland. The delimitation definition is given in the Norwegian Polar Research Policy (2014-2023).*

We also recommend that you study the entire survey form before you start answering the questions, as several of the questions may cover different aspects of the same topics.

All submissions will be reviewed and validated by the Evaluation Secretariat before the material is forwarded to the Evaluation Committee.

Self-Evaluation Survey
Evaluation of Norwegian Polar Research 2017

Dialogue meetings between the Evaluation Committee and a selection of the large research units are scheduled to take place 27-30 March 2017. Once the Evaluation Committee has completed the draft report, the relevant sections will be sent to each department for fact-checking and comments before the final report is submitted to the Research Council of Norway. This is not an evaluation of individual researchers but of the national research landscape in an international context. The evaluation is therefore limited to assessments and recommendations at the department/research institute level, and individual researchers will not be mentioned.

Please also note that this is NOT a new mapping of Norwegian polar research. Your unit participated in the 2015 mapping of Norwegian polar research (NIFU 2015:37), providing numbers for the fiscal year 2014. If significant changes in expenditure during the years 2015-2016 has occurred, please use point 7 a) to provide these. If there are only minor changes, please leave point 7 a) open. Please also consider to allow the Evaluation Committee to access the detailed data your unit submitted to the 2015 mapping by answering yes in point 1 c).

This self-evaluation survey provides confidential information that will only be disclosed for the Evaluation Committee, the Secretariat and the Research Council of Norway. Information that is directly or indirectly extracted from the survey form will be used by the Evaluation Committee in their report without reference to the respondents.

1. Information about the unit being assessed

a) Unit

Name of unit	
Parent university/institute	

b) Contact person

Name	
Position	
Email address	
Phone	

c) Release of information from earlier mapping of Norwegian polar research

Your unit participated in the 2015 mapping of Norwegian polar research (NIFU 2015:37), providing numbers for the fiscal year 2014. The detailed information from your unit is of importance for the Evaluation Committee. As information were provided by the institutions under a clause of confidentiality we will need the acceptance from the institution in order to release this information to the Evaluation Committee. You are of course entitled to say no, but we do hope for your cooperation.

	Mark with letter X in appropriate cell
	Yes, we confirm that the information submitted as part of the mapping of Norwegian polar research (NIFU 2015:37) can be released by NIFU to the Evaluation Committee, the Secretariat and the Research Council of Norway
	No, we do not accept that the information submitted as part of the mapping of Norwegian polar research (NIFU 2015:37) can be released by NIFU to the Evaluation Committee, the Secretariat and the Research Council of Norway

2. Research quality, impact and capacity

This section aim to demonstrate the scientific quality of your polar research, with specific reference to the polar-related scientific publishing of your institute/department, as well as the unit's capacity and the impact of its research.

a) Number of personnel in full-time equivalents (T=total and PR=involved in polar research)

Positions	**Univ/RI basic budget***		**External grants****		**Gender**	
	T	PR	T	PR	F	M
Professor						
Associate professor						
Adjunct professor						
Adjunct associate professor						
Researcher (with PhD)						
Post-doctoral research fellow						
Doctoral students						
Administrative personnel						
Technical personnel						
Research assistants (without PhD)						
Total						

** "Univ"/"RI": financed by the university basic budget/research institute basic budget*

*** "External": financed by external grants*

b) How many peer reviewed scientific publications within polar research have your unit delivered in the period 2014–2016 (where each one is only counted once)?

	2014	***2015***	***2016***
Arctic (in general)			
Svalbard (specifically)			
Antarctic			

c) Specify degree of national and international co-authorship in the publications reported in b)

Publications published with internal* authorship only		%
Publications published with national co-authorship		%
Publications published with international co-authorship		%
Publications published as co-authorship with stakeholders		%

** Colleagues from same institution*

d) Which countries are the top three collaborators for international co-authorship in the publications reported in b)?

1	
2	
3	

e) How many publications within polar research have your unit delivered in total in the period 2014–2016 in the following categories (where each one is only counted once)?

	Books	***Reports***	***Datasets***
Arctic (in general)			
Svalbard (specifically)			
Antarctic			

f) Describe the impact (e.g. scientific, societal, industrial…) of your publications

Free text – maximum 300 words

g) Please list the 5 most important polar research articles in international peer reviewed scientific journals (2007–2016) from your unit and comment why you find them important

Free text – maximum 300 words

h) Which polar research infrastructures* are your unit using, and rate their importance from 1 (low) to 5 (high)?

** Of national or international character, such as research vessels, field stations, data services or observational technology*

Mark with letter X in appropriate cell	Low				High
Title of infrastructure	***1***	***2***	***3***	***4***	***5***

i) Which polar research infrastructures* are your unit hosting (list with short description)?

** Of national or international character, such as research vessels, field stations, data services or observational technology*

Free text – maximum 300 words

j) What are the strengths, specific to polar research, of your unit?

Free text – maximum 300 words

k) Are there any bottlenecks that impact progress of your unit in polar research?

Free text – maximum 300 words

l) Other comments on research quality, impact and capacity

Free text – maximum 200 words

3. Research partnerships – national & international

This section aim to describe the national and international research collaboration in polar research of your institute/department.

Self-Evaluation Survey
Evaluation of Norwegian Polar Research 2017

a) What are the top 5 national polar research partnerships for your unit (ranked after importance)?

		Mark with letter X in appropriate cell	
	Partner	***Leadership****	***Participation***
1			
2			
3			
4			
5			

** Leadership means partners that have leading role in your co-operation and others are only participation partners*

b) What are the top 5 international polar research partnerships for your unit (ranked after importance)?

		Mark with letter X in appropriate cell	
	Partner	***Leadership****	***Participation***
1			
2			
3			
4			
5			

** Leadership means partners that have leading role in your co-operation and others are only participation partners*

c) Which research initiatives are relevant to your unit (rank maximum 5 in order of importance)?

1	
2	
3	
4	
5	

d) Which international global change research programmes are relevant for your unit, and rate their importance from 1 (little important) to 5 (very important)?

Mark with letter X in appropriate cell	Little important				Very important
Title of research programme	***1***	***2***	***3***	***4***	***5***

e) Other comments on research partnerships

Free text – maximum 200 words

4. Strategic focus and future plans

This section aim to describe the strategic focus of your polar research, and how this is related to the thematic polar research areas.

a) Which Norwegian thematic priority areas* for polar research are covered by your unit and to what degree (1=low degree, 5=high degree)?

Mark with letter X in appropriate cell	Low				High
Thematic priority area	***1***	***2***	***3***	***4***	***5***

** **Norwegian thematic priority areas** are identified in the Norwegian polar research policy as: **1. International interaction**, **2. A changing climate and an environment under pressure** (Atmosphere and earth´s proximal space, Glaciers and permafrost, Oceans and seabeds, Ecosystems, Pollution, People and cultural heritage) and **3. Natural resources and industrial activity** (Petroleum activities, Maritime operation, Fisheries and biomarine resources, Mineral extraction, Travel and tourism).*

b) Which strategic areas for polar research do you see for your own activities?

1	
2	
3	
4	
5	

c) Which areas of interdisciplinary polar research are implemented in your unit (rank them from 1=low to 5=high)?

Mark with letter X in appropriate cell	Low				High
Areas of interdisciplinary polar research	***1***	***2***	***3***	***4***	***5***

d) Which areas of Norwegian polar research policy influence the research priorities of your unit (from 1=low to 5=high)?

Mark with letter X in appropriate cell	Low				High
Areas of Norwegian polar research policy	***1***	***2***	***3***	***4***	***5***

Comments

Free text – maximum 200 words

e) To what degree do polar research policy priorities given in international strategy documents influence the research priorities of your unit (from 1=low to 5=high)?

Mark with letter X in appropriate cell	Low				High
International polar research policy priorities	***1***	***2***	***3***	***4***	***5***

Comments

Free text – maximum 200 words

f) List examples where researchers at your unit are engaged in assessment processes, such as IPCC, Arctic Council initiatives, etc. (1=low, 5=high):

Mark with letter X in appropriate cell	Low				High
Assessment process	***1***	***2***	***3***	***4***	***5***

Comments

Free text – maximum 200 words

g) To what degree (0=none, 1=low, 5=high) is your unit involved in shaping future research priorities at the following levels:

	Insert a number from 0 to 5 in appropriate cell		
	Science policies	***Research priorities***	***Funding instruments***
National			
Nordic			
European			
International			

h) Please describe in a few words the future plans of your unit on the basis of your strategy plan on polar research in relation to these key areas:

International interaction	
A changing climate and an environment under pressure	
Natural resources and industrial activity	
Any other	

i) Other comments on strategic focus and future plans

Free text – maximum 200 words

5. Societal relevance and communication with stakeholders

This section aims to describe the societal relevance of your polar research.

a) Specify the five most important target user groups and rate the relation to these based on the following factors (0=none, 1=low, 5=high):

Insert a number from 0 to 5 in appropriate cell				
	Target user group	***Level of interaction***	***Application of research results***	***Research results impact on policy***
1				
2				
3				
4				
5				

b) Please give a brief description of your contribution to how societal needs are brought into the development of polar research agendas, the formulation of research questions, and the development of new knowledge, instruments or techniques.

Free text – maximum 300 words

c) Specify to what extend your unit is involved in co-design, if any.

Free text – maximum 300 words

d) Other comments on societal relevance and communication with stakeholders

Free text – maximum 200 words

6. Future plans and recommendations

This section gives you the opportunity to make recommendations for the further development of Norwegian polar research in general, in a 5-10 year horizon.

a) Please provide your view on the main challenges for future Norwegian polar research

Free text – maximum 200 words

b) Please provide your view on the future needs for polar-related knowledge

Free text – maximum 200 words

c) Please provide your view on how Norwegian polar research policy should address these challenges and knowledge needs

Free text – maximum 200 words

d) List the most important funding and coordination programs in future for your research (1=low importance, 5=high importance)?

Mark with letter X in appropriate cell	Low				High
Funding and coordination programs	***1***	***2***	***3***	***4***	***5***

e) Do you have any suggestions on changes RCN could implement to improve the conditions for polar research?

Free text – maximum 200 words

f) Other comments on future plans and recommendations

Free text – maximum 200 words

7. Other comments

This final section gives you the opportunity to provide extra information in addition to the more rigid structure of the first chapters of this self-evaluation survey form.

a) Updated information with respect to the numbers provided in the mapping of Norwegian polar research (NIFU 2015:37)

Your unit participated in the 2015 mapping of Norwegian polar research (NIFU 2015:37), providing numbers for the fiscal year 2014. This point is an opportunity for you to provide information of significant changes in expenditure and personnel etc. during the years 2015-2016. If there are only minor changes, please leave this field open.

Free text

b) You are invited to provide further comments that you feel has not been addressed in the previous sections of this self-evaluation form.

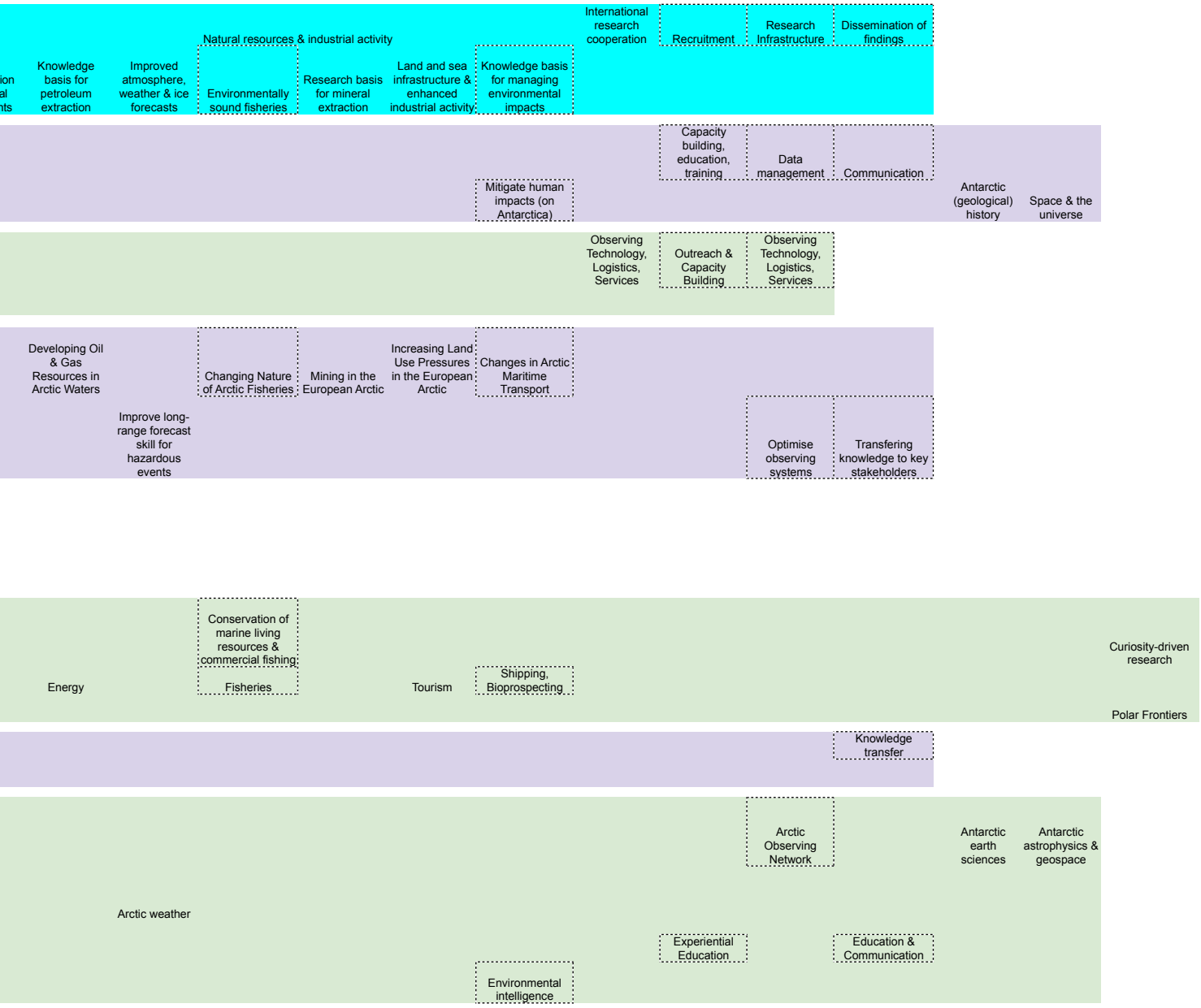
Free text – maximum two pages

Appendix 4 - List of units participating in interviews and self-evaluation

	Institution	Department	Survey	Interview
1	Research Counsil of Norway (RCN)	Division for Energy, Resources and the Environment		●
2	Akvaplan-niva		■	●
3	CICERO		■	
4	Fridtjof Nansen Institute (FNI)		■	
5	IMR		■	●
6	IRIS	Microbiology and Biotechnology	■	
7	NERSC		■	●
8	NGU	Geological Survey of Norway	■	
9	NILU		■	●
10	NINA		■	
11	NORD universitet	Fakultet for biovitenskap og akvakultur	■	
12	NORSAR		■	
13	Norwegian Computing Center (NR)		■	
14	Norwegian Polar Institute (NPI)		■	●
15	NTNU	Department of Biology	■	●
16		Department of Circulation and Medical Imaging	■	
17		Department of Geography	■	
18		Institutt for Bygg og Miljøteknikk	■	
19		Institutt for Marin Teknikk	■	
20	SINTEF		■	●
21	UiB	Department of Biology	■	●
22		Department of Earth Science	■	
23		Geophysical Institute	■	
24	UiO	Department of Biosciences	■	●
25		Department of Geoscience	■	
26		Department of Physics	■	
27		Department of political science	■	
28		Mechanics section, Dep of mathematics	■	
29	UiS	Faculty of Science and Technology	■	
30	UiT	Department of Arctic and Marine Biology	■	●
31		Department of Chemistry	■	
32		Department of Geosciences	■	
33		Det juridiske fakultet, K. G. Jebsen senter for havrett	■	
34		Institutt for historie og religionsvitenskap	■	
35	UniResearch Miljø		■	
36	UNIS	Department of Arctic Geology	■	●
37		Department of Arctic Technology	■	
38		Dept Arctic Biology	■	
39		The Arctic Geophysics Department	■	

Appendix 5 - Norway polar external scan

Topics specified in RCN Polar Research Policy	International interaction			Changing climate & environment under pressure							
	Geopolitical issues related to change	Polar polices & collaborations	Resource management, environmental protection, safety, security	Polar processes in Earth system models	Polar climate system & links to global climate	Polar ecosystems	Changes in ocean circulation	Long-range & local pollution	Impacts on Arctic communities	Factors in Svalbard development	Preservat of cultur monumer
SCAR Strategic Plan (adopts Horizon Scan for science)	Science leadership	Membership	Advice (to Antarctic treaty)								
SCAR Horizon Scan (Kennicut et al.)				Ice sheets	Antarctic atmosphere & Southern Ocean	Antarctic life (marine & terrestrial)					
IASC ICARP III priority areas					Climate System & Transformations	Societies & Ecosystems			Societies & Ecosystems		
IASC Working Groups				Atmosphere WG		Marine WG Terrestrial WG	Marine WG	Atmosphere WG	Social & Human WG		
Preparatory Action for a European Arctic Information Centre (PA-EUAIC) EU Polar Board					Climate Change in the Arctic				Social & Cultural Changes in the European Arctic		
H2020 Blue-Action proposal (DMI, AC UoL, CNRS, DTU, GEOMAR, MPI-M, MRI-Iceland, NCAR, Nansen ERSC, NIOZ, NOC-NERC, Univ. Bergen, WHOI, others				Improve modeling of Arctic processes in Earth system models	Impacts of Arctic on northern hemisphere circulation		North Atlantic impacts on predictive capabilities				
World Climate Research Program 'Melting Ice' Grand Challenge				Ice sheets models, Permafrost Carbon	Sea Ice & Snow in Changing Climate						
Alfred Wegener Institute, focus on:				Permafrost	Sea ice	Ocean acidification	Arctic Ocean	Marine litter			
UK Science in Antarctica (policy document)				Modelling Antarctic systems	Understanding & managing environmental change	Antarctic biodiversity					
Adapting to Change, UK Policy towards the Arctic					Climate Change	Biodiversity		Safeguarding the Environment			
British Antarctic Survey Grand Challenges for Polar Science:				Earth & the Poles	Polar Change				People & the Poles		
Canada Arctic Net program areas:		Northern policies			Marine systems	Terrestrial systems			Inuit health		
Canada First Research Excellence Fund: Sentinel North				Ecosystems, geosystems & human-environment interactions							
USA NSF Polar Programs				Arctic System Science, Antarctic glaciology	Antarctic Integrated Systems	Arctic Natural Science, Antarctic Organisms & Ecosystems	Antarctic ocean & atmosphere		Arctic Social Science		
USA NOAA (Arctic Report Card)				Greenland ice sheet, carbon Ice sheets	Sea ice, snow cover Sea ice	Ocean acidification, Terrestrial ecosystems	Ocean SST, Arctic ocean productivity				
USA NASA Cryosphere Program											
Arctic Research Consortium US					Sea ice	Environmental Arctic Change					
IARPC's Arctic Research Plan: FY2017–2021				Glaciers & sea level, Permafrost	Atmosphere, Sea ice	Marine & terrestrial ecosystems			Health & Well-being, Coastal resilience		


International research cooperation
Recruitment
Research Infrastructure
Dissemination of findings
Natural resources & industrial activity
Knowledge basis for petroleum extraction
Improved atmosphere, weather & ice forecasts
Environmentally sound fisheries
Research basis for mineral extraction
Land and sea infrastructure & enhanced industrial activity
Knowledge basis for managing environmental impacts
Capacity building, education, training
Data management
Communication
Mitigate human impacts (on Antarctica)
Antarctic (geological) history
Space & the universe
Observing Technology, Logistics, Services
Outreach & Capacity Building
Observing Technology, Logistics, Services
Developing Oil & Gas Resources in Arctic Waters
Changing Nature of Arctic Fisheries
Mining in the European Arctic
Increasing Land Use Pressures in the European Arctic
Changes in Arctic Maritime Transport
Improve long-range forecast skill for hazardous events
Optimise observing systems
Transfering knowledge to key stakeholders
Conservation of marine living resources & commercial fishing
Curiosity-driven research
Energy
Fisheries
Tourism
Shipping, Bioprospecting
Polar Frontiers
Knowledge transfer
Arctic Observing Network
Antarctic earth sciences
Antarctic astrophysics & geospace
Arctic weather
Experiential Education
Education & Communication
Environmental intelligence

Appendix 6 - Composition of the Polar Evaluation Committee

Name	Institution
Dr. David Carlson (chair)	World Climate Research Programme (WCRP)
Prof. Martin Siegert	Imperial College London
Ms. Taneil Uttal	National Oceanic and Atmospheric Administration (NOAA)
Prof. Leif Anderson	University of Gothenburg
Dr. Naja Mikkelsen	Geological Survey of Denmark and Greenland (GEUS)
Prof. Terry Callaghan	University of Sheffield
Prof. Bettina Meyer	Alfred-Wegener-Institut (AWI)
Prof. Pentti Kujala	Aalto University
Prof. Joan Nymand Larsen	University of Akureyri
Dr. Björn Dahlbäck	Swedish Polar Research Secretariat

10.3 List of abbreviations and acronyms

ABDS	The Arctic Biodiversity Data Service
AC	Arctic Council
ADC	International Arctic Science Committee/ Sustaining Arctic Observing Networks Arctic Data Committee
AIA	Aleut International Association
AMAP	Arctic Monitoring and Assessment Program (AC Working Group)
APECS	Association of Polar Early Career Scientists
ARCUS	Arctic Research Consortium of the US
ASSW	Arctic Science Summit Week
AWI	Alfred Wegener Institut Helmholtz Zentrum für Polar und Meeresforschung
BAS	NERC - British Antarctic Survey
CACCON	Circumpolar Arctic Coastal Communities Observatory Network
CAFF	Conservation of Arctic Flora and Fauna (AC Working Group)
CBMP	Circumpolar Biodiversity Monitoring Program
CEDAR	Coupling, Energetics and Dynamics of Atmospheric Regions
CNRS	Centre National de la Recherché Scientifique
COMNAP	Council of Managers of National Antarctic Programmes
CNARC	China-Nordic Arctic Research Center
EPB	European Polar Board
EPPR	Emergency Prevention, Preparedness and Response (AC Working Group)
ERA-NET	European Research Area Network (Framework 7 programmes
ESSD	Earth System Science Data journal
FARO	Forum of Arctic Research Operators
GCW	Global Cryosphere Watch
GEUS	Geological Survey of Denmark and Greenland
GTN-P	Global Terrestrial Network for Permafrost
IACS	International Association of Cryospheric Sciences
IASC	International Arctic Science Committee
IASSA	International Arctic Social Sciences Association
ICARP	International Conference on Arctic Research Planning
ICC	Inuit Circumpolar Council
ICES	International Council for the Exploration of the Sea
IIASA	International Institute for Advanced Systems Analysis
IMBER	Integrated Marine Biosphere Research
INTERACT	International Network for Terrestrial Research and Monitoring in the Arctic
IPA	International Permafrost Association
IPCC	Intergovernmental Panel on Climate Change
IPEV	Institut Polaire Français - Paul Emile Victor
IPS	Arctic Council Indigenous Peoples Secretariat
IPY	International Polar Year 2007-2008
ISAC	International Study of Arctic Change
Met.No	Norwegian Meteorological Institute
MOSAiC	Multidisciplinary drifting Observatory for the Study of Arctic Climate Change
NIFU	Nordic Institute for Studies in Innovation
NPI	Norwegian Polar Institute
NVP	Norwegian Scientific Academy for Polar Research
NySMAC	Ny-Ålesund Science Managers Committee
PAG	Pacific Arctic Group
PAGES	Past Global Changes
PAME	Protection of the Arctic Marine Environment (AC Working Group)
RAIPON	Russian Association of Indigenous Peoples of the North
RBINS	Royal Belgian Institute of Natural Science
RCN	Research Council of Norway (NFR, Norges Forskningsråd)
SAON	Sustaining Arctic Observing Networks
SCAR	Scientific Committee on Antarctic Research
SDWG	Sustainable Development Working Group (AC Working Group)
SPRS	Swedish Polar Research Secretariat
UArctic	University of the Arctic
WCRP	World Climate Research Programme
WOC	World Ocean Council
YOPP	Year Of Polar Predictions

The Research Council of Norway
Drammensveien 288
P.O. Box 564
N0-1327 Lysaker, Norway

Telephone: +47 22 03 70 00
post@forskningsradet.no
www.forskningsradet.no

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