

Responsible Development of the Arctic: Opportunities and Challenges - Pathways to Action

Annual Reporting of Nordic Centres of Excellence

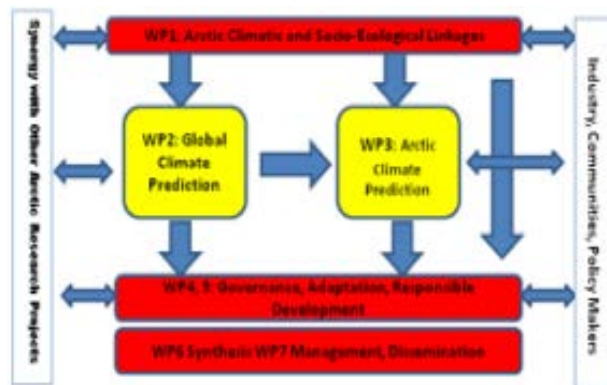
General information

Arctic Climate Predictions: Pathways to Resilient Sustainable Societies (ARCPATH) 01.01.2016-12.31. 2020.		Yongqi Gao and Astrid Ogilvie
Name of the responsible leader of the NCoE:		Yongqi Gao and Astrid Ogilvie
Reporting period		2018-01-01 - 2018-12-31

(A list of acronyms is found in Appendix 2 / page 30)

1. PROGRESS AND RESEARCH RESULTS:

Unique Research Achievements and Key Findings



The ARCPATH project is structured in such a way that there are 7 discrete but interlinked work packages. These are illustrated in the diagram to the left. WP7 on *Project Management and Dissemination* is discussed below in Section 5 on “Governance”. WP6 on *Synthesis* is discussed first in this section followed by highlights and examples of synthesis from the individual work packages.

ARCPATH is a ground-breaking project designed specifically to synthesize results deriving from a variety of traditionally very different and separate

academic disciplines. To note the project aims: ARCPATH seeks to address the complex and interlinked issues of climate and socio-economic and social-ecological change occurring in the Arctic by focusing on near-term changes, with the overarching goal of fostering responsible and sustainable development. This requires the reconciliation of **environmental**, **social**, and **economic** demands. The synthesis work package is designed to: i) Harvest the principal scientific findings of ARCPATH, and to generate new cross-cutting insights and concepts; ii) Explore the policy and action relevance of these findings; iii) Mobilize the knowledge generated (to the academic community, policy-makers, practitioners, NGOs, the media and the general public); and iv) Identify lessons learned as well as remaining gaps in knowledge and directions for future research. In the first sail-off project meeting and all subsequent meetings much emphasis has been

placed on how to achieve synthesis. As noted in the project application: ***Unlike other international collaborative projects, we shall not wait until the end of the project to synthesise and identify the significant joint findings, meanings and significance of those findings. Rather, synthesis will be built into data collection.***

Due to the proliferation of complex inter and trans-disciplinary international projects focussing on climate change, researchers are now recognizing the importance of synthesis of research findings in order to facilitate knowledge mobilization and project legacy. However, many of these projects attempt to conduct synthesis at the very end of the research. ARCPATH is unique in that it is developing methods of building synthesis into the research process at all phases of research from design to application and legacy. Thus, ARCPATH research findings will include identification, analysis, and evaluation of synthesis methods as well as synthesis and connections among findings as they emerge in the research process. This has been and will continue to be an iterative process with early synthesis feeding into the research which will adapt data collection and analysis as well as action within the research communities to those findings. Early identification of gaps in the records and consistency of approach will ensure better analysis and mobilization of knowledge produced by the project. To this end, discussions and practice of synthesis are ongoing among project researchers and participants. As an example, we note the Annual Project Meeting for 2018 held in Bergen in Norway. The theme of the meeting was “Back to Basics” with ARCPATH members seeking to educate each other in terms of the basic elements of historical, sociocultural, ecological, anthropological and climate research and modelling. For such meetings, in addition to presenting emerging findings from the work packages, researchers have been asked to identify linkages and connections across the work packages. This ensures that researchers from the different work packages and disciplines are required to engage with one another on an ongoing basis. The tasks of synthesis include learning the language and methods of the different disciplines represented in the project and developing ways of discerning the connections and linking those connections to create truly interdisciplinary findings.

Project synthesis tasks are as follows: *1: Harvest findings of ARCPATH (emerging and final findings) by identifying the most significant findings in terms of contributions to existing knowledge, to the research community, to policy and practice, to our research communities and to Arctic communities in general. This is being done through: 1. Consultations with the team members and partners and with the communities mentioned above, both academic and practical, through a series of meetings (including ARCPATH Annual meetings, Work Package meetings, teleconferences, focus groups, and academic conferences) to harvest significant findings; 2. Identifying opportunities for impact and engagement in the application of findings for Arctic communities as the research team does significant field work in the ARCPATH case study communities; 3: Consulting with partners, research communities and Arctic policy makers to identify policy implications and pathways for application of the findings; 4. Engaging with policy makers and community and regional leadership and identifying opportunities to influence Arctic policy and practice, for example presenting and engaging participants in the Arctic Circle Assembly and other venues including the University of the Arctic and the Arctic Council; 5. Expanding the research networks with whom ARCPATH researchers interact; 6. Identifying new transformative development paths that can contribute to the future social and economic sustainability of Arctic communities, notably by ARCPATH researchers and participants by conveying information and data concerning governance regime impacts, climate impacts at the regional level, sea-level rise, loss of sea ice, changing ocean currents and marine species distribution to communities in the research areas); 7. Identifying pathways to Arctic sustainability so Arctic communities can not only survive, but thrive, by taking advantage of new*

opportunities and development options particularly by ARCPATH researchers conducting fisheries and marine-mammal research and engaging with local communities; 8. Communicating synthesis to research, policy and political communities for example through presentations to high-level policy conferences; 9. Identifying continuing/persistent knowledge gaps, and recommending future research to fill these gaps, for example reaching out to other Centres of Excellence and research projects and networks in which team members participate. All of these examples have been the synthesis activities of ARCPATH during the past year.

For ARCPATH, Knowledge mobilization (KMb) and synthesis are inextricably connected; thus one of the synthesis responsibilities of all partners is to identify synthetic outputs, jointly authored journal articles, web postings, social and popular media etc., which are communicating synthesis outputs of the project at this phase of the research and will continue throughout the remaining time of the project. We are planning an International Synthesis Conference at the end of the project that will bring together researchers, policy makers, civil society and (knowledge brokers to link them) to present these synthesized research findings, wrest meaning from them and clarify the policy and planning implications of the findings as well as knowledge gaps and needs for future research. The conference will thus address the synthesis goals above and coordinate and communicate the synthesis outputs of the entire project. This conference and the meetings leading up to it will be the culmination of the synthesis process and will demonstrate the co-production of research findings and applications. Examples of specific synthesis findings emerging to date from and across the work packages include identifying the implications of finer-scaled regional climate models for community and economic planning in the case-study countries (WPs 1,2,3). To give some examples: synthesis findings from WP4 include ways in which changing migratory patterns of cetaceans might determine livelihood and economic opportunities in coastal communities. WP5 further explores these linkages by investigating institutions and governance in a changing world in particular the role of fisheries and ocean governance in planning the future of Arctic communities in Iceland, Norway and Greenland. Throughout this report and in the Work Package summaries can be found other examples of synthesis.

The main goal of WP1 *Arctic Linkages: Climate, Environmental Change, and Human Eco-Dynamics* is to form an historical context for the project as a whole, in that it is exploring and establishing linkages between changes in climate, social-ecological systems, and marine systems. Work has continued on analyzing past climate variations, together with adaptations to climate impacts on economic activities such as fishing and multiple use of cetaceans. The focus during 2017 was on analysis of the past sea-ice record for Iceland, in particular in terms of correlations with the North Atlantic Oscillation (NAO) index. During this past year of 2018 emphasis has been primarily on temperature variations for Iceland (which correlate well with the sea-ice index) plus analyses of storminess, ecosystem services of cetaceans and fisheries in the past, and perceived adaptations to climate impacts. In particular there has been a focus on these specific tasks: To examine correlations between fisheries and temperature changes in the North Atlantic back to ca AD 1700; and to evaluate the incidence of extreme weather events, such as increased storminess, and human adaptation responses in our study areas in the past. It is clear that a correlation exists between ocean temperatures and marine stocks. Although other factors were involved, it is highly likely therefore that climate was of importance for the fisheries in several respects. If the weather was particularly stormy, for example, then many lives were lost at sea, and more fishermen were drowned during cold and stormy periods (as in 1698 to 1704). Until comparatively recent times, when many different fish species began to be caught in Iceland waters due to warmer ocean temperatures, the main species caught was cod - a fish that is highly dependent on water temperatures for survival - with 4 to 7 degrees Celsius being optimal. During the period from 1680 to 1760, for example, when many severe

years occurred, fisheries were generally poor. It is possible therefore, that the waters around Iceland became less favourable for cod reproduction and survival. There is an interesting parallel here with work for WP 4 which shows that blue whales and white-beaked dolphins appear to be changing their migration routes due to changing water temperatures.

The main objective of WP2 *Improved Global Climate Prediction by Initialization of Arctic Sea Ice and Sea-Surface Temperatures* is to improve our capability for decadal climate predictions by starting the predictions from realistic ocean and sea-ice conditions. Furthermore, prediction uncertainties will also be partly reduced by using two different climate models EC-Earth3 and NorCPM. We initialized the ocean and sea ice with a so-called anomaly initialization, which means that we add observed deviations from the mean climate to the mean climate of the model. This method is used because the climate that is simulated by a model differs somewhat from the observed climate, and starting a prediction from the pure raw observations leads to unwanted drifts in the model, which makes the prediction unreliable.

The sea-ice component of EC-Earth has been substantially improved. We now use a 5-category ice thickness module, which means that we can represent 5 different ice thicknesses in each grid box of the model instead of having the same ice thickness within each grid box as we did previously. A more advanced (non-linear) method to link the observed to the modelled sea-ice conditions has been developed. To test the impact of the improved initialization, first test simulations with EC-Earth were carried out. We find that the improved sea-ice initialization is important for the near surface atmosphere in the first two years of prediction. Tian *et al.*, have submitted an abstract to EGU 2019 based on the work in 2018 as described above.

We have also analyzed the skill of decadal climate predictions based on already existing climate predictions from the CMIP5 data archive (6 different models) and from the EC-Earth (v2.3) decadal experiments. In general, only weak prediction skill is found in surface air temperature for predictions going further than 3 years into the future.

The second prediction system in ARCPATH is the Norwegian Climate Prediction Model (NorCPM) similar to EC-Earth. This uses a multi-category sea-ice model and an advanced method to merge (assimilate) observational data into the model (Ensemble Kalman filter, EnKF). In 2018 we have implemented and tested the assimilation of sea-ice concentration into the NorCPM (Kimmritz *et al.*, 2018). We found that updating the multi-category sea-ice state is of great importance in reducing errors of sea-ice concentration and thickness, near-surface temperature and salinity. Further, the NorCPM is the first system demonstrating the benefit of strongly-coupled data assimilation of ocean and sea ice in a fully-coupled system. We found, while assimilating only SSTs already provides good skill for sea-ice extent in winter, assimilation of sea-ice concentration prolongs the skill into the summer by reducing the error of sea-ice thickness in the first year (as shown in Kimmritz *et al.*, 2018).

We have also tested the added value of assimilating new observational estimates of sea-ice thickness from satellites (Xie *et al.*, 2018) into NorCPM. It remains to be tested to what extent this improvement will lead to improved prediction skill. Together with WP3, we have discussed a first case for performing high-resolution predictions with regional models in WP3.

The main goal of WP3 *Arctic Climate Predictions and Regional Downscaling* is to improve climate predictions for the Arctic/Nordic Seas to the year 2030 by using high-resolution global-coupled simulations and regional downscalings. High resolution in climate models means that climate processes can be better resolved and variables can be provided at smaller spatial scales. This is especially important in regions where e.g., temperature or precipitation varies over small distances as in mountainous regions or along coastlines. Our focus-regions in ARCPATH, coastal communities of Iceland, Greenland and Norway, are exactly such regions, requiring a high spatial resolution. These regions are affected by complex interactions of socio-economic, biological and climatic changes. This WP aims to provide more reliable information concerning changes in climatic variables, which are relevant for livelihoods in coastal communities. In order to deliver relevant climate information on the local scale to WP4 and WP5, we follow two strategies. The first is to perform high resolution global climate predictions (25 km resolution)

and the second is to perform regional model simulations (around 10 km resolution) where we use the predictions with our global models in standard resolution (around 100 km resolution) from WP2 as forcing data at the boundaries of the regional model.

High-resolution simulations with EC-Earth from 1950-2014 have been performed for the Arctic regions. They indicate a stronger and more realistic deep-water convection in the Labrador Sea and more realistic sea-ice conditions in the Barents and Greenland Seas. For the regional downscaling a regional atmosphere model (HCLIM) and a regional ocean model which covers key ARCPATH regions will be used. The global predictions from WP2 will be used as input to the regional models at their boundaries. The regional model then has the potential to modify (in the best case improve) the climate predictions from the global models, and provide information which is needed for the ARCPATH coastal regions.

A case study for regional downscaling of the global predictions for the Nordic regions was discussed. We decided to focus on the period 2002-2011. This period includes the large, observed ocean temperature changes in 2003-2004, which are likely to be linked to the movement of whales from southwestern parts to northern parts of Iceland in this year. A first ensemble member of the 2002-2011 period has been performed with NorCPM and provided for downscaling in the regional model HCLIM. The downscaling with HCLIM of this first prediction period has been started.

The main focus of WP4 **Climate, Social-Ecological Systems, Cetaceans and Tourism** is to analyse to what extent climate change, tourism, and industrial development puts cetaceans (and human societies dependent on their use) under increasing and unsustainable pressure. Thus there is an integrative focus on marine changes in the Arctic, with particular regard to linkages between environmental changes and changes in cetacean populations, and the growth of whale-watching tourism.

Good progress has been made in 2018 with social, economic and marine biological research and fieldwork taking place in Iceland, Greenland, and the seas around Svalbard and northern Norway. This includes anthropological fieldwork in Húsavík documenting present and historical multiple marine resource use, including fishing and whale-watching activities, as well as collaboration with local authorities in terms of developing a Marine Protected Area to better manage the multiple and growing use of the seaspace of Skjálfandi Bay. Ethnographic fieldwork during the spring and autumn of 2018 focused on the seasonal use of marine mammals by vocational and recreational hunters in Ittoqqortoormiit in East Greenland. This involved mapping the annual hunting cycle, including the hunting of narwhal and polar bear. For northern Norway, the focus has been on the shifting relationships between migrating whales, fisheries, and tourism in Andøya and Skervøy and how research can contribute to new knowledge dialogues to develop responsible whale-watching practices.

Blue whales have increasingly been moving north and currently come into Skjálfandi Bay every summer in June. We now have a photo-identification catalogue of 148 different individuals (Madsen, 2018; Madsen *et al.*, 2019) and for the first time we have matches of the same blue whales sighted off Svalbard and from Húsavík. This possible shift might be due to warming Arctic waters and climate change. It has been suggested earlier that blue whales are moving even further north for this reason (Iversen *et al.*, 2010). An important input for this part of ARCPATH is that data collection has been completed for a PhD project with a whole year of c-pod data from Skjálfandi Bay and adjacent Eyjafjörður for harbour porpoise and white-beaked dolphin abundance. These data are currently being analyzed.

A further key task focuses on social ecological systems, ecosystem services and cetaceans in the Arctic, where the research objective is to analyse trade-offs between different ecosystem services (ES) derived from multiple uses of cetaceans. To address this task the following 5 research questions were posed: (1) What is available in terms of previous research on the topic? (2) How do people benefit from and value the ES provided by marine mammals in the Arctic? (3) What are the different social groups that co-produce and use the ES associated with marine mammals? How are the benefits distributed between social groups within communities? (4) How have marine mammals in the Arctic been managed to date and what are the trajectories for their future management? (5) What are the actors and institutions involved? (6) How

can the valuation of whale ES be used to inform decision-making processes and the governance of marine protected areas?

Work in 2018 addressed all 5 research questions. To address research question 1, two literature reviews have been written and submitted to high impact journals. To address research questions 2-4, field work was conducted in 2018 in two locations; one week of fieldwork in Húsavík and one week in Andenes (Andøya). A total of 34 semi-structured interviews with stakeholders were conducted across the two weeks. In addition a socio-cultural survey was conducted in Andenes, following a successful pilot study in Húsavík. A full survey will be conducted in Húsavík and Disko Bay, Greenland in 2019.

To address questions 2 and 5, a contingent valuation survey on *Willingness To Pay* (WTP) for the expansion of the Faxaflói Whale Sanctuary was issued by the Social Science Research Institute at the University of Iceland, with 630 responses (data were analysed in autumn 2018). A publication is forthcoming on this study. To address research question 5, a review was conducted on selected whale sanctuaries and this research will continue into 2019 with interviews.

For this WP we have continued to work with the ARCPATH spin-off initiative at the Autonomous University of Barcelona, the CER-ARCTIC Research Centre, on the interconnected issues of Arctic social-ecological change that lend themselves well to cross-regional comparisons and knowledge transfer by the use of empirical cases.

The emphasis in Work Package 5 is on ***Marine Governance, Security and Rapid Social and Environmental Change***. In 2018 work concentrated on field research on fisheries governance issues, including investigating social and economic impacts of Individual Transferable Quota (ITQ) systems in coastal communities. Our research is finding serious flaws in the design of this form of marine resource governance due to significant social, economic and ecological externalities that are not sufficiently dealt with in policy design, implementations and assessments. A major publication that we contributed to in the *Proceedings of the National Academy of Science* (Young *et al.*, 2018) has shown that ITQs are panacea solutions to fisheries governance that need to be reviewed due a range of negative social equity issues as well as a lack of flexibility and sophisticated ecosystem understanding. In fisheries management—as in environmental governance more generally—regulatory arrangements that are thought to be helpful in some contexts frequently become panaceas or, in other words, simple formulaic policy prescriptions believed to solve a given problem in a wide range of contexts, regardless of their actual consequences. When this happens, management is likely to fail, and negative side effects are common. Several of the key case studies and arguments in this publication derive from our research.

We are finding that fisheries policy is a key driver of change in fisheries-dependent coastal communities. We are thus focusing on the social, cultural, environmental and economic externalities related to the introduction of the ITQ system, concentrating on Icelandic fisheries (but also considering Norway) and how this management model continues to impact people's livelihoods and human development in fishing villages, especially in terms of opportunities of small-scale and local actors regarding fishing rights. One common outcome of ITQ systems is the consolidation of fishing rights or quotas in large companies and away from small communities. This can lead to decreased access for newcomers, reduced training opportunities for youth on the remaining vessels, and increased cost of quotas as a limited commodity. The lack of job opportunities in the fishing sector causes increased rates of outmigration by youth and women, which threatens the resilience of those communities. At the same time, we are seeing that there continues to be an interest from youth in partaking in fisheries livelihoods and local governments are looking for options for the renewal of the fisheries workforce. We propose experimenting with programmes that increase access to fisheries for youth and newcomers such as recruitment and educational programmes, summer youth fisheries, and newcomer quotas. In 2019 and 2020 we plan to do more research focusing on intergenerational and gender aspects and the current or future youth and newcomer cohort in Icelandic fisheries. We are also developing several practical recommendations to enhance local and national policies towards a more sustainable fisheries management that includes options for newcomers and women, and that protects workers rights, including immigrants. These would include

important considerations for human well-being and job satisfaction, the right to work, gender equality, human rights, low environmental impacts, and equity in sustainable development.

Iceland, like many other fishing nations, has mostly focused on the ecological and the economic aspect of sustainable fisheries, overlooking other ecosystem services of ocean environments such as heritage, cultural value of food items, recreation, and education. Research here is leading towards a critical investigation of the definition of sustainable fisheries. Small-scale fisheries in particular can provide locally-sourced food with reduced food miles, fuel costs and greenhouse gas emissions. These fisheries offer not only flexible use of ecosystem services and diverse employment but also a sense of local fate control, belonging, cultural identity and pride in the community. These are all core aspects of Arctic human development. Such environmental and social aspects of energy efficiency and quality of life are seldom considered in definitions of sustainable fisheries, but may in fact be some of the more important factors in future climate change mitigation.

ii) Nordic added value the project brings 1) scientifically, 2) for the consortium 3) for stakeholders

As noted in the original ARCPATH application, the rapid and far-reaching changes in the Arctic will cause global effects but will first and foremost impact Arctic Nordic regions. It is thus essential that Nordic researchers combine their expertise in order to elucidate and understand these changes. ARCPATH has built a Nordic Centre of Excellence that builds on the long experience of established researchers, leading experts in their fields, as well as including many young scientists who bring fresh insights and who will help to achieve long-term Nordic added value. Because these goals and achievements are well established for ARCPATH, this section remains relatively unchanged from the report for 2017.

Scientifically: The strong, multi-disciplinary, and collaborative group that constitutes ARCPATH is generating knowledge of high importance for development in the Arctic Region, actively **creating a critical mass for success and expertise**. Within ARCPATH we facilitate close collaboration between disciplines such as physical sciences focusing on climate predictions, natural sciences focusing on ecology and behaviour of cetaceans and social sciences such as anthropology and economics focusing on the societal importance of cetaceans and the implications of climate change. The project therefore not only acknowledges that multiple disciplines are needed to identify responsible development paths for the Arctic region but in fact is integrating them in the research.

For the consortium: Combining the expertise of each institution is facilitating important synergies in knowledge creation, and it is clear that the research conducted could not be done by each partner institution on its own. For example, linking climatological data (NERSC, SAI) with the ecology and behaviour of marine mammals (HRC). ARCPATH is already drawing international talent to the Nordic region through international recruitment of senior scholars, post doctoral researchers and PhD students. For example, a Fulbright scholar from the United States joined the ARCPATH team in 2018 and another Fulbright scholar visited SAI for two months in 2018. ARCPATH is also creating international networking and research opportunities for Nordic scholars, for example in Cambridge, USA, where an ARCPATH PhD student was invited to a seminar at MIT due to her affiliation with ARCPATH.

For stakeholders: The transdisciplinary approach of ARCPATH, which by definition relies on active collaboration with stakeholders, is expected to deliver significant added value for stakeholders. Stakeholders participate in the research through qualitative (interviews) and quantitative (surveys) research methods and are expected to be able to rely on the results for better-informed decision-making. For example, the project aims to deliver tangible knowledge for decision-makers contemplating the establishment of an MPA in Skjálfandi bay in northern Iceland.

(iii) Description of the development of gender perspectives and an analysis of the importance of this development

ARCPATH places great emphasis on gender perspectives, *not least in the fact that the project has both a female and a male lead*. ARCPATH complies with the general objectives of NordForsk to increase recruitment of women and improve gender balance in projects. Climate science has traditionally been dominated by males; however, this project has an excellent gender balance and includes leading female scientists for both climate and social science spheres. ARCPATH involves an excellent gender balance among the team leaders (7 female and 7 male). Of the 7 project work packages, 4 are led or co-led by women (WP1 and WP6 are led by Dr Astrid Ogilvie, WP4 is led by Dr Marianne Rasmussen and WP 2 is co-led by Dr Shuting Yang). Dr Ogilvie is also the co-leader of WP5. It is noteworthy that the leading women are in charge of some of the most innovative and central WPs of the project and as noted, one of the project leads is female.

Issues of gender tend to be under-represented in the Arctic discourse, requiring greater emphasis on gendered dynamics in projects, research, community well-being, policy making to mention but a few. Themes of power relations, decision-making, and access to resources including knowledge and information are often missing in assessments of community well-being and increased economic activity in the region. This relates to a multitude of issues including education, job opportunities, gendered work and spaces and adaptation to globalization. There is an inherent gender imbalance in policy discussions and decision making about the Arctic, as women are under-represented in Arctic governing bodies, administration, business and science. In terms of current developments, through partnership between the Stefansson Arctic Institute (SAI) and the Arctic Council project *Gender Equality in the Arctic (GEA)* ARCPATH is exploring ways in which to address this imbalance. The purpose and objective of GEA is to raise visibility and understanding of the importance of gender issues in the Arctic, to identify priorities and concrete strategies for increased diversity and gender balance in policy- and decision-making processes and to provide information to facilitate sustainable policy making for the future.

(iv) Any difficulties encountered - e.g., in staffing, data analysis, etc. and how these are addressed

There are no specific difficulties in undertaking ARCPATH research except for those caused by the fall of the Norwegian currency against the Icelandic which we are dealing with as best we may. In addition to this, due to the unfortunate long-term illness of the responsible scientist at the SMHI-Ocean department, the ocean downscaling in WP3 could not be continued. It is problematic to replace this scientist as he is the only person on the team who has expertise in running the regional MIT ocean model. The return of the MIT-model expert is expected in April 2019. Alternative options are being discussed in the event that this scientist will not be able to return to work. One option is to use high-resolution simulations with the NEMO-ocean model instead of the MIT-model.

(v) Changes introduced or envisaged in the research objectives or design

There are no changes in the research objectives or design.

vi) Specific efforts undertaken to encourage synergistic collaboration across academic fields and disciplines both in the research and outreach efforts of your project?

ARCPATH has a very strong international component with active research partners drawn from: Canada, the USA, China and Russia. Astrid Ogilvie has spent time at INSTAAR, at the University of Colorado at Boulder, USA, working with colleagues there, in particular with Professor James McGoodwin at INSTAAR and Dr Shari Fox at NSIDC. Professor Leslie King, of RRU, Canada, is a particularly active

ARCPATH member and it may be noted that Astrid Ogilvie is an Adjunct Professor in Professor King's department at RRU. Yongqi Gao continues to work with the Nansen-Zhu International Research Centre in China. Colleagues who have been recruited as unfunded but collaborating Associate Scientists include: Dr Margaret Willson, anthropologist, Department of Anthropology, University of Washington, Seattle, USA; Elizabeth Ogilvie, Environmental Artist, University of Edinburgh; Dr Françoise Breton; anthropologist and Director of the new CER ARCTIC Research Centre at the Autonomous University of Barcelona; Dr Anniken Førde, social scientist at the Arctic University of Tromsø, Norway; and Kerry Koepping, photographer and Director, Arctic Arts, Boulder, Colorado, USA. Dr Willson has been recruited to contribute to questions regarding gender issues and Elizabeth Ogilvie and Kerry Koepping to help with dissemination. Gender parity within the project itself is excellent.

As noted in last year's report, significant international development is that through the active participation and contribution of Dr Niels Einarsson and Dr Astrid Ogilvie at the Stefansson Arctic Institute, with Dr Marianne Rasmussen, Professor Brynhildur Daviðsdóttir and Dr Anniken Forde, ARCPATH has provided scientific inspiration and paradigm input for two new Arctic research centres. These ARCPATH spin-offs are: the interdisciplinary Autonomous University of Barcelona Arctic Research Centre (CER-ARCTIC), led by ARCPATH Research Associate Professor Françoise Breton, and a new Arctic institute at the University of Washington, also an interdisciplinary research institute launched in late 2018, led by another ARCPATH Research Associate, Dr Margaret Willson. See <http://www.svs.is/static/files/cer-arctic-inauguration-programme-flyer-22.11.17-ne.pdf>. The Centre in Barcelona was inaugurated on 1. December 2017. Lack of space prevents further discussion of this section here. For further information on ARCPATH's significant synergistic collaboration see Section 3 on Meetings and Networking and Section 7 Progress Plan for the Coming Year

2. RESEARCHER MOBILITY

Please specify research stay outside the Nordic countries as well as visits by non-Nordic researchers. Here mobility is defined as a stay outside the Nordic countries of at least 2 weeks duration.

Gender, job title, organisation	Site of work	Purpose of visit	Duration of visit	Comments, output of the visit
Male, Dr Baoqiang TIAN, Nansen-Zhu Center	NERSC	WP2	1/4/-31/5/2018	Manuscript
Female, Dr Marianne Rasmussen, HRD	University of Southern Denmark	WP4	30/11/2018-31/1/2019	Manuscript
Male, Dr Brad Barr, NOAA, Fulbright Scholar	SAI	WP4	2 months, spring	Manuscript, lecture
Male, Dr Joe Roman, UVM,	Uol	WP4	All of 2018	Manuscripts, lectures,

Fulbright Scholar				workshops, research proposals
Female, Dr Francoise Breton, Director, CER- ARCTIC, Barcelona	SAI and Uoi Húsavík	WP4/WP5	3 weeks, summer	Fieldwork data, manuscript, lectures
Female, Dr Astrid Ogilvie, SAI	Climatic Research Unit, Norwich, UK	WP1	18-22 July 2018	Manuscript
Female, Dr Astrid Ogilvie, SAI	INSTAAR, Univ. of Colorado Boulder	WP1	19/11/-31/12/ 2018	Manuscript Grant proposal

	Female	Male
Number of visiting months by gender	4.25	16
Number of visiting researchers by gender	4	3

3. RESEARCHER TRAINING AND EDUCATION

Please list the number of recruited PhD and Post Docs, both Nordic and non-Nordic is asked for.

	Female	Male
Number of Nordic PhD students recruited	0	0
Number of non-Nordic PhD students recruited	1	0
Number of Nordic Post Docs recruited	0	0
Number of non-Nordic Post Docs recruited	0	1

Specify the number of PhD degrees achieved at the Centre in reporting period.

	Female	Male
Number of PhD degrees achieved	0	0

4. MEETINGS AND NETWORKING

Please describe *briefly* any major meetings, workshops, conferences or other events organised by the NCoE

Significant dissemination and networking events included: the *International Symposium Arctic-East Asia Climate Research: Observations, Modelling, Teleconnections and Predictions* in Beijing, China, October 16-17 2018 with 31 talks and more than 100 participants (organised by Yongqi Gao); the *Seasonal School in Climate and Extreme Weather Events: Benefits of Better Understanding of Climate Teleconnections* in Tbilisi, Georgia, 27 August-2 September 2018 (organised by Yongqi Gao). Two separate panel presentations were given at the Arctic Circle Assembly conference held in Reykjavík, Iceland during 18-21 October 2018. One was on the topic of changes in sea ice and effects on coastal communities, entitled *Out of Ice*. This title was taken from the film and the book launched at this event by Elizabeth Ogilvie, ARCPATH and SAI affiliate. In the spirit of the synthesis of art and science ARCPATH presentations were given by Astrid Ogilvie and Níels Einarsson. (Organisers: Elizabeth Ogilvie, Astrid Ogilvie and Níels Einarsson). The other ARCPATH session at the Arctic Circle was entitled *The Value of Arctic Marine Ecosystem Services*. This session was chaired by Professor Brynhildur Daviðsdóttir and had three speakers from the core ARCPATH team: Tom Barry, Executive Secretary, CAFF, on *Arctic Ecosystem Services*; Laura Malinauskaite, PhD Candidate, UoI on *The Economic Valuation of Ecosystem Services of Whales in Faxaflói Bay*; David Cook, Post-Doctoral Researcher, UoI: *Classifying and Valuing Ecosystem Services Sourced from Whales*. The other two speakers were a Fulbright Scholar from the USA, Joseph Roman, Associate Professor at the University of Vermont (now affiliated with ARCPATH) who spoke on *Assessing Regulation and Supporting Services Derived from Whales*; and Ståle Navrud, Professor at the Norwegian University of Life Sciences who spoke on *Valuing Marine and Coastal Ecosystem Services in Arctic Areas for Policy Use*. The Arctic Circle Assembly is a significant dissemination event with more than 2000 delegates present including scientists, government representatives and stakeholders from Arctic communities.

Another important event in 2018 was the ARCPATH summer school held in Norheimsund near Bergen, Norway, during 30 June-6 July entitled *Climate Teleconnections and Predictions: Past, Present and Future*. This was held in conjunction with the project CONNECTED which is a Chinese-Norwegian partnership in climate teleconnection and prediction which supported by the Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education led by Professor Tore Furevik from the University of Bergen. Some 30 graduate students attended (from Norway, China, France and Germany) and presentations were given by ARCPATH members: Yongqi Gao, Astrid Ogilvie, Noel Keenlyside, Shuting Yang and Francis Counillon.

A marine mammal field course led by Marianne Rasmussen was held at the Research Centre in Húsavík, Iceland from 3-13 June 2018 with 15 graduate students from 12 countries. A guest lecture was given by ARCPATH affiliate Françoise Breton. The Summer Course is a field course on the fundamentals of a suite of field methodologies used in the study of free-ranging cetaceans (whales and dolphins). Students received lectures on the diverse assemblage of dolphins and whales off Húsavík, as well as learning the theory and practice of the use of each of the different cetacean research methodologies. See

http://rannsoknasetur.hi.is/summer_course

The Annual Vilhjálmur Stefansson Memorial lecture was held at the University of Washington (UW)

Seattle, on 5 December 2018. The invited speaker was Leslie King, ARCPATH international member. The title of her lecture was *Learning from Northern Peoples*. The event was organised by Níels Einarsson, Astrid Ogilvie and Ross Virginia of Dartmouth College in partnership with colleagues at the UW, in particular Margaret Willson, ARCPATH affiliate, who is spearheading a new Arctic Centre at UW in partnership with ARCPATH. In conjunction with this event there were networking meetings with a number of UW institutes and departments. Also at this same time there was an inception meeting/workshop for the project *Northern Knowledge for Resilience, Sustainable Environments and Adaptation in Coastal Communities* (NORSEACC) recently funded by the Social Sciences and Humanities Research Council of Canada with Leslie King as PI and Astrid Ogilvie as Co-PI. While still in the planning stage this project was mentioned in earlier reports as having close synergy with ARCPATH and continuing ARCPATH goals. We are pleased to note the funding of this project. At this time it was also decided that Margaret Willson would spearhead a networking proposal to the new NSF call on *Navigating the New Arctic* and Astrid Ogilvie, Leslie King and Níels Einarsson would submit a full proposal <https://www.nsf.gov/pubs/2019/nsf19511/nsf19511.htm>. See Section 7 below.

5. INFRASTRUCTURE AND DATA POLICY

Please give a short description of infrastructure use and needs, including coordination and organisation both within the NCoE and with non-Nordic stakeholders. Please outline the sharing of infrastructures. Please briefly describe schedule and the progress of open data policy within the NCoE.

During the third year of ARCPATH, the partners have continued to use their institutional and/or national infrastructures to compile climate and marine data for integrated analysis, assimilation into models and intercomparison with model projections. The same infrastructures are used to store the new datasets resulting from these analysis and modelling activities, in accordance with the data policies of their organisations.

ARCPATH will, as part of its Open Science pilot, establish a data catalogue offering open access to datasets generated in the project. This pilot will adhere to standard metadata and data formats for geo-scientific datasets, in line with recommendations from INSPIRE and EC. Work on assessing candidate tools for implementing the ARCPATH data catalogue has started, as described above (Part 1, Sec 4(c)). The catalogue will then be established and populated with metadata records describing the dataset generated by ARCPATH. These metadata will, among others, include description of parameters, units, accuracy, data licenses and links for data access.

ARCPATH partners use their national and institutional infrastructures for generating climate model projections, and for storing and analysing the model results. Partners also use these infrastructures to compile climate and marine data for integrated analysis, conduct the analysis, assimilate observational data into models and intercomparison with model projections. The new datasets resulting from analysis and modelling activities within the project are stored by the same infrastructures, in accordance with the data policies of their respective organisations. National infrastructures can be shared by the institutions of that country, e.g. Norwegian ARCPATH partners all have access to advanced HPC facilities in the National Infrastructure for Research Data (NIRD), and can store data in among others, NIRD and the Norwegian Marine Data Centre (NMDC).

All partners are committed to making ARCPATH datasets publicly available without undue delay and at the latest after the Project has been concluded. The datasets will be registered in the ARCPATH data catalogue, which is being developed at NERSC. For the data catalogue, we have chosen the open source data management system CKAN (Comprehensive Knowledge Archive Network). The CKAN open source community offers numerous extensions that can be used as-is or adapted to implement customised functionality for the targeted user communities. This allows for setting up a fully functional data catalogue with reasonable effort and include more features as needed by developing own plugins or install additional community plugins. As partners generate new datasets in the Project, these will be registered in the ARCPATH data catalogue with links providing data access for other scientists and stakeholders.

6. GOVERNANCE

Please describe the governance of your Centre over the Programme period briefly. Emphasis should be on joint Nordic management and its development in the Centre.

Reflecting the project's focus on gender equality the project is managed in equal part by the Project Leader Yongqi Gao and Co-Leader Astrid Ogilvie. Kjetil Lygre is the Project Manager at NERSC. As is inevitable and necessary with such a large, interdisciplinary and international project encompassing a stellar team, the project PIs also play a vital role in management. ARCPATH also has a designated management team (Yongqi Gao, Astrid Ogilvie, Níels Einarsson, Marianne Rasmussen, Noel Keenlyside and Torben Koenigk). The team is drawn from the Nordic countries of Norway, Iceland and Sweden) and an active international Advisory Board (Cecilia Bitz, Michael Bravo, Lawrence Hamilton and Burkhardt Rockel). Here it may be noted that Professors Hamilton and Rockel attended the 2018 ARCPATH annual meeting and gave presentations with a focus on synthesis. As ARCPATH is also led from SAI, Níels Einarsson, the Director of SAI, plays a significant management role. At SAI we are also assisted by the Office Manager, Lára Ólafsdóttir. All ARCPATH team members undertake project dissemination and a democratic approach ensures that all ARCPATH members - whether senior scientists, post doctoral researchers or graduate students - have a voice that can be heard. Specific management duties during 2018 included events such as the annual meeting held in Bergen, Norway, during 6-7 September. The emphasis was placed primarily on project synthesis (Organisers: Kjetil Lygre, Astrid Ogilvie and Yongqi Gao) as well as the organisation of significant dissemination and networking events. These are discussed in Section 3 above. The project report for 2017 was written by Astrid Ogilvie with significant input from Yongqi Gao, Kjetil Lygre, Níels Einarsson, and with contributions from all ARCPATH members. The ARCPATH communication plan was written by Astrid Ogilvie and Leslie King, with valuable input from: Níels Einarsson; Torben Koenigk; Laura Malinauskaite; and David Cook. All ARCPATH members have an opportunity to read and comment upon such documents and the annual reports. The annual report for 2018 has been written and edited by Astrid Ogilvie with significant writing input from Níels Einarsson. Leslie King contributed much to comments on synthesis and Yongqi Gao and Torben Koenigk in particular provided the climate information. All ARCPATH team members have contributed specific information

on their publications and activities. The Project Manager, Kjetil Lygre, has finalised the report. ARCPATH websites are maintained and updated www.ncoe-arcpath.org and <http://www.svs.is/en/projects/arcpath>.

7. OUTPUT AND DISSEMINATION OF RESEARCH

Report the output of the research, e.g., publications. The table is for publications, reports and outreach activities with the main activities/collaboration where the NCoE research has contributed. Also, report the number of Open Access publications. Please attach a complete publication list (see attached format file Publication Report Format 2014)

Outreach and Dissemination where the NCoE has contributed during the reporting period.

Peer-reviewed Publications / of which Open Access	11 / 8
Non-peer-reviewed Publications / of which Open Access	0
Reports	1
Invited conference presentations	11
Conference presentations, oral / poster	20 +8
Number of appearances in media	5
<p>Outreach and dissemination to the public</p> <p>In cooperation with the CRESCENDO schools network (organized by the EU-H2020 project CRESCENDO) Torben Koenigk gave two lectures (1 Feb 2018, 16 Oct 2018) to school classes (Kunskapsgymnasiet Norrköping and Luleå Gymnasietskola) on Arctic climate change.</p> <p>T. Koenigk: Climate Adaptation Meeting with Swedish Agencies, Gothenburg, 27 Oct 2018: Kvantifiering av osäkerheter av regionala klimattrender och dess konsekvenser för beslutsfattande om klimatanpassning</p> <p>Laura Malinauskaite, 2018: Economic Valuation of Ecosystem Services of Whales. Presentation at a board meeting of IceWhale – Icelandic Whale Watching Association. Reykjavik, Iceland, October 2018.</p> <p>Laura Malinauskaite, 2018: ARCPATH: Socio-Ecological Systems, Ecosystem Services and Marine Mammals in the Arctic. Guest lecture in Environmental Economics. University of the Iceland, April 2018.</p> <p>David Cook, 2018: Lecture on theory of economic valuation, applications to whale ecosystem services and ARCPATH activities. University of the Westfjords for the Coastal and Marine Management Masters students, November 2018.</p> <p>Marianne Rasmussen, 2018: Whale research in Skjálfandi Bay, Marine Protected Area Symposium, Whales of Iceland, Reykjavik, Iceland</p> <p>Marianne Rasmussen, 2018: Whale research in Skjálfandi Bay, Húsavík Whale Museum, Húsavík, Iceland</p>	<p>7</p> <p>(+19 other (chairing of sessions, panel participations, lectures))</p>

8. PROGRESS PLAN FOR THE COMING YEAR

Please describe your plans for the next year of the NCoE, as well as foreseen challenges, and how to address them including concise risk analysis. Describe your plans to utilize and develop new technologies in your NCoE. Describe your Continuation Strategy (new plans for cooperation beyond the funding period).

ARCPATH plans to perform decadal hindcast predictions (both global and regional) with updated external forcings (e.g., solar and aerosol forcings) from the CMIP6 (Coupled Model Intercomparison Project, Phase 6, <https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6>). The prediction skill will be assessed and the contribution of external forcing to Arctic predictability will be quantified. ARCPATH will combine newly available observations from EU H2020 INTAROS (Integrated Arctic Observation System, <http://www.intaros.eu/>) using a dynamically consistent method to perform the decadal hindcast and future predictions.

The coming year will see a particular emphasis on the Greenland component of ARCPATH and the interlinkages between historical records, marine mammal migrations and ecosystem services as well as changes in climate and sea ice. Astrid Ogilvie has been invited to take part in an expedition to Disko Bay at the end of May 2019 organised by the Director of Education Abroad at the University of Colorado, Boulder and the Danish Institute of Institutional Relations (DIS). The expedition will focus on the Illulisat and Disko Bay areas. DIS has close collaboration with the Arctic Station, an environmental research facility on Disko Island. This ties in well with the expanded focus in WP4 on Aasiaat on the southern shore of Disko Bay. Fieldwork in the form of interviews and socio-cultural surveys will be undertaken there in 2019. Particular efforts are being made to ensure ARCPATH cooperation beyond the funding period. Four examples may be given. A proposal led by Torben Koenigk and including the ARCPATH partners Yongqi Gao, Astrid Ogilvie, Niels Einarsson and Marianne Rasmussen as well as new partners from Japan and elsewhere entitled *Impacts of Climate Change on Ocean Systems and Society: Mitigation Pathways and Adaptation Options for Sustainability (OSMOSIS)* was recently submitted to the Belmont Forum call (<http://www.jpi-oceans.eu/news-events/news/belmont-forum-future-earth-and-jpi-oceans-co-branded-collaborative-research-action>). ARCPATH researchers also participated strongly in a Horizon 2020 application submitted in February 2019 and entitled *Justice in the Arctic (JUSTNORTH)* and led by the University of Uppsala including two work packages by ARCPATH members. One on fisheries and equity issues led by Niels Einarsson and Catherine Chambers and one on whale tourism and governance issues led by Niels Einarsson and colleagues at the ARCPATH spin off CER Arctic Research Centre at the Autonomous University of Barcelona. SAI Senior Scientist and Professor Edvard Huijbens will also play a significant role in leading the project. In early March 2019 a proposal was submitted to the NSF “Navigating the New Arctic” call by Astrid Ogilvie (as PI) and with Leslie King and Marianne Rasmussen as Co-PIs. Niels Einarsson, Janne Flora, Anniken Førde and Elizabeth Ogilvie are named Consultants. Also as Co-PI is Joe Roman, Fulbright Fellow in Iceland, currently collaborating with ARCPATH colleagues on whale biology and ecology and ecosystem services. Two postdoctoral researchers currently working with Aran Mooney, a whale biologist currently collaborating with Marianne Rasmussen, are also named on this proposal. Noel Keenlyside, Yongqi Gao and Torben Koenigk provided letters of support as unfunded collaborators. As with ARCPATH, the geographical focus is Iceland, Norway and Greenland - within the wider Arctic and Subarctic context. The title of the project is:

Observations and Responses: Convergent Challenges in the Arctic and Subarctic (ORCCAS).

In September 2017, the Icelandic Arctic Cooperation Network (IACN) and the Arctic University of Tromsø (UiT) applied for an “Arctic Research and Studies” mobility grant to establish long-term cooperation and initiate a project addressing “Risks in the Arctic”. By June 2018 a permanent partnership between UiT, IACN, the Icelandic Coast Guard, the Arctic Safety Centre, the University of Svalbard (UNIS), the University of Iceland, the Centre for Arctic Policy Studies, and the Arctic Technology Centre in Sisimiut was established to develop a project entitled *Resilience Assessment and Management: Toward a Resilient Tourism Infrastructure in the Arctic (RAMTIA)*. This spin-off project from ARCPATH focuses on, among other things, the fact that, over the last few years, almost every coastal community located in the North Atlantic region has seen a very substantial increase in the number of visiting cruise ships. Lack of infrastructure, harsh physical conditions and remoteness are only a few of the challenges related with Arctic shipping. In March 2019 the RAMTIA partnership applied to NORA (Nordic Atlantic Cooperation) for further funding.

A recently-funded (by the Social Sciences and Humanities Research Council - SSHRC) ARCPATH spin-off project is *Northern Knowledge for Resilience, Sustainable Environments and Adaptation in Coastal Communities (NORSEACC)* with Leslie King as PI and Astrid Ogilvie as Co-PI. NORSEACC will be conducted simultaneously in four countries over four years. The research aims to increase knowledge concerning the consequences of climate and social changes and to use that knowledge to create strategies to respond to these challenges.

9. SUCCESS STORIES AND UNEXPECTED RESULTS

Please shortly describe any major success stories or unexpected results of your NCoE and how they contribute to the overall aims of the Arctic Programme, and what they have learned from successes and challenges. The Programme Memorandum is the reference document when assessing the success.

An unexpected aspect of ARCPATH is the collaboration we have begun with environmental artist Elizabeth Ogilvie and photographer Kerry Koepping. Through their efforts incorporating various media outputs we are able to provide outreach and dissemination in a way that we could not have envisaged at the start of the project. There has also been a two-way process with this collaboration. Thus, ARCPATH has contributed a physical science element to Elizabeth Ogilvie’s book *Out of Ice* with a chapter on the basics of sea ice by Astrid Ogilvie (with input from Noel Keenlyside).

Below we outline a few examples of ARCPATH’s many success stories.

Blue whales have increasingly been moving north and currently come into Skjálfandi Bay every summer in June. We now have a photo-identification catalogue of 148 different individuals (Madsen, 2018; Madsen *et al.*, 2019) and for the first time we have matches of the same blue whales sighted off Svalbard and from Húsavík. This possible shift might be due to warming Arctic waters and climate change. It has been suggested earlier that blue whales are moving even further north for this reason. An important input for this part of ARCPATH is that data collection has been completed for a PhD project with a whole year of c-pod data from Skjálfandi Bay and adjacent Eyjafjörður for harbour porpoise and white-beaked

dolphin abundance. These data are currently being analyzed.

We are finding that fisheries policy is a key driver of change in fisheries-dependent coastal communities. We are thus focusing on the social, cultural, environmental and economic externalities related to the introduction of the ITQ system, concentrating on Icelandic fisheries (but also considering Norway) and how this management model continues to impact people's livelihoods and human development in fishing villages, especially in terms of opportunities of small-scale and local actors regarding fishing rights. One common outcome of ITQ systems is the consolidation of fishing rights or quotas in large companies and away from small communities. This can lead to decreased access for newcomers, reduced training opportunities for youth on the remaining vessels, and increased cost of quotas as a limited commodity. The lack of job opportunities in the fishing sector causes increased rates of outmigration by youth and women, which threatens the resilience of those communities. At the same time, we are seeing that there continues to be an interest from youth in taking part in fisheries livelihoods and, at the same time, local governments are looking for options for the renewal of the fisheries workforce.

We have continued to collaborate with a number of Nordic partners in building on the successful preparatory phase of the ARCPATH spinoff project RAMTIA – *Resilience Assessment and Management: Toward a Resilient Tourism Infrastructure in the Arctic*- with a focus on measures to tackle and reduce risks related to Arctic shipping, specifically impacts of growing marine tourism activities on local communities. The overall objective is to improve tourism critical infrastructure resilience in Arctic natural and man-made hazards through a holistic interdisciplinary approach to resilience assessment. Outcomes of the project will have direct implications for future assessment of risk and perceptions thereof, with further implications for sustainable policy making in the Arctic.

In 2018, through WP5 in particular, ARCPATH has taken a special turn towards a focus on young people and women, intergenerational equity and gender equality to inform better governance models. This also includes contributing to the Arctic Council project Gender Equality in the Arctic (GEA) the aim of which is to raise visibility and understanding of the importance of gender-issues in the Arctic, to identify priorities and concrete strategies for increased diversity and gender balance in policy- and decision-making processes and to provide information to facilitate sustainable policy making for the future.

Regarding high resolution global modelling: The final EC-Earth CMIP6 has now been finalized and long pre-industrial simulations and historical simulations between 1850 and 2015 have been performed. We worked on the method to initialize the observed sea ice across our five different ice thickness categories in EC-Earth. This method will be used for both the predictions in standard resolution in WP2 and the high resolution predictions in WP3. High-resolution simulations with EC-Earth from 1950-2014, which have been performed in the EU-project PRIMAVERA, have been analyzed for ARCPATH purposes for the Arctic regions. They indicate a stronger and more realistic deep-water convection in the Labrador Sea, an improved position of the Gulf Stream, enhanced northwards ocean heat transport, and consequently slightly reduced and more realistic sea ice conditions in the Barents and Greenland Seas. Further, the effect of implementing a sophisticated melt-pond scheme into the EC-Earth model has been tested in both standard and high resolution.

10. STAKEHOLDER INVOLVEMENT

Please identify the stakeholders and their role in the NCoE activities, describe the capacities of involvement in the NCoE and among the stakeholders. Describe communication methods and how the NCoE takes into account stakeholder's specific needs.

Which internationally approved ethical guidelines does the NCoE apply in stakeholder involvement? How does the NCoE use stakeholders' feedback on the involvement process? Describe your plans for active learning and continuous improvement of evaluation practice in stakeholder involvement shortly.

ARCPATH results are being disseminated to three main groups: i) the research community (including students and fellow researchers) encompassing both the Nordic and international climate research community, as well as partners in ARCPATH working with environmental and socio-economic related research; ii) the general public; iii) stakeholders in local communities. In this regard, it is useful to define the term "stakeholder". The term suggests a person or persons with "something at stake". It is a modern term, not to be found in, for example, the two-volume *Shorter Oxford English Dictionary*. The online *Cambridge English Dictionary* gives two basic definitions: i) a person or group of people who own a share in a business; ii) a person such as an employee, customer, or citizen who is involved with an organization, society, etc., and therefore has responsibilities towards it and an interest in its success. It is felt that this latter broad definition resonates well with the ARCPATH concept of a stakeholder which could be defined thus: a person living in a specific location who has a strong interest in the community belonging to that location. It is her or his home and homeland; or, indeed, who does not necessarily live in the community but who still has some kind of "stake" in it. Thus, the interests of stakeholders do not necessarily always coincide. For example, a local person may not wish that a factory be built, or fishing rights sold from a community while a business person may see this as a strong investment or transaction potential.

ARCPATH focuses on three main research locations: Iceland - specifically the northwest and the northeast, particularly the Húsavík and Skjálfandi Bay area, but also the Westfjords and the southwest; Norway - specifically regions located in Troms county, such as Tromsø itself, areas close to the island of Skjervøy, also Andenes in the Vesterålen district of Nordland county; and Greenland - specifically the Scoresbysund/Ittoqqortoormiit region of East Greenland. A new focus is the Disko Bay area in west Greenland. ARCPATH stakeholders are the individuals who live in these communities or who have a significant interest in them. These include small-scale fishers, whale-watching operators, tourism business owners, hunters, seasonal workers, etc. For WP4 in particular, stakeholder engagement is an integral part of the methods applied in assessing the economic and socio-cultural values of cetaceans. In 2018, 34 semi-structured interviews with stakeholders were conducted in Húsavík, Iceland and Andenes, Norway.

As regards ethical guidelines it is possible to undergo training such as with the Collaborative Institutional Training Initiative (CITI) programme on Research Ethics and Compliance Training (see <https://about.citiprogram.org/en/homepage/>). Astrid Ogilvie has up-to-date CITY training. ARCPATH also takes into account guidelines such as the Principles for Conducting Research in the Arctic published by the Interagency Arctic Research Policy Committee (IARPC). This organisation emphasises five core principles: be accountable; establish effective communication; respect indigenous knowledge and cultures; build and sustain relationships; pursue responsible environmental stewardship (see <https://www.iarpcollaborations.org/principles.html>).

11. RELEVANCE FOR SOCIETY

The principal objective of the Arctic initiative is to create pathways to action by strengthening the knowledge base for political decision making, education, industrial and human development. The Programme invites the full range of stakeholder communities, including politicians, industrial actors, public sector officials, educators, NGOs, and local communities, to take an active part in the creation of new integrative knowledge. Please describe how your NCoE contribute to this objective.

This is a complex issue; we cannot simply approach our stakeholders with the attitude that we have a message that they need to heed. Certainly, we may indeed have factual information that is potentially of use to them, and of course we wish to impart this. But to go into a community with the attitude that we can tell them what they should be doing would be patronizing and asking for negative reactions. Adaptation is a local social process where research can help but it should not be assumed that it has all solutions. We try to have the attitude that we can learn from our communities as much as they can learn from us. Hence the value of "indigenous and local knowledge". Thus, for example, stakeholders in Húsavík and Andenes have been keen to share their views and help with the research, anticipating that this may help to inform marine governance, especially as related to management of whale-watching activities, shipping and industry. Nonetheless, we can assume that people in local communities will not read our scientific articles (although this assumption is not always correct). Hence it is pragmatic to deliver plain language summaries with our publications and to make our web and social media communications attractive and compelling. In presentations to conferences and meetings (such as the Arctic Circle Assembly) where there will be an audience composed of both academics and non-academics, we present basic concepts in non-specialist language before proceeding to specific examples. We will be looking into the possibility of translating core findings into local non-English languages. Our conference presentations are often aimed at a wider, more general audience and include attractive multi-media presentations in plain language. Our policy briefs will interpret our findings in order that they may be readily translated into action by policy-makers.

12. LONG-TERM EFFECTS ON POLICY

What is the NCoE's contribution to the sustainable policy process and outcomes in the Arctic?

A primary objective of ARCPATH is to ensure that our findings are communicated to all relevant researchers and communities and to inform the public. As ARCPATH has a major focus on climate prediction an important objective is to provide new insights in this and to provide a better understanding of possible near-term future climate change. In conjunction with this, ARCPATH focuses on socio-economic changes and it is equally important to inform communities of our findings regarding these. In an ideal world, we may also influence policy, and even if this can be a difficult and delicate matter, we have considerable opportunities to introduce policy relevant findings to such important Arctic governance stakeholders as the Arctic Council (AC), not least now that Iceland is taking over the chairmanship for two years, commencing in May 2019. A meeting introducing ARCPATH has already been held with the incoming Chair of the AC Senior Arctic Officials at the Stefansson Arctic Institute in September 2018. A further example is that the University of Iceland's Institute for Economic Research is interested in using the results of the ARCPATH contingent valuation study in their report to the profitability of whaling in Iceland that will later be sent to the Icelandic government.

As regards results and findings it is very important to communicate in an appropriate manner. Language and presentations to the scientific communities take the usual scientific format but presentations to the

public and policy makers are communicated in very different, more accessible formats e.g., policy briefs, media releases, appearances in documentaries etc. While all team members present at scientific conferences, we also attend and speak at meetings with a more general audience e.g., the Arctic Circle Assembly and Arctic Science Ministerial Science Summit conferences.

ARCPATH methods of communication are: scientific papers; conference presentations; media releases; open lectures; websites; policy briefs; plain language summaries; brochures and flyers; blogs and social media posts, and university and school curriculum materials. We are also exploring novel ways of disseminating our information. Thus, we have teamed up with colleagues who are photographers and environmental artists. At the Arctic Circle conference in October 2018, for example, we organized an ARCPATH panel showcasing the film and book launch of Elizabeth Ogilvie's *Out of Ice* which document the implications of melting ice in the Arctic. We are also at an early stage of evaluating, updating, and using an existing multilingual (in 6 languages) web resource on humans and ecosystems in the Arctic, produced by the Stefansson Arctic Institute, Scott Polar Research Institute at Cambridge, Dartmouth College, the Arctic Centre in Rovaniemi and other partners, for public outreach. The plan would also be to add material in Russian, Spanish and Greenlandic (see www.thearctic.is).

13. PROGRAMME EVALUATION

Send feedback to the NordForsk secretariat, Programme Committee, Scientific Advisory Board with affirmation, critique, suggestions, etc, to assist in Programme self-evaluation and development. How has the Arctic programme worked (organisation, cooperation etc.) from the point of view of your NCoE? Please include your views both on success factors as well as development potential.

The opportunity to undertake interdisciplinary and cross-disciplinary synthetic research encompassing a wide variety of individual disciplines in the service of sustainable development in the Arctic is a pleasure and a privilege. Liaison with the NordForsk secretariat has been excellent and encouraging at all stages. As requested, feedback with regard to annual reporting to the Scientific Advisory Board will also be made here. Although very time consuming, it is felt that compiling such a report is a valuable exercise in many ways; it is satisfying for team members to reflect on progress that has been made both within the different disciplines involved and regarding synthesis, and to take stock of the different outputs produced by the team in terms of publications, presentations and outreach. The comment was made by the SAB that the report should be compiled and edited by one person. This is in fact the case (albeit with input from all team members) as noted above in Section 5 on Governance.

The ARCPATH team appreciates the time taken by the SAB to comment on the progress of the project. Just a few further clarifications may be made here: i) It was stated that the climate science reporting included much “jargon”. Effort was made by the editor of the report to clarify technical terms as far as possible. However, if a comprehensive account of progress in the climate and sea-ice sections of the report is to be given then it is hard to avoid the use of technical terms without becoming overly simplistic; ii) It was suggested that the addition of a Project Manager would be beneficial. We have an excellent Project Manager (Kjetil Lygre) and have had for the duration of the project; iii) We note the comment regarding synthesis “the one concern here is that the report gives the appearance that the team is going to synthesize results when the study is near completion ...”. We do not understand how this impression has been given as, on the contrary, we constantly emphasize the importance of incorporating synthesis from the start of the project, and endeavour to do so. Communication and collaboration between all team members is excellent.

Annual Reporting of Nordic Centres of Excellence Appendix 1.

14. STANDARD REPORT FORMAT OF ACADEMIC OUTPUT

Title:	Author(s)	Journal/Conference/Publisher	Publication type	Open Access
<i>Cyclone Activity in the Arctic from an Ensemble of Regional Climate Models (Arctic CORDEX).</i>	Akperov, M. , A. et al. including Koenigk T.	JGR-Atmos 123, https://doi.org/10.1002/2017JD02770 3 - 2018	Journal article	yes
<i>Valuing ecosystem services sourced from whales – informing trade-offs and decision-making.</i>	Cook, D., Malinauskaite, L., Daviðsdóttir, B. & Ögmundardóttir, H.	<i>Ocean and Coastal Management.</i> (IN REVIEW).	Journal article	
<i>Systemic risk of maritime-related oil spills viewed from an Arctic and insurance perspective</i>	Jóhannsdóttir, L., & Cook, D.	<i>Ocean and Coastal Management.</i> (IN REVIEW).	Journal article	
<i>Analysis of ensemble mean forecasts: The blessings of high dimensionality.</i>	Christiansen, B.	<i>Monthly Weather Review.</i> Accepted	Journal article	
<i>Reply to “Comment on ‘Ensemble Averaging and the Curse of Dimensionality.</i>	Christiansen, B.	Journal of Climate, 31, 9017-9019, DOI: 10.1175/JCLI-D-18-0416.1	Journal article	
Historical records of earthquakes for Greenland and Labrador in Moravian Missionary Journals	Demarée, G.R. Ogilvie, A.E.J. and Kusman, D.	Journal of Seismology. 10.1007/s10950-018-9796-z . Online 4 October 2018.	Journal article.	Yes
<i>Optimising assimilation of sea ice concentration in an Earth system model with a multcategory sea ice model</i>	Kimmritz M, Counillon F, Bitz CM, Massonnet F, Bethke I, Gao Y.	Tellus. Series A, Dynamic meteorology and oceanography. 2018;70:1435945	Journal article	yes
<i>Impact of Arctic sea ice variations on winter temperature anomalies in northern hemispheric land areas.</i>	Koenigk, T., Y. Gao, G. Gastineau, N. Keenlyside, T. Nakamura, F. Ogawa, Y. Orsolini, V. Semenov, L. Suo, T. Tian, T. Wang, J. J. Wettstein, S. Yang	Climate Dynamics (published online) 1-27, DOI 10.1007/s00382-018-4305-1 - 2018	Journal article	yes
<i>Arctic ecosystem services: a literature review</i>	Malinauskaite, L., Cook, D., Daviðsdóttir, B. & Ögmundardóttir, H.	<i>Ecosystem Services</i> (IN PRESS).	Journal article	“green open access”

<i>Sea-ice stories from Iceland and Labrador.</i>	Ogilvie, A.E.J.	https://bifrostonline.org/sea-ice-stories-from-iceland-and-labrador/	Online publication	Yes
<i>Impact of assimilating a merged sea-ice thickness from CryoSat-2 and SMOS in the Arctic reanalysis</i>	Xie J, Counillon F, Bertino L.	The Cryosphere. 2018;12(11)	Journal article	yes
<i>Moving beyond panaceas in fisheries governance</i>	Young, O.R. et al	PNAS September 11, 2018 vol. 115 no. 37 9065-9073	Journal article	
<i>Regional Coupled Model and Data Assimilation</i>	Zhang, S., Xie, Y., Counillon, F., Ma, X., Yu, P. and Jing, Z.	Advances in Meteorology	Journal article Special issue	yes
<i>The 1780s: Global Climate Anomalies, Floods, Droughts, and Famines</i>	Damodaran, V., Allan, R., Ogilvie, A.E.J., Demarée, G.R., Gergis, J., Mikami, T., Mikhail, A., Nicolson, S.E., Norrgård, S. and Hamilton, J.	In: White S., Pfister C., Mauelshagen F. (eds) The Palgrave Handbook of Climate History. Palgrave Macmillan, London, pp. 517-550. First Online 18 July 2018 DOI https://doi.org/10.1057/978-1-137-43020-5_34 . eBook ISBN 978-1-137-43020-5; Hardcover ISBN 978-1-137-43019-9.	Book chapter (published)	Available online.
<i>Feasting on friends. Whales, puffins and tourism in Iceland</i>	Huijbens, E. and Einarsson, N.	In C. Kline (Ed.) <i>Animals as Food: Ethical Implications for Tourism</i> . London: Routledge, 10-27.	Book chapter	No
<i>A Fleet of Silver: Local Knowledge Perceptions of Sea Ice from Iceland and Labrador</i> /Nunatsiavut	Ogilvie, A.E.J., Hill, B.T. and Demarée, G.R.	<i>North Atlantic Island Biota: Aspects of the Past, Choices for the Future</i> . Edited by Eva Panagiotakopulu and Jon Sadler. Wiley-Blackwell.	Book Chapter (in press)	
<i>Early Modern Europe</i>	Pfister C., Brázdil R., Luterbacher J., Ogilvie A.E.J., and White S.	In: White S., Pfister C., Mauelshagen F. (eds) The Palgrave Handbook of Climate History. Palgrave Macmillan, London, pp. 265-295. First Online 18 July 2018 DOI https://doi.org/10.1057/978-1-137-43020-5_23 . eBook ISBN 978-1-137-43020-5; Hardcover ISBN 978-1-137-43019-9.	Book chapter (published)	Available online.
<i>Coupled Data Assimilation for Integrated Earth System Analysis and Prediction: Goals, Challenges, and Recommendations</i>	Penny SG, Akella S, Buehner M, Chevallier M, Counillon F, Draper C, Frolov S, Fujii Y, Karspeck A, Kumar A.	World meteorological Organisation	white paper	yes
<i>Classifying and valuing ecosystem services sourced</i>	David Cook	<i>Proceedings of the Arctic Circle Assembly</i> , Reykjavik, Iceland,	Conference proceedings	

<i>from whales</i>		October 2018.	Lecture	
<i>Classifying and valuing ecosystem services sourced from whales</i>	David Cook	<i>Proceedings of the 4th World Conference on Marine Biodiversity</i> , Montreal, Canada, May 2018.	Conference proceedings Lecture	
<i>Socio-Ecological Systems, Ecosystem Services and Cetaceans in the Arctic</i>	Laura Malinauskaite	Presentation at an Arctic-focused international workshop at the Massachusetts Institute of Technology, Boston, April 2018.	Conference proceedings Lecture	
<i>Economic Valuation of Ecosystem Services of Whales</i>	Laura Malinauskaite	<i>Proceedings of the Arctic Circle Assembly</i> , Reykjavik, Iceland, October 2018.	Conference proceedings Lecture	
<i>EnKF Initialised Climate Prediction with the Norwegian Climate Prediction Model</i>	F. Counillon, N. Keenlyside, M. Kimmritz, Y. Wang, I. Bethke, H. Langehaug	Workshop on Climate Data Assimilation, Model Initialization and Parameter Estimation, 4-5 Oct, 2018, Hamburg	Conference presentation - Invited	
<i>Risky environments and rapid change: Research on adaptation and coastal communities in the North Atlantic Arctic</i>	Einarsson, N.	Arctic Science Ministerial Science Forum, Berlin, 25 October 2018	Conference Presentation-Invited	Available online
<i>Contradictions of Arctic Extinction Travel: Lessons from Greenland and Iceland</i>	Einarsson, N.	Climate Existence Conference, Sigtunastiftelsen, Sigtuna, Sweden, 7-9 May 2018.	Conference presentation-Invited	
<i>Assimilation of sea ice in an Earth system model and its impacts for climate prediction</i>	M. Kimmritz, F. Counillon, Y. Wang, N. Keenlyside, I. Bethke	Modeling, Teleconnections and Predictions, October 16-17, 2018 Beijing, China	Conference presentation - invited	
<i>Optimised Assimilation of Sea-Ice Concentration and Implications for Climate Prediction</i>	M. Kimmritz, F. Counillon, C.M. Bitz, F. Massonnet, I. Bethke, Y. Wang, Y. Gao, L. Bertino, N. Keenlyside	Workshop on observations and analysis of sea-surface temperature and sea ice for NWP and Climate Applications (ECMWF), 22-25 Reading, UK.	Conference presentation - Invited	
<i>Evaluating impacts of Arctic sea ice loss and variation on the northern hemisphere</i>	Koenigk, T.	Arctic Frontiers Conference, Tromsø, 23 Jan 2018	Conference Presentation-Invited Keynote talk	
<i>Arctic Explorers: Stefansson's "Friendly Arctic" and lessons learned</i>	Ogilvie, A.E.J., with Einarsson, Niels and Virginia, Ross	Invited oral presentation Dartmouth College, New Hampshire, 27 February 2018.	Conference presentation - Invited	Available online.

<i>from John Rae, early adopter of Inuit traditional knowledge.</i>				
<i>Reflections on Weather and Climate by Travellers to the North</i>	Ogilvie, A.E.J.	Climate Existence Conference, Sigtunastiftelsen, Sigtuna, Sweden, 7-9 May 2018.	Conference Presentation - Invited	
<i>Climate, Sea Ice and Human Ecodynamic Systems in Northeastern Iceland: Lessons from the Past and Perspectives from the Future</i>	Ogilvie, A.E.J.	Royal Academy for Overseas Sciences International Conference. Climate and Cultures: Perspectives for the Future, Palais des Académies, Brussels, Belgium. <i>Invited Keynote Lecture</i> , 23-24 May 2018.	Conference Presentation - Invited Keynote	
<i>Dynamical climate predictions at the Bjerknes Centre</i>	Y. Wang, F. Counillon, N. Keenlyside, M. Kimmritz, I. Bethke, H.R. Langehaug, F. Li	International Symposium Arctic-East Asia Climate Research: Observations, Modeling, Teleconnections and Predictions, October 16-17, 2018 Beijing, China	Conference presentation - invited	
<i>Development of Coupled Data Assimilation in Norwegian Climate Prediction Model</i>	Y. Wang, F. Counillon, N. Keenlyside, M. Kimmritz, I. Bethke, H.R. Langehaug, F. Li	International coupled data assimilation symposium, Tsingtao, China (5-8 Nov. 2017)	Conference presentation - invited	
<i>2018 Ensemble averaging and the curse of dimensionality</i>	Christiansen, B	EGU 2018, Vienna, April 2018	Conference Presentation (Oral)	
<i>The blessings of high Dimensionality: Explaining Ensemble Behavior</i>	Christiansen, B.	AGU 2018, Washington DC., USA. December 2018.	Conference Presentation (Oral)	
<i>Arctic climate change, international collaboration and multidisciplinary research: The ARCPATH project</i>	Einarsson, N.	Arctic Circle Assembly 2018, Climate Change in Arctic Iceland", session organised by the Ministry for Foreign Affairs of Iceland	Conference presentation (oral)	
<i>Assimilation of sea ice in an Earth system model and its impacts for climate prediction</i>	M. Kimmritz, F. Counillon, I Bethke, N. Keenlyside , Cecilia Bitz, F. Massonnet , Y. Wang	EGU-2018 General Assembly, Vienna, 9 April 2018	Conference presentation (Poster)	
<i>Assimilation of sea ice in an Earth system model and its impacts for climate prediction</i>	M. Kimmritz, F. Counillon, Y. Wang, N Keenlyside , I. Bethke	Conference on subseasonal-to-decadal climate prediction, Boulder, 17-21 September 2018	Conference presentation (Poster)	
<i>Assimilation of Sea Ice in an</i>	M. Kimmritz, F.	Polar conference, Davos,	Conference	

<i>Earth System Model</i>	Counillon, C. M. Bitz, F. Massonnet, Y. Wang, I. Bethke, N. Keenlyside, Y. Gao	Switzerland, 15-26 June, 2018	presentation (Poster)	
<i>Assimilation of Sea Ice in an Earth System Model and its Impacts for Climate Prediction</i>	M. Kimmritz, F. Counillon, C. M. Bitz, F. Massonnet, Y. Wang, I. Bethke, N. Keenlyside, Y. Gao	EnKF workshop 28-30 May 2018, Bergen, Norway	Conference presentation (Poster)	
<i>Assimilation of Sea Ice in an Earth System Model and Impacts for Climate Prediction</i>	M. Kimmritz, F. Counillon, Y. Wang, N. Keenlyside, I. Bethke	FAMOS meeting, 23-26 Oct 2018 Bergen, Norway	Conference presentation (Poster)	
<i>Evaluating impacts of Arctic sea ice loss and variation on the northern hemisphere climate</i>	Koenigk, T.	EGU-2018 General Assembly, Vienna, 9 April 2018	Conference Presentation (Poster)	
<i>Siberian cooling trends and the linkage to Arctic sea ice loss</i>	Koenigk, T.	SPARC-General Assembly, Kyoto, 3 Oct 2018	Conference Presentation (Poster)	
<i>The migratory movements of blue whales (Balaenoptera musculus) inhabiting Arctic and Sub-Arctic areas of the Northeast Atlantic</i>	Madsen, R, Rasmussen, MH, Olsen, MT, Lydersen, C, Vikingsson, V, Kovacs, KM, Palmer, MKH, Bertelsen, JL, Jacobsen, JS, Jørgensen, MS, Whittaker, M, Jacobsen, T, Scott, J and icersen, MR	Danish Marine Mammal Symposium, Odense, Denmark, January 2019.	Conference presentation (Oral)	
<i>From Narratives to Numbers: Blending the Humanities and Natural Science in Northern Research.</i>	King, L., Ogilvie, A.E.J., Ingimundarson, J.H., Hreinsson, V., and Hartman, S.	4th International St Magnus Conference Alternative Fact and Actual Fiction: Constructing the Social Narrative, Orkney Islands, Scotland, 16-18 April 2018.	Conference presentation (oral)	
<i>The Foundations of Map-Making and Geography in Iceland</i>	Ogilvie, A.E.J.	48th International Arctic Workshop, Program and Abstracts 2018, Institute of Arctic and Alpine Research (INSTAAR), University of Colorado at Boulder, 82-85.	Conference presentation (Oral) and Abstract.	Available online
<i>Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)</i>	Ogilvie, A.E.J. and Yongqi Gao (with contributions from ARCPATH members).	NordForsk Annual Meeting, University of Helsinki, Finland 28-31 May 2018.	Conference Presentation (oral)	

<i>Climate, Sea Ice and Human Ecodynamic Systems in Northeastern Iceland</i>	Ogilvie, A.E.J.	Hay and Wetland Management Workshop, Hannesarholt, Reykjavik, Iceland, 14-17 June 2018	Conference Presentation (Oral. Workshop).	
<i>Studying Past Climates: A Focus on Documentary Evidence</i>	Ogilvie, A.E.J.	ARCPATH Summer Course, Climate Teleconnections and Predictions: Past, Present and Future, Norheimsund, Norway, 4 July 2018.	Conference Presentation (oral) ARCPATH summer school.	
<i>Examples of Climate Impacts: Case Studies from Iceland</i>	Ogilvie, A.E. J.	ARCPATH Summer Course, Climate Teleconnections and Predictions: Past, Present and Future, Norheimsund, Norway, July 2018.	Conference Presentaton (oral) ARCPATH summer school.	
<i>Impact of anomaly initialisation on the Arctic Ocean on decadal prediction using the EC-Earth model</i>	Tian, T., et al.	Arctic Climate Predictions: Pathways to Resilient Sustainable Societies (ARCPATH) Annual Meeting 2018, Bergen, Sept. 6-7, 2018.	Conference presentation (Oral)	
<i>Seasonal-to-decadal prediction with the Norwegian Climate Prediction Mode</i>	Wang, Y.; Counillon, F.; Keenlyside, N.; Bethke, I.; Dai, P.i; Langehaug, H.; Kimmritz, M.; Gleixner, S.; Svendsen, L.	EGU-2018 General Assembly, Vienna, 9 April 2018	Conference presentation (Poster)	
<i>Norwegian Climate Prediction Model</i>	Wang, Y.; Counillon, F.; Keenlyside, N.; Bethke, I.; Dai, P.i; Langehaug, H.; Kimmritz, M.; Gleixner, S.; Svendsen, L.	Arctic Frontier Science 2018, Tromsø, 21-26 January 2018	Conference presentation (Oral)	
<i>Development and current S2D prediction skill of the Norwegian Climate Prediction Model</i>	Wang, Y.; Counillon, F.; Keenlyside, N.; Kimmritz, M.; Bethke, I.; Langehaug, H. R.; Li, F.	Conference on subseasonal-to-decadal climate prediction, Boulder, 17-21 September 2018	Conference presentation (Oral)	
<i>The fate of Arctic sea ice: Prediction and projection using climate models.</i>	Yang, S.	Danish-Chinese Arctic Science Workshop 2018, Copenhagen, Oct. 17-18, 2018.	Conference presentation (Oral)	
<i>Arctic sea ice loss and extreme cold winters in Europe: revisited.</i>	Yang, S., et al.	Workshop on Knowledge Gaps of Cryospheric Extremes, Helsinki, Finland, 25 - 27 April, 2018.	Conference presentation (Oral)	

Arctic Marine Protected Areas	Barry, T.	Arctic Biodiversity Congress, Rovaniemi, 8 October, 2018. co-organized by Arctic Council Conservation of Arctic Flora and Fauna and UNEP World Conservation Monitoring Centre	Chaired a session	
Sustainable Management of Biological Resources	David Cook	Attendance and representing ARCPATH at Science for Ocean Actions – Sustainable Management of Biological Resources: The importance of knowledge to find regional solutions to global challenges. High-level Panel on Building a Sustainable Ocean Economy, initiated by the Norwegian Prime Minister, Erna Solberg. Bergen, Norway, November 2018.	Panel	
Arctic indigenous peoples: A dialogue and perspectives on common concerns for sustainable societies	Einarsson, N.	Seminar and roundtable organized by the Icelandic Ministry for Foreign Affairs, Arctic council Indigenous Peoples' Secretariat, the Icelandic Arctic Cooperation Network and Stefansson Arctic Institute, Reykjavik 15 May 2018	Roundtable participation	
Assessing vulnerability and building resilience of Arctic environments and societies.	Einarsson, N	Arctic Science Ministerial Science Forum, Berlin, 25 October 2018	Panel participation	Available online
Comments on Animals, Ice, people and policies	Einarsson, N.	Arctic Circle Assembly, Reykjavik 19 October 2018, OUT OF ICE session Open Forum, Film Screening, Book Launch	Panel presentation	
Arctic climate research and YOPP	Koenigk, T.	EGU General Assembly, Vienna, 9th April 2018	Panel discussion	
Arctic Indigenous Peoples: A Dialogue and Perspectives on Common Concerns for Sustainable Societies	Oddsdóttir, E.	Seminar and roundtable organized by the Icelandic Ministry for Foreign Affairs, Arctic council Indigenous Peoples' Secretariat, the Icelandic Arctic Cooperation Network and Stefansson Arctic Institute, Reykjavik 15 May 2018	Roundtable discussion	
Introduction to Elizabeth Ogilvie's Book and Film Launch Out of Ice with ARCPATH focus.	Ogilvie, A.E.J.	Arctic Circle Assembly, Harpa, Reykjavik, Iceland, 19 October 2018.	Panel presentation.	
Predicting Arctic Sea Ice:	M. Kimmritz	ARCPATH Summer school (30.06.2018-	Lecture	

Challenges and Perspectives		06.07.2018)		
<i>Climate History of Iceland and the Lake Mývatn Area</i>	Ogilvie, A.E.J.	Svartárfkot Culture-Nature Project, Human ecology and culture at Lake Mývatn 1700-2000: Dimensions of Environmental and Cultural Change, Bárðardalur, northern Iceland, 24 August 2018.	Presentation to Svartárfkot summer course.	
<i>Examples of Climate Impacts: Case Studies from Iceland in General and Mývatn in Particular</i>	Ogilvie, A.E.J.	Svartárfkot Culture-Nature Project, Human ecology and culture at Lake Mývatn 1700-2000: Dimensions of Environmental and Cultural Change, Bárðardalur, northern Iceland, 24 August 2018.	Presentation to Svartárfkot summer course.	
<i>Back to Basics: Historical Climate Research.</i>	Ogilvie, A.E.J.	ARCPATH Annual Meeting, Nansen Environmental and Remote Sensing Centre, Bergen, Norway, 6 September 2018.	Presentation to ARCPATH annual meeting.	
<i>General Climate History of Iceland: Documentary Evidence ca. 1600-2018</i>	Ogilvie, A.E.J.	University of Iceland Course on Society and Environment in Mývatn area, northern Iceland. University of Iceland, Reykjavik, 9 November 2018	Presentation to course for graduate students.	
<i>Climate Impacts ca. 1700-1950: Examples from Iceland in General and Mývatnssveit in Particular.</i>	Ogilvie, A.E.J.	University of Iceland Course on Society and Environment in Mývatn area, northern Iceland. University of Iceland, Reykjavik, 9 November 2018	Presentation to course for graduate students.	
<i>Whale research in Northeast Iceland</i>	Rasmussen, M	NOAA/Stellwagen Bank National Marine Sanctuary, Scituate, USA	Guest lecture	
<i>Whale research in Northeast Iceland</i>	Rasmussen, M.	Wood Hole Oceanographic Institution, Woods Hole, USA	Guest lecture	
<i>Theory of economic valuation, applications to whale ecosystem services and ARCPATH activities</i>	David Cook	Lecture. University of the Westfjords for the Coastal and Marine Management Masters students, November 2018.	Lecture	
<i>Economic Valuation of Ecosystem Services of Whales</i>	Laura Malinauskaite	Presentation at a board meeting of IceWhale – Icelandic Whale Watching Association. Reykjavik, Iceland, October 2018	Lecture	
<i>ARCPATH: Socio-Ecological Systems, Ecosystem Services and Marine Mammals in the Arctic</i>	Laura Malinauskaite	Guest lecture in Environmental Economics. University of the Iceland, April 2018.	Lecture	

<i>On the potential linkage between Arctic ice loss and cold weather in Sweden.</i>	Koenigk, T.	Sveriges Radio, 1 March 2018	Media profiling	
<i>Skrämmande att Arktis starkaste is har brutits sönder</i>	Koenigk, T.	Aftonbladet, 23 Aug 2018	Media profiling	
<i>"In Iceland, activists, industry are waging war over commercial whaling"</i>	Rasmussen, M.	American Nightline: October 2018. (https://abcnews.go.com/International/iceland-activists-industry-raging-war-commercial-whaling/story?id=58561835)	Media profiling	
<i>Advisors to, and appear in interviews in, a documentary series on impacts of fisheries governance titled "The Price of Fish"</i>	Einarsson, N. and Chambers, C.	New Zealand documentary maker Barry Torkington. The series will be launched by a NZ network and possibly also Netflix in the spring of 2019.	Media profiling	
<i>Interview for a UTube video</i>	Astrid and Elizabeth Ogilvie	Arctic Circle Assembly conference in October 2018 https://www.youtube.com/watch?v=AvsXSNyPjwk	Media profiling	

APPENDIX 2: LIST OF ACRONYMS

AB: Advisory Board; **AWI:** Alfred Wegener Institute, Germany; **CAFF:** Conservation of Arctic Flora and Fauna; **DMI:** Danish Meteorological Institute, Denmark; **HRC:** University of Iceland’s Research Centre in Húsavík; **INSPIRE:** Infrastructure for Spatial Information in Europe; **INSTAAR:** Institute of Arctic and Alpine Research; **IORAS:** P.P.Shirshov Institute of Oceanology, Russian Academy of Science; **IP:** International Partner; **MIT:** Massachusetts Institute of Technology; **MPA:** Marine Protected Area; **NEMO** Ocean Model: Nucleus for European Modelling of the Ocean; **NERSC:** Nansen Environmental and Remote Sensing Centre; **NorCPM:** Norwegian Climate Prediction Model; **NSIDC:** National Snow and Ice Data Centre; **NZC:** Nansen-Zhu International Research Centre, Institute of Atmospheric Physics (**IAP**), Chinese Academy of Sciences; **SAB:** Scientific Advisory Board; **SAI:** Stefansson Arctic Institute; **RRU:** Royal Roads University, Canada; **UiB:** University of Bergen, Norway; **UiT:** University of Tromsø – The Arctic University of Norway; **UoI:** University of Iceland; **UVM:** University of Vermont; **UW:** University of Washington.

Definition of Terms according to the ARCPATH project: The SAB suggested that key concepts from the proposal be defined and gave the examples of the terms “interdisciplinary”, “multidisciplinary”, “transdisciplinary” and “cross-disciplinary”. The terms “interdisciplinary” and “multidisciplinary” are often used interchangeably. However, there is a subtle difference. “Multidisciplinary” means the use of several different disciplines to cast light on a research problem but the results are often viewed separately rather than being combined. It has been suggested that with multidisciplinary the effect is “additive rather than integrative”. The quotation comes from a blog which discusses the precise meaning of the different terms (<https://polytechnic.purdue.edu/blog/what-transdisciplinarity>). “Interdisciplinary” research also combines different disciplines but takes the process to further integration. It has been suggested that “transdisciplinary” requires yet one more step where integration of knowledge is combined into a meaningful whole and individual disciplines are transcended. Cross-disciplinarity is more general and can refer to any of the above. ARCPATH strives primarily for transdisciplinarity. This term suggests the inclusion of local knowledge from stakeholders and others as well academics. Terms relating to climatological and socio-ecological analyses are defined in the original proposal.