

Responsible Development of the Arctic: Opportunities and Challenges -  
Pathways to Action  
*Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)*  
(2016.01.01-2020.12.31)  
Report - Part 1 (Part 2: p. 20)



### Original Project Aims

ARCPATH seeks to address the complex and interlinked issues of climate and socio-economic 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. These aspects are central to the project's **three main goals**: *i) To predict regional changes in Arctic climate over the coming decades using innovative methods to capture both anthropogenic and natural factors in global and high-resolution regional models; ii) To increase understanding and reduce uncertainties regarding how changes in climate interact with multiple societal factors, including the development of local and regional adaptation measures; iii) To combine improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions in order to supply new knowledge on potential "pathways to action".* The project's home and leadership is shared by the Nansen Environmental and Remote Sensing Centre (NERSC) in Bergen (Dr Yongqi Gao as lead) and the Stefansson Arctic Institute (Dr Astrid Ogilvie as co-lead). Project websites are: <http://www.ncoe-arcpath.org/> and <http://www.svs.is/en/projects/arcpath>

### 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; **IC**: International Partner; **INSTAAR**: Institute of Arctic and Alpine Research; **IORAS**: P.P.Shirshov Institute of Oceanology, Russian Academy of Science; **MPA**: Marine Protected Area; **NERSC**: Nansen Environmental and Remote Sensing Centre; **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.

### *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 (Petrie, 1992). 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.

### **Design and Methods:**

ARCPATH methods involve extensive cross-disciplinary collaboration including: climatology (global modelling; dynamic downscaling; historical climatology); environmental science; economics; oceanography and cryosphere research; marine and fisheries biology; fisheries management; anthropology; governance systems; human eco-dynamics; and traditional ecological knowledge (TEK). Drawing on these separate but interlinking disciplines is enabling ARCPATH to form a truly synergistic Centre of Excellence. The project is collecting, assembling, and analysing a wide variety of different data sets and information with a focus on local communities in Iceland, Greenland and northern Norway. ARCPATH methods include the use of: i) Earth System Models - the Norwegian Climate Prediction Model (NorCPM) and the European ESM (EC-Earth) Model with data assimilation from oceans and sea ice in order to perform global climate predictions; ii) Regional Arctic Climate Models to perform Arctic climate predictions; iii) Quantitative economic modelling, supported by qualitative interviews. The quantitative modelling follows the Economics of Ecosystems and Biodiversity (<http://www.teebweb.org/>) ecosystem services economic modelling framework. ARCPATH uses proven ethnographic research methods to solicit community insights concerning local changes, and to document how people are adapting/adjusting to these changes and impacts. The main research methods involve: participant observation, semi-structured and specialist interviews, official documents and surveys. Evaluation of historical data follows established methods of analysis.

### **Practical changes to original plan:**

There are no significant practical changes to the original research plan. ARCPATH has had a very successful year in 2017 and continues to focus on the original project goals.

## **Detailed research progress:**

### **1. Résumé of the development of the research**

*Comments of NordForsk Advisory Board re. Annual Report for 2016*

Before presenting details of project progress, a brief discussion is devoted to the feedback provided by the SAB on the ARCPATH annual report for 2016. While this was primarily favourable, several specific comments/suggestions were made which the ARCPATH team has sought to address. In particular, these were: i) that it would be valuable to continue the broader scope of Greenland and northern Norway as study regions in spite of the lack of funds due to the unfavourable exchange rate between the Norwegian and Icelandic currencies. Ways have been found to ameliorate this situation, in particular through collaboration with our international partners and by fostering new collaboration with unfunded Associate Scientists, as well as hiring part-time staff, as described in WPs 4 and 5; ii) Regarding synthesis, to achieve this is a major goal of the project; iii) The issue of synthesis spills into the comments of the SAB on the importance of cross-disciplinary aspects of the work undertaken. Because of the good collaboration between the team members, much effort goes into having the different work packages “talk” to each other. Team members have frequent discussions and also make as much effort as they can to elucidate their different disciplines; iv) The co-operation with non-Nordic researchers is extensive within the ARCPATH project. The SAB felt that although this was stated

in 2016 no specifics were given. For further information on 2017 see **Section 3**; v) Regarding the Nordic added value of the NCoE. The SAB felt that the project “is largely focused on Iceland”. The 2017 annual report will demonstrate that, as the project has progressed, there is also considerable focus on Greenland and northern Norway; vi) Gender perspectives are commented on in **Section 4 (b) gender perspectives in the research**; vii) The SAB noted that there is a crossover/affiliation with the *Arctic Youth and Sustainable Futures* project but that there was no discussion of why this might matter or be appropriate. This is addressed in the section on **Nordic Added Value**; viii) There has been considerable Post Doc recruitment in 2017; viii) Regarding “mobility” it was stated that it was “frequently lacking” in Year 1. During 2017 there has been considerable mobility; ix) It is stated in the SAB report that “user/community/public/stakeholder/industry involvement should be an integral part of each project”. This is of course vital and it is indeed a key part of the ARCPATH project. However, the issues regarding involvement are complex. Further discussion on this aspect may be found under **WPs 4 and 5** below.

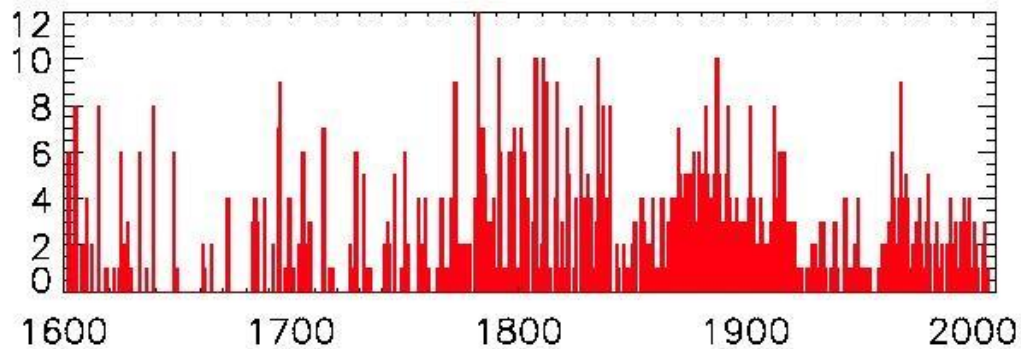
### *ARCPATH Progress Across the Work Packages*

**WP1. Arctic Linkages: Climate, Environmental Change, and Human Eco-Dynamics** . Leader: Astrid Ogilvie (SAI); Co-Leader: Noel Keenlyside (UiB). Participants: SAI; UiB; UoI; DMI; IC: NSIDC.

An analysis of the sea-ice record for Iceland has resulted in an excellent example of cross-disciplinary research, described below. The sea-ice index is based on an historical reconstruction of the amount of ice sighted from Iceland, measuring the amount of ice in the Greenland Sea. The index covers the period 1600-2000 and is an important and independent source of information for past climate in Europe and the North Atlantic region. The index (Fig. 1) shows variability on all time-scales with large values around 1800 and 1900 and small values in the first 200 years. The index decreased in the first half of the 20th century and has stabilized thereafter. Comparing it with other indices from the instrumental era (last 100-150 years) we find a significant and robust negative correlation between the ice index and the summer northern hemisphere mean surface temperature (HadCRUT4). Significant and robust negative correlations in summer are also found between the ice index and the Hurrell station-based NAO index. The connection to summer temperatures and the NAO is further confirmed by studying correlations between gridded temperature (HadCRUT4) and sea-level pressure fields (Jones et al., 2014). In particular for temperature, significant negative correlations are found for large areas in the Atlantic and Arctic regions. We also find positive correlations between the ice index and the Fram strait ice transport calculated from historical records of 'storis' from southwestern Greenland (Schmith and Hansen, 2003).

While these results show that the ice index is an important indicator for the NAO and the NAO-related climate variability we do not find any significant correlations between the ice index and other NAO reconstructions when the full 400 years period is considered. Weak or vanishing correlations are also found between the ice index and temperature sensitive proxies in the northern hemisphere as well as between the ice index and measures of solar activity. The reason for these missing correlations are at present unknown but it should be noted that temperature reconstructions in general only explain a small part of the temperature variability. The analysis shows that the variability on the longest time-scales is mainly connected to changes in the frequency of ice-free years. More specifically, the raw ice index has a statistically significant trend of 0.5/century while there is no significant trend when the ice-free years are excluded. This work has also led to an outreach publication (Ogilvie, 2017).

Because of the wealth of data that have been discovered relating to climate, social change, fish stock and marine-mammal data the analyses of these elements in WP1 will continue through month 48.



**Fig 1.** Sea-ice index is based on an historical reconstruction of the amount of ice sighted from Iceland

**WP2. Improved Global Climate Prediction by Initialization of Arctic Sea Ice and Sea-Surface Temperatures.**

Leader: Noel Keenlyside (UiB); Co-leader: Shuting Yang. Participants: NERSC; UiB; DMI; SMHI; IC: IORAS; UCI; IAPRAS; NZC; AWI.

NERSC and UiB have used the Norwegian Climate Prediction Model that is based on the Norwegian Earth System model and the Ensemble Kalman Filter. Assimilation of sea-ice concentration in NorCPM has been implemented and tested and hindcast predictions have been performed. DMI and SHMI have worked on developing the decadal prediction system of EC-Earth3 using the anomaly initialization method. The EC-Earth3 is the new generation of the Earth System Model EC-Earth and will be used in the CMIP6 (Coupled Model Intercomparison Project Phase 6). This prediction system will also be used for the CMIP6 endorsed MIP Decadal Climate Prediction Project (DCPP). Experiments using the prediction system with NEMOVAR ocean and sea ice anomalies have been planned. The period of experiments was decided to be from 1990 to 2000 with every two years as the starting years and 20 members (10 performed by DMI and 10 by SHMI) for each starting date.

In 2017 much effort was spent on debugging, tuning and finalizing the EC-Earth3 model together with other EC-Earth partners as well as working on the initialization system. The system applies the anomaly initialization method for both ocean and sea ice. The setup of ocean initialization from the previous version of EC-Earth was adapted to EC-Earth3 and preliminary tests were made using NEMOVAR ocean reanalysis. For sea ice initialization, an extra step is needed to make the sea-ice initialization field. As the sea-ice model (i.e., LIM3) in EC-Earth3 defines sea ice into multiple categories, the sea-ice concentration and thickness obtained from NEMOVAR (or any other sources) which are given as a single category need to be first converted to multi-category sea ice in order to be used in the model. A code has been developed to do a linear conversion of sea ice from a single category to multi-category, and the obtained categorized sea-ice data were implemented in the test run.

To better understand Arctic sea-ice variability, the long-term sea-ice reanalysis data from ERA-20C and NCEP were also analyzed. The results show that September sea-ice variability initiates mainly between May-August and its correlation with the preceding winter varies on decadal time scales. Such analysis might help us to more clearly comprehend the decadal variability of the Arctic sea ice.

**WP3. Arctic Climate Predictions and Regional Downscaling (SMHI).** Leader Markus Meier (SMHI); Co-Leader: Torben Koenigk (SMHI). Participants: SMHI; DMI; SAI; IC: IORAS; NZC.

The main goal of WP3 is to improve climate prediction for the Arctic/ Nordic Seas to the year 2030 by using high-resolution global-coupled simulations and regional downscalings. In 2017, regional ocean and atmosphere models have been prepared for downscaling of the global predictions from WP2 and first test simulations with observed forcing and model forcing have been performed. The global high-resolution version of the coupled EC-Earth model has been tested and a long-coupled simulation has been performed. The model output has been discussed and agreed on with WP4 and WP5.

High resolution global modelling: The final EC-Earth CMIP6 version is still under development. The aim is to use this CMIP6 version in ARCPATH. However, in the HighResMIP-context and the EU-project PRIMAVERA, a high-resolution pre-CMIP6 version of EC-Earth has successfully been used to perform long climate simulations (50-year spin-up + 1950-2014 historical simulation). In case of further delays in the CMIP6-version, this pre-CMIP6 version will be used for the high-resolution simulations in ARCPATH. The high-resolution PRIMAVERA-simulations have been analyzed for ARCPATH purposes for the Arctic regions. They indicate stronger and more realistic deep-water convection in the Labrador Sea. This is important for the Atlantic meridional overturning circulation, which is the main predictor for climate in the North Atlantic Arctic climate sector on multi-annual to decadal time-scales. The position of the Gulf Stream is slightly improved. Sea-ice cover in the Atlantic sector is slightly overestimated and a cold bias of 1-2K occurs in parts of the Greenland Sea, Iceland and Norwegian Seas.

Regional atmosphere modelling: The HARMONIE-Climate model (HCLIM) has been set up for a Nordic region covering Greenland, Iceland, the Nordic Seas, Barents Sea and Scandinavia. Two simulations using different physical packages (ALARO and ALADIN) have been run with ERA-interim data as boundary forcing at 50 km resolution. Further, a HCLIM-ALARO simulation has been performed at 12km resolution. The atmospheric circulation is very well simulated with seasonal biases below 2hPa almost everywhere. Furthermore, the temperature and precipitation distributions are well simulated. Over the Scandinavian mountains, the temperature is slightly too cold and precipitation is somewhat overestimated. Over Greenland, temperature biases are larger but here uncertainties in the observational based data sets are high as well. The input data that are necessary for downscaling the global predictions have been discussed with the WP2-groups.

Regional ocean modelling: During the second year of the project, the work focused on making a first downscaling experiment with the MITgcm 18km configuration. A historical simulation with EC-Earth was successfully downscaled showing that the concept works from a technical point of view. A first analysis showed reasonable results for 1850–2005 simulation. However, before the climate prediction experiments can be run, the runoff needs to be updated to the EC-Earth runoff rather than the climatology that was used.

Part of the project time was also spent on studying how changes in river runoff, in the Arctic region, impacts the water mass transform (in NorESM). The analysis combined two novel analysis methods (Pemberton et al, 2015; Marshall et al, 2017), and one interesting finding was estimates of the predictability of the different water mass transformation processes. A manuscript (Lambert et al.) has been submitted and is under revision in JGR Oceans.

**WP4. Climate, Socio-Ecological Systems, Cetaceans and Tourism.** Leader: Marianne Rasmussen (HRC); Co-Leader: Níels Einarsson (SAI); Participants: Uol; SAI; DMI; IC: NSIDC.

Considerable progress has been made in WP4 in 2017. Anthropological fieldwork in Scoresbysund in August, undertaken by Níels Einarsson, yielded substantial insight into social and ecological change in the community and the seascape of the fjord and surrounding areas, used for hunting and tourism activities. During interviews and observations hunters and other villagers expressed concerns about increasing marine traffic,



from cruise ships to pleasure boats, in terms of marine noise disturbance. By many these are seen as linked to the less predictable migration and movement of the valuable narwhal in the fjord, causing problems to the hunters. This anthropological/socioecological study will provide background for the planned ecosystem services research in Scoresbysund (see below). A graduate student, Ms Marianna Leoni, at the Department of Geography and Tourism, University of Iceland, has been recruited to join ARCPATH with her thesis work on social and environmental impacts of marine tourism in Scoresbysund, based on her fieldwork there during the summer of 2017, with Dr Einarsson as her co-supervisor.

In Iceland, and in particular, Skjálfandi Bay, ethnographic fieldwork has been undertaken by SAI researcher Gunnar Már Gunnarsson. His sub-project is *Coastal Seascapes in 'Skjálfandi' Bay': Historical Mapping of Marine Resource Use, and Conflicting Perceptions*. The move towards an MPA or similar regulatory arrangement in Skjálfandi Bay, due to the intense and somewhat unregulated use of the bay's seascape, is moving slowly. This is to some extent due to the delay of the locally initiated first assessment of the feasibility of an MPA, expected to come out in March 2018, but also due to the fact that the process needs to be solidly grounded in local grassroots and bottom-up activities. This takes time. We, as researchers, are aware that it would be a mistake for us to present the idea of an MPA without very firm support of the local community, anchoring the project in local aspirations and expectations for use of the bay, providing the much-needed legitimacy and credibility that an efficient new management system/structure calls for. There are countless examples of the introduction of MPAs where they have failed, often due to the perception of local people and users that they are an alien arrangement, introduced from above and without consultation and knowledge of local needs (Hoyt, 2011). This we need to avoid. Our role can be to provide advice, support and knowledge, based on existing international literature on MPAs, and our own research, ranging from cultural perception of the bay to marine mammal biology, but we do not wish to spearhead what many locals could perceive as essentially a foreign and alien idea as the introduction of whale watching was in 1995 (Einarsson, 2009; Rasmussen 2014, Huijbens and Einarsson, 2018; Barry et al., 2017). Understanding the social, economic and cultural context of the community of Húsavík, and engaging with key actors, calls for further fieldwork, and we have a team of anthropologists in the project who will focus on this task (Dr Einarsson, Mr Gunnarsson and Professor Françoise Breton).

Tom Barry has provided a valuable link to the policy community, at a time when the focus of the Arctic Council is about to shift solidly to maritime issues and ocean governance. He and Dr Einarsson have participated in the preparation of the upcoming Icelandic AC chairmanship programme 2019-2021 and will be involved in advising during the chairmanship itself. This will provide an excellent opportunity to disseminate ARCPATH research results to stakeholders and a governance body that is increasingly appreciated and visible on the international scene, as can be seen by the recent nomination of the Arctic Council to the Nobel Peace Prize.

For our north Norwegian case study we were joined in 2017 by Dr Anniken Førde, a social scientist and Associate Professor at the UiT Arctic University of Norway and an expert in coastal communities. Dr Førde and Dr Einarsson are also participants in a project that will link closely to, and provide synergy with, ARCPATH, called *Whalefeast - Ecological, commercial and social challenges of the recent extreme winter arrivals of whales in northern Norway*, consisting of a network of marine biologists and social scientists in Tromsø, with international partners, working on the management of marine mammals and whale tourism in the Tromsø region. This project has recently received funding for three years from the Norwegian Research Council.

The task (4.4.) of the UoI Ecosystem Services Team involves assessing the tradeoffs between different ecosystem services derived from the multifaceted importance of cetaceans (including cultural importance). The team relies on using the Common International Classification of Ecosystem Services (CICES classification framework (see <https://cices.eu/>) for ecosystem services and state-of the art economic evaluation methods

that are supported by qualitative analysis. Economic use and non-use values will be evaluated from the identified ecosystem services and relative economic importance derived. In 2017, significant progress was made. Two employees were hired, a post doc (David Cook) and a PhD student (Laura Malinauskaite). After the hiring of personnel a detailed research plan for the task was devised describing how multiple ecosystem services of cetaceans will be assessed using diverse valuation methods. The following list of journal articles will be formal deliverables of this task, as described in the research plan:

1. A review of the academic literature concerning Arctic ecosystem services, with a particular focus on current gaps linked to marine mammals, especially whales;
2. A thematic study of ecosystem services deriving from marine environments where whales are prevalent, progressing to the point of considering how best to value - either economically or using non-monetary information - respective services;
3. A description of the deeper socio-ecological interactions of changes in ecosystem services linked to whales, including a specific focus on the gender effects of increased tourism in local communities.
4. A presentation of at least one (potentially up to three) economic valuation studies (likely using the contingent valuation method) researching the existence value of whales in a marine context, where greater protection is potentially deemed necessary;
5. A study relying on a case-study focused approach to uncover insights related to the management and environmental regulation of marine mammals and their ecosystem services in an Arctic context, including the development of understanding concerning the likely influences of climate change.

Researchers have prepared the writing of journal articles 1 and 2 with thorough literature reviews, and methodological preparations have taken place for articles 3 and 4. Four case studies have been decided on: i) south of Iceland; ii) north of Iceland; iii) northwestern Norway including Tromsø; iv) Ittoqqortoormiit in Greenland.

In 2017 PhD student Olli Loisa was hired at the UoI HRC. He has worked with C-PODs (Porpoise detectors) that were deployed in Skjálfandi Bay and Eyjafjörður to record and detect the abundance and presence of both white-beaked dolphins and harbour porpoises in these two bays. The first deployments were done in August 2017. Two extra C-PODs were deployed in Skjálfandi Bay as part of Eva Prendergast's thesis work and these two were retrieved in September. The results have been accepted as a speed talk at the next European Cetacean Society conference in April. The rest of the C-PODS were retrieved and redeployed in November 2017 and the next retrieval and re-deployment has been scheduled for April 2018.

Dr Rasmussen and former Masters student Belen Ovide went to Kaldfjord in Norway for one week in January 2018 to join the North Sailing whale watching vessel there in order to record whale sounds. Unfortunately, the whales were not in the fjord as in previous years and it seems that, in connection with this, the herring had changed their migration earlier than expected. Discussions were also held with colleagues in Norway at this time and it came to light that there were increased numbers of sightings of blue whales around Svalbard in 2017. A Masters student at the University of Copenhagen is currently looking for matches between Iceland and Svalbard. Blue whales have not been seen around Svalbard in the past so it could be that they are now moving further north. There were fewer sightings of blue whales in Skjálfandi Bay than the previous year.

**WP5. Responsible Governance, Security and Abrupt Climate Change in North Atlantic Arctic Coastal Communities.** Leader: Níels Einarsson (SAI); Co-Leader: Astrid Ogilvie (SAI). Participants: SAI; UoI; IC: INSTAAR; RRU; NSIDC; UiT.

The emphasis in WP5 is on marine governance, security and rapid social and environmental change with considerable overlap with WP4. Excellent progress has been made in WP5, for example through the collaboration between Dr Chambers, Dr Einarsson and Dr Karlsdóttir (from the Nordic Centre for Spatial Development (NordRegio), Stockholm) on the recent changes taking place in the governance of small-scale fishing in Iceland. Using the Arctic island of Grímsey, adjacent to Skjálfandi Bay, as a case study, the authors show how fishing culture itself, through the logic of the Individual Transferable Quota (ITQ) system, has become inextricably and irreversibly entwined with national and even global financial institutions and processes, with major impacts on the resilience and viability of Grímsey and other fishing communities in the country (Chambers, Einarsson and Karlsdóttir, In Press; cf Part 2 Sec 12). Drs Ogilvie and Einarsson have also worked on material with Grímsey in Skjálfandadjúp as point of departure, but with more focus on the interaction and cumulative impacts of biophysical and social change.

Other ARCPATH members have been looking at the risk and environmental security issues involved in increased shipping linked to industrial activity and tourism in the Arctic. Embla Eir Oddsdóttir has focused on issues relating specifically to task 4.1 in WP4 and task 5.1 in WP5 and that are especially pertinent to task 5.7 in WP5. This work is leading to the understanding and untangling of the relationships between risk assessment, perceptions of security and Arctic security (human as well as state) policy. Professor Huijbens has been involved in discussions with the Icelandic Coast Guard regarding four distinct student projects that have been formulated, gauging priorities and concerns when it comes to increased cruise and marine tourism traffic in Icelandic/Greenlandic waters. These projects have been disseminated amongst students in several universities in Iceland for the autumn and spring semester of 2017 and 2018. In 2017, Dr Janne Flora, anthropologist and eskimologist with expertise on Greenland, was invited to join ARCPATH as a part-time staff member of the SAI, starting in 2018. Dr Flora will be a major resource person for the project's work in Scoresbysund where she is already working with hunters and the community on the Greenland East Coast Oil Spill Sensitivity Atlas, [http://pure.au.dk/portal/en/persons/id\(41b507df-d0ce-44c4-86ae-eb90027444f8\).html](http://pure.au.dk/portal/en/persons/id(41b507df-d0ce-44c4-86ae-eb90027444f8).html) She will contribute to both WP4 and 5. Dr Margaret Willson, anthropologist at the University of Washington joined ARCPATH as a Research Associate in 2017. She is an expert on women and gender issues in Arctic coastal communities and brings to the table extensive expertise on social externalities of fisheries management in coastal cultures. Professors Hoogensen-Gjørsv and Bertelsen of UiT met with Dr Einarsson early in the year in Tromsø and have focused on questions of risk governance and trans-arctic shipping. Hoogensen has in particular emphasised the need to look at the relationship between gender, security and peace in the Arctic (Hoogensen-Gjørsv 2017a, Hoogensen-Gjørsv 2017b).

**WP6: Project Synthesis.** Leaders: Astrid Ogilvie (SAI) and Leslie King (RRU); Co-Leader: Yongqi Gao (NERSC). All project participants.

Project members recognize that synthesis is particularly challenging for complex, large-scale inter- and transdisciplinary research projects such as ARCPATH which include different cultures, disciplines, languages, methods, and time-scales. We take a transdisciplinary approach to synthesis, engaging researchers, the public and policy-makers to promote the resilience and sustainability of Arctic communities and to develop new pathways to action (Lang et al., 2012). Because of her great experience in applying synthesis to large projects, Professor Leslie King has kindly agreed to play a leadership role in project synthesis.

The synthesis goals of the project include: 1. Harvest the principal scientific findings of ARCPATH and generate new cross-cutting insights and concepts; 2. Explore the governance, policy, planning and action, regional and community relevance of these findings; 3. Mobilize the knowledge generated (to the academic community, policy-makers, practitioners, NGOs, the media, northern communities and the general public); 4. Identify lessons learned as well as remaining gaps in knowledge and directions for future research.



From the outset we recognized the importance of conducting synthesis from the beginning of the project, not just as an add-on at the end. At the first annual meeting in Bergen, in 2016, we therefore had a long discussion about synthesis structures, processes, products and knowledge mobilization, including identifying synthesis questions and themes that would guide synthesis throughout the project. We identified and constituted a synthesis committee, made up of work package leaders as well as the management committee. At the ARCPATH annual meeting in Reykjavík in October 2017, researchers and WP leads reported on synthesis insights and findings from their research. We had a wide-ranging and rich discussion of the implication of those findings and queried each other's work package findings. Synthesis is an agenda item for all ARCPATH meetings and teleconferences.

For the ARCPATH project, 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 will communicate synthesis of the project throughout the entire 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 identify 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. Specific synthesis findings emerging from 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.

**WP7: Project Management and Dissemination.** Leader: Yongqi Gao (NERSC); Co-Leader: Astrid Ogilvie (SAI). All project participants.

ARCPATH is primarily managed by the Project Leader and Co-Leader but all decisions are taken in a democratic manner with input from the entire project team. Manager Kjetil Lygre is a great asset in facilitating management of many tasks, from arranging meetings to providing input to the project reports. Torill Hamre is in charge of the project website. ARCPATH also has a core management team consisting of the Project Leader and Co-Leader plus work package leaders: Niels Einarsson; Marianne Rasmussen; Noel Keenlyside; and Torben Königk. There are regular Skype meetings in order to coordinate research activities and to facilitate collaboration. Email is used a great deal and work package leaders are in touch virtually every week. ARCPATH team members disseminated research findings in the usual manner at conferences and workshops and at public lectures as well as producing a number of scientific and popular articles. For details see Table 8, Part 2.

While several meetings of project members took place over the year, the highlight was undoubtedly the ARCPATH annual meeting in Reykjavík during October 16-18, 2017. This was combined with the final meeting of the project *Impacts of Future Sea-Ice and Snow-Cover Changes on Climate, Green Growth and Society (GREENICE)*. The focus was highly interdisciplinary with talks by social scientists interspersed with those of natural scientists. The timing of the annual meeting was planned to dovetail with the prestigious Arctic Circle meeting in Reykjavík during 13-15 October (<http://www.arcticcircle.org/>). This is described in more detail below in the section on stakeholders. In 2017 ARCPATH team members also began to start planning for the first ARCPATH summer school, a prime example of dissemination and outreach.

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

**Scientifically:** The powerful, multi-disciplinary, and collaborative group 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 behavior of marine mammals (HRC). ARCPATH is already drawing international talent to the Nordic region through international recruitment of senior scholars, post docs and PhD students. For example, a Fulbright scholar from the United States will join the ARCPATH team in 2018. ARCPATH is also creating international networking and research opportunities for Nordic scholars, for example in Cambridge, USA, where an ARCPATH PhD student has been 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 both 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. Dissemination is already taking place, for example through the transatlantic MPA network meeting held in Húsavík in October where members of the ARCPATH team participated.

## **2. Demonstrate how the Centre has facilitated and developed cooperation with non-Nordic research groups within Arctic research**

ARCPATH has a very strong international component with active research partners drawn from: Canada, the USA, China and Russia. Several of these attended the ARCPATH annual meeting and ARCPATH session in the Arctic Circle conference in October 2017 in Iceland. 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. It is planned that a young researcher from this Centre will be invited to Bergen during April-June 2018 for further collaboration. Many presentations have been given to international conferences. All of these conferences involved fruitful discussions with international colleagues. 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; 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.

A 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 Davíðsdóttir 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 which will be launched in early 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. At this time the Stefansson Annual Memorial Lecture (sponsored by the Stefansson Arctic Institute and Dartmouth College, USA) was given by Professor Brynhildur Daviðsdóttir.

New cooperation has been developed in WP4 with a focus on socio-ecological systems and ecosystem services of cetaceans. Laura Malinauskaite, a PhD candidate at UoI, spent two months in Japan looking into Japanese whaling history and current trends, management of coastal and marine ecosystems and the development of ecosystem services-based approaches to coastal management (*Satoumi*; <http://satoyama-initiative.org/about/>). Some parallels can be drawn in the management of marine resources between the Arctic countries and Japan, and future scientific collaboration is feasible. A one-day seminar was held at UoI in April with the title: "What is the Role of whales in the Ecosystem?" where Marianne Rasmussen gave a presentation. Also speaking was Professor Joe Roman, a conservation biologist at the University of Vermont in Burlington, USA. As a result, a new collaboration has been forged with Professor Roman, with a focus on assessing ecosystem services of cetaceans and he will join the UoI WP4 team late in 2018.

### 3. Discuss:

#### (a) Cross-disciplinary aspects of the work undertaken

A key element of the ARCPATH project is its cross- and transdisciplinarity. Thus, for example, WP1 combines physical science climate data with historical records of climate and marine-mammal variability. While WP2 and 3 focus heavily on natural science with a combination of global and regional climate predictions, they form the backbone for knowledge regarding Arctic "pathways to sustainability". WPs4 and 5 consider elements both from the perspectives of natural and social sciences relating to climate change, marine mammal biology, fisheries governance systems and tourism. WP7 focuses on synthesis whereby all the different strands and key elements of the project will be used to illuminate each other. In addition, WPs 4 to 7 can be characterized as transdisciplinary in that they interact with communities, governments, the private sector and civil society to identify connections and applications in the case-study countries. They will use different sources of knowledge and will promote a lasting legacy of the project to solve community and regional problems and enable communities to become more resilient and sustainable in the long term. A specific example of cross-disciplinarity is that in 2017 we identified the shift of movements of whales in 2003/2004 around Icelandic waters. This shift is likely to be related to the change in the sea water temperature around Icelandic waters. This specific case study builds on a combination of WPs 2, 3 and 4.

#### (b) gender perspectives in the research

Gender issues are an important focus area for ARCPATH. However, the situation cannot be defined in simplistic terms. Iceland is the leading country in the world regarding gender equality. The [Global Gender Gap Report 2017](#) reveals that Iceland has now closed more than 87% of its overall gender gap. Norway ranks second in this report. The situation in Greenland is far more complex because of its diversity. In Arctic locations such as Greenland and northern Canada, recent decades have seen a very noticeable trend: that young women leave their communities in order to find work and education elsewhere. Of relevance here is the growth of whale watching tourism, a major focus of the ARCPATH project. Thus, for example, from around the last decade of the twentieth century, Arctic whale watching has grown enormously in popularity among visitors to Iceland and other Arctic and sub-Arctic regions. This growth has been in line with the ever-

increasing numbers of tourists coming to Iceland. (Since 2010 the increase has been over 20% per year.) Growth in jobs in the tourism industry, not least with regard to whale watching may enhance opportunities for women and make them more likely to stay in their communities. As a recreational and cultural activity, whale watching thus meshes with ecosystem dynamics and can be of great importance for regions struggling to develop and diversify their economy and social conditions. In line with this focus ARCPATH has noted that the SAB suggested that the project could see “if tourism industry opportunities may affect female mobility and/or participation in the economy”. This is being done. Furthermore, in order to help address gender, the project has recruited Dr Margaret Willson of the University of Seattle, an expert in gender issues in coastal settings. Thus, for example, while common perceptions might suggest that fishers always tended to be male in Iceland her research has shown that this is far from the case (Willson, 2016).

WP4, in particular, is in the early stages of transdisciplinary research which, among other things, will examine gendered impacts of the growing tourism industry in the Arctic associated with changing uses of marine mammals and ecosystem services associated with them. This part of the research will, in particular, look at three Arctic coastal communities – Ittoqqortoormiit in Greenland, Húsavík in Iceland and the Tromsø area in Norway – with the aim to identify how both genders are being affected by the dynamics in ecological and social systems and their interactions caused by climate change and growth of tourism. This will be done by combining research methods from anthropology, gender studies and environmental economics. The fieldwork will commence in summer 2018. Among project team members there is an excellent gender balance.

### **(c) contribution to open science**

ARCPATH is contributing to improved access of scientific data through peer-reviewed and popular publications, presentations at conferences, public lectures and schools, and via software and educational material that will bring new information to debates on current Arctic issues. Supported by the Centre and the E-ARCPATH project (also funded by NordForsk), the ARCPATH website (<http://www.ncoe-arcpath.org>) serves as an important contact point regarding contributions to open science. Details of all presentations given in 2017 are provided here. The project has a striking and evocative logo designed by the artist Marina Rees from Húsavík. As noted by Níels Einarsson, the logo encapsulates the essential components that link the project's research foci of climate, ice, marine traffic and fishing, and cetaceans, with the key symbol of the whale fluke like a warning finger reminding us of all the risks and responsibilities we must be concerned with. The E-ARCPATH (Open Science pilot for the ARCPATH NCoE) project is led by NERSC, with UiB, DMI and SMHI as partners with the objective to broaden and strengthen the dissemination activities in ARCPATH. This is undertaken by establishing a data catalogue offering open access to datasets generated in the Centre of Excellence, and by organizing a dedicated ARCPATH session at EGU 2019 to present obtained results to a wide international scientific community.

NERSC has commenced the initial investigation of potential open source tools that can be used to establish a data catalogue for the ARCPATH project. Three candidate tools have been identified:

- (1) GeoNetwork (<https://geonetwork-opensource.org/>, GPL v2 license)
- (2) GeoNode (<http://geonode.org/>, GNU GPL v3)
- (3) CKAN (<https://ckan.org/>, Affero General Public License)

We have used GeoNetwork in earlier projects, among others in the Norwegian Marine Data Centre (NMDC) project funded by the Norwegian Research Council. While GeoNetwork supports several standard metadata search protocols such as OAI-PMH, OGC-CSW and OpenSearch, it does not provide good mapping for DIF (a

widely used metadata standard, used e.g. by NASA's GCMD). GeoNetwork is, however, widely used, and newer versions (current 3.4.0) may have improved functionalities such as a more flexible and user-friendly interface (GUI). We will keep GeoNetwork on the list of candidate tools until we have completed the evaluation of the others.

CKAN is a powerful and flexible tool, but also more complex than e.g., GeoNetwork. We have started looking into its capabilities, and found several features that make it a promising candidate for the ARCPATH data catalogue. Among others, CKAN offers an appealing user interface that can be customised, a number of plugins (modules) e.g., for harvesting metadata through OAI-PMH, uploading and storing (data) files, and displaying datasets in the catalogue. CKAN also has a built-in extension mechanism that allows development and integration of own plugins. We will investigate CKAN further, and also compare it with the two other candidates GeoNetwork and GeoNode. ARCPATH is also developing a Data Management Plan (DMP). The first version of the DMP describes the different categories of data that ARCPATH will generate (such as improved initialization fields of Arctic sea ice and ocean temperature and salinity and model projections on both global and regional scales) and how these new datasets will be managed according to guidelines for FAIR data management in H2020. This plan will be a "live document", being updated at regular intervals to include the description of new datasets that partners generate as part of ARCPATH activities. The ARCPATH data catalogue will contain metadata (i.e. "data about data") for the datasets, including links to access them. The datasets themselves will be hosted by the data owner on an institutional server or by an established national or international data infrastructure.

#### **(d) the contribution of users of research results (industry, policymakers, local communities etc) to the Centre at this stage**

NERSC has established contact with DNV-GL in Bergen to discuss which climate parameters are needed by the shipping industry. ARCPATH will disseminate the information from climate predictions to DNV-GL if requested. The contribution of users in Ittoqortoormiit and Húsavík are discussed elsewhere in the report.

#### **4. Any difficulties encountered - e.g. in staffing, access, data analysis etc., how these have or are being addressed and if they are expected to have an impact that requires updating/reviewing the initial objectives;**

There are no specific difficulties other than those caused by the fall of the Norwegian currency against the Icelandic which we are dealing with as best we may.

#### **Changes introduced or envisaged in the research objectives or design**

There were no changes introduced or envisaged in the research objectives or design during the second project year.

#### **An updated schedule of milestones and/or timetable, including major impact products, supported by a commentary on any future risks or anticipated slippage.**

There is an update in milestones and/or the milestones in WP2 and accordingly WP3. This is due to the delayed start of ARCPATH and the delayed CMP16 forcing data sets which were envisaged to be used in NorCPM and in EC-Earth. Because of the wealth of data that have been discovered for WP1, work will continue through month 48.



## Governance:

ARCPATH is led by the Project Leader and Co-Leader. The management group consists of the Project Leader, Co-Leader and four other work-package leaders. Members are drawn from three different Nordic countries (Norway, Sweden and Iceland) and the gender balance is also addressed. The management group is responsible for promoting and facilitating cooperation between the partners in the Centre. Where necessary, decisions regarding the Centre will be taken according to a majority vote. An Advisory Board (AB) consisting of highly-qualified colleagues from both natural and social science disciplines has been set up for the Centre. The role of the AB is to provide advice and support to better achieve project goals. The AB consists of: Professor Cecilia Bitz, University of Washington, USA; Dr Burkhardt Rockel, the Helmholtz-Zentrum Geesthacht Institute for Coastal Research; Professor Lawrence C. Hamilton, Professor of Sociology at the University of New Hampshire, USA; and Professor Michael Bravo, Fellow of Downing College, and Senior Lecturer, Department of Geography, University of Cambridge, and Head of the Circumpolar History and Public Policy Research Group at the Scott Polar Research Institute, Cambridge.

## Highlights of the research:

### 1. Key findings:

- High resolution in EC-Earth improves the representation of deep-water formation in the Labrador Sea.
- Regional atmosphere and ocean downscaling over the Nordic Seas region provide realistic results.
- Assimilation of sea-ice concentration in the ARCPATH dynamical prediction system efficiently constrains most of the sea ice and near-ocean variability in the Arctic
- Changes in whale observations around Iceland can be linked to variations of the sea-surface temperature
- There is a significant research gap in the pluralistic valuation of ecosystem services of cetaceans, yet their importance is likely to be significant to local communities.
- Increasing tourism is putting pressure on the sustainability of seascapes and socioecological systems in Iceland, East Greenland and northern Norway, calling for the design of nimble and adaptive governance arrangements.
- The introduction of market-based fisheries governance systems can be seen as having multiple social and economic externalities in fishing communities, linking their fate to processes beyond local control, such as the logic of financial institutions.

### 2. Warrant

A major goal of the ARCPATH project is to combine improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions in order to supply new knowledge on Arctic "pathways to action". This transdisciplinary project is possible because of the combined multidisciplinary expertise of team members. This includes: climatology (regional and global modelling; dynamic downscaling; historical climatology); environmental science; environmental economics; oceanography and cryosphere research; marine and fisheries biology; fisheries management; anthropology; governance systems; human eco-dynamics; and traditional ecological knowledge. The team members, as well as the international collaborators, are leaders in their fields and have an excellent track record of many successfully completed projects. They thus have all the necessary expertise to achieve ARCPATH goals.

3. **Researcher mobility.** Please refer to Section 3 of Part 2
4. **Researcher training and education.** Please refer to Section 4 of Part 2
5. **Output and dissemination.** Please refer to Section 8 of Part 2
6. **Meetings and networking.** Please refer to Section 5 of Part 2.

## 7. Infrastructure and data policy

During the second 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 (Wilkinson et al., 2016). Work on assessing candidate tools for implementing the ARCPATH data catalogue has started, as described above (section 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.

## Progress and contributions towards Programme aims:

### 1. to strengthen the Nordic region's position within educational research in Europe and beyond

ARCPATH has recruited graduate students at the PhD level. Two PhD students have been recruited in Iceland at UoI and HRC and one Post Doctoral candidate at UoI (David Cook). Two Post Doctoral positions were recruited at NERSC; and at UiB; and two at SMHI. SAI is in the process of employing one Post Doc. All these efforts will help to strengthen the Nordic region's position within educational research in Europe. ARCPATH members will organise two summer schools. One will be held in 2018 in Bergen and another will be held in 2019 in Iceland. ARCPATH will also be active in other summer schools e.g, the biennial Nansen-Zhu Summer School, see <http://nzc.iap.ac.cn/summer2016>) and a unique graduate course in Human Ecology and Environmental Change in Iceland in August 2018 see <http://scn.akademia.is/>. ARCPATH is also collaborating with *Arctic Youth and Sustainable Futures* (led by non ARCPATH SAI members). This project convenes an international working group of Arctic scholars, alongside Arctic youth representatives, to investigate and conduct research on the needs, opportunities and aspirations of Arctic youth, to fill an identified gap in knowledge on the lives, ambitions, needs and challenges of youth – indigenous and non-indigenous – across the circumpolar Arctic (<http://www.svs.is/en/projects/arctic-youth-and-sustainable-futures>). Clearly, ARCPATH's overarching goal of fostering responsible and sustainable development will ultimately depend on future generations. As stated in the project proposal: "Through the training of young scientists, ARCPATH will help secure the long-term capacity in this field [Arctic studies] in the Nordic regions."

### 2. to contribute to a knowledge-based policy for the educational sector in the Nordic countries by analysing issues of substantial importance and relevance to both the sector itself, policy makers and researchers

ARCPATH research is of great educational relevance in the Nordic countries, both because of the global significance of its Arctic research, and also because of its novel approach and focus that aims at providing policy relevant and robust knowledge that will directly benefit Arctic residents. Research results will have clearly defined socio-economic relevance to the national interest of Nordic countries, and these will be disseminated to policy makers and stakeholder groups. ARCPATH will facilitate planning adaptation strategies, and will also take advantage of new opportunities to reduce environmental and economic risks. ARCPATH brings together a strong team, leaders in their respective fields, experienced in collaborative studies, and situated at institutions in the forefront of Arctic research. The combined multi-disciplinary expertise of team members, covering climate and social sciences, and extending from marine biology to environmental economics, will create the synergistic environment needed to address the crucial issues facing northern societies. Through the training of young scientists, ARCPATH will help secure the long-term capacity in this field in the Nordic regions.

## **2. to disseminate the results to a wide array of stakeholders in the Nordic region and internationally;**

Project results have been disseminated during 2017 in ongoing meetings. Examples are: i) the transatlantic MPA network meeting held in Húsavík in October, where both Marianne Rasmussen and Níels Einarsson participated. This was an EU-funded network (<https://transatlanticmpanetwork.eu/>) and Dr Rasmussen was subsequently invited to their final meeting in Brussels in January 2018. One of the group members of this network, Ben Haskell, of the Stellwagen Bank National Marine Sanctuary, National Oceanic and Atmospheric Administration (NOAA) also attended this workshop; ii) a one-day seminar was held at University of Iceland in April 2017 with the title: “What is the Role of whales in the Ecosystem?” where Marianne Rasmussen gave a presentation; iii) A prestigious stakeholder event was the panel presented to the Arctic Circle conference held in Reykjavík in October 2018. This has become a highly-acclaimed annual event drawing some 2,000 international delegates including politicians, business people, scientists, members of the public and other stakeholders. The focus included various aspects of ARCPATH and GREENICE research. Speakers were: Noel Keenlyside, Níels Einarsson, Astrid Ogilvie, Marianne Rasmussen, Leslie King, and Elizabeth Ogilvie, who presented her film “Out of Ice”. The Moderator was Brynhildur Davíðsdóttir. The panel description was as follows: “This panel will introduce and discuss the NordForsk-funded Nordic Centre of Excellence project *Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)* - a direct continuation of the NordForsk project *Impacts of Sea-Ice and Snow-Cover Changes on Climate, Green Growth, and Society (GREENICE)*. The scope and aims of the session reflected those of the projects: to supply new knowledge on Arctic issues by combining improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions. The panel was very well-attended, not only by academics and politicians, but also by students, including students from the School for International Training (SIT) graduate student group on climate change, who Astrid Ogilvie had recently given several lectures to in Akureyri, including lectures on ARCPATH research. The panel resulted in a very lively discussion and may be considered to have been a highly successful Outreach and Dissemination activity.

Further to this, ARCPATH results continue to be disseminated through many meetings attended by the international collaborators from Canada, China, Russia and USA, specifically through projects such as the EU H2020 INTAROS, Blue-Action and Belmont/JPI InterDec) and through various international conferences (e.g., the Arctic Circle; Arctic Frontiers; the Arctic Science Summit Week; the International Conference on Climate Service). In particular, the National Marine Environmental Forecast Centre (NMEFC) in China will collaborate with ARCPATH. The project’s webpage (<http://www.ncoe-arcpath.org>) will serve as a ‘permanent’ base for dissemination purposes.

## Impact strategies and plans:

ARCPATH invites representatives from industry, policy makers and local communities to meetings where this is appropriate and keeps them updated concerning project developments and outreach activities such as the planned summer schools. In order to ensure that ARCPATH activities are firmly anchored in society and are of benefit and relevance to Arctic inhabitants, and of policy relevance to decision makers, the project actively seeks the involvement of a wide range of users and stakeholders, from local communities to commercial companies to national policy making authorities.

Of particular note is the close collaboration with the Whale Museum in Húsavík, as well as with one of the leading whale watching companies which has operations both in northern Iceland as well as in Scoresbysund (Kangertittivaq) in East Greenland. Further to this there is collaboration with the regional labour union *Framsýn* which represents fishermen and fish workers throughout northeastern Iceland. Icelandic authorities involved are the Ministry for the Environment and Natural Resources, and Members of Parliament from the northeast constituency. ARCPATH will also cooperate with the projects EU H2020 INTAROS and Blue-Action and Belmont/JPI InterDec and with other NCoEs to strengthen synergy and research impacts. Furthermore, ARCPATH has established excellent contacts with the National Marine Environmental Forecast Centre in China (a Chinese national forecast provider for the Arctic).

## Potential media stories:

Dr Einarsson appeared in an interview with Icelandic State Television, Channel One, concerning rapid climatic change in the North Atlantic Arctic and impacts on coastal communities on 17 January 2017.

He also appeared as the main interviewee in a documentary film “Whales, Science and the Local Community in Húsavík, Iceland” by Miquel Such and John Grothier that was premiered in Barcelona at the inauguration of the Autonomous University of Barcelona Arctic Research Centre, 1. December <http://www.svs.is/static/files/cer-arctic-inauguration-programme-flyer-22.11.17-ne.pdf>

An upcoming television documentary on Arctic coastal communities and impacts of marine resource governance systems with Dr Einarsson as advisor will be made by a New Zealand team in 2018.

The work of Dr Astrid Ogilvie was featured in the *Nature* Careers Feature *Hidden in the Past* on the use of historical data for climate reconstruction (*Nature* 549, 419-421; 2017).

## Supplementary funding:

ARCPATH partners are involved in the newly-funded EU H2020 projects (INTAROS, Blue-Action) and the Belmont/JPI Inter Dec project. Efforts have also been made to augment the funds available for the focus on northern Norway. Specifically, an application was made by Astrid Ogilvie to RANNÍS (The Icelandic Research Council) to the call for research in “Cooperation in the Field of Arctic Studies in Iceland and Norway” (see <https://en.rannis.is/funding/research/arctic-studies/>). The project was entitled “Arctic Climate Change, Marine Mammals and Tourism (ARCMART)” and a major focus was a comparative study regarding these topics between the Skjálfandi Bay and Húsavík areas in Iceland, and the Tromsø area in Norway. Co-PIs from ARCPATH: Yongqi Gao, Noel Keenlyside, Níels Einarsson, Marianne Rasmussen and Edward Huijbens. Other Co-PIs: Anniken Førde and Lars Henrik Smedsrud. The project was primarily a networking one, with Icelandic team members spending time in Norway, and vice versa. Unfortunately, the project was not funded. It was

explained that this did not reflect negatively on the application, but was due to the fact that funds were simply not available. Further attempts with similar applications will be made in the future.

Astrid Ogilvie and Leslie King applied for supplementary funding for ARCPATH to the Social Science and Humanities Research Council of Canada (SSHRC) in October 2017 with a project entitled: “Northern Knowledge for Resilience, Sustainable Environments and Adaptation in Coastal Communities (NORSEACC)”. The results have not yet been announced.

## Future plans for the NCoE and cooperation beyond the funding period:

Most of the ARCPATH team members have been collaborating for some time in interdisciplinary, international projects. ARCPATH is also recruiting many new younger colleagues. It is envisaged that research that has had its outsprings in ARCPATH will continue far beyond the life of the project. The Arctic is of fundamental importance in the climate system and impacts on fragile Arctic communities in terms of both climatic and socioeconomic change are ever increasing. There is little doubt that the collaborative links forged through ARCPATH will continue with further research into issues related to changes in the Arctic. Of particular note here are the two new Arctic research centres established as “spin-offs” from ARCPATH in Barcelona and Washington as described above. It is envisaged that there will also be close cooperation between ARCPATH members and these institutes for long after the life of the project.

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# Annual Reporting of Nordic Centres of Excellence

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## Report – Part 2

### General information

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|   |   |
|---|---|
| Name of the Nordic Centre of Excellence:    | <i>ARCPATH - Arctic Climate Predictions:<br/>Pathways to Resilient, Sustainable Societies</i> |
| Name of the responsible leader of the NCoE: | Dr Yongqi Gao (Lead), Dr Astrid Ogilvie (Co-Lead)   |
| Reporting period                            | 01.01.2017 – 31.12.2017   |

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## 1. PERSONNEL OF THE CENTRE

List the names of the research team leaders involved in the NCoE. Please give the number of other researchers and students who have worked within the project. Also, please indicate the number persons in each category as listed (number of, number of person years in total and the number of person years paid by the NCoE). Each category is divided by Gender.

| Name of the research team leader                              | Gender | Host Institution  |
|---|--------|---|
| <b>Dr Yongqi Gao</b>  | M      | Nansen Environmental and Remote Sensing Centre, Norway                                      |
| <b>Dr Torill Hamre</b>  | F      | Nansen Environmental and Remote Sensing Centre Norway                                       |
| Dr Francois Counillon   | M      | Nansen Environmental and Remote Sensing Centre Norway                                       |
| Dr Kjetil Lygre   | M      | Nansen Environmental and Remote Sensing Centre Norway                                       |
| Dr Madlen Kimmritz  | F      | Nansen Environmental and Remote Sensing Centre Norway                                       |
| Dr Yiguo Wang   | M      | Nansen Environmental and Remote Sensing Centre Norway                                       |
| <b>Dr Astrid Ogilvie</b>                                      | F      | Stefansson Arctic Institute, Iceland  |
| <b>Dr Níels Einarsson</b>                                     | M      | Stefansson Arctic Institute, Iceland  |
| Dr Edward Huijbens, SAI and Professor, University of Akureyri | N      | Stefansson Arctic Institute, Iceland  |
| Gunnar Már Gunnarsson   | M      | SAI and International Arctic Science Committee (IASC)                                       |
| Dr Embla Eir Oddsdóttir                                       | F      | SAI and Director, Icelandic Arctic Cooperation Network                                      |
| Dr Janne Flora  | F      | Stefansson Arctic Institute, Iceland  |
| <u>Associate Scientists</u>                                   |        |   |
| Dr Tom Barry  | M      | Executive Secretary of the Conservation of Arctic Flora and Fauna (CAFF), Akureyri, Iceland |
| Prof. Françoise Breton Renard                                 | F      | Director, UAB Arctic Research Centre (CER-ARCTIC) <sup>[SEP]</sup> , Barcelona, Spain       |
| Dr Catherine Chambers   | F      | University Centre of the Westfjords, ísafjord, Iceland                                      |
| Dr Anniken Førde  | F      | The Arctic University, Tromsø, Norway   |
| Dr Margaret Willson   |        | Department of Anthropology, University of Washington, Seattle                               |
| Elizabeth Ogilvie   | F      | Environmental Artist, University of Edinburgh   |

|                                     |   |   |
|-------------------------------------|---|---|
| Kerry Koepping                      | M | Arctic Arts, INSTAAR, University of Colorado  |
| <u>International Partners</u>       |   |   |
| Professor Gunhild Hoogensen Gjørsv  | F | University of Tromsø – The Arctic University of Norway  |
| Professor Rasmus Gjedssø Bertelsen  | M | University of Tromsø – The Arctic University of Norway  |
| <b>Noel Keenlyside</b>              | M | University of Bergen, Norway  |
| <b>Dr Shuting Yang</b>              | F | Danish Meteorological Institute, Denmark  |
| Dr Bo Christiansen                  | M | Danish Meteorological Institute, Denmark  |
| Dr. Tian Tian                       | F | Danish Meteorological Institute, Denmark  |
| <b>Dr Marianne Helene Rasmussen</b> | F | The Research Center in Husavik, University of Iceland   |
| PhD Candidate Olli Loisa            | M | The Research Center in Husavik, University of Iceland   |
| <b>Dr Brynhildur Daviðsdóttir</b>   | F | Institute of Sustainability Studies, University of Iceland  |
| Dr David Cook                       | M | Institute of Sustainability Studies, University of Iceland  |
| Dr Helga Ögmundardóttir             | M | Department of Anthropology, University of Iceland   |
| PhD Candidate Laura Malinauskaite   | F | Environment and Natural Resources Programme, University of Iceland  |
| PhD Candidate Marianna Leoni        | F | Department of Geography and Tourism, University of Iceland  |
| <b>Dr Markus Meier</b>              | M | Swedish Meteorological and Hydrological Institute, Sweden   |
| Dr Torben Koenigk                   | M | Swedish Meteorological and Hydrological Institute, Sweden   |
| Dr Mihaela Caian                    | F | Swedish Meteorological and Hydrological Institute, Sweden   |
| Dr Pasha Karami                     | F | Swedish Meteorological and Hydrological Institute, Sweden   |
| Dr Per Pemberton                    | M | Swedish Meteorological and Hydrological Institute, Sweden   |
| Prof. Ke Fan                        | F | Institute of Atmospheric Physics, Chinese Academy of Sciences, China  |
| <b>Prof. Leslie King</b>            | F | School of Environment and Sustainability, Director, Canadian Centre for Environmental Education, Canada       |
| Prof. James R. McGoodwin            | M | University of Colorado, Department of Anthropology and Institute of Arctic and Alpine Research (INSTAAR), USA |

|                       |   |   |
|-----------------------|---|---|
| Prof. Sergey K. Gulev | M | P.P. Shirshov Institute of Oceanology, Russian Academy of Science, Russia |
|-----------------------|---|---|

|  | Number of Persons by Gender |      | Person years in Total by Gender |       | Person years paid by the NCoE by Gender |       |
|--|-----------------------------|------|---------------------------------|-------|---|-------|
|  | Female                      | Male | Female                          | Male  | Female                                  | Male  |
| Professors and associate professors                      | 3                           | 3    | 0                               | 0.3   | 0                                       | 0.16  |
| Senior researchers                                       | 5                           | 4    | 0.9                             | 1.12  | 0.57                                    | 1.02  |
| Postdoctoral researchers                                 | 2                           | 5    | 1.8                             | 1.575 | 0.3                                     | 1.825 |
| Postgraduate students                                    | 1                           | 1    | 0.17                            | .5    | .17                                     | 0     |
| Other academic personnel                                 | 0                           | 2    | 0                               | .05   | 0                                       | .01   |
| Auxiliary personnel (office, technical, other personnel) | 0                           | 0    | 0                               | 0     | 0                                       | .04   |

## 2. PROGRESS AND RESEARCH RESULTS

*Report on the research progress including:*

For details, please refer to Part 1

WP1: An analysis of the sea-ice record for Iceland has resulted in an excellent example of cross-disciplinary research. The sea-ice index is based on an historical reconstruction of the amount of ice sighted from Iceland, measuring the amount of ice in the Greenland Sea. The index covers the period 1600-2000 and is an important and independent source for information of past climate in Europe and the North Atlantic region.

WP2: NERSC and UiB have used the Norwegian Climate Prediction Model that is based on the Norwegian Earth System model and the Ensemble Kalman Filter. Assimilation of sea-ice concentration in NorCPM has been implemented and tested and hindcast predictions have been performed. DMI and SHMI have been working on developing the decadal prediction system of EC-Earth3 using the anomaly initialization method.



The EC-Earth3 is the new generation of the Earth System Model EC-Earth and will be used in the CMIP6 (Coupled Model Intercomparison Project Phase 6).

WP3: Regional ocean and atmosphere models have been prepared for downscaling of the global predictions from WP2 and first test simulations with observed forcing and model forcing have been performed. The global high-resolution version of the coupled EC-Earth model has been tested and a long, coupled simulation has been performed. The model output has been discussed and agreed on with WP4 and WP5

WP4: Anthropological fieldwork in Scoresbysund, Greenland, in August yielded considerable insight into social and ecological change in the community and the seascape of the fjord and surrounding areas, used for hunting and tourism activities.

Ethnographic fieldwork has also been undertaken in in Skjálfandi Bay in the vicinity of Húsavík, Iceland. Here the role of ARCPATH scientists can be to contribute advice, support and knowledge to provide the much-needed legitimacy and credibility that a new management system/structure such as a Marine Protected Area requires. ARCPATH input ranges from cultural perceptions of the region to marine-mammal biology, with the important proviso that sensitivity is used to avoid imposing what many locals could perceive as essentially a foreign and alien idea.

C-PODs (Porpoise detectors) have been deployed (August and September) 2017 in Skjálfandi Bay and adjacent Eyjafjörður to record and detect the abundance and presence of both white-beaked dolphins and harbour porpoises in these two bays. The rest of the C-PODS were retrieved and redeployed in November 2017 and the next retrieval and re-deployment has been scheduled for April 2018.

WP5: Using the Arctic island of Grímsey as a case study, it has been shown how fishing culture itself, through the logic of the Individual Transferable Quota (ITQ) system, has become inextricably and irreversibly entwined with national and even global financial institutions and processes, with major impacts on the resilience and viability of Grímsey and other fishing communities in the country.

Research on shipping is providing understanding and untangling of the relationships between risk assessment, perceptions of security and Arctic security (human as well as state) policy. There have been discussions with the Icelandic Coast Guard regarding four distinct student projects that have been formulated, gauging priorities and concerns regarding increased cruise and marine tourism traffic in Icelandic/ Greenlandic waters. Relationships between gender, security and peace in the Arctic are also addressed.

WP6: A synthesis committee has been formed, consisting of work package leaders as well as the management committee. At the ARCPATH annual meeting in Reykjavík in October 2017, researchers and WP leads reported on synthesis insights and findings from their research. Synthesis is an agenda item for all ARCPATH meetings and teleconferences. Substantial output from the synthesis activity will appear during the second half of ARCPATH.

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### 3. RESEARCHER MOBILITY

Please specify research stay abroad as well as visits by foreign researchers. Here mobility is defined as a stay abroad of at least 2 weeks duration.

| Name, gender, job title, organisation        | Site of work                             | Purpose of visit  | Duration of visit | Comments, output of the visit                                      |
|--|--|---|-------------------|--|
| Laura Malinauskaite, F, PhD student, Uol ISS | United Nations Research Institute, Tokyo | Initiating research collaboration   | 4 months          | Research relationships, future collaboration                       |
| Astrid Ogilvie, F, Project Co-leader, SAI    | INSTAAR, Colorado                        | Research collaboration  | 3.5 months        | Research and writing   |
| Marianne H Rasmussen, F, Uol Húsavik         | Univ. S. Denmark                         | Collaboration on different research projects and supervising of Master students | 2.5               | writing on publications together and future research collaboration |

| Number of:                     | Female | Male |
|--------------------------------|--------|------|
| Visiting months by gender      | 7.75   |      |
| Visiting researchers by gender | 3      |      |

## 4. RESEARCHER TRAINING AND EDUCATION

Please list courses organized. Specify the number of students participating (own students, from other NCoEs, and other students) and number of ECTS points gained in the courses. Also, the number of PhD and Post Docs, both national and international is asked for.

| Course (name of course, institution, person responsible) | Own Students | Students from other NCoEs | Other students | Number of ECTS points |
|--|--------------|---------------------------|----------------|-----------------------|
|  |              |                           |                |                       |

|  | Female | Male | Female | Male | Female | Male | Female | Male |
|--|--------|------|--------|------|--------|------|--------|------|
| Marine Mammal field course (University of Iceland, Marianne Rasmussen) | 1      | 0    | 0      | 0    | 14     | 4    | 90     | 24   |

**How many PhDs and Post Docs are recruited nationally and how many are recruited internationally?**

|  | Female | Male |
|--|--------|------|
| Number of PhD students recruited nationally      | 0      | 0    |
| Number of PhD students recruited internationally | 1      | 1    |
| Number of Post Docs recruited nationally         | 0      | 1    |
| Number of Post Docs recruited internationally    | 0      | 2    |

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

|                               | Female | Male |
|-------------------------------|--------|------|
| Number of PhD degree achieved | 0      | 0    |

*Give a short description of any cooperation on research education and training, in particular cooperation between NCoEs within the TRI programme.*

ARCPATH has recruited two graduate students at the PhD level in Iceland. One at UoI and one at HRC. Post Doctoral candidates have also been recruited: one at UoI, two at NERSC and at UiB and two at SMHI. SAI is in the process of employing one Post Doc. All these efforts will help to strengthen the Nordic region's position within educational research in Europe. ARCPATH will organise two summer schools, one in 2018 in Norheimsund, Norway and one in 2019 in Iceland. ARCPATH will also be active in other summer schools e.g., the biennial Nansen-Zhu Summer School, and a unique graduate course in Human Ecology and Environmental Change in Iceland in August 2018 see <http://scn.akademia.is/>. ARCPATH is also collaborating with *Arctic Youth and Sustainable Futures* (led by non ARCPATH SAI members). This project investigates and conducts research on the needs, opportunities and aspirations of Arctic youth, to fill an identified gap in knowledge on the lives, ambitions, needs and challenges of youth – indigenous and non-indigenous – across the circumpolar Arctic. In cooperation with the CRESCENDO schools network (organized by the EU-H2020 project CRESCENDO): SMHI is engaged in a programme to strengthen knowledge on climate and climate change in schools: two ARCPATH-lectures have been given by Torben Koenigk to school classes (Kunskaps gymnasiet Norrköping) on Arctic climate and ocean circulation. Astrid Ogilvie was an invited lecturer for a graduate course on *Iceland and Greenland: Climate Change and the Arctic* organised by the

School for International Training (<http://studyabroad.sit.edu/programs/semester/fall-2017/icc/>) held in Akureyri and presented a total of 5 lectures on ARCPATH-related topics.

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ARCPATH research is of great educational relevance in the Nordic countries, both because of the global significance of its Arctic research, and also because of its novel approach and focus that aims at providing policy relevant and robust knowledge that will directly benefit Arctic residents. Through the training of young scientists, ARCPATH will help secure the long-term capacity in this field in the Nordic regions.

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## 5. MEETINGS AND NETWORKING

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

A prestigious stakeholder event was the panel presented to the Arctic Circle conference held in Reykjavík in October 2018. The Arctic Circle meeting has become a highly acclaimed annual event drawing some 2,000 international delegates including politicians, business people, scientists, members of the public and other stakeholders. The focus included various aspects of ARCPATH and GREENICE research. Speakers were: Noel Keenlyside, Níels Einarsson, Astrid Ogilvie, Marianne Rasmussen, Leslie King, and Elizabeth Ogilvie, who presented her film “Out of Ice”. The Moderator was Brynhildur Daviðsdóttir.

The annual meeting of ARCPATH was held in Reykjavík 16-18 October 2017 (in conjunction with the final meeting of the project “Impacts of Future Sea-Ice and Snow-Cover Changes on Climate, Green Growth and Society (GREENICE)” where presentations were made by both natural and social scientists with a specific emphasis on making their perspectives intelligible to each other.

The transatlantic MPA network meeting was held in Húsavík in October, where both Marianne Rasmussen and Níels Einarsson participated. This is an EU-funded network (<https://transatlanticmpanetwork.eu/>).

Many presentations have been given to international conferences. To give a few examples: Astrid Ogilvie gave an invited outreach presentation to the Denver Museum of Nature and Science on “North Atlantic Exploration and Climate” in March 2017. Leslie King, Astrid Ogilvie and Níels Einarsson gave a presentation on ARCPATH research at the Ninth International Congress of Arctic Social Sciences: People and Place (ICASS IX) in Umeå in Sweden in June 2017. Leslie King, Astrid Ogilvie and Níels Einarsson gave an ARCPATH presentation to the University of the Highlands and Islands Archaeology Conference in September 2017 in Orkney, Scotland

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*Number of workshops with invited speakers, conferences and other academic events organised by the NCoE:*

Workshops

1

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|                       |   |
|-----------------------|---|
| Conferences           | 1 |
| Other academic events | 1 |
| <hr/>                 |   |
| Total                 | 3 |
| <hr/>                 |   |

## 6. INFRASTRUCTURE AND DATA POLICY

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

During the second 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.

## 7. GOVERNANCE

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

ARCPATH is led by the Project Leader and Co-Leader. The management group consists of the Project Leader, Co-Leader and four other work-package leaders. Members are drawn from three different Nordic countries (Norway, Sweden and Iceland) and the gender balance is also addressed. The management group is responsible for promoting and facilitating cooperation between the partners in ARCPATH. Where necessary, decisions regarding the Centre will be taken according to a majority vote. An Advisory Board (AB) consisting

of highly-qualified colleagues from both natural and social science disciplines has been set up for ARCPATH. The role of the AB is to provide advice and support to better achieve project goals. The AB consists of: Professor Cecilia Bitz, University of Washington, USA; Dr Burkhardt Rockel, the Helmholtz-Zentrum Geesthacht Institute for Coastal Research; Professor Lawrence C. Hamilton, Professor of Sociology at the University of New Hampshire, USA; and Professor Michael Bravo, Fellow of Downing College, and Senior Lecturer, Department of Geography, University of Cambridge, and Head of the Circumpolar History and Public Policy Research Group at the Scott Polar Research Institute, Cambridge.

## 8. OUTPUT AND DISSEMINATION OF RESEARCH

*Report the output of the research, e.g. publications.*

**Two tables are provided.** The first table is for publications, reports and outreach activities with the main activities/collaboration funded by the NCoE. The second table is for publications, reports and outreach activities 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 main activities/collaboration funded by the NCoE

|  |     |
|--|-----|
| <b>Peer reviewed Publications / of which Open Access</b><br>Kimmritz, M., F. Counillon, C. M. Bitz, F. Massonnet, I. Bethke, and Y. Gao, 2017. Optimising assimilation of sea ice concentration in an Earth system model with a multicategory sea ice model." Submitted to Tellus A.<br>Wang, Yiguo, Noel Keenlyside, Stephanie Gleixner, Panxi Dai, Francois Counillon, Yongqi Gao, and Lea Svendsen. 2017, in preparation. Seasonal prediction skill of Norwegian Climate Prediction Model with initialisation of sea surface temperature].<br>Xie J, Counillon F., Bertino L. 2017. Impact of assimilating the merged product of sea ice thickness from Cryosat-2 and SMOS in the Arctic (in preparation for submission to <i>the Cryosphere</i> ). | 3/3 |
| <b>Non peer-reviewed Publications / of which Open Access</b>   | 0   |
| <b>Reports</b>   | 0   |
| <b>Invited conference presentations</b>  | 0   |
| <b>Conference presentations, oral / poster</b>   | 0   |



|   |   |
|---|---|
| <p><b>Number of appearances in media</b></p> <p>Dr Einarsson appeared in an interview with Icelandic State Television, Channell One, concerning rapid climatic change in the North Atlantic Arctic and impacts on coastal communities on 17 January 2017.</p> <p>He also appeared as the main interviewee in a documentary film "Whales, Science and the Local Community in Húsavík, Iceland" by Miquel Such and John Grothier that was premiered in Barcelona at the inauguration of the Autonomous University of Barcelona Arctic Research Centre, 1. December <a href="http://www.svs.is/static/files/cer-arctic-inauguration-programme-flyer-22.11.17-ne.pdf">http://www.svs.is/static/files/cer-arctic-inauguration-programme-flyer-22.11.17-ne.pdf</a></p> <p>An upcoming television documentary on Arctic coastal communities and impacts of marine resource governance systems with Dr Einarsson as advisor will be made by a New Zealand team in 2018.</p> | 3 |
| <p><b>Outreach and dissemination to the public</b></p>  | 0 |

**Outreach and Dissemination where the NCoE has contributed**

|  |     |
|--|-----|
| <p><b>Peer reviewed Publications / of which Open Access</b></p> <p>Barry, Tom, Hólmgrímur Helgason and Soffía Guðmundsdóttir. 2017. Arctic protected areas in 2017: status and trends, <i>Biodiversity</i>, 18:4, 186-195, DOI: <a href="https://doi.org/10.1080/14888386.2017.1390496">10.1080/14888386.2017.1390496</a><a href="https://www.tandfonline.com/doi/citedby/10.1080/14888386.2017.1390496?scroll=top&amp;needAccess=true">https://www.tandfonline.com/doi/citedby/10.1080/14888386.2017.1390496?scroll=top&amp;needAccess=true</a>.</p> <p>Demarée, G.R. and Ogilvie, A.E.J. 2017. L'eruption du Lakagígur en Islande ou 'Annus Mirabilis 1783' Chronique d'une année extraordinaire (The eruption of Lakagígur in Islande or 'Annus Mirabilis 1783' – Chronicle of an extraordinary year), <i>Sémata, Ciências Sociais e Humanidades</i>, 229: 239-260.</p> <p>Hartman, S., Ogilvie, A.E.J., Ingimundarson, J.H., Dugmore, A.J., Hambrecht, George, McGovern, T.H. 2017. Medieval Iceland, Greenland, and the New Human Condition: A case study in integrated environmental humanities, <i>Global and Planetary Change</i> 156, 123-139, <a href="https://doi.org/10.1016/j.gloplacha.2017.04.007">https://doi.org/10.1016/j.gloplacha.2017.04.007</a></p> <p>Hoogensen-Gjørv, G. 2017a. "Finding Gender in the Arctic: A Call to Intersectionality and Diverse Methods" in <i>The Interconnected Arctic — UArctic Congress 2016</i>. Latola, Kirsti and Hannele Savela (eds). Springer. <a href="https://link.springer.com/chapter/10.1007/978-3-319-57532-2_30">https://link.springer.com/chapter/10.1007/978-3-319-57532-2_30</a></p> <p>Hoogensen-Gjørv, G. (2017b). "Tensions between Environmental, Economic, and Energy Security in the Arctic" in <i>Northern Sustainabilities: Understanding and Addressing Change in a Circumpolar World</i>. Gail Fondahl and Gary Wilson (eds). Cham, Switzerland: Springer International Publishing. <a href="http://www.springer.com/gp/book/9783319461489">http://www.springer.com/gp/book/9783319461489</a></p> <p>Lambert, E., A. Nummelin, P. Pemberton, M. Ilicak, Tracing the imprint of runoff variability on Arctic water mass transformation, under revision in <i>JGR Oceans</i>.</p> <p>Ogilvie, A.E.J. 2017. A Brief Description of Sea Ice. In: Elizabeth Ogilvie, ed., <i>Out of Ice</i>, Black Dog Publishing, London, 88-90.</p> <p>Xie J, Bertino L, Counillon E, Lisæter KA, Sakov P. Quality assessment of the TOPAZ4 reanalysis in the Arctic over the period 1991–2013. <i>Ocean Science</i>. 2017;13.<a href="https://www.nersc.no/biblio/quality-assessment-topaz4-reanalysis-arctic-over-period-1991-2013">https://www.nersc.no/biblio/quality-assessment-topaz4-reanalysis-arctic-over-period-1991-2013</a> <a href="https://www.ocean-sci.net/13/123/2017/">https://www.ocean-sci.net/13/123/2017/</a></p> <p>2018:</p> | 8/6 |
|--|-----|





|   |    |
|---|----|
| Huijbens, E. and Einarsson, N. 2018. Feasting on friends: Whales, puffins and tourism in Iceland. Pp. 10-27 in Appstate, C. (Ed.): Tourism Experiences and Animal Consumption-Contested Values, Morality and Ethics. Routledge Ethics of Tourism Series. ISBN 978-1-138-29161.  |    |
| <b>Non peer-reviewed Publications / of which Open Access</b>  | 0  |
| <b>Reports</b>  | 0  |
| <p><b>Invited conference presentations</b></p> <p>Keenlyside, N. Challenges towards environmentally based ecosystem prediction, Advances in Integrated Ocean Research towards Sustainable Development, Kiel, Germany, 3.7. 2017. <b>Keynote speaker.</b></p> <p>Kimmritz, M., I. Bethke, F. Counillon, P. Dai, H. Langehaug, F. Li, N. Keenlyside, M.-L. Shen, Y. Wang, Climate prediction with the Norwegian model NorCPM, Nansen Zhu annual meeting, Beijing, China. 31 Oct 2017.</p> <p>Kimmritz, M., F. Counillon, C.M. Bitz, F. Massonnet, I. Bethke, Y. Gao, Lecture on optimising the assimilation of sea ice concentration in a fully coupled Earth system model with a multicategory sea ice model, National Marine Environmental Forecasting Center, Beijing, China. 30 Oct 2017</p> <p>Kimmritz, M., Assimilation of sea ice within the Norwegian Climate Prediction Model, Polar Prediction Workshop, Bremerhaven, Germany. 28 Mar 2017. <b>Keynote speaker.</b></p> <p>Ogilvie, A.E.J. 2017. <i>North Atlantic Exploration and Climate</i>. 2 Invited Outreach presentation to Denver Museum of Nature and Science re. exhibit <i>Vikings: Beyond the Legend</i>. 21 February 2017.</p> <p>Ogilvie, A.E.J. 2017. <i>Reconstructing the Past Climate of Iceland Using Documentary Sources</i>. Invited lecture to School for International Training (SIT) Graduate Student Group on: <i>Iceland and Greenland: Climate Change and the Arctic</i>, Akureyri, 9 October 2017.</p> <p>Ogilvie, A.E.J. 2017. <i>Sagas and Science: Documentary Evidence of Changes in Climate and Sea-Ice Incidence in Iceland from the Settlement to the Late 1800s</i>. Invited lecture to the University of Iceland Centre for Medieval Studies (<i>Miðaldastofa</i>), Reykjavík, 9 March 2017.</p> <p>Ogilvie, A.E.J. 2017. <i>Sagas and Science: Reconstructing the Past Climate of Iceland Using Documentary Sources</i>. Invited lecture to School for International Training (SIT) Graduate Student Group on: <i>Iceland and Greenland: Climate Change and the Arctic</i>, Akureyri, 15 March 2017.</p> <p>Ogilvie, A.E.J. 2017. <i>Cross-Disciplinary Investigations of the Long-Term Sustainability of Human Ecodynamic Systems in Northeastern Iceland</i>. Invited lecture to School for International Training (SIT) Graduate Student Group on: <i>Iceland and Greenland: Climate Change and the Arctic</i>, Akureyri, 16 March 2017.</p> <p>Ogilvie, A.E.J. 2017. <i>The ARCPATH Project and Changes in the Arctic</i>. Invited lecture to School for International Training (SIT) Graduate Student Group on: <i>Iceland and Greenland: Climate Change and the Arctic</i>, Akureyri, 17 March 2017.</p> <p>Wang, Yiguo, COST/CLIVAR Workshop on ocean reanalyses and inter-comparisons, Toulouse, France (29-30 June 2017).</p> <p>Wang, Y. International symposium on advances in S2D prediction, Beijing, China (18-20 Sep 2017).</p> <p>Wang, YWang, Y. International coupled data assimilation symposium, Qingdao, China (5-8 Nov 2017).</p> <p>Organisation of Meetings:<br/> 28-29 Sep 2017 Mini-Symposium "Modelling and Simulation of Sea Ice", ENUMATH, 2017, Voss, Norway. (Organised by <b>M. Kimmritz</b> and T. Richter).</p> <p>16-18 October 2017. ARCPATH Annual and GREENICE final meeting, Reykjavik, Iceland. (Organised by <b>Astrid Ogilvie</b>, Niels Einarsson and Brynhildur Daviðsdóttir).</p> | 13 |



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| <p>2018:</p> <p>Koenigk T. Evaluating impacts of Arctic sea ice loss and variation on the northern hemisphere. Arctic Frontiers Science 2018, Tromsø, Norway, 21-26 January 2018. Key note speaker.</p> <p>Kimmritz, M., F. Counillon, C.M. Bitz, F. Massonnet, I. Bethke, Y. Wang, Y. Gao, L. Bertino, N. Keenlyside, Optimised assimilation of sea ice concentration and implications for climate prediction, Workshop on observations and analysis of sea-surface temperature and sea ice for NWP and Climate Applications (ECMWF), Reading, UK. Jan 2018.</p>  |           |
| <p><a href="#">Conference presentations, oral / poster</a></p> <p>ORAL if not stated otherwise</p> <p>Barry, Tom. <i>Policy, research and conservation areas in the Arctic: Relevance for ARCPATH</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017.</p> <p>Hoffman Cheung. <i>Assessing the role of Arctic sea ice changes in future Northern Hemisphere circulation changes</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Christiansen, Bo. <i>Analyses of the Long Historical Time Series of Iceland Sea Ice</i>, ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Cook, D., <i>Ecosystem Services and Marine Mammals in the Arctic - New Research Possibilities</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Einarsson, N. <i>Coastal communities, climate and rapid socioecological change: Reflections on ongoing ARCPATH research</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Einarsson, N. and Ogilvie, A.E.J. 2017. <i>Sea Ice, Climate, and Resource Governance in a Northern Community: The Case of Grímsey Island, Iceland</i>, ARCPATH Annual and GREENICE final meeting, University of Iceland, Reykjavík, Iceland, 17 October 2017.</p> <p>Einarsson, Niels. <i>Sea Changes in North Atlantic Arctic Coastal Communities</i>. ARCPATH Annual and GREENICE final meeting, University of Iceland, Reykjavík, Iceland, 17 October 2017.</p> <p>Gunnarsonm Gunnar Már. <i>Historical Reflections: A Geo-Historical Introduction to Skjálfandi Bay, Iceland and Ittoqqortoormiit, Greenland</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Huijbens, Edward including a 14 March Presentation for the DG Mare CBSS' Expert Group on Maritime Policy (EGMP). Title: Cruise and Marine Tourism in Iceland; 15 March: Meeting with Icelandic Coast Guard security engineer at SAI; Second Joint Arctic SAR Workshop &amp; TTX, Reykjavík 5 &amp; 6 April 2017; 3-4 April: Cruising in Iceland Conference, Ísafjörður. Marine traffic in Iceland, challenges and opportunities.</p> <p>Huijbens, E. <i>Arctic Tourism in the Anthropocene: Relevance for ARCPATH</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Keenlyside, Noel, et al., <i>Impact of Arctic sea ice decline on recently observed climate change: a coordinated multi-model study</i>, JpGU-AGU Joint Meeting 2017, Japan, 24.5.2017.</p> <p>Keenlyside, Noel. <i>Global and Arctic Climate Predictions. Panel on Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH) Arctic Circle Assembly</i>, Harpa, Reykjavík, Iceland, 14 October 2017.</p> <p>Kimmritz, M. and François Counillon. <i>Recent Developments in NorCPM (Norwegian Climate Prediction Model) for Enhancing Arctic Climate Prediction Skill</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017</p> <p>Kimmritz, M., F. Counillon, C.M. Bitz, F. Massonnet, I. Bethke, Y. Gao, <i>Data assimilation of sea ice - investigating key strategies in an Earth system model with a multi-category sea ice model</i>, GOVST-VIII Science Day within the 8th Annual meeting of the GODAE OceanView Science Team, Bergen, Norway. 09 Nov 2017</p> | <p>35</p> |



- Kimmitz, M., F. Counillon, C.M. Bitz, F. Massonnet, I. Bethke, Y. Gao, Data assimilation of sea ice - investigating key strategies in an Earth system model with a multi-category sea ice model, GOVST-VIII Science Day within the 8th Annual meeting of the GODAE OceanView Science Team, Bergen, Norway. 09 Nov 2017.
- King, Leslie. *Interdisciplinary Projects: The Challenge of Synthesis*. Panel on Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH) Arctic Circle Assembly, Harpa, Reykjavík, Iceland, 14 October 2017.
- King, Leslie. ARCPATH - An Interdisciplinary Project: The Challenge of Synthesis. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017
- King, L., Ogilvie, A.E.J. and Einarsson, Niels. 2017. Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH), ICASS IX, Umeå, Sweden, 10 June 2017.
- King, L., Ogilvie, A.E.J. and Einarsson, Niels. 2017. *Pathways to Resilient and Sustainable Northern Societies: Looking to the Past and the Future*, University of the Highlands and Islands Archaeology Institute Archaeology Conference: *Our Islands, Our Past*, Kirkwall, Orkney, 14-17 September 2017.
- Koenigk, T. Impact of Arctic sea ice variations on winter temperature anomalies in northern hemisphere land areas. EGU-2017 General Assembly, Vienna, 26 April 2017.
- Koenigk, T. et al., The impact of Arctic sea ice on climate in lower latitudes. 20-year Rossby Centre, Norrköping, 13 Sep 2017:
- Koenigk, T. et al., Arctic-lower latitude linkages in observations, atmosphere models and coupled models. GREENICE-ARCPATH-meeting, Reykjavik. 16 Oct 2017.
- Malinauskaitė, Laura gave a presentation about ARCPATH and her study subject at the United Nations University's Institute for the Advanced Study of Sustainability (<https://ias.unu.edu/en/>) in Tokyo, which was met with enthusiasm by environmental scientists from around the globe and confirmed the wide-spread interest in the Arctic.
- Oddsþóttir, Embla Eir. *Best Available Technology - The Perception of Risk*. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017
- Ogilvie, A.E.J. 2017. *Documentary Records of Climate Change*, ARCPATH/GREENICE writing workshop, Bergen, 8-11 May 2017.
- Ogilvie, A.E.J., Sigurðardóttir, Ragnhildur, Júlíusson, Árni Daníel, Hreinsson, Viðar and Hicks, Megan. 2017. *Climate, Environment and Adaptation in Northeastern Iceland A.D. 1750 to the Present*. Session 5.3. *Evaluation and Planning for Uncertain Times in a Rapidly Changing Environment*, ICASS IX, Umeå, Sweden, 9 June 2017.
- Ogilvie, A.E.J. and Gao, Yongqi. 2017. Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH), Nordforsk Joint Nordic Initiative on Arctic Research Annual Conference, Umeå, Sweden, 13-14 June 2017.
- Ogilvie, A.E.J. 2017. *Introduction to the ARCPATH and GREENICE Projects: Arctic Climate and Environmental Change and Human Eco-Dynamics*, Panel on Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH) Arctic Circle Assembly, Harpa, Reykjavík, Iceland, 14 October 2017.
- Ogilvie, A.E.J. 2017. *Why Study Past Climates? The Historical Sea-Ice Record from Iceland*, ARCPATH annual meeting, Nordic House, Reykjavík, Iceland, 16 October, 2017.
- Ogilvie, E. *Out of Ice: Sea Ice and Northern Communities*. Panel on Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH) Arctic Circle Assembly, Harpa, Reykjavík, Iceland, 14 October 2017.
- Pemberton, P. *Progress Concerning the Ocean Downscaling Work*. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017.
- Rasmussen, M.. *Climate, Cetaceans, Tourism and Anthropogenic Noise*. Panel on Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH) Arctic Circle Assembly, Harpa, Reykjavík, Iceland, 14 October 2017.

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| <p>Rasmussen, M., Uol. <i>Cetaceans, Climate Changes and Anthropogenic Noise</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017.</p> <p>Willson, M., <i>Gender issues, fisheries governance and community resilience in North Atlantic Arctic coastal communities, with a special focus on Iceland</i>. ARCPATH annual meeting, Reykjavík, Iceland, 16 -18 October, 2017.</p> <p>Yang, Shuting, et al. 2017. Development of the EC-Earth Decadal prediction system in ARCPATH, ARCPATH and GREENICE joint meeting, Reykjavik, Oct. 16-18, 2017.</p> |          |
| <p><b>Number of appearances in media</b></p> <p>2018:</p> <p>1 March 2018: Sveriges Radio: On the potential linkage between Arctic ice loss and cold weather in Sweden. T. Koenigk.</p>  | <p>1</p> |
| <p><b>Outreach and dissemination to the public</b></p> <p>F. Counillon taught at the "Crash Course on Data Assimilation" (June 2017) - Theoretical foundations and advanced applications with focus on ensemble methods, Bergen, Norway.</p> <p>In cooperation with the CRESCENDO schools network (organized by the EU-H2020 project CRESCENDO) Torben Koenigk gave two lectures to school classes (Kunskapsgymnasiet Norrköping) on Arctic climate and ocean circulation.</p>   | <p>2</p> |

*In addition to the scientific achievements, please provide information on possible results that may open opportunities for important industrial, social or cultural dividends.*

This will be reported more in depth in the later stage of the project.

As an example, during the last 2-3 decades Arctic whale watching has grown enormously in popularity among visitors to Iceland and other Arctic and sub-Arctic regions, in line with the ever-increasing numbers of tourists coming to Iceland. Growth in jobs in the tourism industry, not least with regard to whale watching may enhance opportunities for women and make them more likely to stay in their communities. As a recreational and cultural activity, whale watching thus meshes with ecosystem dynamics and can be of great importance for regions struggling to develop and diversify their economy and social conditions.

## 9. 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. Please also provide information on any deviance from original plan and possible budget implications, if any. Finally, describe your Continuation Strategy (new plans for cooperation beyond the funding period).*

WP1 Analysis of historical climate and marine data: Tasks 1.1-1.6. Extended to Month 48.

WP2: Global climate prediction: Tasks 2.1-2.5: decadal hindcast prediction with NorCPM.

WP2: First decadal prediction data available for downscaling (Month 30).

WP3: Arctic climate prediction: Tasks 3.1-3.4.

WP3: First data from global and regional prediction made fully available to WP4-5 (Month 36.)

WP3: regional downscaling of atmosphere and ocean forced by NorCPM.

WP4: Climate, cetaceans, tourism: Tasks 4.1-4.7. (Extended to Month 48).

WP4: Reports on risk assessment and socio-ecological impacts on tourism, cetaceans, and coastal communities in the context of climate change (Month 36).

WP5: Governance, resource use, abrupt climate change: Tasks 5.1-5.7.

WP6: Synthesis. Ongoing, but will be emphasized last half of project duration.

WP7: Marine Mammal summer course, 3-12 June 2018, Húsavík, Iceland.

WP7: Summer school on climate teleconnections and predictions, Norheimsund, Norway, June 30-July 6.

WP7: ARCPATH annual meeting, September 2018.

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## 10. UNIQUE ACHIEVEMENTS AND WHICH SCIENTIFIC CHALLENGES TO BE ADDRESSED

*In your view, what unique achievements have you achieved with the NCoE funding.  
What scientific challenges should be addressed in the near future?*

- High resolution in EC-Earth improves the representation of deep water formation in the Labrador Sea.
- Regional atmosphere and ocean downscaling over the Nordic Seas region provide realistic results.
- Assimilation of sea-ice concentration in the ARCPATH dynamical prediction system efficiently constrains most of the sea ice and near-ocean variability in the Arctic.
- Changes in whale observations around Iceland can be linked to variations of the sea-surface temperature.
- There is a significant research gap in the pluralistic valuation of ecosystem services of cetaceans, yet their importance is likely to be significant to local communities.
- Increasing tourism is putting pressure on the sustainability of seascapes and socioecological systems in Iceland, East Greenland and northern Norway, calling for the design of nimble and adaptive governance arrangements.
- The introduction of market-based fisheries governance systems can be seen as having multiple social and economic externalities in fishing communities, linking local and global financial institutions and processes.
- An analysis of the sea-ice record for Iceland combining historical data and natural science methods has resulted in an excellent example of cross-disciplinary research.

Synthesis is particularly challenging for complex, large-scale inter- and transdisciplinary research projects such as ARCPATH which include different cultures, disciplines, languages, methods, and time-scales. We take a transdisciplinary approach to synthesis, engaging researchers, the public and policy-makers to promote the resilience and sustainability of Arctic communities and to develop new pathways to action

A synthesis committee has been constituted, made up of work package leaders as well as the management committee. Synthesis is an agenda item for all ARCPATH meetings and teleconferences.

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 identify 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.

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## 11. FEEDBACK

*How has the X programme worked (organisation, cooperation etc.) from the point of view of your NCoE? Kindly include your views both on success factors as well as development potential.*

The ARCPATH consortium is extremely grateful for the support from NordForsk for this interdisciplinary, international project that considers pathways to resilient, sustainable societies in the context of climate and socio-economic change in the Arctic. To support interdisciplinary research in this way makes NordForsk a unique funding agency in the world. Because of all the many disciplines involved in ARCPATH - from historical climatology to marine biology to climate prediction - the possibilities for development potential are virtually endless.

## 12. STANDARD REPORT FORMAT OF ACADEMIC OUTPUT

**Please refer to Table 8**