ICE-ARC First Periodic Report

Section 1

Publishable Summary

Section 1.1 - Summary description of the project context and the main objectives

Ice, Climate and Economics- Arctic Research on Change (ICE-ARC)

The Arctic has been described as a barometer for the health of the global environment, but over recent decades it has warmed more than any other region. This 'Arctic amplification' of global warming has led to major and quantifiable changes across the region, from the melting of glaciers and ice sheets, to the thawing of permafrost, and the changing of the physical environment in, on, and above the Arctic Ocean. One of the most visible changes has been the reduction of the summer sea ice. Sea ice has declined by over 13% per decade, reducing from around 7 million km^2 in the 1970s to 3.4 million km^2 in 2012 (Figure 1); a reduction of over 50% since the 1970s. The melting on the Arctic sea ice cover has potential wide-reaching consequences for climate, for society, and for the local and the global economy.

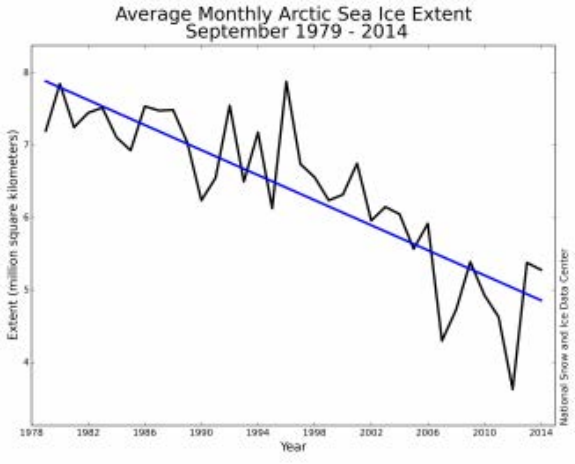

Figure 1. September ice extent for 1979 to 2014 as seen by satellite data. The linear rate of decline for September Arctic ice extent is 13.3% per decade, relative to the 1981 to 2010 average. The ten lowest September ice extents over the satellite record have all occurred in the last ten years. (source: NSIDC http://nsidc.org/arcticseaicenews/2014/10/2014-melt-season-in-review/)

The Arctic region abounds with natural resources, and the potential exploitation of which are providing opportunities for investment, with estimates of $100bn or more coming in to the Arctic region over the next decade. The environmental, socio-economic, and geopolitical consequences associated with the transformations arising from increased global interest in

the region bring opportunities and possibilities, but also potential conflicts and risks for human activities across the Arctic and the globe. Understanding what is driving such unprecedented change in this sensitive environment, and the possible future environmental, socio-economic, and geopolitical consequences, is a significant scientific challenge with major implications. Developing policies to balance the needs of sustainable development in the Arctic with environmental protection is a challenge for the region and wider world.

Assessing the environmental, social, and economic impact of Arctic change

ICE-ARC's international team of leading experts will, for the first time, directly assess the environmental, social, and economic impact of observed and projected climate change in the Arctic. To unravel the multifaceted impact of Arctic change ICE-ARC brings together the multidisciplinary expertise of 23 leading institutions from 11 European Union countries and Russia. This assembly of leading experts from around Europe has the broad expertise required to cover this enormous spectrum of science. This unique and multi-sectorial approach is only achievable through a €12 million programme of research, funded by the European Union.

Our multidisciplinary team will combine new observations of the Arctic atmosphere, ocean, and ecological systems with state-of-the-art climate models, which will improve climate predictions for the Arctic region and beyond. In addition, a physical climate model will be combined with a leading economic Integrated Assessment Model. Through this new approach, the ICE-ARC team will estimate the monetary value of the projected physical changes upon the global economy and society. Together the ICE-ARC team aims to:

① Improve Arctic climate predictions.

② Elucidate the impact Arctic change has on marine ecosystems, as well as understanding how changes in these living marine resources effect human communities.

③ Understand the global economic impact of Arctic marine change.

④ Understand the socioeconomic impact of change in the Arctic marine system and provide effective policy and management options for societal responses to Arctic change.

By addressing these four interlinked objectives effective and achievable policy and management options for societal responses to climate change can be developed. ICE-ARC aims to provide robust scientific information to politicians and policy makers during a period of both heightened commercial investment and activity for the Arctic, as well as accelerated environmental change.

Section 1.2 - Work performed since the beginning of the project and the main results achieved so far

Managing risks arising from changes to the Arctic marine environment poses unique challenges and opportunities for the region, Europe and the world. Risk mitigation requires up-to-date information on emerging threats, which drives the effective development of innovative solutions. Paying attention to early warning signs of physical change is the first step in dealing with emerging threats. The next step is translating these physical changes into quantifiable impacts, and then identifying various policy and management options to mitigate these impacts.

To address these scientific and socio-economic challenges with Arctic change we have structured ICE-ARC around six complementary interlinked Work Packages (WPs), see figure 2. The WP structure is as follows.

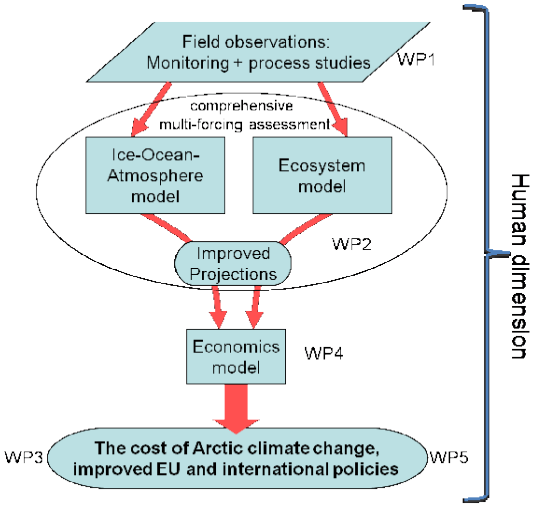

Figure 2. Schematic showing the interlinked nature of the WP structure within ICE-ARC.

- **WP1: Improving observational capabilities and reducing uncertainties.**
  - Lead: Christine Provost (France), Pedro Elosegui (Spain/USA),
- **WP2: Improving modelling capabilities and reducing uncertainties.**
  - Lead: Ingrid Ellingsen (Norway), Rüdiger Gerdes (Germany).
- **WP3: Identifying socio-economic vulnerabilities within Arctic region: Human communities and marine living resources.**
  - Lead: Mark Nuttall (Greenland), Naja Mikkelsen (Denmark)
- **WP4: Modelling socio-economic vulnerabilities and assessing management options arising from Arctic marine change.**
  - Lead: Gail Whiteman (Netherlands), Peter Wadhams (UK)
- **WP5 Dissemination of results: An impact strategy for developing policy and management options.**
  - Lead: Jeremy Wilkinson (UK), Gail Whiteman (The Netherlands, UK)
- **WP6: Project management and coordination**.
  - Lead: Elaina Ford (UK)

We describe below some of the highlights from each work package from the first reporting period.

WP1: Improving observational capabilities and reducing uncertainties.

Highlights: *WP1 has successfully carried out observational campaigns from satellites, aircraft, ice-strengthened ships, and with local hunters. These campaigns have covered the length and breadth of the Arctic. The deployment of a suite of 'robots' has enabled ICE-ARC to have a long-term observational presence in the Arctic, and by doing so it has improved our operational capability and our understanding of the Arctic enormously. Collaboration with other WPs and international Partners has been a particular highlight of this WP.*

WP2: Improving modelling capabilities and reducing uncertainties.

Highlights: *Highlights: Improving the representation of sea ice processes within models, increasing the resolution of models, climate change impacts on Arctic and boreal terrestrial ecosystems, better understanding atmospheric processes, and the development of a book-keeping model, are a few of the many advances made within WP2. This has been achieved by having a strong team and by developing solid relationship with the other WPs, especially with WP1 and WP4.*

WP3: Identifying socio-economic vulnerabilities within Arctic region: Human communities and marine living resources.

Highlights: *Understanding the impact of climate change on local communities requires an understanding of other pressing social, economic, and environmental changes. Our community consultations with Inuit in Greenland have gathered local knowledge and experiences on these topics. Furthermore, sediment cores obtained from the region can identify possible links between past changes in climate and events of human adaptation in NW Greenland.*

WP4: Modelling socio-economic vulnerabilities and assessing management options arising from Arctic marine change.

Highlights: *We have produced an Arctic-ready version of the economic integrated assessment model (IAM) PAGE09. This new version, known as PAGE-ICE, has been updated with the latest IPCC results, a semi-empirical dynamic model for carbon emissions from land permafrost, methane emissions from subsea permafrost, and the latest estimates of sea-level rise. Studies are now underway regarding the assessment of the social and economic impacts of changes to the Arctic marine environment globally. Industry sector vulnerabilities, risks, and opportunities have been explored and two industry sector case studies (global agriculture and regional shipping) have been completed.*

WP5 Dissemination of results: An impact strategy for developing policy and management options.

> ***Highlights:*** *The ICE-ARC website (www.ice-arc.eu) and Twitter account (@ICEARCEU) are portals for information, news, and data. We have built up a dialogue and knowledge exchange with key stakeholders to Arctic change. We have held special Arctic sessions at key events such as our 'standing room only' COP21 event in Paris, COP22, Ilulissat Climate Days, Arctic Circle, and the Arctic Science Summit Week. Seven Arctic info-blogs have been published on the World Economic Forum's website.*

WP6: Project management and coordination.

> ***Highlights:*** *The ICE-ARC project is well on track, and all milestones and deliverables to date have been submitted on time. Interaction between partners and WPs is strong, with good attendance by members at the Kick-Off meeting and first and Second General Assembly Meetings. The Steering Committee meet regularly.*

Section 1.3 - Final results and their potential impacts and use

Understanding the multi-sectorial impacts of change in the Arctic marine environment is extremely complex. It involves a determined and collaborative effort from many physical and social scientific disciplines, as well as engineers, economists, modellers, and satellite specialists. All of these disciplines, which are represented within ICE-ARC, have their own definitions, language, and standpoint when describing Arctic change. The difficultly of bringing these disciplines into one programme should not be underestimated.

Right from the onset the ICE-ARC team placed significant effort on team building, consolidation, and interaction between Work Packages (WPs). As a result there has always been a number internal meetings, teleconferences, and workshops between WPs, as well as internal to a WP. We have found that this team building effort has paid dividends. Internally, the Work Packages are working tremendously well, and the interactions between the different WPs are bearing fruit. At present Deliverables are on track and highlights from each WP can been seen in the previous Section 1.2 - Work performed since the beginning of the project and the main results achieved so far.

Overall, we have had a very successful first and second reporting period, ICE-ARC has 'brand recognition' within the European and international scientific community, and we are making good progress with our communication strategy to other key stakeholders and actors. Importantly ICE-ARC is making great strides in providing robust scientific information on the socio-economic impact and the wider societal implications of Arctic Change to the broad range of Arctic stakeholders. From collaborative research and participatory-based community

research programmes and workshops in NW Greenland, through to solidifying our international links with non-European countries such as Canada, China, Japan, South Korea, and the US, as well as providing high-level information sessions at premier events such as at the Paris COP21 and Ministerial Briefings regarding Arctic change and its impacts.

Interestingly the political momentum behind Climate Change has shifted, in a positive way, during ICE-ARC's lifetime. The Paris Agreement (at the COP21) has now come in to force. This agreement sets out a global action plan to put the world on track to avoid some of the most dangerous aspects of climate change by limiting global warming to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. These strong targets were not set when ICE-ARC started, and as such, we have reflected on this momentum shift in climate change policy and are adapting some of our Deliverables appropriately.

However many people are still not aware of the implications of Arctic change. In order to reach the widest audience possible regarding Arctic change the World Economic Forum's (WEF) Global Agenda Council on Arctic change invited ICE-ARC to deliver a four-part blog series on the WEF's website. Given the reach of the WEF, it is likely that these blogs have been viewed by millions of people right across the world. Following the success of these blogs, WEF invited us to post three more blogs on Arctic Change.

ICE-ARC has now established an effective and efficient dissemination mechanism for the project's results to a wide audience. In addition, we have broadened the knowledge of Arctic change to key stakeholder groups and have engaged in discussions/forums so that policy options and action plans aimed at sustainability and protection of the Arctic marine environment can be developed.