

Evaluation of the Greenland Climate Research Centre

Committee

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INTRODUCTION¹

This report reflects the results of an external review of the Greenland Climate Research Centre by a committee of experts appointed by the Danish Agency for Science, Technology, and Innovation (DASTI) and the Commission for Scientific Research in Greenland (KVUG). As directed, the committee evaluated the quality of GCRC research programs and other activities with reference to the scientific, societal and organizational goals defined for the Centre within four priority areas: nature and environment; society and commerce; technology and infrastructure; and the interaction between the three sectors. After careful consideration, the committee elected to provide a set of recommendations, both as a Greenlandic/Danish institution and as a critical global resource for understanding climate change and its consequences in the coming decades. The committee provides four high level recommendations, which include a resident Director, a clear vision, greater outreach, and more focused use of resources. In addition, the committee provides several other recommendations, all of which it believes are critical to the GCRC's long-term success as a leading climate research center.

Charge to the Committee

The Greenland Climate Research Centre (GCRC), was established in 2009 by the Commission for Scientific Research in Greenland (KVUG), the Greenland Institute of Natural Resources (GINR) and the University of Greenland (Ilisimatusarfik) as a Centre for research on the expected impacts of climate change on Arctic marine, limnic and terrestrial environments, and on Greenlandic society. In 2012, DASTI and KVUG requested an external review of the GCRC. Accordingly, a panel of internationally recognized experts in interdisciplinary climate research was appointed to conduct the evaluation and prepare a report by the end of the Centre's fourth year (1 May 2013). This committee was charged with that task. The purpose of the evaluation is to rate the quality of GCRC activities and preliminary results within the Centre's four priority areas:

- Nature and environment
- Society and commerce
- Technology and infrastructure
- Interaction between the three sectors

¹ Introductory materials adapted from the Terms of Reference (Appendix C) and GCRC Overview provided to the committee by the Danish Agency Science, Technology and Innovation.

As directed, the committee evaluated the quality of GCRC activities and results with reference to the scientific, societal and organizational goals defined for the Centre.

Background of the GCRC

The GCRC consists of a broad network of researchers, support staff and graduate students located primarily in Greenland, Denmark and Canada. The network structure is flexible and in 2012 the GCRC had approximately 80 researchers attached to 24 different projects organized within ten research units focused on areas that include ocean and fjord systems; sea ice; ice sheets and glaciers; terrestrial, marine and limnic ecosystems; weather and climate and societal implications. Figure 1 shows the research funding allocations from 2010 and 2011. In February 2012, a new program began, 'Climate and Society', which addresses climate change issues at the intersection of social science, climate science and public policy that are relevant to Greenlandic society, and to society more broadly. The overwhelming majority of researchers is not resident in Greenland, but resides outside the country and is affiliated with Danish universities and governmental institutions. Indeed, in 2012 the personnel residing in Greenland consisted of seven researchers, including three Ph.D. students.

The GCRC was established by a funding allocation under the Danish National Budget. Funds are administered by DASTI and allocated by KVUG; DKK 73.8m was allocated to run the Centre for a five-year period ending 1 May 2014. KVUG issued an initial letter of grant, followed by seven others that were divided into four categories:

1. Climate research - DKK 38.8 M.
2. Climate Centre operations - DKK 20.0 M
3. Climate Centre management - DKK 5.0 M
4. Social Science professorship - DKK 10.0 M

The funding process for individual projects is similar to that of a traditional funding agency in that GCRC solicits proposals from the scientific community and awards grants based on a competitive, peer reviewed process. The first request for proposals in 2009 resulted in 36 applications that totaled DKK 54.0 M. In 2010, two calls for proposals followed, resulting in 19 applications totaling DKK 15.9 M and 24 applications totaling DKK 18.0 M. Following the solicitation period, the Director and GCRC leadership prioritize the submissions and assemble a summary for review by an outside scientific panel. A scientific jury committee appointed by KVUG, composed of Professor Minik Rosing, Professor Bo Thamdrup and Director Klaus Nygaard, assess and prioritize the applications within the overall funding limit; all decisions should be based on scientific merit. During renewal phases, the Director has a critical role in deciding which funded projects will be renewed at the completion of a funding cycle. During the initial proposal

cycle in 2009, 9 projects were funded; in 2010 the original 9 projects plus 3 new projects were continued/funded; and in 2011, 11 of the 12 existing projects plus an additional 4 projects were continued/funded; one project that was previously funded was not renewed.

GCRC Project	2010	2011
Oceanography (GCRC 6501)	10	10
Land Eco-systems (GCRC 6502)	13	13
Socio-economics (GCRC 6503)	4	3
Climate Models (GCRC 6504)	5	7
Plankton Dynamics (GCRC 6505)	23	23
Atlantic Cod (GCRC 6506)	6	8
Marine Carbon Cycle (GCRC 6507)	9	12
Satellite Observations (GCRC 6508)	10	10
Coastal Glaciers (GCRC 6509)	11	11
Whales (GCRC 6510)		4
Optics (GCRC 6511)		3
Drifting Buoys (GCRC 6512)		4
Intertidal Ecology (GCRC 6513)		
Small Copepods (GCRC 6514)		
Mooring Network (GCRC 6515)		
Winter Moorings (GCRC 6516)		
TOTAL	91	108

Figure 1²: Research projects funded by GCRC, and number of employees in each of the research units. Empty cells are where projects started after 2010 / 2011.

Review Criteria and Information Collection Process

The committee evaluated research and other activities of the Centre based on criteria that were provided as part of the original statement of work. The criteria stated that the Centre should be evaluated in reference to the goals of achieving a high standard of scientific merit, as well as societal and organizational goals, including:

- Make a high-profile, expert contribution focusing on the impacts of climate change in the Arctic,
- Continuously coordinate activities with other research programs,
- Conduct application-oriented and innovative research,
- Make significant contributions to assessment of the influence of climate change on the Arctic marine, limnic and terrestrial environments and on Greenlandic society, including its economy, commerce and technology, and
- Achieve capacity building and a permanent base of support in Greenland.

² Adapted from GCRC Self-Evaluation Report, November 2012, pgs. 11-12.

Data and other information were collected through three primary sources:

1. *Self-evaluation reports* – Leadership, principle investigator's (PI's) representing the ten research units and Ph.D. students provided written reports detailing the strengths and weaknesses of the overall Centre, and analysis of the individual research activities and results achieved within the time since the program(s) was initiated. The KVUG Secretariat drafted preliminary questions; the committee reviewed, edited and provided additional questions to guide preparation of the reports.
2. *Interviews* – The committee conducted in person and remote interviews with the leadership of GCRC, individual PI's of the core research projects, Ph.D. students and other GCRC staff. The interviews provided the committee the opportunity to ask questions to clarify and supplement information that was provided through the self-evaluation reports.
3. *Existing documentation* – The committee reviewed supporting documents on the framework of the GCRC, such as the letter of allocation, funding descriptions, the organization chart, 'vision, mission, goals and strategies' and collaboration agreements. In addition, the committee reviewed scientific reports and publication lists that resulted from individual projects.

This report responds to the charge to the committee to evaluate the activities of the GCRC since its inception in 2009. As indicated above, the committee drew from reports and other materials that were submitted by GCRC leadership and research groups, and conducted face-to-face interviews to complete its investigations. The report is composed of two main sections; the following section provides an overview of the panel's understanding of the GCRC program, including the committees' assessment of the Centre's strengths and weaknesses; the subsequent section is composed of the committee's recommendations to the Centre leadership. Four key recommendations are highlighted, followed by additional recommendations.

PROGRAM OVERVIEW

The physical location of Greenland in the Earth system makes this region one of the most critical and sensitive to changes in climate and its attendant effects on ecology and subarctic society on the planet. Greenland's ice sheet is highly sensitive to climate warming and is currently losing mass, contributing significantly to global sea level rise. The sea-ice surrounding Greenland is experiencing abrupt change, and deep water formation in the surrounding seas is known to have switched on and off in recent decades. Archives of past climate change in coastal western Greenland show abrupt shifts that are correlated with past societal changes. Greenland's ecosystems are subject to accelerating climate change in the face of multiple drivers. Attempts to understand ecosystem response – including the potential for abrupt change due to internal dynamics (e.g. trophic cascades) or rapid external forcing – requires understanding of ecosystem structure. GCRC is in a strong position to advance this structural understanding, taking advantage of their year-round proximity to key ecosystems. In particular, the marine ecosystem of the Godthåbsfjord region provides a central focus to which work on, for example, surrounding glaciers can be connected.

Climate change poses significant social, economic, and political challenges for Greenland. Its cultural engagement with European society is nearly 300 years old and its cultural traditions are much older still. The people of Greenland have always been intensely interested in the changing climate and its significance for their livelihoods, and their well being and resilience have depended on having detailed knowledge of the changing ecological systems. The socio-economic trends towards urbanization and centralization require an environmental research capacity to analyze complex emerging socio-economic challenges. As Greenland pursues its goals of increasing political autonomy and regional integration, developing its own research capacity to understand the relationship between climate, ecology and social economy is taking on greater importance than ever before.

Situated in one of the most important emerging urban centers in the Arctic, the GCRC is in a uniquely strong position to explore the complex social and ecological interactions impacting Nuuk. Although the international science community and media often overlook the ecological setting of Arctic towns and cities, it is crucial for understanding Greenland's future and putting in place well-designed planning procedures. Without the GCRC to undertake a series of long-term, sustained studies, Nuuk would remain relatively unexplored with potentially long lasting negative consequences for health and environments. By contrast, developing close ties with Nuuk's institutions and communities provides a crucial basis for integrated research that addresses the GCRC's four priority areas.

Strengths and Weaknesses

GCRC has the potential to be a leading facility in Arctic and climate research. Most of the researchers are very cognizant of their potential impact in science and societal issues. From interviews and inspection of their records, the committee clearly appreciated that most GCRC researchers can and are taking advantage of the unique environment and geographical location to engage in studies that have implications for our understanding of Arctic systems both locally and globally. Indeed, the Centre, by its very existence, provides a solid foundation to support diverse research through the many resources that are currently in place, including the instrumentation, equipment and facilities necessary to collect and utilize unique datasets. In addition, Centre researchers and staff possess local knowledge that is essential to accessing and working in difficult and remote field locations that not only benefits their own activities but also is critical to the success of international researchers who wish to work in Greenland. Already, many of the Centre's PI's are engaged in research that is contributing to our understanding of important Arctic processes and feedbacks, for example with studies focused on interactions between ice sheet/sea ice dynamics, ecological interactions and climate change.

The publication record of the GCRC thus far is extensive, and clearly shows the quality of science that can be achieved with engaged faculty and students. However, with very few exceptions, the publications are in specialized journals where the readership is largely focused on specific issues in a discipline. The few publications that address climate change in the Arctic from a broad perspective, published for example in *Nature Climate Change*, are not yet of high impact and the direct contribution of GCRC members to the publications are not immediately clear. Regardless, it is reasonable to assume that with a more engaged Director and more extensive communication between investigators, a focus on broad issues and historical data analysis, a more coherent, high profile contribution on the impacts of climate change in the Arctic should emerge. Indeed, this should be a goal for a symposium or a dedicated volume of a high profile journal.

Defining whether a research portfolio is "basic" or "applied" is always fraught with conceptual definitions. There is nothing better to guide "applied" research than a good theory. There is little new theory in the publications from the GCRC to date – and that leads the committee to infer that most of the publications are application oriented, but are they innovative? The committee concludes that the hard-hitting innovative research products (e.g., publications, patents, interactions with industrial partners, etc.) are largely lacking. The GCRC has the potential to develop high quality innovative research on fisheries (e.g., match/mismatch theory in the context of global climate change, recruitment and sustainability), on ice sheet stability and climate feedback, on

thermohaline circulation and the paleo-oceanographic record of the adjacent seaways, on the cultural disruptions on Greenlandic economies and social interactions, and many others. While these are only examples of themes that are “application oriented”, and there are undoubtedly many more, concerted efforts in these areas depends on leadership, communication, and motivation.

The collaborative environment at GCRC has been an essential component of many research projects being undertaken, and is particularly helpful in addressing the cross-disciplinary nature of diverse issues around climate research. By promoting joint research and partnerships, and encouraging research that is interdisciplinary by nature, the Centre has been successful in creating opportunities for researchers in different fields to work together. This has been particularly true in promoting partnerships between researchers in Greenland and Denmark. For example, the GCRC has played a positive role in promoting Danish Arctic Science by facilitating collaborative efforts between terrestrial and aquatic groups that normally work in isolation from each other.

Collaborative work is particularly important to the new ‘Climate and Society’ Program, which seeks to establish links between the natural and social sciences in Greenland. Until recently, the position of Associate Director of the GCRC responsible for organizing and leading the efforts on impacts of climate change on Greenlandic society was unfilled. Although there have been delays in the execution of this program, the committee was pleased that an extremely competent scientist and leader was identified to fill the vacant position, and that under Professor Nuttall’s direction the various efforts in this critical area are finally becoming a key focus for the GCRC. The committee also noted that the fledgling social science efforts have already resulted in communication between social science researchers and policy makers in Greenland. However, without a coherent vision of the GCRC, the gaps between natural and social sciences may not be addressed adequately. This issue is especially critical as commercial interests in mining and other industries that seek to exploit Greenland’s natural resources potentially disrupt Greenlandic society and structure.

Gaining a shared interdisciplinary understanding of climate change processes will be critical for assessing the influence of climate change on Greenlandic society, particularly where its economy, commerce and technology depend on the changing marine, limnic and terrestrial environments. Social science research on the impacts of Arctic climate change has developed significantly in recent years. Nevertheless more research is required to assess the impacts of climate change for Greenland’s social-economic future. Traditional distinctions between urban and rural environments may need to be rethought to face up to the challenges posed by climate change. Integrated methods will be required to assess how climate change alters the perceptions and calculation of risk in relation to

non-renewable resource extraction. Investigating how the Greenlandic public understands the changing environment will also be valuable for establishing responsive evidence-based health policies. In summary a social research program is required that fully explores relationships between society, environment and technology in order to provide an ongoing evaluation of the multiple dimensions of risk to environment and health.

To maximize the Centre's research potential and opportunities to ensure the long-term viability and success, there are some major weaknesses within the current structure that urgently need to be addressed. First, the GCRC does not appear to have a coherent strategic plan. While there may be intersecting themes in the research program, the researchers often work in relative isolation, and many groups have little or no connections to each other, especially across disciplines. This issue must be remedied. The overall vision has not been clearly articulated and the structure now embodies a diverse suite of programs that often work separately, rather than focus on a central mission.

The lack of a coherent vision appears to be due, in large part, to the lack of a full-time, dedicated Director that focuses on driving the strategic directions of the Centre and distinguishing the ongoing studies and research opportunities to the outside research community and to Greenlandic society. The GCRC needs to be recognized for the research and activities that has grown from the Centre and not confused with outside institutions, such as GINR. By having not as yet distinguished itself as an independent institution, the overall Centre and the researchers engaged in quality science are not receiving the recognition they and the center deserve. The GCRC leadership does not appear to be focused on highlighting the research achievements that have developed out of these programs, which will be essential if the Centre is to distinguish itself as a prominent Arctic Science institution.

Lastly, communication between GCRC leadership and the program PI's and other researchers has been limited, and is hampered by a lack of formal structure and a decision making process that is not transparent. This is partially the result of an overall absence of a culture of scientific sharing of information, which appears to stem from the (lack) of leadership. The lack of communication affects each successive level of operation. There are limited opportunities for people at GCRC who are not directly engaged with each other to interact with other researchers, and the PI's rely on a sole annual meeting, that may or may not be located in Greenland, to formally share the results of their research. This lack of formal and regular communication is also problematic for the younger scientists and Ph.D. students, and has resulted in a lack of mentorship for the people that most need it. Current structures for Ph.D.'s don't seem entirely successful, and at least one student lost GCRC funding when a project was not renewed. The issue can be

partially addressed via increased attention to infrastructure (i.e., videoconferencing capabilities), but mostly it requires leadership.

KEY RECOMMENDATIONS

After careful consideration of the strengths and weaknesses of the GCRC, the committee elected to provide a set of recommendations for the future of the GCRC, both as a Greenlandic/Danish institution and as a critical global resource for understanding climate change and its consequences in coming decades. The committee fully realized that long-term funding for the GCRC is critical and assumed that funding would continue at present or higher levels to help the institution meet its expected goals. To that end, the committee provides four high level recommendations, which, if not accommodated, almost certainly will result in underperformance if not outright failure of the GCRC in coming years.

Recommendation 1: *The GCRC needs a dedicated full-time Director.*

The Director is essential to the success of the GCRC. Whilst a key role will be to engage the wider external community and promote the Centre, the Director should reside in and work primarily from Greenland. The Director must be accessible to the resident GCRC staff and visiting scientists and be involved in day-to-day decisions about the strategic scientific and administrative issues confronting the GCRC.

- The Director should develop a coherent strategic plan with input from the research community and external stakeholders, particularly those in Greenland and Denmark, and including input from political stakeholders and members of Greenlandic society.
- The Director should engage in activities that build relationships with Greenlandic society to ensure the science is relevant to local needs and to develop strong support from local leaders and decision makers.
- The Director should be highly engaged with the activities of resident and visiting scientists.

Recommendation 2: *The program needs a clear vision.*

The committee recommends the development of a focused and prioritized research program, which includes emphasis on social science research and its integration with natural science to form a truly inter-disciplinary research program.

- This plan should identify clear goals of the Centre and not be a vehicle for the requirements of external stakeholders.

- The GCRC should focus on core climate change research in Greenland, such as the fate of the ice sheet and surrounding ocean circulation, sea-ice and atmosphere, which all play a critical role in determining much wider climate change impacts *and* take advantage of Greenland's unique physical systems and ecosystems to address under-studied but important components of this coupled system.
- The intersection between natural and social sciences should be organized across disciplinary boundaries to help provide unvarnished, objective data and analyses for policy makers and Greenlandic society.

Recommendation 3: ***The program needs to become independent and to reach out far more to the international community.***

The GCRC should aim to become an independent Centre recognized for its research in Arctic climate science by 2020.

- The GCRC has the potential to be a strong 'brand' in climate change research. At present the Centre has low visibility and is not clearly distinct from GINR (e.g. on the internet). Outreach and knowledge exchange opportunities should be promoted to raise the profile of the Centre, for example by hosting events with stakeholders.
- PIs should recognize that they are part of the Centre's overall research endeavor, and that the GCRC is the primary institute for all projects funded or facilitated by the Centre. Steps should be taken to identify the GCRC in all research outputs: for example, by being identified on all research publications.

Recommendation 4: ***The program needs resources that make it effective in the long term (i.e. decades).***

To date, the committee feels that the GCRC has invested its resources too broadly, especially in terms of the diversity of natural systems being studied across the projects.

- Lack of funding was identified as limiting many of the PI's ability to consider global issues, create historical records, complete research and analyze data. For example, although there is a Greenland Ecosystem Monitoring program coordinated through Aarhus University, which should be a key focus of the GCRC, the program appears to be limited in its scope of research by lack of resources.

ADDITIONAL RECOMMENDATIONS

Recommendation 5: *A long-term observational program should be established as a central mission for GCRC.*

The program will focus on developing a high quality compilation of historical data, coupled with a long-term monitoring program at key locations both on land and in the ocean. The GCRC should be a “one stop shop” for all key historical data related to climate and natural resources for the region. Although this issue has been articulated in various GCRC documents, the committee could not identify specific personnel dedicated to the task of compiling, verifying, and analyzing historical data related to (e.g.) the physical climate system regionally, fisheries and other natural resources, and social changes over the past century or earlier.

Recommendation 6: *The Director should ensure transparency when making decisions about the funding of projects.*

The basis for all decisions relating to the selection of projects to be funded, extended or discontinued should be based on a transparent evaluation process and formally documented.

- Individual project evaluations should be fully justified according to an explicit set of criteria, and the reasoning behind decisions and recommendations should be formally communicated to senior project investigators.
- A system of appraisals should be introduced that allows senior project investigators the opportunity to provide feedback to Centre leadership.
- Centre leadership should make use of the advice of external reviewers when necessary, for example if additional specialized or technical expertise is required to conduct an informed evaluation, or when important and sensitive decisions need to be made about future funding or termination of a project.

Recommendation 7: *Communication between the Director and Centre leadership, and PI's, students and staff of the GCRC should be strengthened to foster a collaborative research environment.*

This is particularly important for the development of younger scientists, and for the integration of the overall research program.

- The GCRC core team and PI's, researchers and students who are not based in Greenland should commit to participate in a series of regular research seminars, which could be webcast, to bring together geographically separated groups.

- In addition to the annual meeting, which was felt to be insufficient by most project PIs, there needs to be more regular formalized meetings. One option is to meet in person as a whole research Centre twice per year. Another option is to instigate additional meetings for each inter-disciplinary research focus.

Recommendation 8: *External communication and outreach activities should be strengthened to share research outcomes and foster a sense of community between the Centre and Greenlandic society.*

The GCRC should aim to share its sense of community beyond the walls of the institution by seeking ways to communicate the relevance of GCRC's activities and to take opportunities to engage with communities in Nuuk, and where practicable, further afield in Greenland.

Recommendation 9: *Capacity building should become a core component of research activities across the GCRC.*

- The role of Ph.D. students in the program should be re-evaluated in relation to the program's research priorities and to the students' career development. The committee recommends that where practicable, Ph.D. projects should be awarded jointly to a team of supervisors developing and building on links between cognate areas of expertise, and not as part of a grant for a project being overseen by a single senior investigator.
- Mentorship of students and support from their supervisors and institutions needs to become formalized to ensure that students are integrated into the academic community, both within the GCRC and externally in their respective international fields of research. The interdisciplinary projects generated by the GCRC's collaborative research structure should contribute to an inclusive research environment and a sense of community and fellowship amongst Ph.D. students and their supervisors.
- The Director should aim to establish a new Postdoctoral position. In addition to contributing to a well-defined set of research priorities, this position should represent an important opportunity for early career development and leadership. The position should also help to illustrate possible pathways for existing Ph.D. students to move on to postdoctoral research within the GCRC.

APPENDIX A

Committee Biographies

Professor Paul G. Falkowski (*Committee Chair*) is the Bennett Smith Professor in the Department of Earth and Planetary Science and the Business School at Rutgers University and is the Director of the Rutgers Energy Institute. His scientific interests include evolution of the Earth systems, paleoecology, photosynthesis, biophysics, biogeochemical cycles, and symbiosis. Professor Falkowski earned his B.S. and M.Sc. degrees from the City College of the City University of New York and his Ph.D. from the University of British Columbia. After a post-doctoral fellowship at the University of Rhode Island, he joined Brookhaven National Laboratory in 1976 as a scientist in the newly formed Oceanographic Sciences Division. He served as head of the division from 1986 to 1991 and deputy chair in the Department of Applied Science from 1991-1995, responsible for the development and oversight of all environmental science programs. In 1996, he was appointed as the Cecil and Ida Green Distinguished Professor at the University of British Columbia. He moved to Rutgers University in 1998. He received a John Simon Guggenheim Fellowship in 1992; the Huntsman Medal in 1998; the Hutchinson Prize in 2000; the Vernadsky medal from the European Geosciences Union in 2007, the Ecology Institute Prize in 2010 and the Albert 1st Medal in 2011. In 2001, he was elected a Fellow of the American Geophysical Union; in 2002, he was elected to the American Academy of Arts and Sciences; in 2007, he was elected to the United States National Academy of Sciences; and in 2008, he was elected as a Fellow of the American Academy of Microbiology.

Professor Michael T. Bravo is a Fellow of Downing College and Head of the Circumpolar History and Public Policy Research Group at the Scott Polar Research Institute, at the Department of Geography, University of Cambridge. He has published widely around research problems in the history and philosophy of science relating to the history of fieldwork experiments, the reliability of instruments and data, and scientific networks. More broadly he also published extensively on environmental history, cross-cultural encounters, anthropology, and postcolonialism. He earned his B.Eng. in electrical engineering from Carleton University (1985) and his M.Phil. (1986) and Ph.D. degrees (1992) from Cambridge in the history and philosophy of science. After holding a British Academy post-doctoral research fellowship (1993-35), he took up a University Research Fellowship at Manchester University (1995-2000) to develop the use of ethnographic methods in the study of science and technology. In 2000, he was appointed to a University Lectureship at the University of Cambridge and was promoted in 2008 to a Senior Lectureship. He is now Head of the Circumpolar History and Public Policy Research Group at the Scott Polar Research Institute, University of Cambridge. He has held visiting fellowship and professorships at the Huntingdon Library, Pomona College,

the Institute for Advanced Studies in Copenhagen, and the University of Tromsø. He has acted in expert advisory roles to many international organizations including the Carnegie Endowment for International Peace and the Canadian Council of Academies. His published work includes *Narrating the Arctic* (2002) and *Arctic Geopolitics and Autonomy* (2011) as well as many scholarly peer-reviewed articles.

Professor Tim Lenton is Professor of Earth System Science and Professor of Climate Change at the University of Exeter. His research focuses on understanding the behavior of the Earth as a whole system, especially through the development and use of Earth system models. He is particularly interested in how life has reshaped the planet in the past, and what lessons we can draw from this as we proceed to reshape the planet now – as detailed in his book with Andrew Watson on the ‘Revolutions that made the Earth’ (OUP, 2011). Tim’s work identifying the tipping elements in the climate system won the Times Higher Education Award for Research Project of the Year 2008. He has also received a Philip Leverhulme Prize 2004, a European Geosciences Union Outstanding Young Scientist Award 2006, the British Association Charles Lyell Award Lecture 2006, and the Geological Society of London William Smith Fund 2008.

Professor Nicholas J.P. Owens is the Director of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) based in Plymouth and Professor of Ocean Science at the University of Plymouth. He is also a non-executive director of the Centre for Environment, Fisheries and Aquaculture Science, an executive agency of Defra. Professor Owens trained as a marine biologist and received a BSc from the University of Liverpool and a PhD from the University of Dundee. He first worked at the Plymouth Marine Laboratory where he carried out fundamental research primarily in the field of marine plankton and the links with the cycling of nitrogen and carbon. During this time he spent over three years at sea in research ships, large and small, in seas and oceans relatively near to home - the North Sea, Irish Sea and Western Approaches – to further afield including the Indian Ocean and Antarctic Ocean. In all Professor Owens has published over 100 research articles and papers in the learned literature. In 1993, Professor Owens was appointed Professor of Marine Science at the University of Newcastle before returning to the Plymouth Marine Laboratory, in 2000, as its Director. In 2007 Professor Owens became the Director of the British Antarctic Survey during which time he visited all parts of the White Continent as well as the High Arctic. In August of this year Professor Owens became the Director of SAHFOS, an organization which has been monitoring the health of the oceans for over 80 years through research on the plankton: through this move Professor Owens has returned to his first professional love – the plankton.

Secretary

Sherrie Forrest is a Program Officer at the National Research Council (NRC) of the National Academy of Sciences in the Division on Earth and Life Studies. Her current work is with the Disasters Roundtable, which brings together U.S. federal agencies, the private sector and experts in the fields of science, engineering, and other disciplines related to hazards to explore issues around how to mitigate and respond to natural and man-made disasters through advancements in policy, science, technology and research. Previously, she worked with the Board on Science Education and the Ocean Studies Board on projects that include the Roundtable on Climate Change Education, the Conceptual Framework for New Science Education Standards, and the Effects of the Deepwater Horizon Mississippi Canyon-252 Oil Spill on Ecosystem Services in the Gulf of Mexico. Ms. Forrest obtained a M.S. in biological oceanography from the Institute of Marine and Coastal Sciences at Rutgers University and a B.A. in English from Pepperdine University.

APPENDIX B

GCRC Meeting Agenda

Greenland Climate Research Centre Evaluation
GCRC Interview Agenda
Copenhagen, Denmark
November 27, 2012

Interviews

- 10:00-11:00 AM** **Soren Rysgaard**, Professor, Head of GCRC, Internal Staff
Torben Rojle Christensen, Professor, Vice Head of GCRC,
Internal Staff
Peter Schmidt Mikkelsen, Deputy Head, GCRC, Internal Staff
- 11:00-11:20** **Project 6501: Andre Visser**, Associate Professor, External Staff,
National Institute of Aquatic Resources, Technical University of
Denmark (DTU – AQUA), Physical Oceanography, Oceanography
and Marine Ecology Dept., *Physical oceanography in Greenland
waters under climate change*
- 11:20-11:40** **Project 6502: Erik Jeppesen**, Professor, External Staff, Dept. of
Bioscience, Freshwater Ecology, Aarhus University, *Climate
effects on land-based ecosystems and their living resources in
Greenland*
- 11:40-12:00 PM** **Project 6504: Jens Hesselbjerg Christensen**, External Staff,
Scientific Head, Danish Climate Center Danish Meteorological
Institute, *Climate simulations*
- 12:30-12:50** **Jesper Raakjaer** (social science project), External Staff,
Innovative Fishery Mgmt. (IFM), Marine Governance and Coastal
Policy, Professor and Head of Center, Aalborg University, *The
West Greenland marine ecosystem and climate change – The
socio-economic adaptation and governance challenges for
fisheries management*

- 12:50-1:10** **Project 6505: Einar Eg Nielsen**, External Staff, Professor, Section for Population Ecology and Genetics, National Institute of Aquatic Resources, Technical University of Denmark (DTU-Aqua), *The Atlantic cod (*Gadus morhua*) in Greenlandic waters; past and future under climate change*
- 1:10-1:30** **Project 6506: Torkel Gissel Nielsen** (skype), External Staff, Professor, environmental plankton ecology, Section for Marine Ecology and Climate, National Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark (since 2009), *Arctic plankton dynamic - in a changing climate*
- 1:30-1:50** **Project 6507: Ronnie Glud**, Internal Staff, Professor at University of Southern Denmark, *Marine arctic carbon cycle and consequences of climate changes and sea-ice coverage*
- 1:50-2:10** **Project 6508: Leif Tudal**, External Staff, senior researcher, Danish Meteorological Institute, *Satellite surveillance of Greenland Waters*
- 2:40-3:00** **Project 6509: Dorte Dahl Jensen**, Professor, Niels Bohr Institute, University of Copenhagen, *Coastal Glaciers*
- 3:00-3:20** **Project 6511: Colin Stedmon**, Senior Scientist, External Staff, National Institute of Aquatic Resources, Technical University of Denmark (DTU – AQUA), Marine biogeochemistry and optics, *Physical oceanography in Greenland waters under climate change*
- 3:20-3:40** **Project 6510: Malene Simon** (video), Senior Scientist, internal staff, marine mammals, *Baleen whales*
- 3:40-4:20** **Project 6513: Martin Blicher** (video link), Senior Scientist, internal staff, *Internal ecology in West Greenland*
Project 6514: Kristine Arend Scientist, internal staff, zooplankton ecology, *Small copepods*
Project 6515: John Mortensen, Scientist, internal staff, oceanography, *Mooring network*

4:20-4:40

Project 6002: Mark Nuttall (video link), Professor, Head of Climate and Society, Internal Staff

4:40-5:00

Buoys

Project 6512: Peter Winsor (video), Martin Truffer *Drifting*

5:00-5:20

Project 6516: Kunuk Lennert, Program coordinator/PhD student, internal staff, marine ecology *Winter moorings at Kangarsuneq*

APPENDIX C

Terms of Reference

Evaluation of Greenland Climate Research Centre (GCRC)

Background

The Greenland Climate Research Centre (GCRC) is concerned with the expected impacts of climate change on Arctic marine, limnic and terrestrial environments and on Greenlandic society, including adaptation and prevention strategies.

GCRC was established in 2009 by a funding allocation under the Danish National Budget and was realized jointly by the Commission for Scientific Research in Greenland (KVUG), the Greenland Institute of Natural Resources and Ilisimatusarfik - University of Greenland. The Centre is located at the Greenland Institute of Natural Resources in Nuuk. A total of DKK 73.8m has been allocated from the 2009-2012 Globalization Fund³ to run the Centre for a five-year period ending 1 May 2014. KVUG is responsible for allocating the funding within frameworks set out in a letter of allocation from the Danish Agency for Science, Technology and Innovation (FI) to KVUG in 2009.

GCRC activities involve a large number of Greenlandic and Danish researchers, in addition to researchers from other countries. The Centre currently has seven researchers on its staff, including three PhD students and around 80 researchers attached to 24 different projects organized under 10 different research units.

The letter of allocation from FI to KVUG requires an independent center-evaluation to have been conducted by the end of the Centre's fourth year (1 May 2013).

Taking into account the fact that the GCRC has existed for only a few years, the evaluation will be preliminary in nature and concern the Centre's activities and results to date.

Purpose, target audience and application

The purpose of the evaluation is to rate the quality of GCRC activities and preliminary results within the Centre's four priority areas:

- Nature and environment
- Society and commerce
- Technology and infrastructure
- Interaction between the three sectors

³ 2009: DKK 19.6m, 2010: DKK 14.8m, 2011: DKK 19.7m, 2012: DKK 19.7m.

The quality of GCRC activities and results will be evaluated with reference to the scientific, societal and organizational goals defined for the Centre.

The target audience for the evaluation is primarily the political system, including Greenlandic and Danish politicians and authorities, which will be able to use the evaluation in determining whether the Centre has met the defined goals.

Delimitation of the evaluand

The evaluand will comprise the GCRC and the activities carried out under the auspices of the Centre from its establishment in May 2009 onwards. The evaluation will comprise all activities financed by the grant awarded to the Centre.

Evaluation criteria

The evaluation will rate the quality of GCRC activities and results within the Centre's four priority areas; cf. the purpose and letter of allocation. In addition, the evaluation will assess whether the GCRC organization supports attainment of the goals for the Centre.

The goals set out in the letter of allocation are primarily informed by a scientific perspective, but, as mentioned above, the wider goals embody a societal perspective and an organizational perspective in that the Centre is required to:

- make a high profile, expert contribution focusing on the impacts of climate change in the Arctic
- continuously coordinate its activities with other research programmes
- conduct application-oriented and innovative research
- make significant contributions to assessment of the influence of climate change on the Arctic marine, limnic and terrestrial environments and on Greenlandic society, including its economy, commerce and technology
- achieve capacity building and a permanent base of support in Greenland

The following indicators, may, where feasible, be included in evaluation of goal attainment:

- Publications and citations
- Establishment of research infrastructure
- Establishment of social science and natural science research environments in Greenland
- Research training and qualification (e.g. PhD degrees)
- Recruitment of internationally recognized researchers for projects carried out under the auspices of the Centre

- Formalized international research collaboration and research networks (e.g. joint publishing, joint research and funding applications and joint conference hosting)
- Success in attracting external financing
- Consultancy and projects commissioned by public authorities (e.g. articles and scientific reports)
- Participation in commissions and boards
- Research management
- Contribution to education and teaching (e.g. teaching programmes and text books and compendiums)
- Dissemination (e.g. books and features and other publicity to promote research)

Organization

KVUG appoints an independent international peer review panel, which is responsible for conducting the evaluation, including the preparation of an evaluation report. The panel will be composed of internationally recognized researchers in Arctic or Antarctic climate research and cover the Centre's four priority areas: nature and environment, society and commerce, technology and infrastructure and interaction between the three sectors.

The members of the panel are required to have substantial practical experience of research management. The panel is to be composed of up to 3 members and a chairperson. To assist the panel in data collection and preparation of the evaluation report, an independent secretary, e.g. a PhD student, will be appointed.

The KVUG secretariat drafts a set of guidelines for the self-evaluation. In addition, the KVUG secretariat may, by arrangement with the chairperson, assist in quality-assuring the data collection and the preparation of background reports. Finally, the KVUG secretariat may assist the panel with the practicalities of the evaluation such as travel planning and arranging interviews.

Data collection methods

Data will be collected by two methods. Firstly, GCRC is required to perform a self-evaluation. Secondly, the panel will conduct qualitative interviews with Centre Management and a selection of the researchers attached to the Centre. In addition, the evaluation must include existing documentation.

Self-evaluation

The purpose of the self-evaluation is to furnish the panel with the Centre's own description of strengths and weaknesses, including an analysis of the research activities

and results achieved. The panel is also required to use the self-evaluation as a basis for the qualitative interviews.

The self-evaluation will consist of two parts. One part will be completed by Centre Management, the scientific staff, including PhD students, Centre Administration and the Director of the Greenland Institute of Natural Resources. The second part will be completed by the ten research units that have projects funded by the Greenland Climate Research Centre (AAU Innovative Fisheries Management; Centre for Ocean and Ice and Danish Climate Centre (both Danish Meteorological Institute); Dept. of Arctic Environment, Dept. of Marine Ecology, and Dept. of Atmospheric Environment (all National Environmental Research Institute, Aarhus University); DTU Aqua - National Institute of Aquatic Resources (Technical University of Denmark); Ilisimatusarfik - University of Greenland; Niels Bohr Institute (University of Copenhagen); and Institute of Biology, University of Southern Denmark). The responses from the research units are to be drawn up by the management of those units.

The self-evaluation will be prepared on the basis of a set of guidelines prepared by the panel based, in turn, on a draft from the KVUG Secretariat. Centre Management at GCRC is responsible for consolidating the responses from the ten Centre units.

Qualitative interviews

The panel interview with GCRC serves several purposes: first, it is an opportunity for the panel to obtain validation of and supplementary information on the contents of the self-evaluation report, and second, it allows the panel to test the validity of its preliminary assessments following its review of the self-evaluation report and other documentation.

Interviews will be conducted with Centre Management, the scientific staff, including PhD students, the Director of the Greenland Institute of Natural Resources, and with the ten research units. The interviews with the research units may be conducted by telephone, as appropriate. Interviews will be based on an interview guide produced by the panel.

Existing documentation

In addition, the evaluation will consult existing documentation concerning the frameworks for the Centre, its activities and organization, including the following:

- Letter of allocation from FI
- Funding descriptions
- GCRC programme of activities
- Organization chart

- Vision, mission, goals and strategies
- Collaboration agreements between GCRC and projects
- Scientific reports from GCRC to KVUG
- Scientific reports from the projects to GCRC
- Publication lists

GCRC is responsible for procuring an English version of the materials, jointly with the KVUG Secretariat.

Final report

The evaluation will result in a written report in English of no more than 50 pages. The report is to contain a description and analysis of data, the panel's evaluations, together with a summary in Danish suitable for publication.