

Queen Margrethe's and Vigdís Finnbogadóttir's Interdisciplinary Research Centre on Ocean, Climate, and Society (ROCS) funded by the Carlsberg Foundation and the Republic of Iceland

Aim:

The aim of this trans-disciplinary centre is to quantify and analyse the historical relationships between ecosystem structure and climate development in marine and terrestrial environments on and near Iceland. This will enable a new understanding of how the Icelandic population has been impacted by (and has responded to) changes in ecosystem services caused by climate change as well as how this change has been recognised in the society and, conversely, how human interference has impacted ecosystems around them. Through the double vision, the centre will provide both ground-breaking new natural science understanding of the interaction between the climate and the biosphere and examine the how these interactions influence human (as interpreted through the humanities and social sciences)-biosphere interactions. This will make a major contribution to the growing discipline of Earth System science¹.

Justification:

As a relatively isolated island in the North Atlantic, Iceland represents an ideal “laboratory” for studying how climate change signals are translated directly into Earth System functioning through the ocean. This signal reverberates through the ocean biosphere as well as in the realised climate conditions on nearby land, directly affecting the biosphere in Iceland. Humanity in general is directly dependent on the biosphere and its associated services. This will be shown in depth through the case of Iceland, where there are excellent historical records covering the ~1200 years (or more) that Iceland has been inhabited. Thus, Iceland provides a unique arena for studies in social sciences and humanities aimed at elucidating the climate change effects on society that propagate through changes in the biosphere.

Research Strategy:

NB: The details of the studies to be carried out will be worked out in cooperation by relevant research teams in Iceland and Denmark as well as the successful post-doctoral applicants. Post-doc applications are invited in all three areas of research described below:

1. Using ancient molecular proxies to unravel climate-people interactions in Iceland

The Centre will take advantage of recent advanced in molecular genetic research methodology (*ancient DNA*) that, for the first time, provides the ability to describe the historical development of the biosphere (all living organisms). Thus, it becomes possible to describe not only the distribution of iconic species (that preserve well in the fossil record) but also the ecosystem structure. Until now, it has not been

¹ Steffen, W. et al. 2020, [The emergence and evolution of Earth System Science](#) *Nature Reviews. Earth & Environment*. 1: 54-63.

possible to describe the interactions between climate conditions and biosphere function. Yet, recent advancements in the paleo-sciences, particularly ancient molecular proxies (DNA and proteins), have made it possible to reconstruct ancient ecosystem-climate interactions and to address the question of how climate change influences ecosystems and, in turn, how the climate signal appearing in ecosystems propagates to human societies. In this centre, analysis of eDNA in both ocean and lake sediment cores will be applied to describe characteristics of the relationship between climate and ecosystem structure through time. The establishment of this natural science framework will then provide a unique opportunity for applying the humanities and social sciences to interpret human societal responses and adaptations to climate change.

Ocean cores provide the possibility to describe past ocean ecosystem structures potentially over the last 500,000 years. Research at the centre will focus on tracking the ecosystem development back to the last interglacial, i.e. before the last ice age (ca. 123,000 years ago) as this would give the opportunity to relate ecosystem characteristics to a broad range of climate conditions. It would also give the opportunity to address a number of fundamental biological questions (i.e. do the same species dominate in this interglacial as in the last? Does the structure of planktonic ecosystems control fisheries production and the ability of the ocean to sequester carbon? etc.). The red vertical arrow placed beside the ocean sediment cores in Figure 1 reflects the potential for addressing these fundamental questions in the ocean cores.

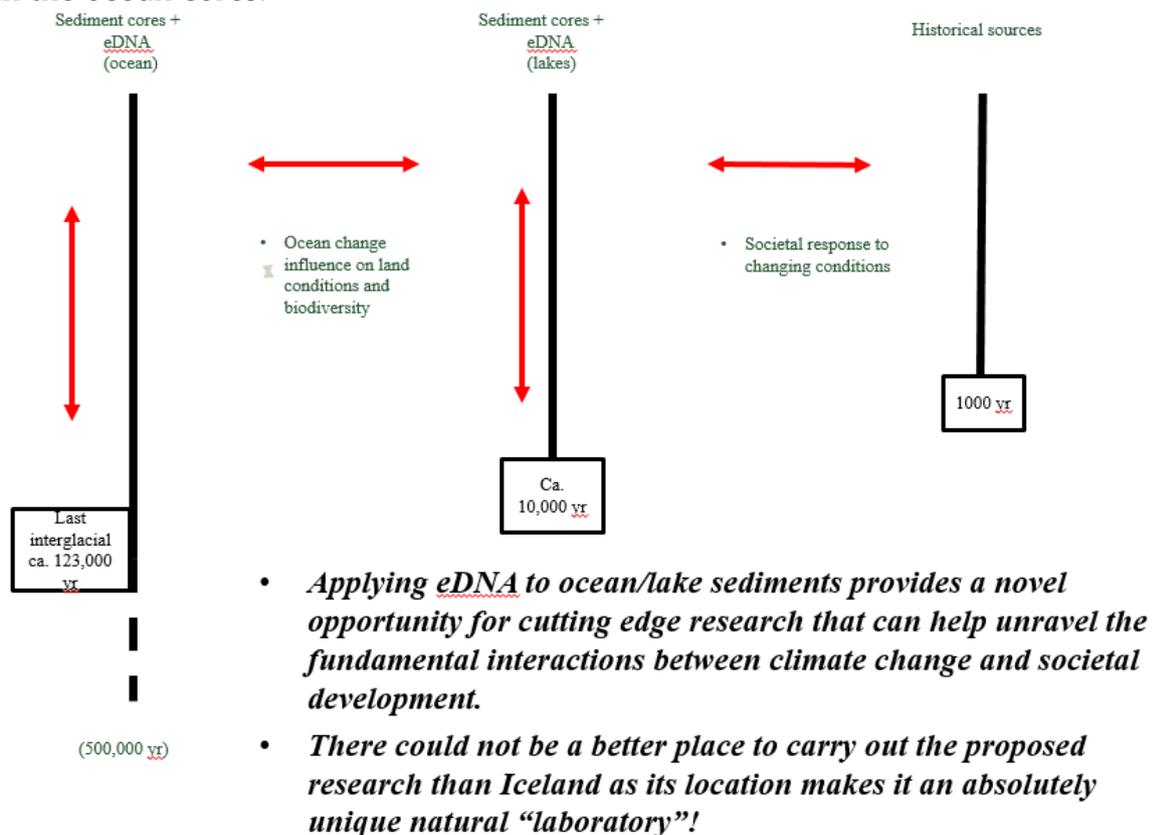


Figure 1: Strategy for elucidating historical ocean climate- biosphere - societal interactions

E-DNA from lake cores will allow us to understand the pristine environment that the first settlers met when they arrived in Iceland around 872 AD and how human activities have influenced the surrounding ecosystems over time. While pollen studies have addressed changes in plant composition, e-DNA helps us to understand organisms at the community level covering all biota; microbes, invertebrates, birds, mammals, and plants. Importantly, such data provide information not only on biodiversity, but also on possible changes in interactions between organisms. Thus, the vertical red arrow positioned next to the lake cores in Figure 1 indicates the potential for answering fundamental research questions on the basis of these cores alone. Note that dating of cores will be supported by the application of stratigraphic correlation using volcanic tephra layers from eruptions in Iceland, providing markers allowing precise correlation between different cores.

More interesting for this proposal, however, are the horizontal red arrows linking the ocean and the lake cores and the lake cores to human societies. Analyzing the marine and lake cores in parallel will enable us to understand to what degree changes in the ocean have controlled changes on land and responses in human societies. Lake core data can be even more directly related to the development of human societies.

2. Mapping relationships between climate conditions and the marine biosphere in the Anthropocene

The analysis of ocean sediment e-DNA will give us the opportunity to test the hypotheses concerning how the structure of ocean plankton ecosystems impacts both fish distributions/abundance and the ability of the ocean to sequester carbon and, thereby, ameliorate human-caused climate change. Iceland's unique geographic positioning allows robust comparisons between the changes happening presently (the Anthropocene) and during earlier periods of major environmental change examined in the sediment cores. The proximity of warm and cold water masses owing both to the surface Earth cooling noted above and occurring southwest of Iceland as well as the fact that Iceland lies at the confluence of cold Arctic and warm ocean currents provides the opportunity to examine in real-time the effect of temperature on ocean ecosystem structure. Given the importance of fisheries for Iceland, real-time studies of the relationship between climate induced changes in the ocean and the marine biosphere are also included in the centre's research.

3. Understanding the impact of biosphere-mediated climate change on society and culture

The elaboration of both historical and contemporary interactions between climate and ecosystems (including both ocean and land ecosystem services) envisioned in the proposed research will provide a rich ground for research within the humanities and social sciences. It is, in fact, hard to envision an aspect of society that is not potentially impacted by changes in the biosphere in which it is embedded and, conversely, the current perception of the Anthropocene makes it more opportune than ever to study the human impact on the biosphere, big or small, and at its own uneven pace.

Three Post-Doc research grants, each of two-year periods in the fields of the humanities and the social sciences are available. Grant applications should address Iceland as a natural and social laboratory in terms of climate change and human-marine interactions. The case of Iceland is somewhat unique in the sense that generations of travellers and scholars – especially Icelanders and Danes, sometimes in collaboration – have written extensively about human engagement with natural forces and habitats (crafting novels, biographies, and scientific texts), contributing to a variety of fields, including marine science, glaciology, and geology.

The central issues for this part of the program involve human engagement with ocean habitat and the anthropogenic changes of recent times, where the guiding enquiry is to explore various kinds of documentation of changes in human-environmental interaction – through, for example, ethnographic accounts, interviews, statistical studies, archival analyses, and studies of travel accounts, literature, and public culture. Case studies of specific communities that have undergone ecological rise and fall (in particular, the sudden decline of important marine species) provide both a window into Icelandic history and an opportunity to draw upon trans-disciplinary approaches.

Priority will be given to post-doctoral research projects that (1) invite both the crossing of national boundaries (studies involving Icelanders, Danes, and others) and trans-disciplinarity, moving within and across the humanities and the social sciences, on the one hand, and, on the other hand, the natural sciences; programs that (2) address historic environmental evidence from the time of Icelandic settlement (including written accounts) as well as studies of the recent past and the present; and, finally, (3) programs that deal with the current environmental crisis of the so-called Anthropocene, the age of humans, and the challenges of the future, for instance with respect to sustainability, equity, and public health.

In recent decades, life on planet Earth has been refashioned on an unprecedented scale through the expansion of human activities. The period in which it is recognised that humans are impacting Earth conditions at the global/planetary level is referred to as the Anthropocene. The human impacts implied by the term of the Anthropocene, like the traces of earlier epochs in geologic history, are recorded in the earth itself and manifest in a variety of ways. Significantly, the reality of the Anthropocene refuses to accept disciplinary confinement, collapsing natural and social history into one another. Not only have humans become a dictating factor, they have significantly changed the Earth itself. Everything is both natural and human at the same time. The North Atlantic is a telling example. The case of Iceland testifies to some of the complexities of human-environmental engagements and the usefulness, if not necessity, of collaborative efforts, benefitting from the historic importance of literature, the continued fascination with texts, and the small scale of everything Icelandic.

As a result of recent anthropogenic changes, environmental studies are bound to be more trans-disciplinary than ever before. For example, the warming of the Arctic involves the melting of glaciers, rising sea levels, ocean acidification, and changing fish migrations, all of which pose new challenges, if not collapse, for coastal communities and, more broadly, Icelandic culture and society. These are

unprecedented changes and understanding them in their social and environmental details is vital for the future. In studying the human-environmental interactions in Iceland at a time of global warming, attention must be given to the ways in which anthropogenic changes reset the environmental landscape to which Icelanders have to adapt. It now seems, for example, that volcanic eruptions - for centuries a major force of destruction in Iceland - are increasingly triggered by human activities, the spin offs of global warming and glacial melting. Such an interactive perspective is timely and essential in order to address the prospects of the future, the kind of habitat the next generations of Icelanders and other earthlings have to live with.

Post-docs employed in the Centre are all expected to take part in trans-disciplinary activities of the Centre - based both in Denmark and Iceland - engaging in the dissemination of research by planning lecture series, seminars and conferences.