CULTCOAST

CULTCOAST

Cultural Heritage Sites in Coastal Areas. Monitor, Manage and Preserve Sites and Landscapes under Climate Change and Development Pressure

April 2019-March 2023 . Researcher project NFR MILJØFORSK/ RCN environmental research, Project Number: 294314

Vibeke Vandrup Martens, NIKU, project leader

Photo: Russekeila TW/NIKU

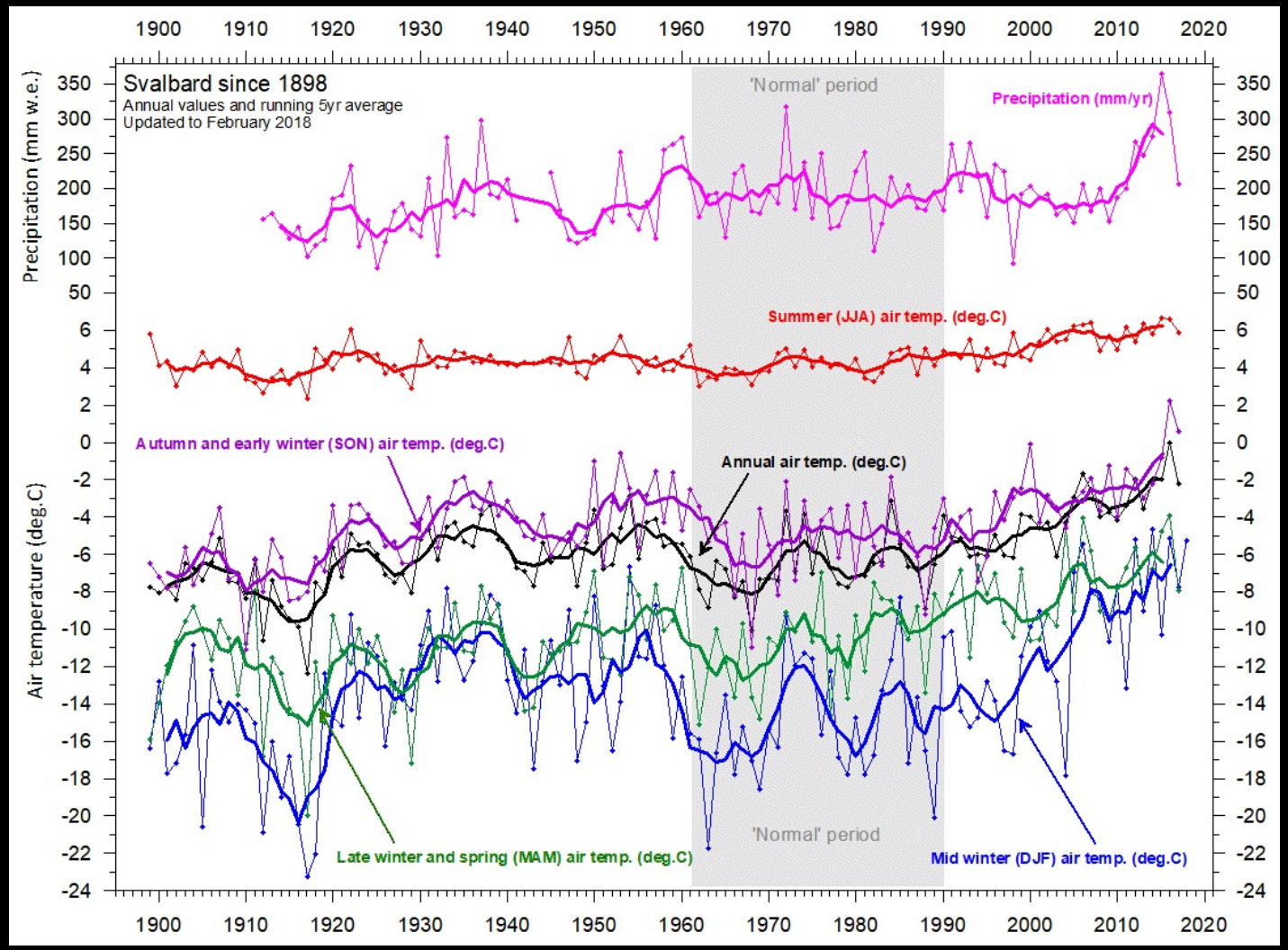
With funding from The Research Council of Norway

NIKU Norwegian Institute for Cultural Heritage Research
NORGES GEOLOGISKE UNDERSØKELSE NGU
USN
SINTEF
University of St Andrews
With funding from The Research Council of Norway

Case sites

- Sites (**Russekeila and Hiorthhamn, Svalbard**; N-W coast of **Andøya, Nordland**) chosen with
  a) heritage remains, archaeology and/or buildings;
  b) existing maps and active geo-hazard processes;
  c) long meteorological data series.

For both Andøya and Svalbard, long observational temperature time series are available, going back to the late 19th Century (1868 for Andøya and 1898 for Svalbard).
The precipitation records for these sites are shorter, but still cover more than 100 years.
This allows for a thorough assessment of temporal variability in temperature and precipitation.



Norwegian Institute for Cultural Heritage Research
With funding from The Research Council of Norway

CULTCOAST consortium.

- PI: Vibeke Vandrup Martens, NIKU. Researcher, PhD, geoarchaeology and Medieval archaeology, environmental monitoring of archaeological sites.
- Co-PI and PhD candidate: Anne-Cathrine Flyen, NIKU. Researcher, architect, preservation and degradation studies, Svalbard.
- Co-PI: Knut Stalsberg, Norway's Geological Survey (NGU). Researcher, PhD, geology, geo-hazards
  - & Lena Rubensdotter, NGU. Researcher, PhD, physical geographer, geo-hazards.
- Co-PI: Hans Renssen, University of South-East Norway, (USN). Professor, PhD, quaternary geology, climate change.
- Co-PI: Cecilie Flyen, SINTEF Community . Researcher, architect, climate change adaptation, stakeholder involvement, citizen science.
- Co-PI: Tom Dawson, University of St Andrews, Scotland, UK . Researcher, PhD, archaeologist, climate change adaptation and public archaeology.
- Co-PI: Ionuț Cristi Nicu, NIKU / Kazan Federal University, Russia / Flinders University, Australia. Researcher, adjunct lecturer, PhD, geographer, geo-hazards, GIS.

Photo: Rusty fuel barrels from airships headed for the North Pole 1896-97. Virgohamna at Svalbard, ACF/NIKU


Vibeke


Anne-Cathrine


Knut


Lena


Hans


Cecilie

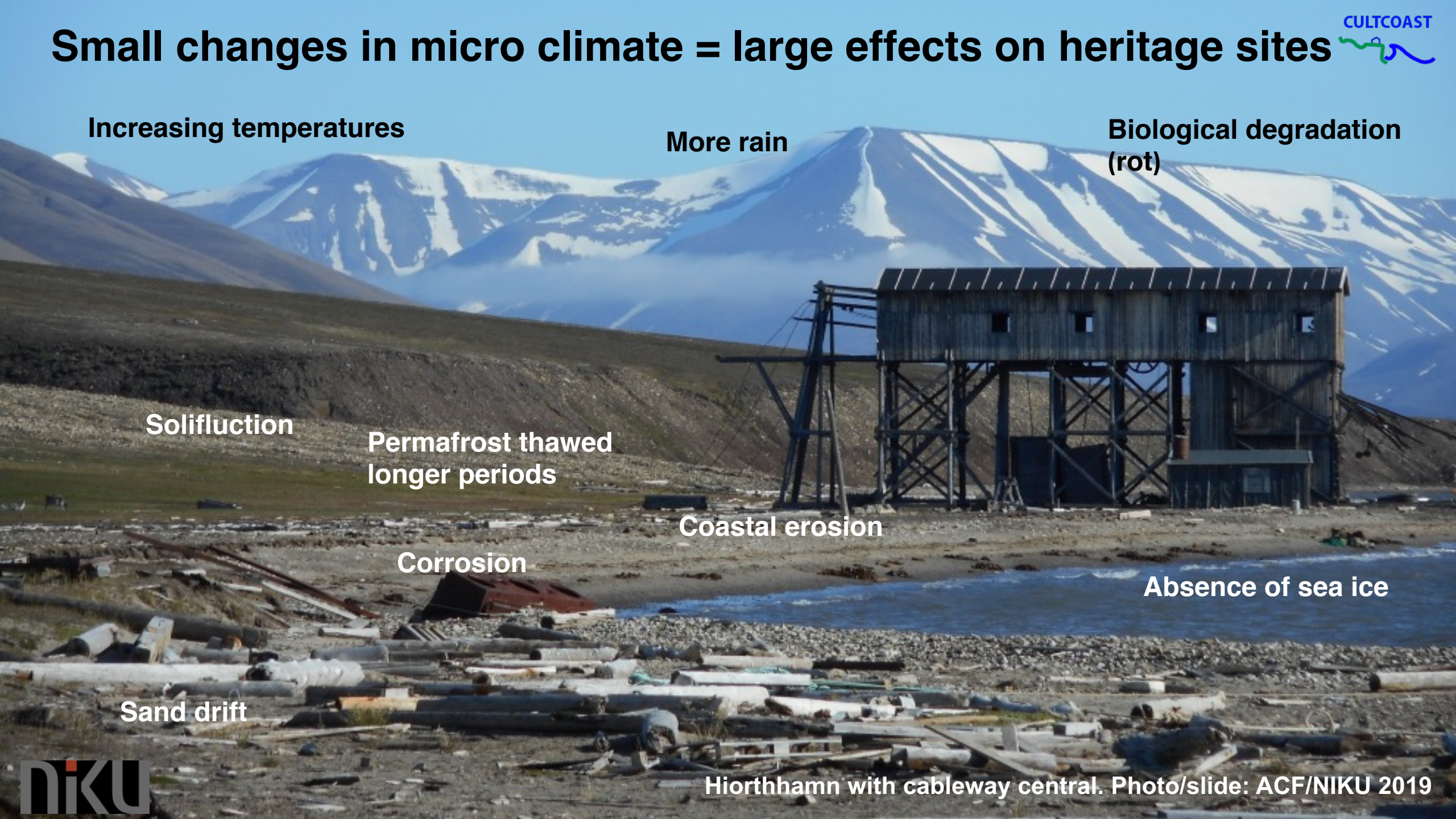

Tom


Cris

Norwegian Institute for Cultural Heritage Research

With funding from The Research Council of Norway

Small changes in micro climate = large effects on heritage sites



Hiorthhamn with cableway central. Photo/slide: ACF/NIKU 2019

Russekeila, Kapp Linné, Svalbard. Russian hunting station 1700-1859

CULTCOAST

The Pomor people had a station at the mouth of the Linné river.
Russekeila is one of the largest archaeological sites of this kind in Svalbard, with visible house remains (with increasingly degrading wood) and a large cemetary, partly threatended by solifluction, partly by river erosion.

Photo: Sysselmannen, the Governor of Svalbard, 2013

Photo: House remains, Russekeila, Svalbard. VVM/NIKU 2019

NIKU Norwegian Institute for Cultural Heritage Research
NORGES GEOLOGISKE UNDERSØKELSE · NGU ·
USN
SINTEF
University of St Andrews
With funding from The Research Council of Norway

Russekeila, Kapp Linné, Svalbard. Russian hunting station a. 1700-1859

Photo: House remains, Russekeila, Svalbard. VVM/NIKU 2019

House remains at the edge of the coastal slope. Heavily degraded wood and very vulnerable.
Active coastal erosion (windblown) – and gravity doing the rest

Photo: House remains, Russekeila, Svalbard. VVM/NIKU 2019

Photo: House remains, Russekeila, Svalbard. VVM/NIKU 2019

CULTCOAST

Norwegian Institute for Cultural Heritage Research

NORGES GEOLOGISKE UNDERSØKELSE

USN

SINTEF

University of St Andrews

With funding from The Research Council of Norway

Refuse deposit at Russekeila threatened by erosion

CULTCOAST

NIKU Norwegian Institute for Cultural Heritage Research
GEOLOGICAL SURVEY OF NORWAY
USN
SINTEF
University of St Andrews
With funding from The Research Council of Norway

Russekeila, Kapp Linné, Svalbard. Norwegian hunting cabin from a. 1850-1900

Photo: House remains, Russekeila, Svalbard. Lise Loktu, Sysselmannen 2020

Remains of house on the plateau above the western river bank. Refuse deposit containing textile, wood, animal bones, ammunition shells etc., buried beneath eroded coastal deposits.

Photo: Russekeila, Svalbard. Lise Loktu, Sysselmannen 2020

Photo: Refuse deposit, Russekeila, Svalbard. Lise Loktu, Sysselmannen 2020

CULTCOAST

NIKU Norwegian Institute for Cultural Heritage Research

GEOLOGICAL SURVEY OF NORWAY

USN

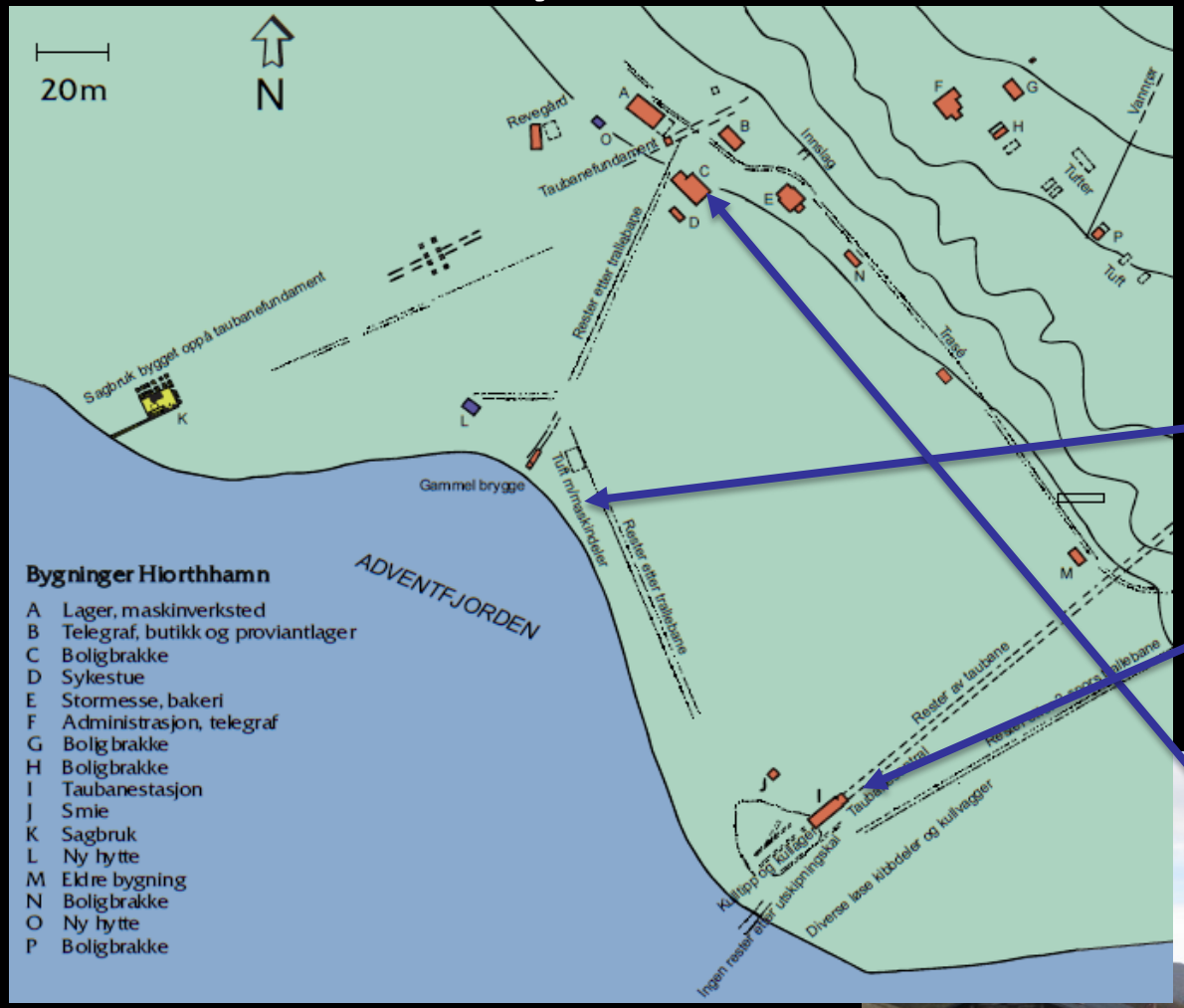
SINTEF

University of St Andrews

With funding from The Research Council of Norway

Hiorthhamn, Svalbard. Coal mining site

CULTCOAST



Cableway central, rails and Scottish steam engine on the beach

Residential barracks (C on enclosed map)

NORGES GEOLOGISKE UNDERSØKELSE - NGU -

USN

SINTEF

University of St Andrews

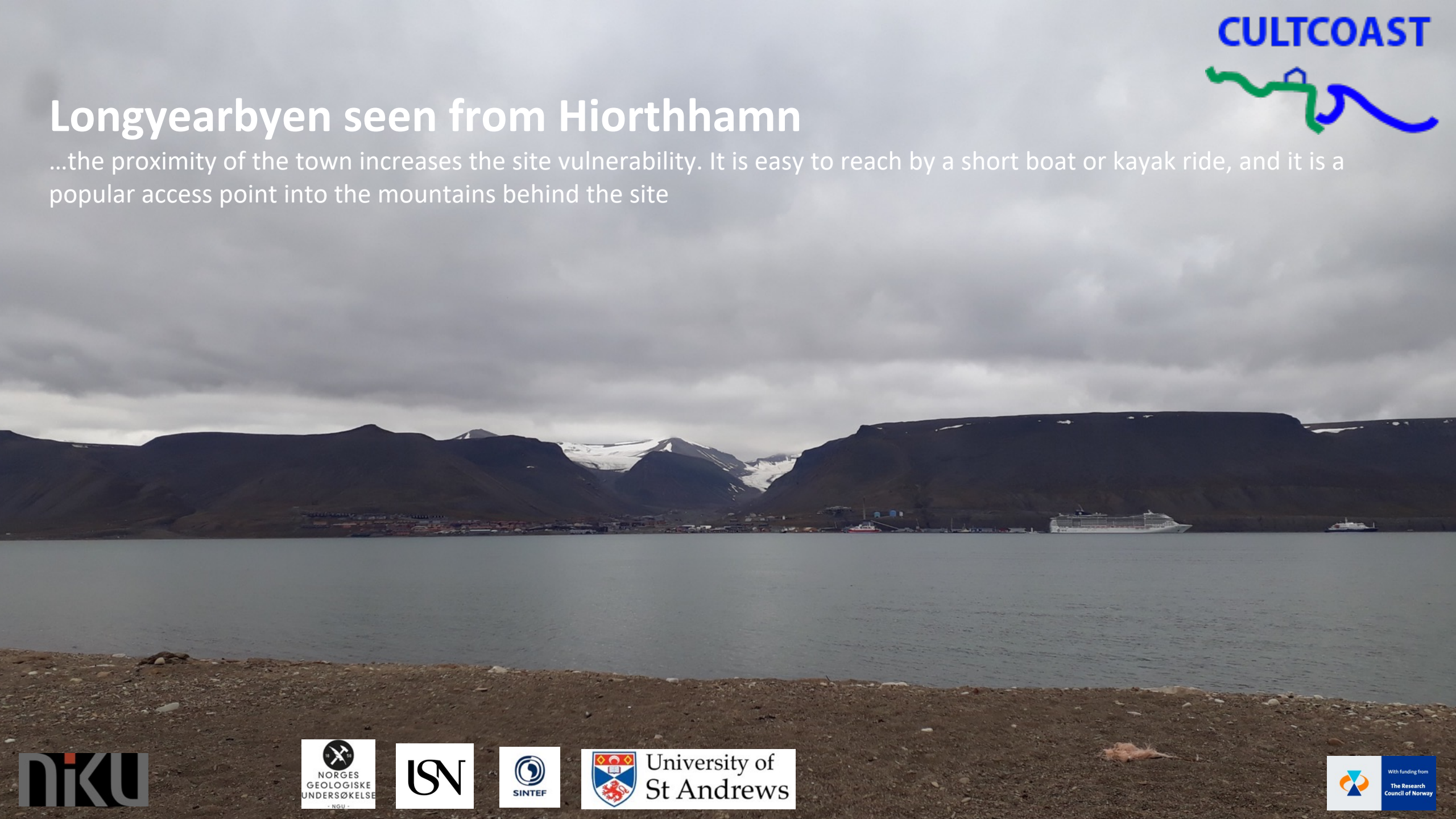
NIKU Norwegian Institute for Cultural Heritage Research

With funding from The Research Council of Norway

CULTCOAST

Longyearbyen seen from Hiorthhamn

…the proximity of the town increases the site vulnerability. It is easy to reach by a short boat or kayak ride, and it is a popular access point into the mountains behind the site



NIKU

NORGES GEOLOGISKE UNDERSØKELSE · NGU ·

USN

SINTEF

University of St Andrews

With funding from The Research Council of Norway

Hiorthhamn, Svalbard. Coal mine site

Hiorthhamn holds the second largest amount of listed buildings and other traces of coal mining activity in Svalbard. During fieldwork August 2019, we could see that the coast line has withdrawn, and the locomotive has sanded over. Listed buildings are damaged by solifluction (note the position of the foundation pile)

Crumbling coastline. Cableway central, rails and steam engine on the beach. Please note how much has been buried since 2011. VVM/NIKU 2019

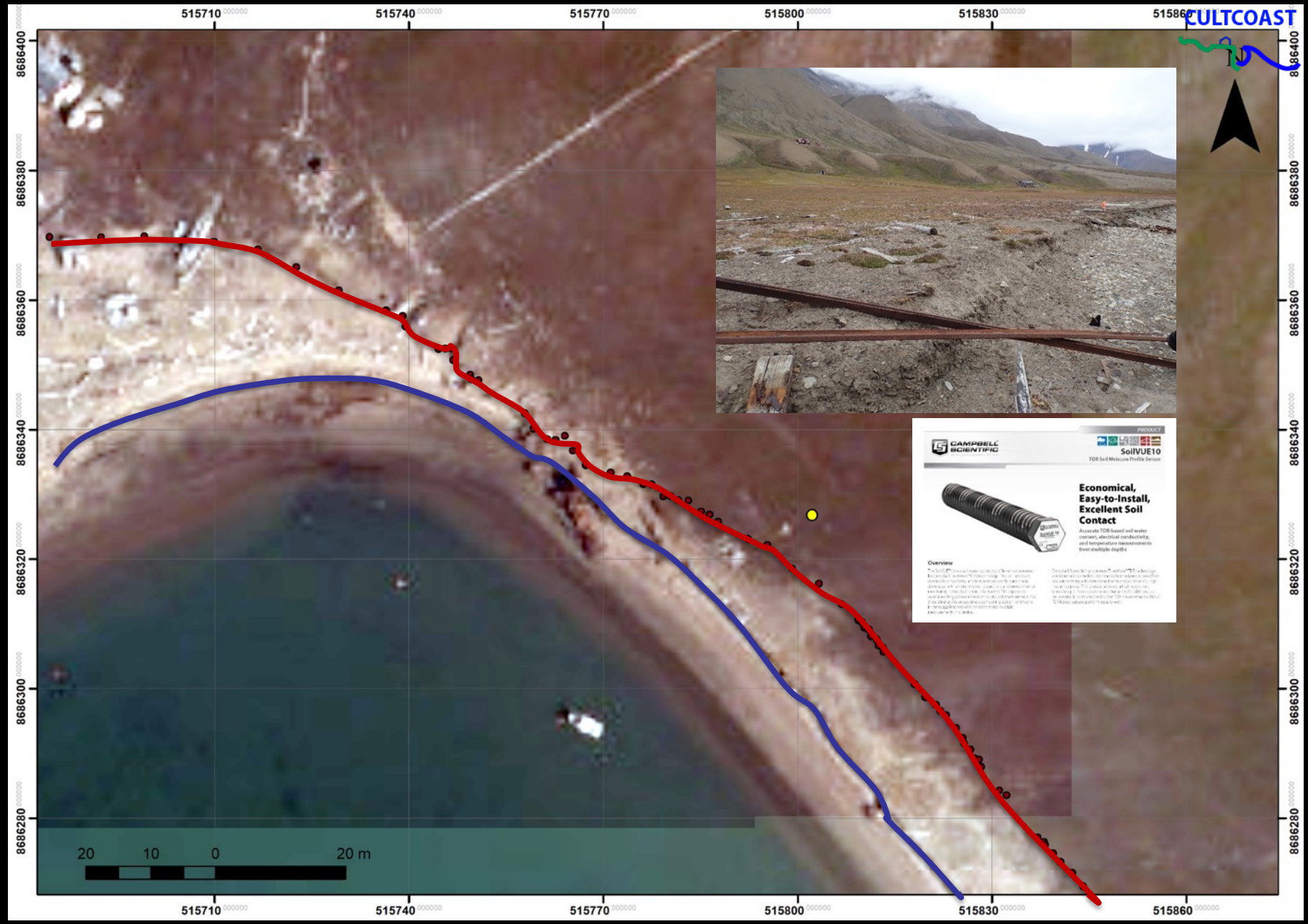
Building pushed off its foundations by solifluction. VVM/NIKU 2019

Cableway central, rails and steam engine on the beach ACF/NIKU 2011

Norwegian Institute for Cultural Heritage Research
GEOLOGICAL SURVEY OF NORWAY
USN
SINTEF
University of St Andrews
With funding from The Research Council of Norway

Shoreline measurements by Cris Nicu & Anne-Cathrine Flyen, 2019

Backround aerial photo from 2013. Blue line shows the coastal slope then, red line and dots now (August 2019). More than 15 metres(!) further inland – in only 6 years. Even more dramatic than expected. Yellow spot indicates placing of monitoring equipment installed 2020, measuring soil temperatures, humidity and conductivity at 9 levels within 1 meter. Probe diameter 5cm.



Norwegian Institute for Cultural Heritage Research
GEOLOGICAL SURVEY OF NORWAY
USN
SINTEF
University of St Andrews
With funding from The Research Council of Norway

CULTCOAST publications … and one associated…

all Open Access

sustainability

MDPI

Article

Coastal Erosion A ffecting Cultural Heritage in Svalbard. A Case Study in Hiorthhamn (Adventfjorden)—An Abandoned Mining Settlement

Ionut Cristi Nicu [1,*], Knut Stalsberg [2], Lena Rubensdotter [3,4], Vibeke Vandrup Martens [5] and Anne-Cathrine Flyen [5]

1 High North Department, Norwegian Institute for Cultural Heritage Research (NIKU), Fram Centre, N-9296 Tromsø, Norway
2 Geological Survey of Norway (NGU), Fram Centre, N-9296 Tromsø, Norway; knut.stalsberg@ngu.no
3 Geological Survey of Norway (NGU), Torgard, P.O. Box 6315, 7491 Trondheim, Norway; lena.rubensdotter@ngu.no
4 Arctic Geology Department, The University Centre in Svalbard (UNIS), P.O. Box 156, 9171 Longyearbyen, Norway
5 Norwegian Institute for Cultural Heritage Research (NIKU), Storgata 2, 0155 Oslo, Norway; vibeke.martens@niku.no (V.V.M.); anne.flyen@niku.no (A.-C.F.)
* Correspondence: ionut.cristi.nicu@niku.no or nicucristi@gmail.com; Tel.: +47-9-806-3607

Received: 24 February 2020; Accepted: 13 March 2020; Published: 16 March 2020

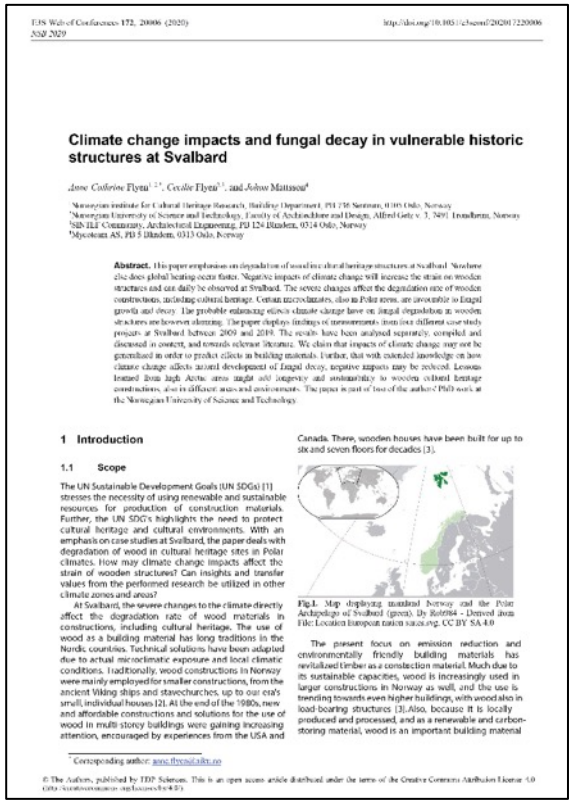
check for updates

Abstract: Hiorthhamn is an abandoned Norwegian coal mining settlement with a loading dock and a lot ofindustrial infrastructure left in the coastal zone. In this study, changes in the position of 1.3 km of the Hiorthhamn shoreline, which a ffect cultural heritage, is described for a time-period spanning 92 years (1927–2019). The shoreline positions were established based on a map (1927), orthophotos (2009) and a topographic survey with di fferential Global Positioning System (GPS) (summer 2019). Detailed geomorphological and surface sediment mapping was conducted to form a framework for understanding shoreline-landscape interaction. The shoreline was divided into three sectors to calculate the erosion /stability /accretion rates by using the DSAS (Digital Shoreline Analysis System) extension of ArcGIS. The DSAS analysis showed very high erosion in Sector 1, while Sectors 2 and 3 showed moderate accretion and moderate erosion, respectively. Sector 1 is geologically composed of easily erodible sorted beach sediments and protected remains from the mining industry such as wrecks of heavy machines, loading carts, wagons and rusty tracks that are directly exposed to coastal erosion. The all-sector average shoreline erosion rate (EPR parameter) for the 92 years period was −0.21 m/year. The high shoreline erosion rates in Sector 1, together with the high potential damage to cultural heritage, supports the urgent need of continued coastal monitoring and sustainable management of cultural heritage in Hiorthhamn.

Keywords: coastal erosion; shoreline; monitoring; geomorphological mapping; cultural heritage; Svalbard; DSAS; high Arctic

1. Introduction

Coastal areas of seas and oceans are among the most dynamic landforms and are permanently under threat of change from natural processes and anthropogenic pressure. A significant proportion of the world's population, at present and throughout history, lives in coastal areas (between 15% and 40%), which are under the direct e ffects of climatic change-related [1,2] processes such as sea-level rise [3] and changes in the intensity and frequency of storms [4]. Over the last decades, coastal areas have been subjected to increased rates of erosion [5], and this will most likely cause significant economic



E3S Web of Conferences 172, 20006 (2020) http://doi.org/10.1051/e3sconf/202017220006
NSB 2020

Climate change impacts and fungal decay in vulnerable historic structures at Svalbard

Anne Cathrine Flyen[1,2,*], Cecilie Flyen[3], and Johan Mattsson[4]

[1]Norwegian Institute for Cultural Heritage Research, Building Department, PB 736 Sentrum, 0105 Oslo, Norway
[2]Norwegian University of Science and Technology, Faculty of Architecture and Design, Alfred Getz v. 3, 7491 Trondheim, Norway
[3]SIN ILE Contemporary, Architectural Engineering, PB 124 Blindern, 0314 Oslo, Norway
[4]Mycoteam AS, PB 5 Blindern, 0313 Oslo, Norway

Abstract. This paper emphasises on degradation of wood in cultural heritage structures at Svalbard. Nowhere else does global heating occur faster. Negative impacts of climatic change will increase the strain on wooden structures and can easily be observed at Svalbard. The severe changes affect the degradation rate of wooden constructions, including cultural heritage. Certain microclimates, also in Polar areas, are favourable to fungal growth and decay. The probable enhancing effects climate change have on fungal degradation in wooden structures are however alarming. The paper displays findings of measurements from four different case study projects at Svalbard between 2009 and 2019. The results have been analysed separately, compiled and discussed in context, and towards relevant literature. We claim that impacts of climatic change may not be generalised in order to predict effects in building materials. Further, that with extended knowledge on how climate change affects natural development of fungal decay, negative impacts may be reduced. Lessons learned from high Arctic areas might add longevity and sustainability to wooden cultural heritage constructions, also in different areas and environments. The paper is part of two of the authors PhD work at the Norwegian University of Science and Technology.

1 Introduction

1.1 Scope

The UN Sustainable Development Goals (UN SDGs) [1] stresses the necessity of using renewable and sustainable resources for production of construction materials. Further, the UN SDG's highlights the need to protect cultural heritage and cultural environments. With an emphasis on case studies at Svalbard, the paper deals with degradation of wood in cultural heritage sites in Polar climates. How may climate change impacts affect the strain of wooden structures? Can insights and transfer values from the performed research be utilized in other climatic zones and areas?

At Svalbard, the severe changes to the climate directly affect the degradation rate of wood materials in constructions, including cultural heritage. The use of wood as a building material has long traditions in the Nordic countries. Technical solutions have been adapted due to actual microclimatic exposure and local climatic conditions. Traditionally, wood constructions in Norway were mainly employed for smaller constructions, from the ancient Viking ships and stavechurches, up to our era's small, individual houses [2]. At the end of the 1980s, new and affordable constructions and solutions for the use of wood in multi storey buildings were gaining increasing attention, encouraged by experiences from the USA and Canada. There, wooden houses have been built for up to six and seven floors for decades [3].

Fig.1. Map displaying mainland Norway and the Polar Archipelago of Svalbard (green). By Rob984 - Derived from File: Location European nation sans.svg. CC BY SA 4.0

The present focus on emission reduction and environmentally friendly building materials has revitalized timber as a construction material. Much due to its sustainable capacities, wood is increasingly used in larger constructions in Norway as well, and the use is trending towards even higher buildings, with wood also in load-bearing structures [3].Also, because it is locally produced and processed, and as a renewable and carbon-storing material, wood is an important building material

* Corresponding author: anne.flyen@ahkr.no

water

MDPI

Article

Coastal Erosion of Arctic Cultural Heritage in Danger: A Case Study from Svalbard, Norway

Ionut Cristi Nicu [1,*], Lena Rubensdotter [2,3], Knut Stalsberg [4] and Erich Nau [5]

1 High North Department, Norwegian Institute for Cultural Heritage Research (NIKU), Fram Centre, N-9296 Tromsø, Norway
2 Geological Survey of Norway (NGU), Torgard, P.O. Box 6315, 7491 Trondheim, Norway; lena.rubensdotter@ngu.no
3 Arctic Geology Department, The University Centre in Svalbard (UNIS), P.O. Box 156, 9171 Longyearbyen, Norway
4 Geological Survey of Norway (NGU), Fram Centre, N-9296 Tromsø, Norway; knut.stalsberg@ngu.no
5 Department of Digital Archaeology, Norwegian Institute for Cultural Heritage Research (NIKU), Storgata 2, 0155 Oslo, Norway; erich.nau@niku.no
* Correspondence: ionut.cristi.nicu@niku.no; Tel.: +47-98063607

Abstract: Strong cultural heritage management relies on a thorough evaluation of the threats faced by heritage sites, both in the present and in the future. In this study, we analysed the changes in the position of Hiorthhamn shoreline (Svalbard), which is affecting coastal cultural heritage sites, for a period of 93 years (1927–2020). Shoreline changes were mapped by using maps, ortophotos, drone images, terrestrial laser scanning (TLS), and topographic surveys. Also, TLS was used to 3D document the endangered coastal cultural heritage sites. Detailed sedimentological and morphological mapping was made in the field and from the newly acquired drone images in order to understand shoreline-landscape interaction and to depict changes occuring from 2019 to 2020. Short-term (2019–2020) and long-term (1927–2020) shoreline erosion/accretion was made with the help of the Digital Shoreline Analysis System (DSAS) and prompted a subdivision of three sectors, based on change pattern. Compared to a previous long-term analysis (1927–2019), this year's average erosion rate analysis (expressed by the EPR parameter) for the 93-year period is −0.14 m/yr. This shift in mean development is due to a newly formed spit bar in Sector 2. Referring strictly to Sector 1, where the protected cultural heritage objects are located, the erosion rate increased from the previous analysis of −0.76 m/yr to −0.77 m/yr. The shoreline forecast analysis highlights that half of the protected cultural heritage objects will likely disappear over the next decade and almost all the cultural heritage objects analysed in this study will disappear in roughly two decades. This shows the great danger the Arctic's cultural heritage sites is in if no mitigation measures are undertaken by the local authorities.

Keywords: coastal erosion; cultural heritage; high arctic; monitoring; Svalbard; DSAS

check for updates

Citation: Nicu, I.C.; Rubensdotter, L.; Stalsberg, K.; Nau, E. Coastal Erosion of Arctic Cultural Heritage in Danger: A Case Study from Svalbard, Norway. Water 2021, 13, 784. https://doi.org/10.3390/w13060784

Academic Editor: Alexander Shiklomanov

Received: 21 February 2021
Accepted: 11 March 2021
Published: 15 March 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Coastal areas are one of the most dynamic landforms on Earth and are under the direct effects of natural processes (sea-level rise, long- and short-term geological processes) and anthropic interventions (deforestations, urbanisation, changes in the habitat, etc.). Throughout history, coastal areas have acted as a magnet when it comes to attracting humans [1]. Today, coastal areas around the globe are under the direct effects of climatic changes; this has been reflected by numerous studies around the world showing increased erosion rates [2,3]. The erosion rates are exacerbated in the Arctic areas [4], which are warming two or three times faster than the global average. The Arctic coastal landscapes are especially sensitive to climate-change-induced morphological processes, from which they were previously protected due to permafrost and seasonal sea ice. Arctic coastal areas

SPECIAL FEATURE: PERSPECTIVE

Coastal heritage, global climate change, public engagement, and citizen science

Tom Dawson [a,b,1], Joanna Hambly [a,c], Alice Kelley [a], William Lees [d], and Sarah Miller [a]

Edited by Daniel H. Sandweiss, University of Maine, Orono, ME, and accepted by Editor-in-Board Member Dolores R. Piperno January 15, 2020 (received for review August 4, 2019)

Climate change is threatening an uncalculated number of archaeological sites globally, totaling perhaps hundreds of thousands of culturally and paleoenvironmentally significant resources. As with all archaeological sites, they provide evidence of humanity 's past and help us understand our place in the present world. Coastal sites, clustered at the water 's edge, are already experiencing some of the most dramatic damage due to anthropogenic climate change, and the situation is predicted to worsen in the future. In the face of catastrophic loss, organizations around the world are developing new ways of working with this threatened coastal resource. This paper uses three examples from Scotland, Florida, and Maine to highlight how new partnerships and citizen science approaches are building communities of practice to better manage threatened coastal heritage. It compares methods on either side of the Atlantic and highlights challenges and solutions. The approaches are applicable to the increasing number of heritage sites everywhere at risk from climate change; the study of coastal sites thus helps society prepare for climate change impacts to heritage worldwide.

archaeology | coastal heritage | climate change | heritage management | citizen science

Coastal environments have long been favored for human settlement, providing access to resources, transportation, trade, and defensible locations (1). Millennia of coastal occupation have produced a wealth of archaeological sites, including evidence of African Middle Stone Age (125,000 to 40,000 years ago) activity (2) and sites from the terminal Pleistocene (11,000 years ago) on the South American coast (3). Intervening time periods throughout the Holocene document indigenous activity and colonial occupations, with some sites specific to maritime activities, but many others reflecting society as a whole. These irreplaceable cultural and paleoenvironmental resources contain valuable information for archaeology and wider society (4, 5), but are under severe threat from the development of coastal regions, environmental degradation, and the impacts of anthropogenic climate change leading to an acceleration of natural erosive processes.

Coasts are dynamic areas subject to a range of forces and natural processes. Cliff and dune erosion, flooding, and inundation put archaeological sites at immediate danger of destruction (Fig. 1). Valuable information is being lost in the sea, and urgent calls for action to rescue data from the most vulnerable sites have led coastal archaeologists to develop new ways of working, involving citizens in projects and building partnerships that record the threatened resource, evolving decision-making and management tools for vulnerable coastal heritage are widely applicable to all threatened heritage. These methodologies will become increasingly important as greater numbers of sites, in a range of environments, are threatened by the impacts of climate change.

An archaeological site 's vulnerability (6) is determined by its exposure (the scale of the potential impact of a climatic event) and its sensitivity (or degree to which it could be affected by that exposure). At the coast, climate impacts result from sea-level rise (SLR), increasing wave height (7), and changing weather patterns, all factors that multiply existing stresses. Some effects, such as inundation, collapse, or even the destruction of sites are immediately visible, while indirect

[a]School of History, University of St Andrews, St Andrews, Fife KY16 9AL, Scotland; [b]The SCAPE Trust, University of St Andrews, St Andrews, Fife KY16 9AR, Scotland; [c]University of Maine, Orono, ME 04469; [d]Florida Public Archaeology Network, University of West Florida, Pensacola, FL 32501; and [e]Florida Public Archaeology Network, Taylor College, St. Augustine, FL 32086

Author contributions: I.D., J.H., A.K., W.L., and S.M. performed research; and wrote the paper.

Competing interest statement: A.K. and S.M.L. are both affiliated with the University of Maine.

This article is a PNAS Direct Submission. D.H.S. is a guest editor invited by the Editorial Board.

Published under the PNAS license.

[1]To whom correspondence may be addressed. Email: tjd4@st-andrews.ac.uk.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.1912746117/-/DCSupplemental.

First published April 13, 2020.

Interdisciplinary cooperation

The strength of joint field work in an interdisciplinary research project – all learn from each other and complete each others knowledge

Photo: CULTCOAST. TW/NIKU 2019

CULTCOAST

Photo: Russekeila, Svalbard. VVM/NIKU 2019

Thank you for your attention!

vvm@niku.no

Norwegian Institute for Cultural Heritage Research

NORGES GEOLOGISKE UNDERSØKELSE

USN

SINTEF

University of St Andrews

With funding from The Research Council of Norway