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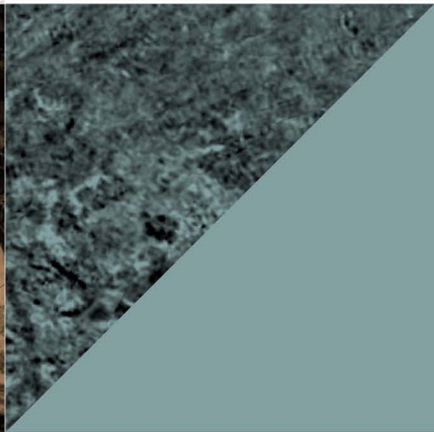

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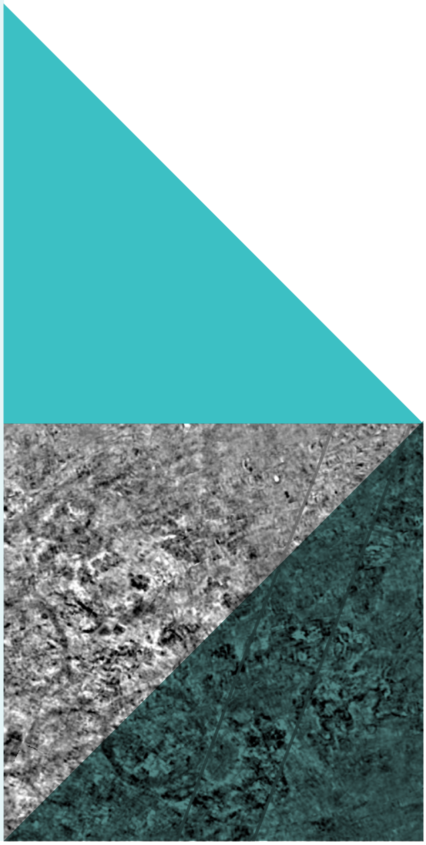
Presenting the PastCoast-project

– A novel interdisciplinary approach to the study of resilience in prehistoric marine coastal environments

Arne Anderson Stamnes

Abstract

This project aims to study changes and breakpoints in utilising prehistoric marine coastal environments, identify possible causes for changes, and create an interpretive framework to identify potential human responses to changing environmental settings. This will be done by combining non-intrusive geophysical survey techniques, palaeoenvironmental studies, trial excavations and digital landscape modelling in an interpretive framework to study human resilience in a changing coastal landscape.



Introduction

In 2021, the Norwegian Research Council awarded a three-year mobility grant for the project PastCoast, which started up in December 2021. The project is led by Dr. Arne Anderson Stamnes, and is a collaboration between the National Museum of Copenhagen, Department of Geoscience in Aarhus and the Department of Archaeology and Cultural History at the NTNU University Museum in Trondheim, Norway. The outset of the project was a desire to study sites known from metal detecting assemblages with geophysical (and hence non-intrusive) methods. By combining the study of metal detecting assemblages, geophysical survey data, GIS modelling and sea level change, the project aims at studying changes and breakpoints in the utilisation of prehistoric marine coastal environments, identify possible causes for changes, and create an interpretive framework to identify possible human responses to changing environmental settings (fig. 1). The PastCoast-project will provide knowledge from an archaeological, palaeoenvironmental, geophysical and geostatistical perspective. Ultimately it will provide new and important insight and knowledge into human-environment interactions in these environments. As this article is mainly presenting work to be done, its main focus will be on presenting a state of the art, proposed methodology and some preliminary feasibility studies.

Background

Human societies have continuously been subjected to external factors influencing settlement and landscape use. In coastal settings, these involve sea-level changes, flash floods and drift sand to mention a few. There is an inherent difficulty in studying the causality between natural variability and societal change. A proposed solution is to examine specific activities put at risk by the ongoing changes and events, and how the society reacted by either altering their environment and activities or responded to a changing environment by counteractive change (Kluiving 2015; Soens 2018). Activities near the coast are more subjected to such effects, and the societies will react to events by absorbing, adapting or transforming their activities. Studies of past activities near the coastline can therefore provide insight into how people reacted to such changes in prehistoric times. Resilience thinking (RT) is a conceptual framework to understand developments within complex adaptive systems. In recent years, there has been a growing emphasis on resilience thinking in archaeology, and the use of resilience planning in environmental management worldwide (Bradtmöller et al 2017; Plieninger & Bieling 2012; Kluiving et al. 2019). Within archaeology, the use of RT is predominantly focussed on the study of behavioural adaptations, and more specifically, on how socio-economic systems absorb, resist or react to stresses from both internal and external sources. Stability and change are both integral and equal components of such systems (Bradtmöller et

Fig. 1. Performing a ground-penetrating radar survey in Northern Norway. Photo: Arne Anderson Stamnes.

al 2017). RT provides a terminology and theoretical fundament to study breakpoints and states of equilibrium in human-landscape interactions, and the interaction between human and natural systems when faced with environmental change. In an international perspective, many studies have focussed the effects of being encountered with a diminishing land mass (Plieninger & Bieling 2012; Soens 2018; Kluiving et al. 2019). Still, very few studies focus on the effects of an increasing land mass on prehistoric societies, such as the situation is in most of Scandinavia. One such study exists from Denmark. This study's conclusions highlight the need for more accurate local sea-level curves to understand causal relationships and the consequences for human-environment interactions in coastal areas (Kristiansen et al. 2020). A landscape- and geoarchaeological approach has great potential for illuminating the interaction between land-water divides and landscape reconstruction. Such "landscape gradients" where elements meet were often preferred locations for settlement and human activity globally. For example, studies of human reactions to changing sea levels show responses that may be either reactive (moving to higher or lower ground) or proactive (altering one's immediate surroundings to counter for changing environments) (Kluiving 2015). Often, long-term regionalised management strategies are lost when replaced by modern, standardised and simplified land uses. This also implies a loss of traditional knowledge systems, which are known to increase a society's capacity to deal with crises and maintain resource flows in changing and uncertain conditions (Plieninger & Bieling 2012:xiiii-xvi).

Methodology

Non-intrusive geophysical survey techniques are very powerful and effective way to locate, delineate and characterise buried archaeological features, sites and landscapes in three dimensions with high certainty (Trinks et al. 2018; Gustavsen et al. 2020). Geophysical survey methods provide knowledge of the presence and absence of archaeological features in the ground over large areas in a fast, efficient and non-intrusive manner. They also provide a wealth of information on the palaeoenvironmental settings of such sites. Non-intrusive methods thereby enable new possibilities for studying relationships between archaeological activity and coastal landscape changes over time in a scale not feasible through conventional archaeological investigations. Moreover, the combination of detailed study of surface-find assemblages and geophysical information on subsoil archaeological features and palaeoenvironmental observations can generate a new perspective on the cultural-historical development of coastal sites, their resilience and adaption to a changing landscape. Paired with targeted excavation, for quality control (ground-truthing), and to provide datable evidence, geophysical survey and surface-find studies can tackle important questions of chronological change. In addition, a GIS-modelling approach can reveal spatial patterns of prehistoric activity on a landscape scale and how they might have changed over time. Max Entropy predictive modelling can characterise how much a site location is dependent on various site location parameters such as distance to the shore-line or topographical setting or similar, and thereby also be used to quantify if and how such dependencies change over time (Howeyet al 2016). Ultimately, such an interdisciplinary approach can provide further knowledge and understanding regarding the significance of coastal archaeological sites in time and space in a larger cultural-historical perspective. Research of this kind can also illuminate threats to coastal settlements from future climate change effects and how similar threats have been mitigated in the past. For periods without any written sources, only archaeology can reveal traditional knowledge systems that may provide important insight into how people in the past reacted to similar events.

State of the art

Assemblages of archaeological finds derived from metal detecting identify human presence and provide new information regarding local and regional exploitation of land and settlement patterns. They reveal a wide range of various archaeological sites, both spatially and functionally, in areas close to the shore. These include different types of settlements, including magnate farms, coastal landing places, and possible commercial sites (Christiansen 2017). While metal detecting has a long tradition in Denmark (Dobat 2013), it is mainly within the last decade that it has really caught on in Norway. Here, knowledge of object assemblages has created new challenges in understanding the context of the finds and how best to protect potential archaeological sites (Fredriksen 2019). Exploring possible solutions to this is of general interest to the global archaeological community. Christiansen (2017: 177) has argued that most Danish metal detecting finds represent loss over time or re-depositing of settlement refuse that includes discarded objects on nearby fields as fertiliser rather than representing activities that yield fixed traces in the subsoil. Besides, post-depositional processes such as erosion and ploughing might have shifted the objects in space, and deposition traditions in the past might lead to the deposition of objects elsewhere than the actual settlement or main activity area (Henriksen 2016).

Geophysical survey methods are an increasingly used part of the archaeologists' toolkit, and provide a non-destructive way of mapping and characterising archaeological features, sites and larger landscapes (Stamnes 2016; Gaffney 2008). In Norway, only a handful of recent publications use geophysical methods to investigate find-rich sites as indicated by portable artefacts detected by metal detectorists (Tonning et al. 2017; Gustavsen et al. 2018; Fredriksen & Stamnes 2019; Sand-Eriksen et al 2020). A key aim in these publications was to use the geophysical methods as a tool to investigate the relationship between the occurrence of metal objects in the plough soil and features in the subsoil (Fredriksen 2019). Only a handful of geophysical surveys with similar resolution and scale have been performed in Denmark (Filzwieser et al. 2017; Brown et al. 2014; Nordjyllands Historiske Museum 2019; TV2 Bornholm 2019). Moreover, only very few surveys have targeted sites mainly known through metal detecting in Denmark (Olesen and Rassman 2019; Odense Bys Museer 2019; Loveluck and Salmon 2011). While all of these examples have provided new knowledge on the presence or absence of archaeological features that might explain the metal-detected finds distributions, issues remain with relating the chronology between the object assemblages and the subsoil features identified by the geophysical surveys. The study of Loveluck & Salmon (2011) is the only relevant example that has a particular palaeoenvironmental focus, but it relied on relatively small-scale geophysical surveys.

We know that features such as pit-houses and cooking pits show up very well in geophysical datasets. Moreover, geophysical information is a significant source of palaeoenvironmental information on chronological relationships related to coastal change, and in particular, to identify palaeo-beach ridges (fig. 2-3). While geophysical methods can detect archaeological features and study the spatial relationship between geophysical observation and metal detecting finds, there are still challenges in determining the chronological relationship between these observations (Fredriksen 2019: 72). There is a definite need for more detailed studies of the relationship between find-rich sites and their context both in time and space. The non-destructive techniques provide a large overview for prioritisation to optimise resources and minimise the impact of an archaeological excavations – ensuring maximum gain towards targeted research aim with a minimum of excavations. Therefore, there is an untapped potential to use large-scale geophysical surveys combined with small-scale excavation to understand productive sites and their natural environment better. Unless there is clear typological information from geophysical survey results, e.g. in the form of recognisable and datable house types or similar, targeted excavation and the carbon-14 dating of features observed as geophysical anomalies are essential to properly understand the deposition history of the objects.

Mid- and Northern Scandinavia such as inland Sweden and large parts of Norway have been particularly subjected to isostatic uplift. In Mid-Norway the maximum differences between the sea level today, and the sea level when the ice sheets retreated after the last ice age, is about 180 meters. In areas of Denmark, the maximum transgression was about 8-10 m above the mean sea level of today, and conditions vary, and the shoreline can be receding or eroding away. Although not similar in elevation, the relative sea-level changes still had a profound impact on available land for cultivation and grazing, navigability of coastal waters and inlets, choices of sites for fortification and settlements, as well as possible communication routes. This in large part is due to the emergence of new land caused by the isostatic uplift (Kristiansen et al. 2020).

Two recent works in Scandinavia have demonstrated how a higher definition of local relative sea level (RSL) curves have had a major impact on the analysis of Iron Age settlement changes and the relationship between settlement dynamics and observed landscape changes over time.

At the Ørlandet peninsula at the Trondheimsfjord area's outlet, Norway's largest soil-stripping excavation gave a thorough impression of settlement dynamics throughout the Iron Age and medieval times (Ystgaard 2019). The researchers created a much higher definition RSL-curve for the last

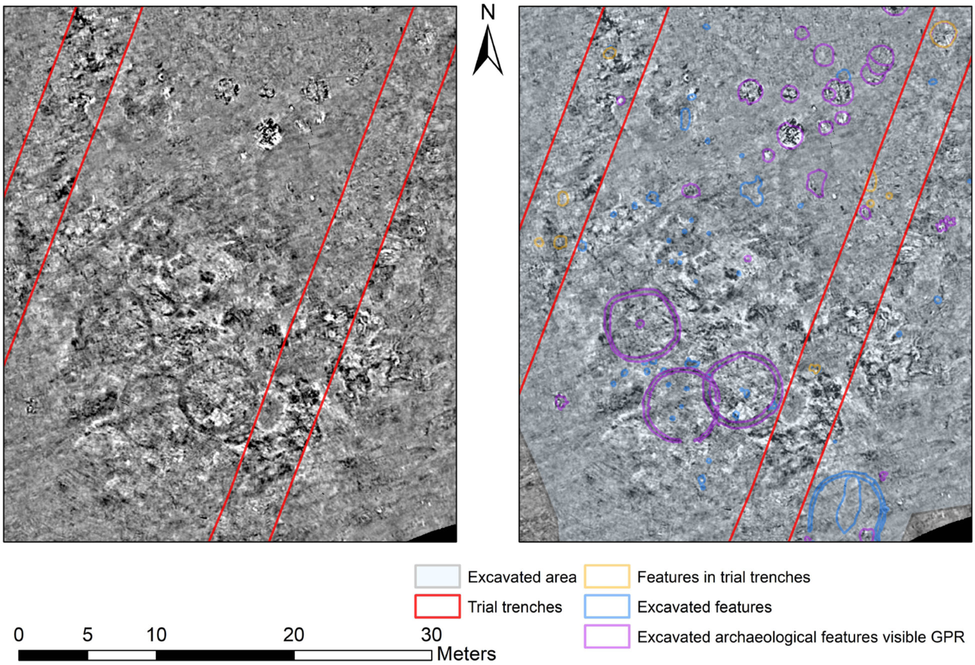


Fig. 2. Comparison of GPR results, features identified by trial trenching and subsequent excavation results (Gustavsen et al. 2020; Stamnes & Gustavsen 2018).

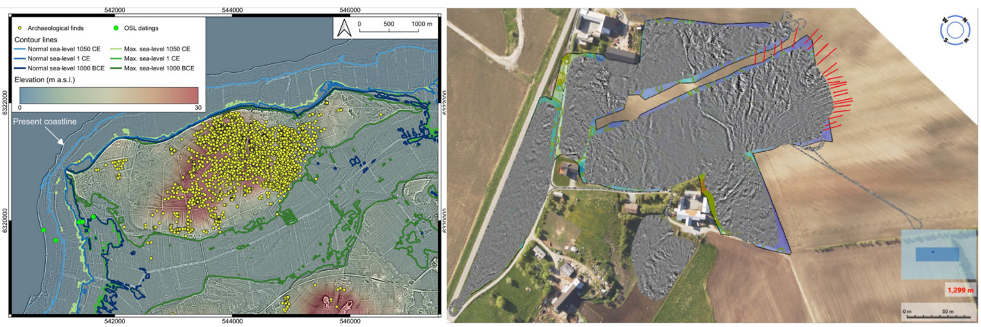


Fig. 3. Left: The relationship between the spread of archaeological finds and dated shorelines at Nørholm in Limfjord (Kristiansen et al. 2020) Right: Red lines indicate the relative direction and spacing between observed beach ridges in plan view from Vik in Ørlandet in GPR data (Stamnes, Ystgaard & Gran 2019).

6000 years than previously available based on isolation basins studies. It proved that this relatively flat landscape changed much more rapid for the time periods of excavated Iron Age settlements than formerly known (Romundset & Lakeman 2019). Kristiansen et al. (2020) used a database of archaeological finds derived mainly from metal detecting based on Christiansen's (Christiansen 2017) work for an area around Limfjorden. They developed a new RSL curve based on dating fossil beach ridges identified in high-resolution digital terrain models and studied settlement patterns on new marine foreland and estimated changes in area and quality for grazing and livestock forage. Archaeological finds and archaeological excavations helped validate relative sea-level curves derived from Optically Stimulated Luminescence (OSL) dated beach ridges. There was a clear correlation in time between all archaeological evidence of human-environment interactions along the prograding coastline, and an improved chronological understanding and higher spatio-temporal accuracy and precision was gained. The Limfjorden estuary in Northern Denmark is a good example of an area that has been subjected to a series of unparalleled changes since the last glacial period (Lewis et al. 2013; Kristiansen et al. 2020).

In addition to the archaeological information, large scale, high-resolution geophysical surveys have tremendous potential as a source of paleoenvironmental information by detecting former beach ridges, palaeochannel systems, palaeotopography and geomorphological processes, as well as providing information on relative chronology of archaeological observations and landscape changes (Conyers 2016; Schneidhofer 2017). The study of beach ridges, in particular, has the potential to provide additional information on relative landscape chronology and be used to create new relative sea-level curves, but often relies on singular GPR sections or visible beach ridges (Otvos 2000; Billy et al. 2015; Romundset & Lakeman 2019; Kristiansen et al. 2020). Large scale, high-resolution geophysical survey examples demonstrate how a much more detailed impression of temporal landscape development is achievable. Such resolution in plan and profile view from such data has to a large degree not been utilised for paleoenvironmental mapping, as the survey parameters are often targeted to much larger scale but at considerably lower resolution (Schneidhofer 2017:76). The example dataset from the former Roman Iron Age shore-line at Vik collected by the author (fig. 3) clearly demonstrate the possibility and feasibility of a much more high resolution and detailed view of the relative changes in sea level by revealing sequences of beach ridges that are not visible on the ground (Stamnes et al. 2019). Tab. 1 shows a calculation of the formation time per beach ridge, and hence indicate the temporal resolution and spatial resolution possible to achieve of landscape changes of the landscape at Vik during these phases of the Iron Age.

Main focus and outcomes of the project

Archaeology has great potential to contribute to debates over global climate change and its social impacts, but has struggled with demonstrating its contribution to such debates. Much of the literature on climate change suggests that our current situation is unprecedented, but it is through archaeological examples that we can properly understand just how unique our current predicament is (Hudson et al. 2012). There is a powerful resonance in knowing that people in the past also altered their lifestyle because of climate change.

The PastCoast project aims to study changes and breakpoints in human utilisation of the landscape, identify possible causes, and create an interpretive framework to identify potential human responses to changing environmental settings. This will be achieved by studying shore-line related archaeological sites known from finds-assemblages identified by metal detecting, identifying the presence and absence of subsoil archaeological features indicated by non-intrusive geophysical survey methods, studying palaeoenvironmental change and GIS-based landscape modelling prehistoric activity on a landscape scale. If, for instance, there is an observed change in the metal detecting assemblages, but not in the palaeoenvironmental or the archaeological information derived from the geophysical datasets, this could indicate a cultural rather than environmental reason for change. Conversely, if a settlement is observed moving parallel to the changing coastline, it would be the environmental proxy that would be the leading cause of change. Again, suppose the sea-level change, but the site preserves its spatial position and archaeological "expression" through its material culture. In that case, this could be interpreted as an expression of resilience against the changes observed in the palaeoenvironmental data.

Ultimately it will provide new and important insight and knowledge into human-environment interactions in these environments. The proposed work will answer and investigate several aspects of such sites that are not known, understood or have been undertaken before:

1. By identifying different landscape use patterns, the project will differentiate what types of sites show the most distinct form of resilience. We do not know the archaeological characteristics and makeup of many of the sites known from metal detecting. Only a few published examples exist of geophysical surveys over coastal sites that focus on investigating the relationship between finds assemblages and any presence or absence of subsoil features. To better characterise these sites, and understand their cultural-historical context and significance, we need to investigate the following aspects:

Mean Above Sea Level (MASL) when deposited				
MASL	*# beach ridges*	*Meter pr ridge*	*Time difference (Years)*	*Formation time (Years)*
5-6m	14	0,071	200	14,3
6-7m	9	0,111	150	16,7
7-8m	3	0,333	150	50,0

Tab. 1. Calculation of the formation time for each beach ridge observed in the GPR data.

a. Can we detect subsoil features at these sites with geophysical survey methods, and interpret them from an archaeological perspective?
b. Is there a spatial relationship – both in a local and regional perspective, between the find assemblages and subsoil features?

2. The chronological relationship between subsoil features and finds assemblages is challenging to understand without additional information. An important source of information is palaeoenvironmental observations in the geophysical datasets. Large-scale, high-resolution geophysical surveys have recently been scarce in palaeoenvironmental studies, but have demonstrated a significant untapped potential to gain an additional temporal understanding of landscape changes (see fig. 3 and tab. 1). To gain more insight into this, it is necessary to:
   a. Investigate what potential the studies of fossil beach ridges and other palaoetopographical and palaeohydrological observations have for improving the chronological accuracy of landscape changes.
   b. Investigate if and how new knowledge of landscape development derived from large-scale, high-resolution data can shed light on natural – and cultural-historical landscape changes over time and space. This involves evaluating the chronological relationship, both spatially and temporally, between finds assemblages, subsoil features, and observed natural landscape changes.

3. The study of coastal sites known from finds assemblages can alter our understanding of more extensive cultural-historical human-environment interactions. Still, new knowledge and evidence on all of these aspects will be produced as a result of the PastCoast project and needs to be analysed and evaluated to yield new information on the resilience of past human activity. Therefore, it is necessary to:
   a. Discuss the results of objective 1 and 2 concerning the study

of resilience and adaptability of past societies to changing environment, and the human-environment interactions in a larger natural- and cultural-historical landscape context.

b. Demonstrate how people responded to climate changes in the past, and provide an evidence base for the management of cultural and natural landscapes under threat of future climatic changes.

Over the course of 2022 to 2024 the project, in collaboration with project partners, six sites with different isostatic landscape settings in Denmark and Norway will be investigated, and contribute in creating a better overall understanding of the relationship between speed and type of landscape change and resilience. The sites will be selected in collaboration with the project partners and reference group. While the final selection is still to be decided, potential candidates such as Nørholm and Langelands gårde by Limfjorden, Strandby/Gammeltoft on Funen and Austrått and Viggja in the Trøndelag region of Norway have been suggested. The selection criteria are as follows: shore-bound location, archaeological indications of longevity of use, known metal detecting assemblages, located in an area with a relatively high density of other known finds, monuments and sites, and placed within geological conditions with a drift geology that would make the detection past beach ridges more probable. It is feasible to investigate up to 15 hectares of each site with geophysical methods within this mobility grant's time frame. These will involve the use of cutting-edge magnetometer and ground-penetrating radar (GPR) surveys (see fig. 1). They measure magnetic properties and electromagnetic contrast respectively and are complementary methods. While a conductivity contrast detected by GPR might indicate the presence of a pit, the magnetometer results can tell if this is backfilled with burned material. Survey reports with archaeological interpretations will conform to established standards (Schmidt et al. 2016), and made publicly available. Project partners are from Odense Bys museer, Nordjylland Historiske Museum in Aalborg, Museum Thy and Ørland kultursenter in Norway.

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