PUBLIC ARCHAEOLOGY & CLIMATE CHANGE

EDITED BY

Tom Dawson, Courtney Nimura, Elias Lopez-Romero & Marie-Yvane Daire

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List of Contributors

Bo Albrechtsen
Greenland National Museum and Archives
Hans Egedesvej 8
Boks 145, 3900, Nuuk, Greenland
bo@natmus.gl

Allison Bain
Département des sciences historiques, Université Laval
1030, avenue des Sciences-Humaines
Quebec, G1V 0A6, Canada
allison.bain@hst.ulaval.ca

Pau Olmos Benlloch
Institut Català d'Arqueologia Clàssica
Plaça d'en Rovellat, s/n
43003 Tarragona, Spain
polmos@icac.cat

Rebecca Boger
Brooklyn College CUNY/Barbuda Research Complex,
Antigua and Barbuda
2900 Bedford Avenue
Brooklyn, NY 11210, USA
beckyboger@gmail.com

James Bonsall
Institute of Technology, Sligo
Ash Lane
Sligo, F91 YW50, Ireland
bonsall.james@itsligo.ie

Peter Brimblecombe
School of Energy and Environment
City University of Hong Kong
Kowloon, Hong Kong
pbrimble@cityu.edu.hk

Sally Brockwell
Australian National University
Canberra ACT 0200 Australia
sally.brockwell@anu.edu.au

Matthew Brown
Dept of Sociology and Anthropology
Farmingdale State College (SUNY)
2350 Broadhollow Road
Farmingdale, NY, 11735, USA
narmer@hotmail.com

Jacqueline Cahill
Kakadu Hwy, Jabiru, NT 0886, Australia
jacqueline.cahill@environment.gov.au

Bethune Carmichael
Australian National University
Canberra ACT 0200 Australia
Bethune.carmichael@anu.edu.au
Charles Darwin University
17 Grevillea Dr, Alice Springs, NT, 0870, Australia
bethune.carmichael@cdu.edu.au

Nathalie Cohen
Museum of London Archaeology
Mortimer Wheeler House
46 Eagle Wharf Road
London, N1 7ED, UK
ncohen@mola.org.uk

Marie-Yvane Daire
UMR 6566 CReAAH
Centre de Recherche en Archéologie, Archéosciences, Histoire
Laboratoire Archéosciences, Université de Rennes 1263
Avenue du général Leclerc Campus de Beaulieu,
bâtiment 24-25
35042 Rennes Cedex, France
marie-yvane.daire@univ-rennes1.fr

Tom Dawson
University of St Andrews
School of History
St Katharine's Lodge, The Scores
St Andrews, Fife, KY16 9BA, UK
tcd@st-andrews.ac.uk

Bo Elberling
Center for Permafrost (CENPERM), Department of Geoscience and Natural Resource Management, University of Copenhagen
Øster Voldgade 10
DK-1350 Copenhagen K, Denmark
be@ign.ku.dk

Anne Marie Faucher
Département des sciences historiques, Université Laval
1030, avenue des Sciences-Humaines
Quebec, G1V 0A6, Canada
anne-marie.faucher.1@ulaval.ca

Frank J. Feeley
Graduate Center of the City University of New York
365 5th Ave
New York, NY, 10016, USA
ffeeley@gradcenter.cuny.edu

Reno Keoni Franklin
Kashia Band of Pomo Indians
1420 Guerneville Road, Suite 1
Santa Rosa, CA, 95403, USA
reno@stewartspoint.org

Andrés Gascue
Laboratorio de Arqueología del Paisaje y Patrimonio (LAPPU), Facultad de Humanidades y Ciencias de la Educación (FHCE), Centro Universitario Regional del Este (CURE), Universidad de la República (Udelar)
Ruta 9 Km and Ruta 15
Rocha, Uruguay
andresgascue@gmail.com

Claudine Gerrard
National Trust Wales/Ymddiriedolaeth Genedlaethol yng Nghymru
The Granary/Y Ysgubor
Dinefwr Home Farm/Fferm Plas Dinefwr
Llandeilo, SA19 6RT, Wales
claudine.gerrard@nationaltrust.org.uk

Camila Gianotti
Laboratorio de Arqueología del Paisaje y Patrimonio (LAPPU), Facultad de Humanidades y Ciencias de la Educación (FHCE), Centro Universitario Regional del Este (CURE), Universidad de la República (Udelar)
Ruta 9 Km and Ruta 15
Rocha, Uruguay
camila.gianotti@lappu.edu.uy

Ellie Graham
University of St Andrews
School of History
St Katharine's Lodge, The Scores
St Andrews, Fife, KY16 9BA, UK
elg5@st-andrews.ac.uk

Sandrine Grouard
UMR7209 Archéozoologie, Archéobotanique, Sorbonne Universités
CNRS, Muséum National d'Histoire Naturelle, Paris, France
57 Rue Cuvier
75005 Paris, France
grouard@mnhn.fr

Alejandro Güimil-Fariña
DIMENSO
Institute of Heritage Science
Spanish National Research Council (Incipit, CSIC)
Avda. de Vigo s/n
15705 Santiago de Compostela, Spain
alejandro.guimil.farina@gmail.com

Joanna Hambly
University of St Andrews
School of History
St Katharine's Lodge, The Scores
St Andrews, Fife, KY16 9BA, UK
jh105@st-andrews.ac.uk

Mikiko Hayashi
School of Energy and Environment
City University of Hong Kong
Kowloon, Hong Kong
hayashimikiko@gmail.com

Jørgen Hollesen
Department of Conservation and Natural Sciences, National Museum of Denmark
I.C. Modewegsvej
Brede, DK-2800 Lyngby, Denmark
Center for Permafrost (CENPERM), Department of Geoscience and Natural Resource Management, University of Copenhagen
Øster Voldgade 10
DK-1350 Copenhagen K, Denmark
joergen.hollesen@natmus.dk

Hugo Inda
Laboratorio de Arqueología del Paisaje y Patrimonio (LAPPU), Facultad de Humanidades y Ciencias de la Educación (FHCE), Centro Universitario Regional del Este (CURE), Universidad de la República (Udelar)
Ruta 9 Km and Ruta 15
Rocha, Uruguay
hugoboss@paysandu.com

Anne M. Jensen
Ukpeaġvik Iñupiat Corporation, Alaska
UIC Science LLC, PO Box 936
Barrow, AK, 99723, USA
anne.jensen@uicscience.com

Christian Koch Madsen
Greenland National Museum and Archives
Hans Egedesvej 8
Boks 145, 3900, Nuuk, Greenland
christian@natmus.gl

Aart Kroon
Center for Permafrost (CENPERM), Department of Geoscience and Natural Resource Management, University of Copenhagen
Øster Voldgade 10
DK-1350 Copenhagen K, Denmark
ak@ign.ku.dk

Jere H. Lipps
The Dr. John D. Cooper Archaeological and Paleontological Center
Santa Ana, CA, USA
jlipps@exchange.fullerton.edu

Elías López-Romero
LaScArBx Cluster of Excellence-LabEx Sciences Archéologiques de Bordeaux
Maison de l'Archéologie
8 Esplanade des Antilles
33607 Pessac cedex, France
elias.lopez-romero@u-bordeaux-montaigne.fr

Jakob Maase
US National Park Service
10237 US-12
Naches, WA, 98937, USA
jmaase1@ksu.edu

Patricia Mañana-Borrazás
DIMENSO
Institute of Heritage Science
Spanish National Research Council (Incipit, CSIC)
Avda. de Vigo s/n
15705 Santiago de Compostela, Spain
patricia_m_borrazas@hotmail.com

Adam Markham
Union of Concerned Scientists
2 Brattle Square
Cambridge, MA, 02138, USA
amarkham@ucsusa.org

Brandon Mason
Maritime Archaeology Limited
Room 014/11 National Oceanography Centre
Waterfront Campus
Southampton, SO14 3ZH, UK
brandon.mason@maritimearchaeology.co.uk

Henning Matthiesen
Department of Conservation and Natural Sciences, National Museum of Denmark
I.C. Modewegsvej
Brede, DK-2800 Lyngby, Denmark
henning.matthiesen@natmus.dk

July Medina-Triana
Brooklyn College CUNY/Barbuda Research Complex, Antigua and Barbuda
2900 Bedford Avenue
Brooklyn, NY, 11210, USA
julyamt@gmail.com

Gustav Milne
CITiZAN
Museum of London Archaeology
Mortimer Wheeler House
46 Eagle Wharf Road
London, N1 7ED, UK
gmilne@mola.org.uk

Garry Momber
Maritime Archaeology Trust
Room 014/11 National Oceanography Centre
Waterfront Campus
Southampton, SO14 3ZH, UK
garry.momber@maritimearchaeologytrust.org

Sam Moore
Institute of Technology Sligo
Ash Lane
Sligo, F91 YW50, Ireland
moore.sam@itsligo.ie

Sean Nadji
Kakadu Hwy, Jabiru, NT 0886, Australia
Sean.nadji@environment.gov.au

Ivan Namarnyilk
Djelk Rangers
PMB 102, Winnellie, NT, 0822, Australia
Djelk@bawinanga.com

Michael Newland
Environmental Science Associates
1425 McDowell Boulevard, Suite 200
Petaluma, CA, 94954, USA
mnewland@esassoc.com

Courtney Nimura
Place, Evolution and Rock Art Heritage Unit,
Gold Coast Campus
Griffith University, QLD 4222, Australia
Institute of Archaeology,
University of Oxford
34–36 Beaumont Street
Oxford, OX1 2PG, UK
courtneynimura@gmail.com

Stéphane Noël
Département des sciences historiques,
Université Laval
1030, avenue des Sciences-Humaines
Quebec, G1V 0A6, Canada
stephane.noel.2@ulaval.ca

Stephanie Ostrich
CITiZAN
Museum of London Archaeology
Mortimer Wheeler House
46 Eagle Wharf Road
London, N1 7ED, UK
sostrich@mola.org.uk

Lilja Pálsdóttir
Institute of Archaeology, Iceland
Fornleifastofnun Íslands
Bárugötu 3
101 Reykjavík, Iceland
lilja.palsdottir@gmail.com

Jeannine Pedersen-Guzman
The Dr. John D. Cooper Archaeological
and Paleontological Center
Santa Ana, CA, USA
pedersen@exchange.fullerton.edu

Sandra Pentney
ATKINS Global
3570 Carmel Mountain Road, Suite 300
San Diego, CA, 92130, USA
sandra.pentney@atkinsglobal.com

Sophia Perdikaris
Dept of Anthropology and Archaeology
Brooklyn College CUNY/Barbuda Research Complex,
Antigua and Barbuda
2900 Bedford Avenue
Brooklyn, NY, 11210, USA
sophiap@brooklyn.cuny.edu

Reaksha Persaud
Graduate Center CUNY
365 5th Ave
New York, NY, 10016, USA
reaksha@gmail.com

Laura del Puerto
Laboratorio de Arqueología del Paisaje y Patrimonio
(LAPPU), Facultad de Humanidades y Ciencias de la
Educación (FHCE), Centro Universitario Regional del
Este (CURE), Universidad de la República (Udelar)
Ruta 9 Km and Ruta 15
Rocha, Uruguay
lau2phy@yahoo.com

Marcy Rockman
US National Park Service
1849 C St. NW
Washington, DC, 20240, USA
marcy_rockman@nps.gov

Vincent Rousseau
Département des sciences historiques, Université Laval
1030, avenue des Sciences-Humaines
Quebec, G1V 0A6, Canada
vincent.rousseau.4@ulaval.ca

Julie Satchell
Maritime Archaeology Trust
Room 014/11 National Oceanography Centre
Waterfront Campus
Southampton, SO14 3ZH, UK
julie.satchell@maritimearchaeologytrust.org

Suntayea Steinruck
Tolowa Dee-ni' Nation
140 Rowdy Creek Road
Smith River, CA, 95567, USA
sunsteinruck@tolowa.com

Lauren Tidbury
Museum of London Archaeology
Mortimer Wheeler House
46 Eagle Wharf Road
London, N1 7ED, UK
ltidbury@mola.org.uk

Nick Tipon
Sacred Sites Protection Committee of the Federated Indians of Graton Rancheria
1410 Snowy Cloud Way
Santa Rosa, CA, 95409, USA
nicktipon@comcast.net

Xosé Ignacio Vilaseco Vázquez
Grupo de Estudos para a Prehistoria do Noroeste – Arqueoloxía, Antigüidade e Territorio Facultade de Xeografía e Historia
Universidade de Santiago de Compostela
Praza da Universidade, nº 1
15782 Santiago de Compostela, Spain
ignacio.vilaseco@usc.es

Eugenia Villarmarzo
Laboratorio de Arqueología del Paisaje y Patrimonio (LAPPU), Facultad de Humanidades y Ciencias de la Educación (FHCE), Centro Universitario Regional del Este (CURE), Universidad de la República (Udelar)
Ruta 9 Km and Ruta 15
Rocha, Uruguay
eugenia.villarmarzo@lappu.edu.uy

Greg Wilson
Djelk Rangers
PMB 102, Winnellie, NT, 0822, Australia
Djelk@bawinanga.com

Eliott Wragg
Thames Discovery Programme
Museum of London Archaeology
Mortimer Wheeler House
46 Eagle Wharf Road
London, N1 7ED, UK
ewragg@mola.org.uk

Chapter 1

Public archaeology and climate change: reflections and considerations

Courtney Nimura, Tom Dawson, Elías López-Romero and Marie-Yvane Daire

Introduction

Heritage sites have the potential to inform us about past climates and to demonstrate how humans have adapted in times of change. Ironically, many of the sites that hold this information are themselves now vulnerable to changing climates. There is a long-established tradition of rescue archaeology at sites threatened by development, and the principle of the 'polluter pays' is referenced in the planning guidance of many countries. But what happens when there is no developer? Who should take action when natural processes put sites at risk? The threats are many, including flooding, erosion, desertification, sea level rise, thawing of permafrost, and the drying of waterlogged deposits. Worryingly, climate change predictions (*e.g.* Stocker *et al.* 2013) suggest that the problem is likely to increase in the future. Though discussions on action in the face of climate change have been taking place amongst governmental policy makers for many years, it is only very recently that threatened heritage has been included. In fact, the words 'cultural heritage' appear only twice in the 1550-page Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report (Stocker *et al.* 2013). However, archaeologists and heritage managers on the ground are acutely aware of this issue and are employing new approaches at sites threatened by climate change, especially initiatives that engage communities or employ 'citizen science' techniques.

This was the motivation for organising the session 'Engaging the public with archaeology threatened by climate change' at the European Association of Archaeologists' (EAA) 2015 Annual Meeting in Glasgow. This conference session specifically focussed on the threats that climate change poses to heritage, a concern that has gained increased publicity in recent years (several sessions at the COP21: United Nations Conference on Climate Change meeting in 2014 also focussed on the problem: http://www.cop21paris.org/about/cop21). The Glasgow session included 15 presentations that highlighted examples of climate change threatened archaeology from across Europe, the United States, and Australia.

This volume, however, is not a conference proceeding, but rather a curated collection of papers intended to bring together the topics highlighted in our conference session, namely the intersections of climate change studies, public archaeology projects and cultural heritage management strategies. While several reports (*e.g.* English Heritage 2008), sessions and meetings on the threats to cultural and archaeological heritage had been organised by us and other colleagues in previous years (*e.g. Management and investigation of marine, coastal and intertidal prehistoric archaeology: Developing a research agenda* at the EAA 2007 Annual Meeting in Zadar, Croatia; *New challenges for sustainable coastal archaeology in the 21st century* at the *HOMER* 2011 conference in Vannes, France; *Over the edge: Heritage management and coastal erosion* at the EAA 2012 Annual Meeting in Helsinki, Finland; *Current trends in coastal heritage vulnerability and resilience* 2014 meeting in Durham, United Kingdom), the public dimension of the problem had not been the object of a specific, in-depth monograph. This was the main impetus for creating this volume.

In this chapter, we not only introduce the contents of this book (Fig. 1.1), but also discuss a number of concepts

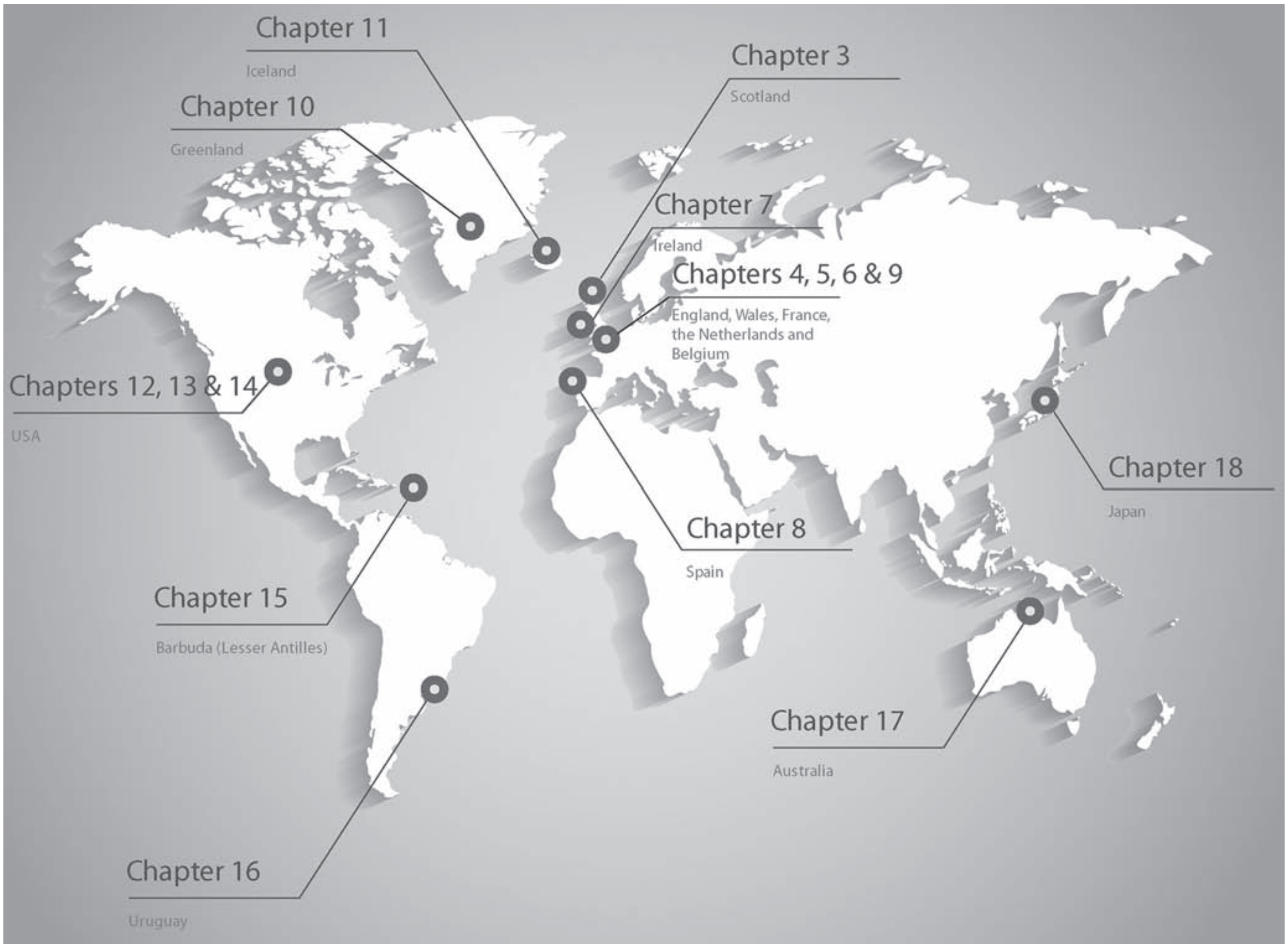

Figure 1.1. Map showing the locations of the case studies featured in the chapters (modified by the authors using the original basemap design by Freepik: http://www.freepik.com).

relating to the aforementioned topics, some of which are only reflected on here, and others which are expounded upon in later chapters.

Defining heritage in a time of climate change

Climate change is a reality – from a long-term geological, archaeological and historical perspective we know that climatic processes and their effects are an inherent part of the shaping and evolution of our planet. From a heritage perspective, however, we cannot idly witness the loss of scientific and cultural information that these changes are causing – we must get involved in their study and preservation. Thousands of archaeological and, more widely, heritage sites are being affected and destroyed by the present global climatic shift, which is both creating new and exacerbating pre-existing threats. In addition to the destruction of more visible sites, deposits containing precious environmental information about the evolution of landscapes are also suffering from these changing conditions.

As the effects of these changes became more evident in the last few decades, concern increased in parallel with the development of an extended, more complex definition of *heritage*. Several attempts have been made to reduce the gap between definitions of 'cultural' and 'natural' heritage, considering that both of them have an equivalent, complementary and inclusive value for human societies. And new terms are being created to better define the ways in which people and communities define heritage for themselves. The process by which specific groups give a social value to objects, places or practices that represent their history, tradition or way of life has become known as *heritagisation* (for other definitions and a debate on this concept see *e.g.* Sánchez-Carretero 2013).

Heritage is approached subjectively, whether by visitors, local residents with a shared heritage, specialists, managers or even by landowners on which sites are located. Therefore, the ways in which different individuals and communities understand heritage at risk is thus equally varied, context- and situation-specific, and subject to the perspectives of the stakeholders involved. The economic activities that take place at or around a site may be seen as a continuation of a traditional way of life that contributes to the preservation of the landscape by some, but as a hindrance to other types of activities by others. In many cases, preservation *in situ* is preferable. When that is not possible, the transfer of a site or some of its elements to a museum outside the local area may take place. This may elicit opposition by the community, which could perceive it as a sort of amputation of something that *belongs* to that place. Many of these scenarios highlight the different levels of heritage policies involved and the complications that might arise between them.

Local and regional policies tend to match the heritage use and preservation expectations of local communities more closely, but national, transnational (*e.g.* cross border) and international (*e.g.* UNESCO) regulations must consider a majority of the populations demands. And these regulations do not always agree. Determinations about accessibility, building of infrastructures, land-use, provision of funds or musealisation (a concept that critically questions the preservation of heritage or cultural material by, for example, placing it in a museum, consolidating structures, creating pathways for visitors or installing information panels *in situ*), may become points of conflict. The fact that, in some instances, several different policy levels converge on one site adds to the complexity of the problem. And different agents will have different priorities, creating gaps between how policy makers, specialists and the community perceive what heritage is, why some types of heritage are protected, and what measures are taken to protect – or not protect – different sites.

This is often the case when discussing the relationship between heritage, economy, development and tourism. On one hand, the effects of climate change on archaeological and heritage sites may negatively impact the economic income of certain areas, *i.e.* a decrease in the number of visits, if preservation issues arise. On the other, they may impact it positively, *i.e.* cruise ships travelling through the Bering Strait due to melting sea ice. As Chapter 8 shows, an uncontrolled increase in the number of tourists to a heritage site may contribute to the acceleration of natural and cultural site destruction in fragile ecosystems. In such cases, even though the economic impact of such tourist activity is positive, local communities may demand restricted access if they perceive tourism as the main threat to preservation. So while the tourist sector may be the main 'consumer' of heritage, several studies have warned of the risks of not adopting sustainable ways of developing the economic value of heritage (*e.g.* Pedersen 2002).

While this book mainly concerns the materiality (archaeology) of specific types of heritage (cultural landscapes, sites, buildings), it also recognises the intrinsic, immaterial values of heritage for the public and specific communities (Smith 2006). While considering the materiality of archaeological remains such as shell middens and rock art in Northern Australia, Chapter 18 shows how the very idea of material heritage loss impacts the meaningful, immaterial heritage represented by the different codes of interpretation passed from generation to generation of communities in the area. It is not just material heritage that is threatened by observed climate changes, but also the ideas, narratives and discourses that different communities have built around that heritage; the relevance of the local environment for defining 'public/community archaeology' is capital (Chapter 3 and see also Moshenska *et al.* 2007).

Heritage is a multi-vocal concept that can have multiple meanings and be thought of and approached from very different perspectives by very different social layers and individuals. Bridging these diverse perspectives is not an easy task. In fact, one could argue that the use of the term heritage itself is more a resource employed by specialists and managers than a widespread, understandable concept for members of the local community. An individual's expectations and ideas about climate change policies related to heritage sites do not always match those of the community, not to mention those of the different institutions responsible – at different stages and degrees – for their management and conservation. These 'fractures' (Sánchez-Carretero 2013) and the different sensibilities attached to archaeological sites threatened by climate change are the object of discussion in the different chapters of this book. To different degrees, each paper analyses the dialogue and conflicts existing between specialists, communities, visitors, managers and policy makers; and proposes ways of reducing the gap between their different points of view.

Public archaeology and climate change: challenges

What is clear from the papers compiled in this book is that the process of building solutions to present climate change threats to cultural – and more precisely archaeological – heritage is well underway in some regions, and we should strive to better integrate public-driven approaches. This integration, as these distinctive case studies show, can take particular forms and can be adapted to very different geographical, societal, collective and individual contexts. But as complicated as the definition and interpretation of the term 'heritage' is, so is the definition of 'public archaeology'. As Gabriel Moshenska (2009, 46) pointed out in his paper 'What is Public Archaeology?': 'there is still a degree of uncertainty about the precise definition and delineation of public archaeology'. Much has changed even since 2009, but it remains clear that we are, perhaps, still working out as an international discipline what is the meaning of public archaeology. The term is often used synonymously with other terms such as community archaeology, active/action archaeology (Sabloff 2008), applied archaeology, and other times terms like community archaeology are presented as a subset of public archaeology (see Sabloff 2012). And it is not always clear what we mean when we refer to the 'public'. Although we could list hundreds of different definitions, each influenced by varied national traditions, this is not the topic of discussion at hand (but see Matsuda 2016; Richardson and Almansa-Sánchez 2015 for recent reviews).

For our purposes here, we should clarify that the authors have interpreted the term 'public archaeology' in a variety of different ways. Generally, they have used the term 'public' to describe people who are not employed as archaeologists or within the heritage sector (other terms such as non-professionals are also used to describe people not employed as archaeologists in various chapters in this book). They use public archaeology as a descriptor for active and direct engagement with members of the public that are interested in their local archaeology (from outreach to education initiatives), indirect engagement with members of the public (publicising the resources and engaging via social media), or to describe archaeological work driven by, undertaken by, or involving community members (from citizen science projects to community excavations). Although grappling with the more political or theoretical aspects of public archaeology was beyond the remit of this book, we have hopefully touched on at least some aspects of these discourses in this chapter (and in this volume). Rather, the chapters herein present project case studies and examples of practical engagement that mainly follow two key aspects of public archaeology: the management of public archaeological resources and conducting archaeology with the public. These case studies show a capacity for acting critically and self reflexively, which has led to new standards for public archaeology practices, and highlight diversity in their approaches, as they attend to their varied heritage and wide array of stakeholders. They also highlight many shared challenges. In some countries national regulations hinder the involvement of the public in archaeological work, from excavation to monitoring to simply knowing the location of archaeological sites; in other places an historical lack of public involvement has delayed the growth or success of this type of work.

One of the main challenges associated with a public-driven approach concerns the very different scales at which the integration of this approach – and the decision-making process attached to this integration – will have to take place, as it would ideally combine local and regional actions with wider national and international activities. This means that there is an urgent need for a more fluent exchange of information and the development of both new and flexible approaches between the managerial/political spheres and the people whom they serve. For instance, while there are regularly scheduled professional meetings on cultural heritage and climate change, very few – if any – of them are aimed at integrating the general public. At the interface of these two poles, the role of heritage professionals, including archaeologists, is pivotal. Considering this overall context, the main challenges archaeology has to face concerning climate change in the years to come can be classified as administrative, societal and technological challenges.

A number of administrative challenges are discussed throughout this book, mainly revolving around the implementation of high-level policies on the ground and negotiating the demands of a wide range of stakeholders. There are also interdisciplinary challenges, as climate change is under the purview of a diverse set of disciplines, which each have particular views when approaching concepts such as risk, vulnerability and resilience. Geographers, biologists, economists and more recently historians and archaeologists have developed their own ideas and nuances around these concepts (*e.g.* Pigeon 2005; Erlandson 2008; Briguglio *et al*. 2009; Thornton *et al*. 2014), which are frequently focal points of climate change discussions. Therefore, there is a need to promote the wider integration of cultural and archaeological heritage into the debate on the effects of climate change at the local, regional, national and international forums. There remains insufficient representation of cultural heritage on some of the leading panels currently discussing climate change across the globe, resulting in the need for a more effective interdisciplinary debate on climate change policies, its perspectives and consequences.

The same can be said for incorporating other parts of society into these discussions. As already stated, we should aim to better integrate the public and communities into the many stages of cultural heritage projects, from planning and research to management and dissemination. One of the most valuable characteristics of local communities is their capacity to observe changes in their local area – a characteristic that is applauded in many of the case studies in this book.

Digital technologies are aiding some of these integration processes, in some cases greatly increasing the numbers of people that are able to take part in surveying, registering, monitoring, preserving, analysing and displaying archaeological sites threatened by climate change. Smartphone apps, interactive websites and virtual displays are already being used to bridge the gap between the research and management of archaeological sites and the communities that live with them. However, as observed in some studies, these innovations also provide their own set of challenges, as some of these tools can be discriminating against those who may not feel comfortable using them. Developing user-friendlier applications, making available training workshops for non-specialists, and offering low-tech or no-tech alternatives, such as paper pro formas, will help to maintain and improve the dialogue between specialists and the public.

Public archaeology and climate change: the contents of this book

Unlike many natural ecosystems, which are subject to cycles and have some potential for regeneration, the inherent resilient capacity of most archaeological sites is extremely low. Once the conditions that have allowed their preservation change, they depend on external human action in order to maintain their balance and a certain degree of resistance against the agents threatening their integrity. This incapacity for regeneration constitutes one of the main aspects that defines the situation of most archaeological sites suffering the effects of climate change, and one that will need to be at the forefront of interdisciplinary discussion on this matter in the short to medium terms. What is highlighted in the case studies throughout this book is that there is no single answer to the issue of climate change threatened archaeology – the effects of climate change are as diverse as the environments on this planet, and as diverse as the archaeological material that it affects. And though the diversity of both the threats and the heritage it threatens presents significant challenges, it is also perhaps a source of potential to test innovative methods across a range of research areas. This is where we begin.

In Chapter 2, Adam Markham provides an overview of the scale of the problem facing heritage sites in a time of changing climate. Noting that climate change is probably the fastest growing threat to cultural heritage worldwide, he describes change at some of the most iconic heritage sites on the planet – those inscribed on the UNESCO World Heritage List. Markham argues that World Heritage sites are important not only for their cultural value, but that they also have economic benefits, are tools for educating the public about the impacts of climate change, and are resources for public engagement. He provides examples from around the world, highlighting different types of threatened world heritage from iconic monuments, sacred sites and objects to traditional lifestyles and intangible cultural heritage. Markham not only summarises the problems facing World Heritage Sites but also outlines the recommendations aimed at addressing climate-related threats to our shared, global cultural heritage.

Although the remaining chapters are based on case studies from specific countries, each contains elements and methodologies that can be applied globally – many of these recurring practices have been pointed out throughout this introductory chapter. In Chapter 3, for example, Tom Dawson and colleagues focus on the surprisingly varied coastline of Scotland (one of the longest in Europe), but the summary of threats posed to heritage sites is applicable to coastal areas around the world. These are areas which, in many countries, are likely to feel the effects of climate change soonest. In Scotland, there has been a tradition of working at sites threatened by coastal processes that extends back to the 19th century. Local and national agencies have developed a range of initiatives to record and monitor vulnerable sites, and there is also a strong Scottish tradition of involving the public in heritage projects, and community action at eroding coastal sites has evolved since community initiatives in the 1990s. The authors discuss *SCHARP*, a recent, two-staged community project. The first stage employs a citizen science approach and mobile technology to updating existing heritage records and redefining priorities. This has been followed by community action at locally-valuable sites, and a range of project types have been undertaken in order to test different approaches. Local groups have collaborated with heritage professionals in projects such as detailed 3D digital recording and the excavation and relocation of a threatened site. The chapter concludes by discussing the role of the non-professional in archaeology, giving examples of the strengths and weaknesses of such projects – a feature of almost every chapter in this book.

Chapter 4 also focuses on the coast, and discusses how heritage data can be useful in helping to understand longer-term environmental change, a topic also raised in Chapter 14. Garry Momber and colleagues present the *Arch-Manche* collaborative project, which showed how coastlines have evolved over time and assessed techniques that can be used by coastal managers and others to give an indication of the scale and rate of past change. The study focussed on the coastlines on either side of the sea that separates England from continental Europe. The team examined old maps, works of art and photographs, comparing them with modern depictions in order to determine change. They also reviewed and recorded ancient monuments, archaeological deposits, and palaeoenvironmental data, each of which was ranked with a score indicating the value of the resource and how useful it is for indicating past coastal change. The results of this review informed the development of a number of more detailed projects, such as fieldwork involving local volunteers. This included an investigation of the western Solent in southern England, where some historic sites were investigated, together with a project looking at submerged soils which were deposited before the area was flooded with sea water. The *Arch-Manche* project emphasises the importance of considering many forms of evidence and taking a long view of coastal processes.

Chapter 5 reviews two important initiatives taking place in England: the *Thames Discovery Programme* (*TDP*; which focuses on the foreshore of London's river) and *CITiZAN* (which records sites around the English coast). Eliott Wragg and his colleagues give a brief history of work at intertidal sites in England, noting the piecemeal nature of foreshore recording in London until a sustained programme of survey began in the 1990s. Over the years, the survey developed into the *TDP*, which has trained a large number of volunteers (known as FROGs) to investigate this unique record. The project is closely connected to the work of *SCHARP* in Scotland (Chapter 3), and together inspired the development of the *CITiZAN* project. *CITiZAN* employs mobile technology to help the public record sites, focussing on four unique attributes of coastal archaeology (boats, coastal military remains, coastal industries and submerged landscape), together with projects that look at coastal change and sea level rise. In fact, the mobile technology was developed by the same company that created the data collection applications for SCHARP, with the goal to enabling better collaboration between volunteers of each programme. The paper concludes by pointing out that more sustainable models for the funding of community archaeology projects are needed, a point that is emphasised throughout this book.

Chapter 6 develops the topic of the sustainability of community projects further, demonstrating the value of a national community heritage project, but also providing an example of what can happen once project funding stops. Claudine Gerrard writes from the perspective of an archaeologist with the National Trust for Wales, a major conservation body that owns just over 25% of the Welsh coastline. Wales is managed by a number of organisations, each with specific responsibilities. In addition to landowners, there is a government body (Cadw), a non-governmental organisation (RCAHMW) and four Archaeological Trusts, each with responsibility for a different region of Wales. Together, these organisations have made all historic environment records publically accessible through the *Archwilio* online portal, and have also been involved in the successful *Arfordir* community project, which recorded threatened sites along the Welsh coastline. However, once funding for the 4-year *Arfordir* project came to an end, the National Trust for Wales, a major landowner and former project partner, was faced with a public that had become accustomed to help and guidance from heritage professionals. The paper gives examples of several coastal sites that have been damaged since *Arfordir* finished. These were places where, despite strong public interest, funding was not available to undertake community projects. Contrasting long and short-term community projects, the author highlights the benefits that the national programme delivered, but warns that the situation in Wales could be repeated in other places undertaking citizen science recording projects with short-term funding.

Continuing both the coastal and sustainability themes, Chapter 7 crosses the Irish Sea to the west coast of Ireland. James Bonsall and Sam Moore note that there is growing evidence for increasing storm damage along the coast of Ireland, leading to erosion and the destruction of heritage. The paper describes the heritage found along the County Sligo coast and under the sea; this rich resource contributes to the local economy and is embedded in the tourism and sustainability plans of Sligo County Council. However, the coastal heritage is threatened and severe storms over the winter of 2014–2015 led to the formation of the *Monitoring the Archaeology of Sligo's Coastline* (*MASC*) project. The project team had many problems to overcome, not least the robust heritage laws of Ireland that have limited the potential for public participation in projects, a problem similar to that experienced in the USA, as described in Chapter 13. There are also restrictions on walking across private land, and most monitoring had to be done from the beach. This chapter describes how the project team started working with the public and a range of societies, encouraging them to contribute information on the condition of threatened heritage sites. The authors describe how they developed their network, using easily accessible tools such as social media and open access software to ensure that volunteers remained informed and that information was shared. Although the benefit and value of this and other public archaeology projects can be demonstrated, as noted above, sustainability remains a major problem.

Chapter 8 focuses on a project to record archaeological remains on an island in Spain. Elías López-Romero and his colleagues demonstrate how heritage can capture local imagination and become a rallying point for community action. Guidoiro Areoso is a small, sandy, low-lying island in Galicia. It is vulnerable to storm damage and high waves, and over the years a number of large archaeological sites, including megalithic monuments, have been exposed (and in some cases destroyed). Recently, the island has seen an increase in tourist numbers as a result of improved access from nearby ports, but also partly due to the release of a video that imaginatively highlighted erosion on the island. The authors wanted to document the changing patterns of erosion, and adopted a crowd-sourcing approach that appealed to the public for historic images of the eroding monuments. People were asked to contribute copies of their holiday photographs, and the successful campaign resulted in an archive of images and video that allowed several of the monuments, including some that were subsequently destroyed, to be recreated as digital 3D models. These demonstrate change over time and have helped to recreate lost monuments, providing new detail that had not been previously recorded. The project has helped reveal erosion rates and has increased the awareness of the public and heritage managers of the scale of the threat. It has also demonstrated that there is a strong and committed public interest in documenting threatened heritage sites.

Chapter 9 moves us to neighbouring France, where the *ALeRT* project has developed a methodology for evaluating the vulnerability and resilience of heritage sites. Pau Olmos Benlloch and his colleagues describe how they have used a simple, standardised evaluation form to record heritage data in Brittany, with observations on threat and resilience converted into numerical values. By applying a simple mathematical calculation, a score is derived which classifies sites as being at low, medium or high risk – creating standardised rubrics for risk management is also a technique employed in Chapter 17. The project team are working with members of the public, and are also collaborating with the *Conservatoire du Littoral*, a wildlife conservation organisation, with a hope of making the project more sustainable. *ALeRT* also created a mobile application for data collection and provided training for its users. Following severe storms over the winter of 2013–2014, the system was put to the test. The paper describes one case study, on the Island of Roc'h Santec, where volunteer surveys enabled the team to assess changes and map damage, partly by making 3D reconstructions (some of the project team also worked on the project described in Chapter 8). Although the project was developed in northern France, the methodology is now being applied to other areas, including parts of Spain. The authors hope that this methodology, together with others developed elsewhere (many of which are discussed in this book), will result in more collaborative partnerships.

Chapter 10 describes the extraordinarily well-preserved heritage of Greenland, where remains spanning over 4000 years of occupation have survived due to low temperatures and favourable soil conditions (see also Chapter 14). This has resulted in the preservation of organic artefacts and other material that does not usually survive. Climate change is often associated with global warming, and Jørgen Hollesen and colleagues describe how rising temperatures will have a devastating effect on the archaeological heritage in Greenland. In order to plan for the future, the authors have been conducting a number of investigations to measure the effects of rising temperatures on permafrost and organic remains. Their scientific observations, together with a comparison of current site conditions with past records, demonstrate that sites are being affected and that evidence is being lost. In order to help further understand and manage this change, the new *REMAINS* project is investigating individual sites. The team are using their results to help predict those areas and site types which will be most at risk, and thus prioritise action at the most threatened sites. Due to the enormity and remote nature of much of Greenland, a project such as this relies partly on the local population. Information about Greenlandic heritage has been provided by local Inuit people, such as the location of sites and their traditional use. The *REMAINS* project will build upon these previous collaborations, creating a methodology for preserving this extraordinary resource at a time of increasing threat.

A medieval fishing station on the west coast site of Iceland is the focus of Chapter 11. The inland area was already well-known for its large farm mound and remarkable collection of dry-stone storehouses or drying sheds. However, the detailed project described here began after a local resident informed the authors that erosion had exposed a number of fishermen's huts along the coast edge. Lilja Pálsdóttir and Frank Feeley describe the collaborative project, which aimed to save as much information as possible before the huts were destroyed. Several seasons of survey and excavation uncovered multiple structures and revealed some of the working practices at the site. The Snæfellsnes Peninsula already attracts large numbers of domestic and overseas tourists, both to the upstanding storehouses and to other local places (the site is on the route to Jules Verne's entrance to the Centre of the Earth). The project team, therefore, had a policy of open access for visitors, providing site tours to inform people about the value of the archaeological site and the threats it faces. They adopted lessons learned from another Icelandic community heritage project and applied them to their work with local schools, preparing educational material and giving talks to students and teachers. They also gave a number of talks in local villages, which resulted not only in increased awareness, but also in local fishermen expressing an interest in past fishing practices; they have since given insights into modern and traditional methods, thus providing a link between past and present.

Crossing the Atlantic, Chapter 12 shows how the US National Park Service (NPS) is highlighting climate change by using the numerous historical places in its care. With more than 280 million sites visitors per year, the NPS uses the cultural sites within its parks to provide information, making them the largest informal education institution in the United States. Marcy Rockman and Jakob Maase explain that the NPS has recognised the enormous impact that climate change will have on heritage sites, and has created response strategies for managing and addressing change within their parks. In addition, the NPS has looked at how the threatened resources can be used to teach the public about the past in order to help people become more aware of what may happen in the future. One recent strategy for educating visitors is the creation of climate stories – short but powerful tales that relate to cultural features within specific parks. The chapter details how this innovative way of interacting with the public evolved and explains how the stories were crafted. It also provides examples of some stories, showing how this technique can help inspire the public to think both about the past and the future.

Chapter 13 discusses the range of threats – the primary two being forest fires and damaging coastal processes – facing the Californian coast and highlights some of the complexities of working at vulnerable sites. Michael Newland and fellow archaeologists together with tribal representatives describe how natural processes will impact upon a range of heritage assets, with many of the vulnerable sites being of importance to Californian tribal groups. The tribal representatives detail how climate change is affecting both tangible and intangible heritage. They present the long view, explaining how tribal groups have cared for their heritage in the past. Within the groups, there is debate on whether action should be taken to prevent sites from being destroyed, highlighting a tension between policymakers and traditional beliefs. In some cases, practical work has been undertaken on public land, and this chapter gives details of collaborative projects that have created records and assessed the state of heritage sites. As in Chapter 7, some of the problems of working with volunteers in parts of the United States are outlined. These include a system which requires archaeologists to hold permits before they can write reports and prohibitions on making site locations known to the public due to a fear of looting. The authors show how they have worked around these restrictions to undertake a project that is bringing real benefits to a range of stakeholders.

Chapter 14 discusses the threatened heritage in the vast, yet sparsely populated North Slope of Alaska. Anne Jensen begins by providing a chronology of the various different groups who have inhabited the area in the past. She discusses how the lifestyles of modern communities in the Arctic have resisted the radical transformations seen in other parts of the globe, with local communities curating a wealth of traditional knowledge. Jensen gives a brief summary of archaeological research, showing that, as in Greenland (Chapter 10), excavators recovered organic and other archaeological material displaying remarkable levels of preservation in the frozen ground. Jensen notes that the pristine condition of many sites means that archaeological and palaeoenvironmental data recovered through excavation should be shared with other scientific disciplines, thus adding an historic element to established observing networks (places where identical data are collected at multiple stations or nodes). However, this valuable resource is threatened, and warming permafrost and massive coastal change is putting sites at risk. Jensen discusses the work undertaken in partnership with local residents who are keen to see their heritage preserved, including training programmes and recording of heritage sites. This chapter also details the rescue excavation at Walakpa, an iconic and deeply stratified archaeological site that is being impacted by storm damage.

Chapter 15 presents a collaborative community project on the Caribbean island of Barbuda. Sophia Perdikaris and her colleagues argue that in many parts of the world, the effects of climate change are abstract, something that will happen elsewhere or in the future. In Barbuda, the effects are already being felt. As with many other island nations, the heritage of Barbuda faces a range of challenges in the face of changing climate. In order to better understand the impacts of predicted climate change, the team created locally-relevant computer models. These showed best and worst case scenarios for sea level rise, and also took various climatic factors into consideration, including hurricanes and other storm events. The models helped to highlight the most vulnerable sites, allowing action to be prioritised. The authors describe how they have employed a multidisciplinary approach to researching the interplay between culture and environment on the island. Collaborative community action was then undertaken at some sites, and the chapter gives four case studies which highlight different threats and shows how projects linked the arts and humanities with natural and social science research. Barbuda is a young nation, and the collaborative research involving the local community is helping to strengthen cultural identity and allowing the present population to see how people faced challenges in the past.

Camila Gianotti and her colleagues detail the different policies that have been developed to protect heritage in Uruguay in Chapter 16. Until recently, national laws legally protected archaeological sites, but this did not mean that they were effectively managed. The situation is now changing due to the creation of new categories of protection, which bring together the management of both cultural resources and natural heritage. The new system allows the effects of climate change to be included in assessments of cultural heritage, leading to new studies and better systems of protection. Three new types of protected area have been established within Uruguay and case studies from each are explored. These detail some of the ways that managers have worked with the public to raise awareness about heritage among the local population, including methods for stimulating heritage-related economic development. In the *Santa Teresa National Park*, archaeological trails and interpretation have been provided and activities created for local schools. At *Laguna de Rocha Protected Landscape*, participatory fieldwork, oral history recording, school projects and the design of exhibitions, including an international photography exhibition, have been undertaken.

Chapter 17 discusses the situation in northern Australia, where some have argued that ecological change is of less concern to indigenous communities because of the social and economic disadvantages that many groups face. Bethune Carmichael and his co-authors demonstrate that the communities do have grave concerns about climate change damage to heritage and spiritual sites, and give details of a collaborative project to help manage impacts. A bottom-up approach was taken during the project, which included interviewing senior Indigenous rangers, many of whom reported damage and loss of heritage sites which they agreed should be kept safe and strong. The project has developed a tool for use in field survey by Indigenous rangers, and a system for prioritising sites according to their significance and sensitivity to hazard was developed. The authors describe the variables recorded to determine risk and significance, and as the tool was intended for use by Traditional Owners, significance is determined according to their values. The paper also discusses the different adaptation options considered by the rangers for threatened sites. Some of the types of action discussed elsewhere in this volume were not seen as appropriate, as many of the sites continue to be used in cultural practice and are important for 'learning on country'. Some options, such as relocation, were dismissed by rangers, while others, such as digital reconstruction, were considered to provide only a partial solution.

Chapter 18 focuses on Japan, a mountainous country where much of the upland area is tree-covered. The abundance of timber is one of the factors that has led to 90% of the important cultural properties and national treasures of Japan being built of wood. Wooden objects and structures present a differing set of vulnerabilities in the face of climate change to other sites discussed in this volume, and Peter Brimblecombe and Mikiko Hayashi note that challenges include temperature variations and rainfall shifts, and also threats associated with fire, insect infestations and mould growth. Additionally, many of the historic buildings are living monuments, associated with festivals that attract large numbers of visitors who view the historic and natural heritage in tandem. Climatic variations are leading to changes in the timing of the flowering of blossom and autumn leaf colour, affecting the experience of many festival visitors and the way in which they appreciate historic properties. Although public understanding of climate change is extremely widespread in Japan, there is, as yet, limited appreciation of the impact of climate change on heritage, with most public understanding centred on extreme events such as earthquakes and tsunamis. The chapter notes that efforts are now underway to improve understanding about climate threats to heritage. The school curriculum already includes lessons on climate change, and some educational groups are developing materials which will include information about heritage as well as climate change.

Researchers and heritage managers around the world are facing severe challenges and developing innovative mechanisms for dealing with them. Increasingly, archaeologists are engaging with practices learned from the natural heritage sector, which has long worked with the public in practical recording projects: citizen science projects involving communities are now being further developed and adopted around the globe. These initiatives develop partnerships that include using mobile technology to collect data; sharing new digital recording techniques; undertaking a range of practical projects; and using innovative outputs to make information more readily available. By involving the public in projects and making data accessible, archaeologists are engaging society in the debate on both threatened heritage and wider discussions on climate change. Community involvement is also key to climate change adaptation strategies, and citizen science projects can help to influence and inform policy makers. The papers included in this book encompass current debates on the topic and propose novel solutions and approaches to managing heritage sites affected by climate change across the globe, making it a key reference for those involved in climate change and heritage studies.

References

Briguglio, L., Cordina, G., Farrugia, N. and Vella, S. 2009. Economic vulnerability and resilience: Concepts and measurements. *Oxford Development Studies* 37(3), 229–47.

English Heritage. 2008. *Heritage Counts 2008, England: Climate Change*. London, English Heritage.

Erlandson, J. M. 2008. Racing the rising tide: Global warming, rising seas and the erosion of human history. *Journal of Island and Coastal Archaeology* 3, 167–69.

Matsuda, A. 2016. A consideration of public archaeology theories. *Public Archaeology*, DOI: 10.1080/14655187.2016.1209377.

Moshenska, G. 2009. What is public archaeology? *Present Pasts* 1(2009), 46–48.

Moshenska, G., Dhanjal, S., Doeser, J., Phillips, S. and Allen, S. 2007. Community archaeology: Against the odds. *Current Archaeology* 213, 34.

Pedersen, A. 2002. *Managing Tourism at World Heritage Sites: A Practical Manual for World Heritage Site Managers*. World Heritage Manuals 1. Paris, UNESCO World Heritage Centre.

Pigeon, P. 2005. *Géographie Critique des Risques*. Paris, Economica-Anthropos.

Richardson, L.-J. and Almansa-Sánchez, J. 2015. Do you even know what public archaeology is? Trends, theory, practice, ethics. *World Archaeology* 47(2), 194–211.

Sabloff, J. A. 2008. *Archaeology Matters: Action Archaeology in the Modern World*. Walnut Creek, CA, Left Coast Press.

Sabloff, J. A. 2012. Public Archaeology. In *Oxford Bibliographies in Anthropology*. Available at: http://www.oxfordbibliographies.com/view/document/obo-9780199766567/obo-9780199766567-0021.xml [accessed 3 January 2017].

Sánchez-Carretero, C. 2013. Significance and social value of cultural heritage: Analyzing the fractures of heritage. In M. A. Rogerio-Candelera, M. Lazzari and E. Cano (eds), *Science and Technology for the Conservation of Cultural Heritage*, 387–92. London, Taylor and Francis.

Smith, L. 2006. *Uses of Heritage*. New York, Routledge.

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P. M. (eds). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, Cambridge University Press. Available at: http://www.ipcc.ch/report/ar5/wg1/ [accessed 3 January 2017].

Thornton, P. K., Ericksen, P. J., Herrero, M. and Challinor, A. J. 2014. Climate variability and vulnerability to climate change: A review. *Global Change Biology* 20, 3313–28.

Chapter 2

The growing vulnerability of World Heritage to rapid climate change and the challenge of managing for an uncertain future

Adam Markham

Abstract

Global average temperature has risen by nearly 1˚C since the second half of the 19th century, driven largely by the burning of fossil fuels. The impacts of climate change are increasingly affecting cultural heritage and resources worldwide, including those meant to be afforded protection under the World Heritage Convention. World Heritage sites include some of the most iconic places on the planet, drawing millions of annual visitors and providing many people with their first close-up encounter with archaeology outside of museums. As such they provide an extraordinary opportunity to educate and engage the public around the threat of climate change. This paper outlines the ways in which a broad array of climate impacts are already damaging cultural World Heritage sites and increasing their vulnerability to multiple stresses. It also highlights key recommendations for monitoring, managing and increasing climate resilience of World Heritage sites to preserve them for future generations.

Introduction

Anthropogenic climate change is now probably the fastest growing global threat to World Heritage sites, and by extension, to cultural heritage worldwide. A 2016 report – *World Heritage and Tourism in a Changing Climate* – published by the United Nations Educational, Scientific and Cultural Organization (UNESCO), The United Nations Environment Program (UNEP) and the Union of Concerned Scientists (UCS), the findings of which this chapter draws upon extensively, concluded that climate change represents 'one of the most significant risks for World Heritage to emerge since the creation of the World Heritage Convention in 1972' (Markham *et al.* 2016, 9). There is a quiet crisis unfolding for vulnerable archaeological sites worldwide, with many threatened by significant damage from climate change, or in the case of many coastal resources, in danger of partial or total loss. There are many ways in which climate change is already impacting World Heritage sites and the archaeological record they contain, including warmer temperatures, melting ice, reduced snow cover, thawing permafrost, increased extreme weather events (including floods, droughts and heatwaves), worsening wildfires, rising seas, coastal inundation and erosion.

Cultural World Heritage sites represent some of the most publicly accessible *in situ* archaeology, historic structures and cultural landscapes on the planet. At their best, well-maintained and expertly interpreted World Heritage sites can provide an inspiring window into the world of archaeology and cultural resources for many of the tens of millions of people that visit them every year, and thus they present an opportunity for the development of public archaeology in the service of climate response and resilience.

Some of the world's most iconic places are on the World Heritage List and many – Venice, the Great Barrier Reef, the Statue of Liberty, Yellowstone National Park, Machu Picchu, Rapa Nui (Easter Island) and the earthen mosques of Timbuktu among them – are vulnerable to, or are already being impacted by climate change. In October 2012 for example, 75% of Liberty Island (on which the Statue of Liberty stands) was inundated by an unprecedented storm surge – made worse by recent sea level rise – when Hurricane Sandy hit New York in October 2012. The storm caused tens of millions of dollars of damage to infrastructure and resulted in the monument being closed to visitors for more than eight months (Holtz *et al.* 2014). Coastal cultural heritage along the whole of the Eastern Seaboard, including thousands of monuments, cemeteries, forts, historic towns, archaeological sites and tribal lands, will increasingly be at risk as sea levels rise, worsening tidal flooding, storm surges and coastal erosion. Furthermore the intensity of North Atlantic hurricanes is expected to increase in the future due to rising upper-ocean and atmospheric temperatures (Sweet *et al.* 2013).

World Heritage sites are not only important legacies for future generations, but they also provide significant opportunities to educate visitors about the impacts of climate change and to engage local communities. They are also significant generators of economic value in the present day. More than eight million people visit either the Statue of Liberty or Yellowstone annually, spending a total of more than $800 million and supporting more than 11,000 jobs (Headwaters Economics 2016). Tourism is one of the fastest growing economic sectors in the world – responsible for 9% of global GDP and one in 11 jobs (UNWTO 2015) and it is inextricably linked with World Heritage sites wherever they are located. Committing to promoting tourism and public access at the site is a condition of being admitted to the World Heritage List, and gaining this status can be particularly important in less developed countries, where the inscription of a site often offers significant potential for economic development and sustainable tourism.

World Heritage sites such as Stonehenge, Pompeii, the Pyramids of Giza, the Altamira Cave, Mesa Verde, Machu Picchu and Angkor Wat are where many people gain their first close-up (or even 'hands-on') exposure to archaeological remains. The international World Heritage system could, with increased support and strategic collaboration from the public archaeology community, provide a potentially very significant resource for public engagement around climate change. In developing such an initiative, engagement through World Heritage sites could help draw attention to the urgency of addressing climate threats to myriad other lesser known sites. To give just one example, Skara Brae, the famous archaeological site in the Heart of Neolithic Orkney World Heritage property in Scotland, draws more than 70,000 visitors annually and is one of the top ten attractions managed by Historic Scotland. In fact, more than half of all visitors to Orkney say in surveys that they visit the islands for the history and archaeology (Gibson 2014). Skara Brae is in some ways the poster child for coastal erosion impacts in northern Europe, having had to be protected by a sea wall that was first constructed in 1925 and requires regular and expensive maintenance. But while Skara Brae receives the attention, and is reasonably well-protected (at least for the near term), Orkney has many, less well-known and unprotected archaeological sites on its coast, at least 50% of which are threatened by coastal erosion (Gibson 2014).

Scotland as a whole, with the second longest coastline in Europe, has so far had more than 11,500 coastal archaeological sites identified, with nearly a third of that number being assessed as needing some sort of action of protection in light of coastal erosion and climate change (Dawson 2013). Skara Brae's World Heritage status and the tourists it draws to Orkney can help catalyse support for public archaeology projects such as the Scotland's Coastal Heritage at Risk Project (SCHARP; see Chapter 3, this volume), which works with local communities and interested individuals bringing citizen science to bear in monitoring, recording, excavating and preserving sites at risk from coastal erosion and climate impacts.

World Heritage in a rapidly changing climate

Climate impacts can harm sites directly, damaging or destroying cultural resources, increasing risk (and insurance costs for managers, visitors and tour operators) and damage infrastructure. For example, the islands of the Caribbean have 41 sites either on or nominated for World Heritage status, but a one-metre sea level rise has been calculated to put 60% of the region's tourist resort properties, as well as many ports and airfields at risk (Nichols 2014). Caribbean World Heritage sites such as Bridgetown (Barbados), Nelson's Dockyard (Antigua and Barbuda) and the communities surrounding the Pitons (St. Lucia) are all vulnerable to climate impacts including sea level rise, more intense storms and extreme rainfall events. Worldwide coral reefs are estimated to contribute US $11.5 billion to the tourism economy (Wong *et al.* 2014) and are important natural systems, but with vital cultural resource implications for local communities and traditional owners in numerous World Heritage sites. Research indicates that coral reefs' ability to adapt to warming waters in coming decades is likely to be outstripped by the rate of global warming (Hoegh-Guldberg 2012). Preserving more than 10% of the world's corals would mean limiting global warming to 1.5˚C or less, and saving 50% would require a limit of 1.2˚C (Frieler *et al.* 2013), a near impossible goal given where we stand today. By 2012, global average temperatures had increased by 0.85˚C since 1880 (IPCC 2013) and, according to NASA, in 2016 global average temperatures had risen by 0.99˚C since 1884 (NASA 2017).

The World Heritage convention protects natural and cultural sites recognised to be of Outstanding Universal Value (OUV) for humankind and each must meet at least one of ten selection criteria, six of which represent cultural values, for example, bearing 'unique or … exceptional testimony to a cultural tradition or civilization …' or, 'to be an outstanding example of a type of building, architectural or technological ensemble or landscape …' (UNESCO nd-a). As of 2016, more than 1000 World Heritage sites in 165 countries had been designated under the system. The majority of these sites have been listed for their cultural criteria, and a small number are so-called 'mixed' sites that satisfy both natural and cultural criteria. Many sites that have been listed only for natural or cultural criteria, do in fact represent other values, but because of complexities in the process of nomination to the World Heritage List have not been formally recognised as such. The Great Barrier Reef in Australia is just such an example. It is listed only for natural values and is known worldwide for its extraordinary coral reef assemblages and biodiversity, but is also immensely important for the cultural heritage and traditions of First Australians including Aboriginal and Torres Strait Islander people who are Traditional Owners. Indigenous people are actively involved in management of the Great Barrier Reef under Traditional Use of Marine Resource Agreements and Indigenous Land Use Agreements (Great Barrier Reef Marine Park Authority 2012). Climate change is now recognised as the most significant long-term threat to the biodiversity and traditional resources of the reef and also puts at risk sacred sites of up to 70 Traditional Owner groups for whom natural resources are inseparable from cultural identity (Great Barrier Reef Marine Park Authority 2012).

Climate change is both a direct threat to World Heritage sites and a threat multiplier (Markham *et al.* 2016). Climate impacts are additive and can exacerbate existing threats, such as urbanisation, habitat destruction, pollution, resource extraction and invasive species, as well as reducing resilience to other stresses including cultural and environmental changes. For example, where weather conditions change from those in which long-standing building traditions were developed, there can be significant damage to historic and archaeological resources. Earthen architecture, for example, can be at high risk from extreme rainfall, despite having survived for centuries in a relatively stable climate. In 2010, extreme rainfall caused two major structural collapses at the 200-year old Franciscan church in Tumacácori National Historic Park in New Mexico, requiring more than 500 adobe bricks and several windows to be replaced (Moss 2010). Events such as this provide a warning sign for managers of earthen structures in World Heritage sites such as Taos Pueblo and for many other sites not on the World Heritage List throughout the American Southwest.

Deferred maintenance or the use of unsuitable materials for restoration and reconstruction can be a contributing factor at some sites. Extreme rainfall events in Italy have caused walls where restoration work was carried out in recent times to collapse, and Nero's Golden House in Rome has suffered major damage from extreme rainfall (Ingrid Rowland pers. comm.). At Kano in Nigeria, changing climate conditions, including greater unpredictability in rainfall and chronic flooding, have been implicated, along with a lack of resources for protection and maintenance, in damage and erosion to earthen walls built between the 11th and 15th centuries, and of the mud stalls in the 15th century Kurmi market (Barau 2010).

Probably the biggest single climate threat to cultural world heritage sites is from sea level rise caused by warming oceans and melting land ice, including glaciers and the Greenland ice sheet. It has been known for at least three decades that sea level rise accelerated by climate change posed a major threat to coastal cultural resources. In 1992, for example, Rowland (1992, 29) said 'There is an urgent need for heritage researchers and managers to address the issue of climate change and its impacts on archaeological sites', highlighting in particular the threat to aboriginal coastal sites in Australia. Seventeen years later the Australian government identified aboriginal archaeological sites in the Kakadu and Tasmanian Wilderness World Heritage sites as potentially threatened resources in one of the first national assessments of World Heritage properties at risk from climate change (ANU 2009). Despite early warnings, the heritage community has been relatively slow to engage with this issue. The last decade has seen a major increase in researcher interest in climate impacts on cultural resources as well as growing policymaker and public engagement. The sense of urgency is growing, but the scale of the problem and the challenges it poses for research, monitoring and management are growing too as governments procrastinate, dispute, debate and delay actions to reduce greenhouse gas emissions. There have been few comprehensive assessments of the vulnerability of cultural World Heritage sites to climate change but a 2014 study from researchers at the Potsdam Institute for Climate Impact Research and the University of Innsbruck analysed the long-term risk of sea level rise to all cultural World Heritage sites and found that 130 of 720 sites analysed were vulnerable including Bulgaria's Ancient City of Nessebar on the Black Sea, Westminster Abbey in London, India's Elephanta Caves, the archaeological site of Carthage in Tunisia, and parts of Roman Arles in France (Marzeion and Leverman 2014).

Sea level rise, storm surge and coastal erosion

One of the most iconic cultural sites on the planet, Venice, is under immediate threat from climate change and sea level rise (UNESCO 2011). Founded in the 5th century, Venice was built on the islands and marshes of the Venetian Lagoon. Today its extraordinary assemblage of Byzantine, gothic, renaissance and baroque architecture spans 18 islands and is connected with canals and bridges. It is one the world's most popular tourist destinations, hosting more than 10 million overnight visitors in 2013 (Città di Venizia 2014) and probably more than twice as many day visitors (Markham *et al.* 2016). Cruise ships alone accounted for 1.8 million visitors in 2011, a nine-fold increase in 20 years (Cocks 2013). Ever increasing pressure from tourism, including the visual and physical impacts of large cruise ships in the lagoon, are combining with climate change to put the city's future in question (Markham *et al.* 2016).

A project to protect the city from flooding during major storms is nearing completion despite decades of disputes, technical difficulties and allegations of corruption. The

MOSE project consists of 97 floodgates distributed over the three entrances to the Venetian Lagoon. The final cost of the project is expected to be in excess of €5.4 billion when completed. However, although the MOSE gates will provide protection from storm surges, water levels have risen by approximately 30 cm since 1897 as result of both climate change and land subsidence (Carbognin *et al.* 2010; UNESCO 2011). Unless they are permanently closed, which would cause significant pollution problems for Venice and the lagoon, the floodgates will be ineffective in preventing the impacts of rising water levels (UNESCO 2011). Water is already impacting hundreds of historic buildings in Venice, damaging brickwork above their stone foundations, rising in the walls and causing structural iron ties to rust (Camuffo 2001; Camuffo *et al.* 2014). The thousand-year old mosaics in St. Marks Basilica are deteriorating 6 m above the floor (Cocks 2013). Statues and monuments are vulnerable too. For example, water entering the Santa Maria Glorioso dei Frari Basilica is being drawn up into the marble statues of the cenotaph built by the sculptor Antonio Canova and causing flaking and blistering (Camuffo *et al.* 2014).

Other World Heritage sites recently highlighted by UNESCO as being under direct threat from inundation due to sea level rise include:

- Hoi An Ancient Town in Vietnam's Quang Nam is an exceptionally well-preserved example of a Far Eastern trading port active during the 15th through the 19th centuries. The town is famous for its more than 1100 wood-framed buildings, 800 of which date from the 17th and 16th centuries. Most of Hoi An is no more than 2 m above sea level and is already quite vulnerable to flooding during storm surges. A recent UN-Habitat study warned that virtually the whole of the An Dinh district, the area of the town with the greatest number of historic structures, is likely to be affected by severe flooding on annual basis as soon as 2020 (Markham *et al*. 2016; UN-Habitat 2014).
- Parts of Old Town Lunenberg on the southern coast of Nova Scotia in Canada are threatened with permanent inundation due to climate change, and areas previously unaffected by flooding or storm surge will increasingly become vulnerable. The best surviving example of a British colonial settlement townscape in North America, Lunenberg has been dependent on its waterfront since its founding in 1753. Amongst the structures most at risk is the Fisheries Museum of the Atlantic, a complex of historic buildings showcasing the town's maritime legacy on the waterfront (Forbes and Wightman 2013).
- The Spanish colonial city of Cartagena is one of the most vulnerable Caribbean coastal cities to sea level rise. Founded in 1533, the city played a major role in the Spanish conquest of South America and was added to the World Heritage List in 1984 because of its complex of 16th, 17th and 18th century military fortifications. Between 1993 and 2010 the rate of sea level rise at Cartagena was more than twice the average for the Caribbean (due to local factors including subsidence) and UNESCO has identified the Fort of San Fernando as having already been damaged by wave action, whilst the Fort of San Jose is being impacted by erosion and will be vulnerable in the future (UNESCO 2014a). Cartagena is, so far, the only city in the region to have developed a comprehensive climate and resilience strategy and to integrate climate vulnerability into all municipal planning processes, including for historic resources (Adams and Castro 2013).

Sea level rise is a complex phenomenon with several important impacts. The most obvious effect of rising ocean levels is the inundation and permanent loss of coastal land as discussed above, but sea level rise also causes worsening and more frequent high tide flooding events (Spanger-Siegfried *et al.* 2014). Higher sea levels also result in more severe storm surges, and higher wave heights and greater wave energy can result in greater storm damage. One of the impacts of climate change is an increase in extreme weather events. More intense storms combined with sea level rise present major problems of coastal erosion for vulnerable World Heritage sites.

Resources in World Heritage properties directly at risk from coastal erosion include the aforementioned Neolithic settlement at Skara Brae in Orkney, Scotland; archaeological sites in Florida's Everglades National Park; parts of the ruins of the medieval port cities of Kilwa Kisiwani and Songo Mnara in Tanzania; and the famous statues of Rapa Nui in Chile. Most of the iconic *moai* (statues) of Rapa Nui stand on *ahu* (platforms) directly at the coast and many are threatened by sea level rise, wave action and erosion. Significant impacts are already being recorded at these ceremonial sites, including to cremation burials and canoe ramps found on the seaward sides of the *ahu*. Increased wave height or energy in storms that batter the coastline could endanger some of the statues, perhaps collapsing their *ahu* bases (UHI 2017). *Ahu* at Tongariki, Hanga Roa, Tahai, Anakena and Ovahe have recently been identified as among the most seriously threatened by wave damage or coastal inundation (Quilliam *et al.* 2014).

Florida's Everglades National Park, listed as a World Heritage Site for its mangrove forests, sawgrass prairies and wetland habitats also protects some remarkable archaeological resources. Early indigenous Floridians lived among the islands and cays of the Ten Thousand Islands coastal region for 4000 years, leaving huge mounds of oyster and clam shells. These mounds are some of the only clues we have – and therefore vitally important – to understanding the human history of Florida's past, but many are at risk from sea level rise, storm damage and erosion (Holtz *et al.* 2014). Prehistoric shell middens are common along the coasts of the United States but those in Florida and the Everglades are unusual, perhaps unique, in having been built by coastal hunter gatherers who relied primarily on marine resources. The shell mounds and mound complexes served well-organised societies and exhibit features such as ‘finger ridges’, ‘plazas’, ‘canals’ and ‘water courts’ (that could have been used as water management structures), fish traps and channels to allow canoes to access the communities (Schwadron 2009). The mounds are often just a few meters high and at their base are in direct contact with the water, so many of them are quite vulnerable to rising sea level and erosion.

Florida has experienced sea level rise of 8–9 in (*c.* 20–23 cm) in the last century and projections are that this will at least double by the mid-21st century. Erosion and storm damage have already damaged the banks of tidal creeks at Sandfly Key in the Everglades, threatening the shell mound structures (Holtz *et al.* 2014). Further north on the Florida’s Atlantic coast at Turtle Mound, a 1200-year-old shell mound, thought to be the highest in North America, is suffering from serious erosion. To help preserve it, the National Park Service and the University of Central Florida have partnered in an innovative project to engage the public in creating submerged mats of oyster shells, spartina grass and mangroves to lessen the impacts of sea level rise and wave action, and slow erosion (University of Central Florida 2011).

Worsening wildfires

Worsening wildfires have become a significant problem in several parts of the world that host World Heritage sites, including the tundra and boreal forests of the Arctic, the Tasmanian wilderness, the Mediterranean basin, the Cape region of South Africa and the Western United States. In many of these places, despite the influence of historical land-use, forest and fire management by humans, the primary factors driving changes in the fire regime are overwhelmingly the warmer, drier conditions resulting from climate change, and the longer summers. In the western forests of the United States for example, the average fire season is up to two and a half months longer than in the 1970s (Climate Central 2012). Large wildfires have increased markedly in the western US and duration of individual fires is also increasing (Westerling *et al.* 2006). Intense wildfires can damage or destroy cultural resources including historic buildings and archaeological and sacred sites. Heavy rains coming in the aftermath of landscape-denuding wildfires often cause flooding, landslides and erosion which can damage or completely wash away archaeological and tribal sacred sites.

Mesa Verde National Park, a World Heritage site in southwestern Colorado in the United States, has protected Native American sites and artefacts since 1906 when President Theodore Roosevelt declared it the first National Park designed to ‘… preserve the works of man’. Now visited by more than 500,000 people every year, there are over 4500 archaeological sites within Mesa Verde’s boundaries, including 600 cliff dwellings created by the Ancestral Pueblo people in the 11th century. Mesa Verde is the largest archaeological preserve in the United States and its treasures represent the cultural heritage of many of today’s tribes, including the Hopi, Zuni and Laguna peoples (Holtz *et al.* 2014). Temperatures in Mesa Verde, especially summer temperatures, have been rising for 50 years, in common with the broader trend in the American Southwest where it has been warmer in the period since 1950 than during any comparable period in the last 600 years (Garfin *et al.* 2013). There has been a 300% increase in annual area burned in the Southwest relative to the 1970s and early 1980s (Fleishman *et al.* 2013). Fires often cause significant damage to infrastructure such as roads and visitor facilities in state and national parks and sometimes cause them to close temporarily, or to evacuate visitors because of fire danger or health risks from smoke.

Fires during the last twenty years in Mesa Verde and New Mexico’s Bandelier National Monument (250 miles/*c.* 402 km southeast in New Mexico) have caused significant damage to archaeological resources at both sites. Fires have burned structures, caused cracking and spalling of masonry in ancient pueblo buildings, and in Mesa Verde they have damaged several significant petroglyphs (NPS 2007; Kelly and McCarthy 2012). Fire-retardant slurry dropped from planes has left highly noticeable red staining along the trail to Spruce Tree House, one of Mesa Verde’s largest cliff dwellings and a prime visitor attraction. Post-fire floods can also cause devastating damage, especially if vegetation has been lost on a large-scale, and when the precipitation falls on hydrophobic soils, causing run-off, flash floods and gulley erosion. The combination of a longer fire season, larger fires and increases in extreme rainfall events is a growing threat to archaeological sites in the western US.

Melting glaciers, sea ice and permafrost

In addition to sea level rise, coastal erosion, storm surges, drought and wildfires, another very significant category of climate impacts on cultural resources is that caused by the warming of the cryosphere. Loss of sea ice, retreating glaciers and thawing permafrost as a result of higher global temperatures have major implications for many cultural World Heritage sites.

The Antarctic and Greenland ice sheets would raise global sea levels by approximately 65 m if completely melted (Rahmstorf 2010), and the rate of future sea level rise is directly linked to the speed with which global ice sheets decline. In the Arctic, warming is occurring at twice the global average rate and summer sea ice has declined to the smallest extent recorded during the satellite era (NRC 2015). The region’s permafrost is thawing, glaciers are shrinking, tundra lakes are drying and tundra fires are occurring at a scale not seen for the last 10,000 years (NRC 2015; Markham 2015).

One of the fastest moving glaciers in the world, Jakobshavn (Sermeq Kujalleq), meets the sea at Disko Bay in the Ilulissat-Icefjord World Heritage site. Jakobshavn retreated 40 km from 1850 to 2010, but the rate of retreat and thinning has increased in recent years (NASA 2014). The glacier reached its peak annual speed of 17 km annually in 2012, a rate three times that recorded during the 1990s (Joughin *et al.* 2014). Ilulissat-Icefjord and the Disko Bay area are rich in preserved palaeo-Eskimo sites dating back at least 3500 years (Weidick and Bennike 2007), and at this World Heritage site as well as many other sites throughout the Arctic, warming conditions are leading to damage and loss of irreplaceable archaeological resources. Arctic archaeological sites are vitally important because the frozen conditions preserve organic material such as wood, bone, animal skin and hair. As described elsewhere in this volume (see Chapter 10), Danish scientists working at Qajaa have demonstrated the effect of warming conditions in recent decades in speeding up decomposition of 4000-year-old preserved wooden artefacts (Hollesen *et al.* 2012; 2015; Matthiesen *et al.* 2013).

In Alaska and the Canadian Arctic too, thawing permafrost and melting ice are severely threatening archaeological sites, cultural resources and historic buildings. Permafrost degradation is damaging important archaeological sites in two US National Park Service properties in Alaska, Cape Krusenstern National Monument and Bering Land Bridge National Preserve, both of which were designated for the importance of the cultural heritage they preserve. Also in Alaska is Wrangell-St. Elias National Park, which jointly with its Canadian neighbour in the Yukon, Kluance National Park, was designated an international World Heritage site in 1978. These two parks are experiencing both challenges and opportunities in relation to studying and preserving cultural resources. The two parks contain extensive archaeological resources and have been at the forefront of a relatively new research trend, partly enabled by climate change and warming temperatures, that of ice patch archaeology. There is evidence that ice patches were used for thousands of years by hunters who knew that caribou would come to the sites during summer to escape the heat and insects, and for fresh water. Since 1997, more than 146 artefacts, mostly parts of throwing darts (*atlatl*) and items related to bow hunting have been found in melting ice patches in Kluance National Park (Hare *et al.* 2004). Carcasses were processed at the sites and meat may have been stored there too because of the ice. Finds from melting ice patches in Wrangell-St. Elias have included bows and arrows, spears, clothing and birch baskets (NPS 2013; Dixon *et al.* 2005; 2007). Whilst these finds are very exciting and have offered new research opportunities, the challenge is that once exposed, organic artefacts that emerge from the melting ice deteriorate rapidly. If not recovered and preserved – a difficult task in these high, remote locations – they are likely to be permanently lost. Increased rates of warming will reduce the time available to investigate and preserve these ice patch sites.

Two Arctic sites that have been proposed for World Heritage listing but which also have cultural resources at risk from climate change are Herschel Island in Canada and Norway’s Svalbard Archipelago. Lying 5 km off the coast of Yukon at the northernmost point in the territory, Herschel Island has the oldest frame building in the Yukon. Sir John Franklin landed there in 1826 and the old settlement has a late Victorian Anglican mission church, graveyards containing European whalers and Inuvialuit, large warehouses, whalers’ cabins, and the remains of the original Pacific Steam Whaling Company house from 1893. Sea level has been rising on the Beaufort Sea coast of the Yukon Territory and continues to do so at an increasing rate. Hershel Island is suffering from erosion, thawing permafrost and waterlogging of structures because the water table is rising. Some buildings have already had to be moved (Colette 2009).

At Longyearbyen on Svalbard, more modern industrial relics are vulnerable to climate change. The wooden supports that hold up the aerial cables that were used to transport coal from the mines to the port are under threat from thawing of permafrost. There are three sets of cables that meet at the cable station and continue on to the old port area, where they used to bring coal from the mine opened in the early 20th century. Each cable support is held up by four timbers sunk into the permafrost. Recent investigations have shown that there has been rapid and extensive fungal decay of the wood during the last century in the area of the permafrost thaw zone – this during a time of relative climate stability. Predicted warming is expected to speed up the rate of decay and endanger many of the remaining structures, all of which were built between 1939 and 1969. The cases of Herschel Island and Svalbard raise the question as to whether or not sites that have been nominated to the World Heritage List should be accepted if there is risk of significant deterioration of their Outstanding Universal Value.

Frozen archaeological remains outside the Arctic are at immediate risk in Russia’s Golden Mountains of Altai World Heritage site. Little is known of the Scythian people, nomadic horsemen and warriors who roamed the steppe from the Black Sea to the Mongolian plains in the 1st millennium BC. But they buried their dead, and with them many possessions including fabrics, leather and gold jewellery, in frozen tombs or kurgans in the more southerly permafrost regions of the Altai Mountains, including within the boundaries of the current World Heritage site. Water seeped into the tombs and then froze, preserving organic artefacts for centuries. Now climate change threatens to thaw the ice and hasten decay in many of the tombs. Efforts are underway to find ways to protect the tombs and their contents as the permafrost in the region thaws and shrinks (Han 2007).

Impacts on indigenous cultures

Whilst much of this chapter deals with the vulnerability of archaeological sites and historic buildings in World Heritage sites, it is also essential to recognise the importance of understanding and maintaining indigenous knowledge, traditions and practices in these extraordinary places. For example, the indigenous Ifugao people of the Philippine Cordilleras have built and developed their rice terraces over a period of at least 2000 years. More intense rainstorms have increased the instability of the rice terraces built on steep mountain slopes, causing landslides and erosion. Many fields have already been damaged or abandoned. Furthermore, local rice varieties developed over hundreds of years under stable climatic conditions by the Ifugao are less adaptable to rapid climate change than modern rice strains. Climate change is an exacerbating risk that builds upon cultural changes, which include increased tourism and the abandonment of rural tradition by young people who are increasingly moving to urban areas (Katutubo 2015; Manila Observatory 2015; Markham *et al.* 2016).

Similarly, changes brought about by climate change put people and communities of the Sherpa culture in and around Sagarmatha (Everest) National Park at risk. One third of the people on earth depend on water resources that flow from the Himalayas, including from Sagarmatha. Warming temperatures and changes in precipitation patterns are causing Himalayan glaciers to retreat and changing the water run-off processes. Loss of glaciers can destabilise surrounding slopes, resulting in catastrophic landslides and excessive meltwater can cause glacial lake outbreaks or flash floods and erosion. If snow and ice accumulation does not match accelerated glacial melting, future water shortages will affect millions of people downstream (Markham *et al.* 2016; Xu *et al.* 2009).

In Lebanon, the dwindling groves of sacred cedars, such as at Ouadi Qadisha (where some of the trees are at least 1500 years old and a very few are perhaps up to 3000 years old), are vulnerable not just to over-grazing, tourism developments and urbanisation, but also new climatic conditions. The cedars are important to Christians, being mentioned more than 100 times in the Bible. The historic importance of the timber from the trees goes back to the building of temples and sanctuaries throughout the Levant, including the First (Solomon's) and Second Temples in Jerusalem (Colette 2009; Loffet 2004). Cedar wood is also inextricably linked with the great boatbuilding and seafaring achievements of the ancient Phoenicians (Meiggs 1998). Changing climate will reduce the availability of suitable habitat to serve as refugia for the ancient cedars which are a cultural keystone species essential to religious life and traditions in the region (Markham *et al.* 2016).

East Rennell in the Solomon Islands (Western Pacific) – globally important for its coral reefs and undisturbed tropical ecosystems including Lake Tegano, the largest brackish lake in the Pacific – was the first World Heritage site to be inscribed with management responsibility lying with traditional and customary owners (UNESCO nd-b). Protected areas and cultural resources managers are increasingly recognising the vital importance of local communities, traditions and living cultural heritage for adaptation and resilience in the face of climate change (Markham *et al.* 2016; UNWTO 2008). However, in East Rennell, villagers are dealing with rising water levels and increased salinity in Lake Tegano as a consequence of sea level rise. Productivity of staple crops including coconut and taro has been significantly reduced as a result (Dingwall 2013).

Just as the tangible and intangible heritage of indigenous and local populations is impacted by and is at risk from climate change, so too they can provide resources, guidance and precedents for climate response and resilience. Past responses to climate change and insights on long-term adaptive and sustainable resource use by indigenous people, derived from archaeological studies or traditional knowledge, can contribute to adaptation strategies. Many communities local to World Heritage can draw on traditional resource management knowledge developed over centuries or even thousands of years, and individuals often are able to interpret local climate, oceanographic or biological phenomenon differently to scientists and in a finer and richer scale (Goswami 2015).

Conclusions

The implications of climate change for World Heritage are huge. However, since the sites on the World Heritage List only protect and draw resources and visitors to 1052 places (814 listed for cultural values and 35 mixed cultural/natural) – a tiny percentage of the world's important sites and resources – the threat is magnified many times over for cultural resources globally. The fact that UNESCO has recognised and become increasingly vocal about the growing threat to World Heritage sites from climate change is a significant advance. UNESCO can very effectively bring public and policymaker attention to the impacts of climate change and the required policy and management responses at every level (from the local to the international), through the World Heritage Centre in Paris, its policy and capacity building efforts, and its technical expertise and publications. Furthermore, UNESCO and the World Heritage committee – made up of States Parties to the World Heritage Convention – could decide to play an international leadership role in identifying and implementing adaptation and resilience strategies for cultural resource management in the face of rapid climate change and in communicating disseminating lessons learned.

Several States Parties, including the USA, Canada, UK, Australia and Netherlands have already shown foresight and innovation in assessing vulnerability of cultural resources and testing strategies and policies for managing and protecting sites under climate change. Both of the official advisory bodies to the World Heritage Committee, the International Union for Conservation of Nature (IUCN) for natural sites and the International Council on Monuments and Sites (ICOMOS) for cultural sites, have also become much more aware of climate impacts and implications in recent years, and especially in the case of IUCN, have begun to integrate the issue much more effectively into their World Heritage work. In 2014, IUCN published its first World Heritage Outlook report, an assessment which determined that climate change is the most serious future threat to natural World Heritage sites (Osipova *et al.* 2014a). Unfortunately, no such assessment exists for cultural sites, although it is much needed. ICOMOS' periodic series of reports on World Heritage at Risk have hardly touched on the issue of climate change, giving it only a cursory mention even in the most recent report (ICOMOS 2014). On the other hand, the International Polar Heritage Committee, a relatively new scientific committee of ICOMOS, has been at the cutting edge of highlighting climate impacts to cultural heritage in the polar regions.

It has been little more than a decade since climate change impacts were formally brought to the attention of the World Heritage Committee (Welling *et al.* 2015). In 2005, the World Heritage Committee called on States Parties to identify the properties most at risk from climate, a task which, more than ten years later, only a handful of governments have even attempted, let alone completed. An important report, *Climate Change and World Heritage: Report on predicting and managing the impacts of climate change on world heritage* (UNESCO 2007a) quickly followed, along with a *Strategy to Assist States parties to the Convention to Implement Appropriate Management Strategies* (UNESCO 2007a). In 2007 at its 16th Session, the General Assembly of States Parties adopted the binding *Policy Document on the Impacts of Climate Change on World Heritage Properties* (UNESCO 2007b). Although now in need of a comprehensive update, the policy has helped to drive increased understanding of the implications of climate change at World Heritage sites as well as stimulating management responses and innovations in resilience planning at some sites.

In 2007, UNESCO produced *Case Studies on Climate Change and World Heritage* (Colette 2009), which is widely credited with being the first publication to draw international policymakers' attention to the range and scale of climate impacts facing both natural and cultural World Heritage sites. This initial set of UNESCO case studies included Venice, Chan Chan and Chavin in Peru, Herschel Island in Canada, Cesky Krumlof and Prague in the Czech Republic, and Timbuktu in Mali.

The first survey undertaken by UNESCO's World Heritage Centre, in an attempt to shed light on the scale of the threat, found that at 72% of properties for which governments provided survey responses, climate change was acknowledged as a risk for natural or cultural sites. However, official reporting about threats to World Heritage sites is through state of conservation reports (SOCs) produced by the World Heritage Centre and the advisory bodies, ICOMOS and the IUCN. A recent analysis of all 2600 SOCs submitted from 1979 to 2013 (most are publicly available in UNESCO's database: http://whc.unesco.org/en/soc) showed that only 41% of cultural sites had had even one SOC report filed during the 33-year period (UNESCO 2014b). Although there has been growing recognition of climate risk in World Heritage SOC reports, the impacts of climate change and consequent site vulnerabilities are clearly still greatly under-reported, even when there is clear scientific evidence available about the threat (Markham *et al.* 2016).

The most recent UNESCO report on climate impacts and World Heritage sites, produced in collaboration with UNEP and the Union of Concerned Scientists and with close collaboration from IUCN and US-ICOMOS (Markham *et al.* 2016) made a series of 18 detailed recommendations aimed at addressing climate change threats to World Heritage. The eight recommendations most relevant for the purposes of this volume are summarised here, because if fully implemented they could help transform the way we monitor, manage and respond to climate impacts and vulnerability in World Heritage sites:

1. *Make climate vulnerability assessment part of the World Heritage site nomination and inscription process.* Because of the potential for climate change to alter or significantly damage heritage values, climate change projections and vulnerability should be considered by States Parties when entering sites on to the Tentative List and when submitting their World Heritage nominations. In their evaluation of the nomination files put forward by the States Parties, the World Heritage Committee and its advisory bodies should also take climate change effects into account in accordance with the *Policy Document on the Impacts of Climate Change* (UNESCO 2007b).
2. *Urgently address the issue of inadequate resourcing for World Heritage site management and climate adaptation.* Inadequate resourcing is the leading cause of poor performance in protected area management (Watson *et al.* 2014). Lack of resources, including financing, personnel, training and capacity building, represents the greatest barrier preventing effective management of World Heritage sites, including the assessment of their vulnerability to climate change, developing and implementing climate adaptation and resilience strategies.

3. *Include cultural heritage in climate vulnerability assessments and policy responses at all levels, from the local to the international.*
   Cultural heritage is not just a casualty of climate change; it is also a source of resilience and, therefore, part of the solution. Neither the knowledge gained from living and past cultures, including from cultural heritage represented under the World Heritage system, nor the value of heritage lost or at risk of loss, has yet been effectively addressed in international scientific assessments of climate change such as the reports of the Intergovernmental Panel on Climate Change (IPCC) (UCS 2014; INTO 2011). The IPCC should include and fully integrate cultural heritage in all future assessment reports. The 2014 *Pocantico Call to Action on Climate Impacts and Cultural Heritage* (UCS 2014) and its call for mechanisms to ensure that cultural heritage voices and expertise are represented in climate policy discussions at all levels from the local to the international should be heeded.
4. *Analyse archaeological data and cultural heritage to use what can be learned from past human response to climatic change to increase climate resilience for the future.*
   Some of the archaeological resources that can provide insights for our future by opening windows on the past are in danger of being lost, particularly in rapidly warming Arctic regions and along eroding coastal and riverine sites. An international response is needed to identify the sites most at risk and to synthesise and use lessons gleaned from the archaeological record and cultural heritage that can help with the development of adaptation strategies for natural and cultural heritage (IHOPE 2015; Jarvis 2014; Rockman 2012).
5. *Fully incorporate the latest climate science and innovation in adaptation strategies into World Heritage site management planning.*
   World Heritage site management plans should also incorporate climate research in decisions on planning and implementation relating to the sustainability of sites and their Outstanding Universal Value (OUV). Tourism management and development strategies should be science based and make use of the latest data on climate change impacts, vulnerability and resilience. There is also an urgent need to incorporate and better understand the climate exposure and sensitivity of OUV in all World Heritage sites and to incorporate arrangements for climate change adaptation and resilience into management strategies, especially at the most vulnerable sites.
6. *Ensure that effective risk reduction, disaster response and preparedness strategies are in place, and are updated regularly using the latest climate science.*
   Climate-related disasters such as severe storms, extreme rainfall events, floods, landslides, droughts and wildfires present a growing threat to the integrity of vulnerable World Heritage sites. Properties should have effective risk reduction and disaster response plans with action priorities in place, and update them regularly based on the latest climate change science. Over the long-term, management authorities should shift from planning primarily for disaster response and recovery, to strategies that focus on disaster preparedness, reducing the vulnerability of sites, and enhancing and strengthening the resilience of local communities in line with the goals of the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC 2015). For site risk assessment, it is important to evaluate the widest possible range of impacts, including low probability outcomes with large consequences (IPCC 2014). Site conservation and management strategies should recognise the inherent potential of sites to reduce disaster risk and adapt to climate change through ecosystem services (Osipova *et al.* 2014b; Renaud and Sudmeier-Rieux 2013; Temmerman *et al.* 2013).
7. *Ensure that indigenous peoples and local communities are fully involved at all stages of climate adaptation and tourism development.*
   Utilising local and traditional knowledge systems for effective adaptation of World Heritage sites is vital in the face of climate change. It is also essential to empower and support local descendent and traditional communities to maintain and preserve what they value, including intangible heritage and subsistence lifestyles (UCS 2014). Indigenous peoples and local communities should be fully involved and their rights recognised in planning for climate adaptation and sustainable tourism development (AAA 2015; UNESCO 2015). It is crucial to ensure that adaptation and resilience efforts aimed at preserving World Heritage fully incorporate local voices and maximise the use of local and traditional knowledge.
8. *Establish targeted programmes to raise awareness among tourists, guides, site managers and local communities about the values and protection needs of World Heritage in a changing climate.*
   Tourists visiting World Heritage sites represent an important target audience for awareness raising about climate impacts, adaptation and mitigation. High-quality interpretive materials and programmes can enhance awareness of the risks posed to cultural heritage, wildlife and natural ecosystems from climate change as well as adaptation strategies. Learning about climate change in the locale where its effects are being felt can be a powerful catalyst and training for tour operators, guides and park rangers can have a magnifying effect. Innovative programmes involving visitor education and ranger training that could serve as models are being developed by the National Park Service in the USA (NPS 2014).

These measures are urgently necessary because global temperatures have risen nearly 1˚C since 1880, nine of the ten warmest years on record have occurred since 2000 (with 2015 being the warmest), and July 2016 was the warmest month ever recorded up to that point (NASA 2016). The growing evidence of current damage and climate change vulnerability of cultural resources in World Heritage sites should act as an alarm bell to spur action to reduce global emissions of greenhouse gases in line with the 2015 Paris Agreement under the UN Framework Convention on Climate Change (UNFCCC 2015) and also for the urgent development and implementation of more effective and better resource management and resilience strategies. Many World Heritage sites at threat from climate change are among the best known and most iconic tourist destinations and archaeological sites on the planet. But there are probably a thousand or more lesser-known, but equally important, heritage sites at risk for every World Heritage site currently on the list. By monitoring, understanding, communicating and responding to the climate threat to World Heritage sites, we can catalyse increased public attention and drive new resources to these other sites.

References

Adams, P. and Castro, J. 2013. *Embedding Climate Change Resilience in Coastal City Planning: Early Lessons from Cartagena de Indias*. Colombia Climate and Development Knowledge Network. Available at: http://cdkn.org/resource/embedding-climate-change-resilience-in-coastal-city-planning-early-lessons-from-cartagena-de-indias-colombia/ [accessed 8 August 2016].

AAA (American Anthropological Association). 2015. *AAA Statement on Humanity and Climate Change*. Arlington, VA, American Anthropological Association.

ANU (Australian National University). 2009. *Implications of Climate Change for Australia's World Heritage Properties: A Preliminary Assessment*. Canberra, Commonwealth of Australia.

Barau, A. S. 2010. Heritage landscapes and challenges of climate change: An example of Kano City, Nigeria. Unpublished paper given at the *First International Urban Heritage Conference 23–28 May 2010, Riyadh, Saudi Arabia*.

Camuffo, D. 2001. Canaletto's paintings open a new window on the relative sea-level rise in Venice. *Journal of Cultural Heritage* 4, 277–81.

Camuffo, D., Bertolin, C. and Schenal, P. 2014. Climate change, sea level rise and impact on monuments in Venice. In M. A. Rogerio-Candelara (ed.), *Science Technology and Cultural Heritage*, 1–17. London, Taylor and Francis.

Carbognin, L., Teatini, P., Tomasin, A. and Tosi, L. 2010. Global change and relative sea level rise at Venice: What impact in terms of flooding. *Climate Dynamics* 35, 1039–47.

Città di Venizia. 2014. *The Annual Tourism Survey Presented Yesterday in Venice: Figures Help the City Decide How to Manage Flows Efficiently*. Available at: http://www.comune.venezia.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/74151 [accessed 5 January 2016].

Cocks, A. S. 2013. The coming death of Venice? *The New York Review of Books* 60(11), 20 June 2013.

Climate Central. 2012. *The Age of Western Wildfires*. Princeton and New York, Climate Central. Available at: http://www.climatecentral.org/news/report-the-age-of-western-wildfires-14873 [accessed 25 August 2016].

Colette, A. 2009. *Case Studies on Climate Change and World Heritage*. 2nd edition. Paris, UNESCO.

Dawson, T. 2013. Erosion and coastal archaeology: Evaluating the threat and prioritising action. In M.-Y. Daire, C. Dupont, A. Baudry, C. Billard, J.-M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coasts*, 77–83. Oxford, BAR International Series 2570.

Dingwall, P. R. 2013. *Report on the Reactive Monitoring Mission to East Rennell, Solomon Islands*. Report for UNESCO World Heritage Committee. Available at: http://whc.unesco.org/en/documents/122248/ [accessed 29 July 2016].

Dixon, E. J., Manley, W. F. and Lee, C. M. 2005. The emerging archaeology of glaciers and ice patches: Examples from Alaska's Wrangell-St. Elias National Park and Preserve. *American Antiquity* 70(1), 129–43.

Dixon, E. J., Lee, C. M., Manley, W. F., Warden, R. A. and Harrison, W. D. 2007. The frozen past of Wrangell-St. Elias National Park and Preserve. *Alaska Park Science* 6, 25–29.

Fleishman, E., Belnap, J., Cobb, N., Enquist, C. A. F., Ford, K., MacDonald, G., Pellant, M., Schoennagel, T., Schmit, L. M., Schwar, M., van Drunick, S., Westerling, A. L., Keyser, A. and Lucas, R. 2013. Natural Ecosystems. In G. A. Garfin, A. Jardine, R. Merideth, M. R. Black and S. LeRoy (eds), *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, 148–67. Washington, DC, Island Press.

Forbes, J. and Wightman, J. 2013. Planning for climate change in the town of Lunenberg, Nova Scotia. Available at: https://climatechange.novascotia.ca/sites/default/files/uploads/2012-2013_Bluenose_1.pdf [accessed 22 August 2016].

Frieler, K., Meinshausen, M., Golly, A., Mengel, M., Lebek, K., Donner, S. D. and Hoegh-Guldberg, O. 2013. Limiting global warming to 2˚C is unlikely to save most coral reefs. *Nature Climate Change* 3, 165–70.

Garfin, G. A., Jardine, A., Merideth, R., Black, M. and LeRoy, S. 2013. *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*. Washington, DC, Island Press.

Gibson, J. 2014. Shaped by the sea: Endangered archaeology of Orkney's maritime communities. In R. Harrison and R. A. Maher (eds), *Human Ecodynamics in the North Atlantic: A Collaborative Model of Humans and Nature through Science and Time*, 21–34. New York/London, Lexington Books.

Goswami, R. 2015. How intangible cultural heritage adapts to a changing world. *World Heritage* 77, 30–36.

Great Barrier Reef Marine Park Authority. 2012. *Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017*. Townsville, Great Barrier Reef Marine Park Authority.

Han, J. 2007. *Heritage at Risk 2006–2007: Impact of Climate Change on the Frozen Tombs in the Altai Mountains*. Available at: http://www.icomos.org/risk/world_report/2006-2007/pdf/H@R_2006-2007_57_ Special_Focus_Altai_Mountains.pdf [accessed 16 January 2016].

Hare, G. P., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C. and Strand, D. 2004. Ethnographic and archaeological investigations of alpine ice patches in Southwest Yukon, Canada. *Arctic* 57(3), 260–72.

Headwaters Economics. 2016. *Economic Impact of National Parks*. Available at: http://headwaterseconomics.org/public-lands/protected-lands/economic-impact-of-national-parks/ [accessed 23 August 2016].

Hoegh-Guldberg, O. 2012. The adaptation of coral reefs to climate change: Is the Red Queen being outpaced? *Scientia Marina* 76(2), 403–08.

Hollesen, J., Jensen, J. B., Matthiesen, H., Elberling, B., Lange, H. and Meldgaard, M. 2012. Kitchen middens and climate change – the preservation of permafrozen sites in a warm future. In C. Gregory and H. Matthiesen (eds), *Proceedings from the 4th Conference on Preserving Archaeological Remains In Situ: Conservation and Management of Archaeological Sites* 14(1–4), 159–68.

Hollesen, J., Matthiesen, H., Møller, A. B. and Elberling, B. 2015. Permafrost thawing in organic Arctic soils accelerated by ground heat production. *Nature Climate Change* 5, 574–78.

Holtz, D., Markham, A., Cell, K. and Ekwurzel, B. 2014. *National Landmarks at Risk: How Rising Seas, Floods and Wildfires are Threatening the United States' Most Cherished Historic Sites*. Cambridge, MA, Union of Concerned Scientists.

ICOMOS (International Council on Monuments and Sites). 2014. *Heritage at Risk World Report 2011–2013 on Monuments and Sites in Danger.* Berlin, ICOMOS.

IHOPE (Integrated History and Future of People on Earth). 2015. *Global Environmental Change Threats to Heritage and Long Term Observing Networks of the Past*. Posted 10 June, 2015 at: http://ihopenet.org/global-environmental-change-threats-to-heritage-and-long-term-observing-networks-of-the-pas/ [accessed 4 March 2016].

INTO (International National Trusts Organization). 2011. *The Victoria Declaration on the Implications for Cultural Sustainability of Climate Change*. Available at: http://www.internationaltrusts.org/wp-content/uploads/2013/07/INTO-THE-VICTORIA- DECLARATION-.pdf [accessed 14 April 2016].

IPCC (Intergovernmental Panel on Climate Change). 2013. Summary for Policymakers. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 3–32. Cambridge, Cambridge University Press. Available at: http://www.ipcc.ch/report/ar5/wg1/ [accessed 4 August 2016].

IPCC (Intergovernmental Panel on Climate Change). 2014. *Synthesis Report for Policymakers*. Bonn, Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/pdf/ assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf [accessed 4 August 2016].

Jarvis, J. 2014. *Climate Change and Stewardship of Cultural Resources*. Policy memorandum 14–02. Washington, DC, US National Park Service.

Joughin, I., Smith, B. E., Shean, D. E. and Floricioiu, D. 2014. Brief communication: Further summer speedup of Jakobshavn Isbrae. *The Cryosphere* 8, 209–14.

Katutubo. 2015. *Science-Policy Forum on the Sustainability of the Rice Terrace Systems (Hani and Ifugao): Building Learning Alliance*. Keynote Speech of Senator Loren Legarda. Available at: http://katutubo.lorenlegarda.com.ph/2015/07/30/keynote-speech-science-policy-forum-on-the-sustainability-of-the-rice-terrace-systems-hani-and-ifugao-building-learning-alliance/ [accessed 16 January 2016].

Kelly, R. E. and McCarthy, D. F. 2012. Fire effects on rock art and similar cultural resources. In K. C. Ryan, A. T. Jones, C. H. Koerner and K. M. Lee (eds), *Wildland Fire in Ecosystems: Effects of Fire on Cultural Resources and Archaeology*, 113–30. Fort Collins, CO, United States Forest Service.

Loffet, H. C. 2004. Sur quelques espèces d'arbres de la zone syro-palestinienne et libanaise exportées vers l'Egypte pharaonique. *Archaeology and History in Lebanon* 9, 10–33.

Manila Observatory. 2015. *Analyzing the Vulnerability of the Philippine Rice Terraces: Towards Resilience and Better Adaptive Capacity to the Potential Impacts of Climate Change*. Available at: http://www.observatory.ph/2015/04/12/analyzing-the-vulnerability-of-the-philippine-rice-terraces-towards-resilience-and-better-adaptive-capacity-to-the-potential-impacts-of-climate-change/ [accessed 16 January 2016].

Markham, A. 2015. *6 Ways Climate Change in Alaska will Affect You*. Available at: http://blog.ucsusa.org/adam-markham/climate-change-in-alaska-864 [accessed 18 August 2016].

Markham, A., Osipova, E., Lafrenz Samuels, K. and Caldas, A. 2016. *World Heritage and Tourism in a Changing Climate*. Nairobi/Paris, United Nations Environment Programme/United Nations Educational, Scientific and Cultural Organization.

Marzeion, B. and Levermann, A. 2014. Loss of cultural world heritage and currently inhabited places to sea level rise. *Environmental Research Letters* 9(034001).

Matthiesen, H., Jensen, J. B., Gregory, D. Hollesen, J. and Elberling, B. 2013. Degradation of archaeological wood under freezing and thawing conditions – effects of permafrost and climate change. *Archaeometry* 56(3), 479–95.

Meiggs, R. 1998. *Trees and Timber in the Ancient Mediterranean World*. Oxford, Oxford University Press.

Moss, J. M. 2010. Climate change and historic structures: The curious case of the west sanctuary window. In V. Salazar-Halfmoon and R. Skeirik (eds), *Vanishing Treasures – A Climate of Change*, 12–16. U.S. National Park Service. Available at: https://www.nps.gov/archeology/vt/2010yr.pdf [accessed 21 July 2016].

NASA (National Aeronautics and Space Administration). 2014. *Retreat of Jakobshavn Glacier, Greenland*. Washington, DC, National Aeronautics and Space Administration. Available at: http://earthobservatory.nasa.gov/IOTD/view. php?id=83837 [accessed 23 July 2016].

NASA (National Aeronautics and Space Administration). 2016. July 2016 was the hottest month on record. *Earth Observatory: Where Every Day is Earth Day*. Available at: https://earthobservatory.nasa.gov/IOTD//view.php?id=88607 [accessed 18 April 2017].

NASA (National Aeronautics and Space Administration). 2017. *Global Climate Change: Vital Signs of the Planet: Carbon Dioxide*. Available at: https://climate.nasa.gov/vital-signs/carbon-dioxide/ [accessed 18 April 2017].

NPS (National Park Service). 2007. *Archaeology and Fire*. Available at: www.nps.gov/meve/parkmgmt/upload/arch_fire_effects.pdf [accessed 23 August 2016].

NPS (National Park Service). 2013. *Climate Change at Wrangell-St. Elias*. Available at: https://www.ncptt.nps.gov/blog/climate-change-case-study-wrangell-st-elias-national-park-and-preserve/ [accessed 16 August 2016].

NPS (National Park Service). 2014. *Enhancing Workforce Climate Literacy*. Washington, DC, US National Park Service. Available at: http://www.nps.gov/subjects/climatechange/upload/Training20141.pdf [accessed 6 August 2016].

Nichols, M. 2014. *Climate Change: Implications for Tourism*. The Hague, European Climate Foundation. Available at: http://europeanclimate.org/wp-content/uploads/2014/06/Tourism_Briefing_Web_EN.pdf [accessed 19 August 2016].

NRC (National Research Council). 2015. *Arctic Matters: The Global Connection to Changes in the Arctic*. Washington, DC, National Research Council.

Osipova, E., Shi, Y., Kormos, C., Shadie, P., Zwahlen, C. and Badman, T. 2014a. *IUCN World Heritage Outlook 2014: A Conservation Assessment of all Natural World Heritage Sites*. Gland, International Union for Conservation of Nature.

Osipova, E., Wilson, L., Blaney, R., Shi, Y., Fancourt, M., Strubel, M., Salvaterra, T., Brown, C. and Verschuuren, B. 2014b. *The Benefits of Natural World Heritage: Identifying and Assessing Ecosystem Services and Benefits Provided by the World's Most Iconic Natural Places*. Gland, International Union for Conservation of Nature.

Quilliam, L., Cox, R., Campbell, P. and Wright, M. 2014. Coastal climate change impacts for Easter Island in 2100. *Rapa Nui Journal* 28(1), 60–67.

Rahmstorf, S. 2010. A new view on sea level rise. *Nature Reports Climate Change*. Available at: http://www.nature.com/climate/2010/1004/full/climate.2010.29.html [accessed 3 January 2016].

Renaud, F. G. and Sudmeier-Rieux, K. (eds). 2013. *The Role of Ecosystems in Disaster Risk Reduction*. Tokyo, United Nations University Press.

Rockman, M. 2012. A l'enfant plan for archaeology. In M. Rockman and J. Flatman (eds), *Archaeology in Society: Its Relevance in the Modern World*, 1–20. New York, Springer.

Rowland, M. J. 1992. Climate change, sea-level rise and the archaeological record. *Australian Archaeology* 34, 29–33.

Schwadron, M. 2009. *Maritime Landscapes of Complexity: Prehistoric Shell Works and the Rise of Social Complexity among Coastal Foragers in South Florida*. Tallahassee, FL, National Park Service, Southeast Archeological Center.

Spanger-Siegfried, E., Fitzpatrick, M. and Dahl, K. 2014. *Encroaching Tides: How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years*. Cambridge, MA, Union of Concerned Scientists.

Sweet, W., Zervas, C., Gill, S. and Park, J. 2013. Hurricane Sandy inundation probabilities today and tomorrow. In T. C. Peterson, M. P. Hoerling, P. A. Stott and S. Herring (eds), *Explaining Extreme Events of 2012 from a Climate Perspective*. *Bulletin of the American Meteorological Society* 94(9), S1–S74.

Temmerman, S., Meire, P., Bouma, T. J., Herman, P. M. J., Ysebaert, T. and DeVriend, H. J. 2013. Ecosystem-based coastal defence in the face of global change. *Nature* 504, 79–83.

UHI (University of the Highlands and Islands Archaeology Institute). 2017. Coastal Erosion in Rapa Nui (Easter Island). Available at: https://archaeologyorkney.com/2017/05/04/coastal-erosion-in-rapa-nui-easter-island/ [accessed 5 May 2017].

UNESCO. nd-a. *The Criteria for Selection*. Available at: http://whc.unesco.org/en/criteria/ [accessed 12 August 2016].

UNESCO. nd-b. *East Rennell*. Available at: http://whc.unesco.org/en/list/854 [accessed 23 August 2016].

UNESCO. 2007a. *Climate Change and World Heritage: Report on Predicting and Managing the Impacts of Climate Change on World Heritage and Strategy to Assist States Parties to Implement Appropriate Management Response*. World Heritage Report 22. Paris, UNESCO World Heritage Centre.

UNESCO. 2007b. *Policy Document on the Impacts of Climate Change on World Heritage Properties*. Paris, UNESCO World Heritage Centre. Available at: http://whc.unesco.org/en/CC-policy- document/ [accessed 23 August 2016].

UNESCO. 2011. *The Future of Venice and its Lagoon in the Context of Global Change: Workshop Reports 1 and 2*. Venice, UNESCO Venice Office.

UNESCO. 2014a. *SOC Report 2014 – Report on the State of Conservation of the Property: Port, Fortresses and Group of Monuments, Cartagena*. UNESCO/Government of Colombia. Available at: http:// whc.unesco.org/en/list/285/documents/ [accessed 21 August 2016].

UNESCO. 2014b. *State of Conservation of World Heritage Properties: A Statistical Analysis 1979–2013*. Paris, UNESCO World Heritage Centre.

UNESCO. 2015. *Policy for the Integration of a Sustainable Development Perspective into the Processes of the World Heritage Convention*. As adopted by the General Assembly of States Parties to the World Heritage Convention at its 20th session. Paris, UNESCO World Heritage Centre. Available at: http://whc.unesco.org/document/139747 [accessed 17 July 2016].

UNFCC (United Nations Framework Convention on Climate Change). 2015. *Adoption of the Paris Agreement. Proposal by the President*. Geneva, United Nations Office at Geneva. Available at: http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600008831 [accessed 4 January 2016].

UN-Habitat. 2014. *Hoi An, Viet Nam: Climate Change Vulnerability Assessment*. Nairobi, United Nations Human Settlements Programme.

UCS (Union of Concerned Scientists). 2014. *The Pocantico Call to Action on Climate and Cultural Heritage*. Washington, DC, Union of Concerned Scientists. Available at: http://www.ucsusa.org/global-warming/solutions/pocantico-call-action-climate-impacts-and-cultural- heritage#.VoqVPTbr_FI [accessed 4 January 2016].

University of Central Florida. 2011. *Saving Oyster Habitat Makes "Heroes" of UCF Biologist and Team*. Available at: https://today.ucf. edu/saving-oyster-habitat-makes-heroes-of-ucf-biologist-and- team/ [accessed 23 August 2016].

UNWTO (United Nations World Tourism Organization). 2008. *Climate Change and Tourism: Responding to Global Challenges*. Madrid, World Tourism Organization.

UNWTO (United Nations World Tourism Organization). 2015. *World Tourism Barometer and Statistical Annex December 2015*. Available at: http://www.e-unwto.org/doi/pdf/10.18111/wtobarometereng.2015.13.6.1 [accessed 12 January 2016].

Watson, J. E. M., Dudley, N., Segan, D. B. and Hockings, M. 2014. The performance and potential of protected areas. *Nature* 515, 67–73.

Weidick, A. and Bennike, O. 2007. *Quaternary Glaciation History and Glaciology of Jakobshavn Ibrae and the Disko Bugt Region, West Greenland: A Review*. Geological Survey of Denmark and Greenland Bulletin 14. Copenhagen, Geological Survey of Denmark and Greenland.

Welling, L., Rockman, M., Watson, J., Mackey, B. and Potts, A. 2015. The role of World Heritage sites in a changing climate. *World Heritage* 77, 4–13.

Westerling, A. L., Hidalgo, H. G., Cayan, D. R. and Swetnam, T. W. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. *Science* 313, 940–43.

Wong, P. P., Losada, I. J., Gattuso, J.-P., Hinkel, J., Khattabi, A., McInnes, K. L., Saito, Y. and Sallenger, A. 2014. Coastal systems and low-lying areas. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea and L. L. White (eds), *Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 361–409. Cambridge, Cambridge University Press.

Xu, J., Grumbine, R. E., Shrestha, A., Eriksson, M., Yang, X., Wang, Y. and Wilkes, A. 2009. The melting Himalayas: Cascading effects of climate change on water, biodiversity, and livelihoods. *Conservation Biology* 23(3), 520–30.

Chapter 3

A central role for communities: climate change and coastal heritage management in Scotland

Tom Dawson, Joanna Hambly and Ellie Graham

Abstract

There has been a long tradition of managing historic sites threatened by coastal processes in Scotland. As the threats increase, new methodologies are being developed that place greater emphasis on public participation. This form of collaborative working builds upon established principles of public involvement in sustainable development, something that is applicable to both climate change adaptation and heritage management. This paper highlights recent ground-breaking advances, showing how public involvement can have real benefits for the management of sites threatened by the sea. Using the Scotland's Coastal Heritage at Risk Project as an example, it shows how a range of organisations, from government to local societies, can collaborate to record and update information, prioritise action and undertake projects at vulnerable sites. This citizen science approach is creating meaningful public archaeology projects, with communities and professionals working together to save information that would otherwise be lost.

Climate change and the historic environment

Climate change in the UK

The latest five-year report by the Committee on Climate Change (an independent, statutory body that advises the UK Government and Devolved Administrations), notes that changes observed in global climate are mirrored in the UK (CCC 2016a, 2). There have been higher average annual temperatures over land and the surrounding seas, with a trend towards milder winters and hotter summers in recent decades. Coastlines are particularly vulnerable to climate change, and sea levels around the UK have risen by 15–20 cm since 1900 (*ibid*., 2). Although natural climate variability has a large influence on weather patterns, there is also evidence for an increase in extreme events. The UK CCC report (*ibid*., 32) also notes that the impacts of flooding and coastal change in the UK are already significant and that damage costs an estimated £1 billion per year.

Looking to the future, there are acknowledged difficulties in trying to project climate-related coastal change, partly due to uncertainty about future storm events (Woolf and Wolf 2013), and partly as a wide range of factors can lead to local variations in relative sea levels. In addition to isostatic adjustment (post-glacial rebound), gravitational variation and oceanographic factors also influence local sea level rise (CCC 2016b, 64). According to the CCC report (2016a, 59), an 'increasing frequency and severity of flooding from a range of sources represents the most significant climate change risk to UK infrastructure'. Contributing to this risk is a projected rise in relative sea level of 50–100 cm by 2100 (*ibid*., 3), which will lead to a corresponding increase in the height of tidal surges. High onshore waves may cause greater coastal erosion along vulnerable coastlines (*ibid*., 60), meaning that some communities will face significantly increased risks.

Although Scotland's northerly situation means that it is generally colder and windier, the country is experiencing a similar climate trend to other parts of the UK. Temperatures are generally rising and there are drier summers, wetter winters and an increase in the frequency of extreme and unpredictable weather events, including storms (Historic Scotland 2012, 4).

The Scottish coast

All parts of the Scottish coast (Fig. 3.1) are currently experiencing relative sea level rise and it is anticipated that

Figure 3.1. A map of Scotland showing locations mentioned in the text.

sea levels will continue to rise over the next century and beyond. An increased frequency of floods has been noted within tide gauge records at several Scottish locations (CCC 2016b, 32). Storm events will lead to waves overtopping sea walls, resulting in flooding that threatens coastal communities and assets around Scotland. Although there are uncertainties over the scale and timing of future flood events (*ibid*., 31 and 64), some projections estimate that there will be a 450% increase in damage from coastal flooding by the 2080s (*ibid*., 80).

Storminess and sea level rise will also contribute to erosion, although the impacts will affect different areas in different ways. Although much of Scotland's 21,000 km coastline is hard and rocky, and thus largely resistant, 21% of the coastline is 'soft' (for example, sand dunes and salt marshes) and liable to erode. This will cause problems for the large proportion of Scotland's infrastructure, including roads, railways, property and golf courses, that are situated behind soft coastline (*ibid*., 31).

Scotland's historic environment

The historic environment is important to the Scottish economy and is estimated to contribute more than £3.1 billion per annum (2013/14) and support over 50,000 jobs, both directly and through supplier industries (Scotland's Environment 2015).

The historic environment also touches upon many other aspects of Scottish life. There are over 45,000 legally protected Listed Buildings in Scottish towns and villages, including castles, historic houses and other properties. There are also more than 8000 scheduled monuments, mainly comprising places that are not lived in, including archaeological sites. In addition there are a huge number of sites that are not legally protected. Over 320,000 historic assets are listed on Canmore, the national database of Historic Environment Scotland (HES). There are several reasons why a historic feature might not be designated. For example, it may not have met designation criteria or may be awaiting assessment; and in some cases, the site may still be awaiting discovery and may not have been recorded. Estimates of the size of Scotland's undesignated historic environment vary, but could account for around 90–95% of all sites. Despite not being legally protected, these places are important and contribute to Scotland's overall historic environment.

The coastal zone is an important location for cultural heritage and archaeological sites (CCC 2016c, 105). Generally speaking, the greatest density of sites is within the coastal zone. This is a reflection of coastal habitation in the past, which was influenced both by the geography and topography of Scotland, with its numerous islands, indented firths and mountainous hinterland, and by the benefits that coastal settlement could bring. Advantages included a proximity to marine resources, access to materials washed up or exposed on beaches and the ability to travel by boat. The movement of people and trade routes opened up by seafarers has long been recognised by archaeologists as an important influence on coastal settlement (see Flatman 2009 for references).

Flatman (2009, 7) has argued that the importance of the coastal heritage resource of the UK means that it should be managed with a presumption in favour of *in situ*, physical preservation. However, management can only happen with good underlying data. Although there are detailed records for some parts of Scotland, other parts of the coast await detailed survey. In addition, the movement of coastal sediment, for example, during storms, often leads to new discoveries. This means that there is still much work to be done, especially in low-lying, soft coastal areas.

The effects of climate change on heritage

It is anticipated that current climatic changes will continue and intensify through the present century, accelerating damage to Scotland's environment and infrastructure and resulting in significant consequences for the economy and society (Historic Scotland 2012). The CCC (2016b, 66) lists risks to 'culturally valued structures and the wider historic environment' as one of the impacts of climate change, noting that although there is some understanding of how climate change might affect the historic environment, there is a lack of quantitative information on the level of current and future risks.

The identified impacts of climate change on the historic environment include more frequent and intense rainfall which may cause flooding, water penetration into masonry and ground instability which can lead to structural collapse. There will be an increased risk of dampness within historic buildings, stonework will decay faster due to increased extremes of wetting and drying, metals will corrode, mould will grow faster, and changes in the distribution of pests and biogenic growth will threaten the integrity of the historic environment (Historic Scotland 2012, 6).

The archaeological heritage of some coastal areas is particularly vulnerable. For example, low lying, sandy areas have attracted settlement for millennia, and some of Scotland's most spectacular archaeological sites were buried in antiquity by blown sand. Some remain hidden; others have been uncovered by erosion (including the World Heritage Site of Skara Brae, which was uncovered during a storm in 1850).

The coast faces all of the climatic challenges of inland areas, but also has challenges specific to the coastal zone. In addition to slow and gradual change, extreme weather events may lead to damage that immediately threatens the very survival of heritage sites in some areas. Rising sea levels and increased storm events when combined, will lead to flooding and coastal erosion, placing historic landscapes, structures, buildings and archaeological sites in danger, including Skara Brae (Historic Scotland 2012, 6). We know that some sites are vulnerable to destruction by single climatic events; what we cannot say is exactly when the particular combination of strong winds, high tides, low pressure and other factors will cause this to happen.

Responding to climate change in Scotland

The two main responses to climate change are mitigation, involving actions to reduce the anthropogenic causes of change, for example by reducing greenhouse gas emissions, and adaptation, preparing for anticipated effects, thereby reducing the impact of changing conditions (Highland Council 2012, 7).

The Scottish Government has set targets and approaches to managing climate change and the Climate Change (Scotland) Act of 2009 guides and regulates most public-sector activities relating to climate change, even where certain governmental powers are technically exercised either at a UK or European Union level (Jackson and Lynch 2011, 120). A key mitigation commitment of the Act is to reduce greenhouse gas emissions by at least 80% by 2050; with an interim target of 42% by 2020, a more ambitious target than the reduction to 34% proposed in UK legislation. The Act also calls for adaptation action to be taken throughout Scotland's economy and society, including by central and local government, the public sector and businesses. It also sees an important role for communities and individuals, something that was previously highlighted in the Rio Declaration on Environment and Development, a United Nations Environment Programme (UNEP) document that provides several key principles on sustainable development. The Rio Declaration advocates that States should encourage public awareness by providing information because 'environmental issues are best handled with the participation of all concerned citizens' (UNEP 1992, Principle 10).

Preparing for coastal change

Climate impacts have the potential to severely affect coasts, and in response, the Scottish Government is developing the Scottish National Coastal Change Assessment (www.dynamiccoast.com), mapping changes between past and present shorelines in order to identify areas at risk from future erosion (CCC 2016b, 32). In addition, non-statutory Shoreline Management Plans (SMPs) have been prepared for some stretches of coast, assessing the risks and presenting management options based on the vulnerability and value of threatened assets. Options include building coastal defences or deciding that no active intervention is necessary. Some private management plans have been published, for example, for the important tourist locations associated with St Andrews golf courses, but most SMPs have been commissioned by Scottish Local Authorities.

Some Local Authorities have also published climate adaptation plans (Jackson and Lynch 2011, 126), and the first was produced by the Highland Council in 2010 and updated in 2012 (Highland Council 2012). The Highland adaptation plan applies guidance contained in Scotland's Climate Change Adaptation Framework (Scottish Government 2009), and focuses on increasing the resilience of communities to climate change. It identifies climate change as one of the greatest threats to the area (Highland Council 2012, 2), especially to the coastal zone, where the majority of the region's population lives. It also recognises the importance of the 'outstanding environmental and cultural heritage of the area and the valuable land-use and tourism industries that depend upon it' and that 'action is needed to safeguard these assets' (*ibid*., 19).

Preparing for the effects of climate change on the historic environment

Historic Environment Scotland published a five-year climate change action plan in 2012. As well as setting targets for mitigating the causes of climate change, the plan notes that HES is 'providing support and guidance on appropriate strategies to increase the resilience of the broader historic environment, including individual buildings and urban areas, infrastructure, monuments, landscapes and archaeology' (Historic Scotland 2012, 16).

HES is conducting its own research and working with a range of external partners to develop a methodology for assessing the impact of climate change on a range of heritage assets, including buried and submerged archaeological sites. The aim is to improve decision-making capabilities for conservation and maintenance programmes (*ibid*., 17).

Preparing for change to the historic environment of the coast

There is a long tradition of work by the guardians of Scotland's historic environment in planning for climate-induced coastal change, such as erosion. Over two decades ago, the predecessor of HES, Historic Scotland, published a paper entitled *Archaeology and the Coastal Zone: Towards a Historic Scotland Policy* (Ashmore 1994). This outlined possible courses of action at threatened sites, echoing options presented in Shoreline Management Plans including defending the coastline or managing retreat by working at sites before they are destroyed. However, the author recognised that ignoring erosion was often the default position. This is different from the SMP option of 'no active intervention' as it allows sites to be destroyed without a process of decision-making, a situation regarded as unacceptable by Ashmore (2003). Unintentional loss of parts of the historic environment is also highlighted by Cassar (2005, 26), who points out that a lack of baseline information means that the heritage resource could 'degrade and disappear without ever having been recorded. The heritage we think is being preserved *in situ* may not remain so'.

In order to gather information to make informed decisions, a programme of state-funded rapid Coastal Zone Assessment surveys (CZA surveys) was initiated by Historic Scotland. The programme started in 1996, based upon survey techniques developed in Wales (Smith 1995; Davidson and Jones 2002). Historic Scotland published guidelines which defined how records should be compiled (Historic Scotland 1996). These stated that the vulnerability of the coast to erosion should be assessed and that recommendations for future action should be recorded when thought necessary. The initial surveys were undertaken by commercial archaeological units and university departments. After 2001, The SCAPE Trust and the University of St Andrews started managing the surveys in partnership with Historic Scotland (Dawson 2015b, 253). More emphasis was placed on community involvement in later surveys, although professional units took the lead role.

Between 1996 and 2011, 29 coastal surveys examined almost 5000 km of coastline, representing about 30% of the coast. Areas thought most likely to be at risk from coastal processes were targeted, including parts of the island archipelagos of Orkney, Shetland and the Western Isles (Dawson 2015a, table 2).

Over 12,000 sites were recorded, and at almost half of these, a recommendation for future action was made. In order to aid informed decision-making, SCAPE and the University of St Andrews analysed the collected information in 2010. Working with a number of stakeholders they prioritised action at recorded sites, based on an assessment of the value of the site and a determination of its vulnerability to erosion (see Dawson 2013). The prioritisation project decreased the number of sites that carried a recommendation based on threat to 940, and a staged series of tasks was proposed for each of these sites, determined on a case-by-case basis.

One important outcome of the analysis and associated fieldwork was evidence to show that some sites had been altered or even destroyed since first being recorded. For this reason, the first recommended action for every site was an assessment of its current condition.

The public, climate change and the historic environment

There are many reasons for involving the public in heritage projects at sites threatened by climate change. Not only does public participation underpin principles of sustainable development, the historic environment can present lessons from the past to help society prepare for future change. As Henson (2011, 123) notes, people 'can be empowered to cope with future climatic change by looking back at the past'. By understanding the processes of change, and the ways that people have adapted, society can better prepare for the future. For example, as described by Rockman (Chapter 12, this volume), involving the public in this process of discovery and interpretation helps create climate stories that can be shared within communities.

The Climate Change (Scotland) Act places an emphasis on the role of communities and individuals in helping to adapt to climate change. The importance of community action is also reflected in Scotland's Historic Environment Strategy, *Our Place in Time,* which sets out a ten-year vision for the historic environment (Scottish Government 2014). In the Ministerial Foreword, the Cabinet Secretary for Culture writes that individuals and communities need to work with other organisations to ensure that the historic environment is able to face current challenges, including climate change (Scottish Government 2014, 1).

Community action at the coast

Scotland has a long tradition of community involvement at coastal sites, and a formal programme of community monitoring was initiated in Scotland as part of the Shorewatch Project in the late 1990s. This was originally coordinated by the Council of Scottish Archaeology (now Archaeology Scotland), and subsequently managed by The SCAPE Trust (Fraser *et al.* 2003). Shorewatch supported groups and individuals to locate, record and monitor vulnerable coastal sites. Although successful in generating community action, consultation with local groups revealed that merely monitoring sites as they were destroyed could actually be counter-productive. Some groups felt that their actions had been futile, leading them to question why nothing had been done to protect the archaeological heritage.

Building defences to protect coastal heritage is not always the best option as it can lead to problems being deflected to other parts of the coast. In order to test other approaches, SCAPE initiated a community rescue excavation project on Britain's most northerly island, Unst (Dawson *et al.* 2011). This and a second initiative to relocate an eroding burnt mound at Cruester, also in Shetland (Dawson 2016) helped to inform thinking about a new community project, one that additionally aimed to build upon the recently completed prioritisation project (referred to above) and the successes of Shorewatch.

Scotland's Coastal Heritage at Risk Project

The Scotland's Coastal Heritage at Risk Project (SCHARP) was launched in Edinburgh Castle in August 2012. The project was initially funded for three years (now extended into a fourth) from a mix of sources, including Historic Environment Scotland (government), the Crown Estate (large landowner), the University of St Andrews (academic) and the Heritage Lottery Fund (a public body accountable to Parliament that distributes profits from the National Lottery). The Heritage Lottery Fund has played an important role in supporting heritage projects since its establishment in 1994, and has been crucial in the development of community projects throughout the UK.

SCHARP's aim was to develop a partnership between communities and heritage professionals in order to manage and, where possible, safeguard the heritage of Scotland's coast. The overall project was divided into two distinct elements, each with its own specific aims and methodologies. ShoreUPDATE sought to improve baseline knowledge on the coastal resource; and ShoreDIG developed practical projects at threatened sites.

ShoreUPDATE

ShoreUPDATE uses information from volunteers to update information on coastal sites in order to refine the prioritised list (derived from the analysis of the Coastal Zone Assessment survey data) and to produce an up-to-date baseline for future monitoring. ShoreUPDATE encourages wide public involvement and volunteers from around the entire coast are involved in the ShoreUPDATE surveys. As well as working with members of pre-existing heritage groups, the project wanted to encourage people who were new to heritage volunteering. In order to stimulate local interest, training and practice sessions were organised around the country. Articles in the local press advertised training events in halls and community centres, and the SCHARP team introduced participants to the project, followed by sessions at the coast edge where techniques could be put into practice.

Although the primary focus was the 940 sites highlighted in the prioritisation project, an interactive *Sites at Risk Map* developed for the project displayed all 12,000 sites recorded during the CZA surveys through a mobile app and web map (www.scharp.co.uk). The sites were colour-coded by their priority ranking and the original information recorded during the coastal surveys was accessible by clicking the site's location marker. This action also opened a link to an interactive *update form* that allowed registered users to suggest changes to the original site record (registration was free and was required so that the SCHARP team could contact volunteers, if needed). In recognition of the many occasions when local knowledge might enhance the record, all previously recorded information could be edited, including the site's name and location. In addition, the web map and app could be used to record newly discovered sites.

A multiple-choice form asked questions about the current condition of sites, so that assessments could be made on the vulnerability of the remains. The update form was designed with simple questions and multiple choice responses in order to standardise incoming information. Volunteers were also asked to provide a set of photographs. These enhanced the written text and provided a visual record for comparison with previous and future surveys.

The *Sites at Risk Map* and update form were made available through android and iOS apps, and the easiest way of undertaking a survey was by utilising the inbuilt GPS and camera of a mobile phone or tablet. As many areas are not within range of a mobile internet signal, the app included the ability to download site records and maps in advance; these could be used in conjunction with the device's GPS to navigate to sites.

After carrying out a survey, the data could either be sent directly, or saved on the device for uploading when connected to the internet. Once records were received by the SCHARP team, the updates and photographs were checked and validated before being added to the project GIS and appended to the online record.

In addition to sharing updated information with local and national heritage databases, the collected data is being analysed by the SCHARP team in order to refine the priority list. The condition of each site is being examined to see if it has become more or less *vulnerable*. The description and photographs are also being used to gain a better understanding of the nature and type of site, which can lead to a refinement of its *heritage value*. The updated *value* and *vulnerability* scores are being used to decide whether a new priority class should be assigned. The next stage of ShoreUPDATE will involve discussions with a range of stakeholders, including the Local Authority archaeologists, to decide upon the final prioritised scores for each site, together with a course of action where necessary. ShoreUPDATE is thus helping to manage eroding coastal heritage in a practical way, action that is only possible because of the significant contribution of the network of over 1000 volunteers around the coast.

The essential role of the public in ShoreUPDATE

The inclusion of local volunteers was an essential element leading to the success of ShoreUPDATE. Working with community groups was crucial for a number of reasons. Although there are a number of definitions of 'community archaeology', a useful starting point is the broad statement by Moshenska *et al.* (2007, 34, my emphasis), that it involves 'people of all ages and backgrounds in studying the archaeology and history of their *local area*'.

Although the project was open to all, the relationship between volunteers and their local places was important, and in general, people did work in their local areas. Most of the original CZA surveys were undertaken by teams of archaeologists who had come from other areas, meaning that they lacked the wealth of knowledge possessed by the local community. Local knowledge can help ascribe different interpretations to features, for example, by referencing oral history or local place name evidence; thus resulting in new and improved information. As Tully (2007) notes, 'better archaeology can be achieved when more diverse voices are involved in the interpretation of the past'.

A second way in which community involvement can lead to better heritage management is due to local people being able to revisit sites at different times of the year. The original CZA surveys were intended to be rapid and fieldwork was of limited duration. In many cases, the surveys were completed in the winter, partly to take advantage of low undergrowth which can obscure features in the summer. The downside of winter survey in Scotland is the limited number of daylight hours, especially important when tidal range is taken into account. Often, it was not practical for survey teams to visit stretches of coastline at low tide, meaning that the coast edge and intertidal features were inaccessible. Members of local communities, however, are able to arrange visits to the coast at low tide more easily. They can also visit sites immediately after storms or when sediment has been shifted from beaches; this is the time that new exposures will be most clearly visible, before they are either washed away or re-covered with sediment.

ShoreDIG

One of the lessons learned from Shorewatch was that simply collecting information neither saves vulnerable sites nor fully satisfies community desires. ShoreDIGs were intended to go beyond recording sites by facilitating different types of community action at locally-valued heritage sites. A variety

Figure 3.2. Members of the local community, Sanday, excavating the Meur burnt mound, a Bronze Age monument uncovered during a storm.

of different types of project were undertaken, including archaeological excavation (Fig. 3.2), filmmaking, traditional survey and 3D digital recording. In addition to increasing knowledge about the historic environment, the projects are providing examples that highlight a wide range of possible actions, hopefully inspiring others to initiate projects at sites threatened by natural processes.

ShoreDIG Methodology

At the outset of SCHARP, a call was made to local communities to nominate sites where they would like projects to take place. In many cases, ShoreDIG projects developed from ShoreUPDATE surveys. After receipt of nominations, meetings were held between the communities, members of the SCHARP team and other heritage professionals. The communities detailed their aspirations for the site; and different types of intervention that could help achieve these aims were considered. The pros and cons of various courses of action were evaluated, including potential costs and methods of ensuring sustainability and legacy. The local groups decided what they would like to do, and worked with the SCHARP team to develop a project plan.

In addition to project planning, the groups were responsible for publicising projects and recruiting local volunteers. In some cases, the complexity of projects meant professional organisations were asked to prepare detailed plans; but one overriding requirement was that projects had to include a programme of training and opportunities for local community involvement.

To date, 14 ShoreDIG projects have been undertaken, involving 458 volunteers who have contributed over 1500 days of their time. Fieldwork can last for several weeks, but the projects always include weekend working to ensure that there are opportunities for people who are busy during the week. The projects have ranged in size and ambition, but all have aimed at producing a legacy that highlights locally valued heritage and explains the threats that it faces. The following case studies present two examples of differing project types in order to demonstrate different project methodologies.

Case study: the Wemyss Caves

Save the Wemyss Ancient Caves Society (SWACS) wished to draw attention to their local caves, situated on a fast-eroding stretch of the Fife coastline and containing a wealth of Pictish and other carvings. In addition to rapid coastal erosion and other natural threats, the former mining area also suffers from levels of social deprivation, and there was a feeling that the caves were neglected and undervalued. After several meetings, it was decided to record the threatened caves using a number of digital recording techniques (Fig. 3.3).

In 2014, SWACS worked with SCAPE and the York Archaeological Trust on a pilot project that applied laser scanning, photogrammetry, Structure from Motion and Reflectance Transformation Imaging to one of the caves (Dawson 2015b; Hambly *et al.* in press). After the successful completion and launching of a pilot project website (www.4dwemysscaves.org), the project was extended in 2015, with another six caves being recorded. As noted in other community archaeology projects (Thomas 2010, 5), local group members brought with them skills from other disciplines, and in addition to the production of the digital record, members of SWACS continued to manage the area around the caves; held regular open days for the public; arranged talks and trips for local schools; and used archival skills to locate photographs and lost rubbings created a century ago, and now housed in London. The group has also enthusiastically contributed to the making of a series of short films for the project website, each explaining different aspects of the caves' history. The group sourced historical costumes, joined forces with a neighbouring community's choir and took starring roles in the films (Fig. 3.4).

The action of SWACS has centred on raising awareness and local pride about the caves and carvings, a resource which they argue would be more sympathetically managed if it were located in a wealthier part of the country. By working with schools and other members of the community, they are trying to ensure that there is a sustainable future for the Wemyss Caves.

Case study: Meur

In the north of Orkney, the newly-formed Sanday Archaeology Group wanted to move some prehistoric structures associated with a Bronze Age burnt mound that had been exposed on a beach and were being destroyed by storms (Dawson 2015b). The site had been the subject of a rapid excavation after its initial exposure (Toolis 2009), and the group wanted to relocate the remaining stonework to their Heritage Centre, where it could act as an attraction for visitors. Using the

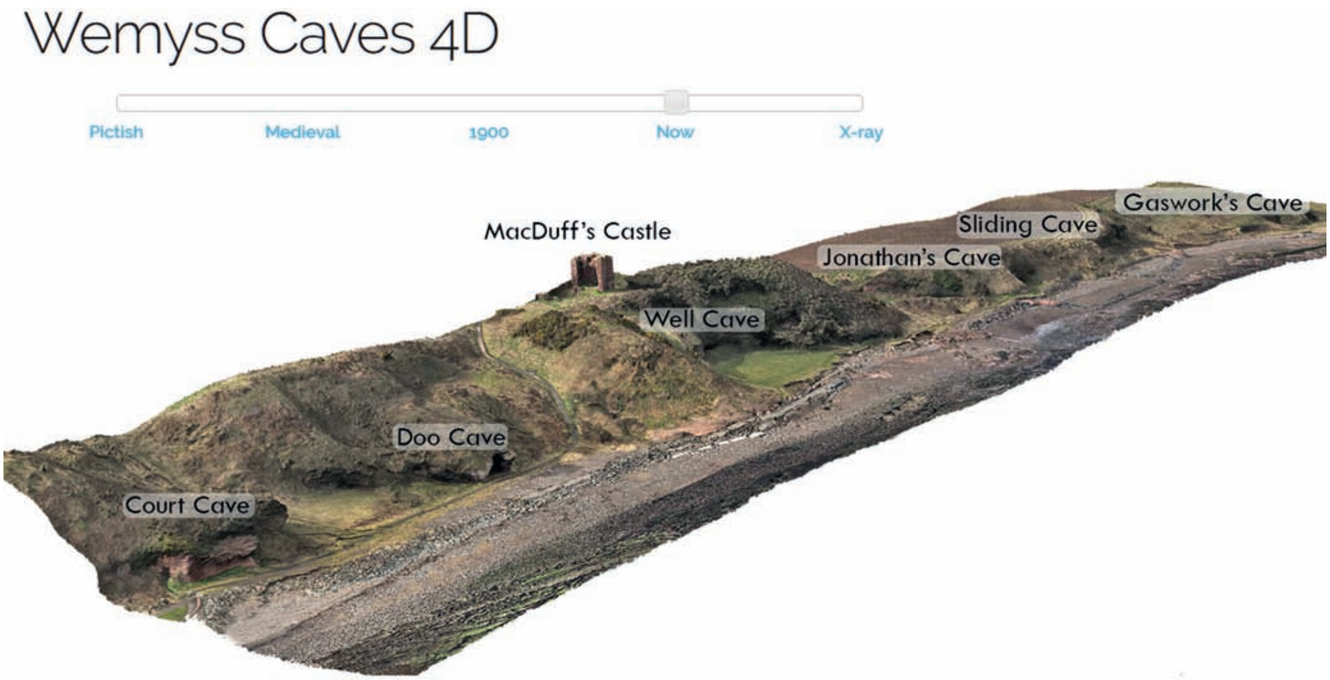

Figure 3.3. The home page of the www.4dwemysscaves.org website showing a digital model of the Wemyss coastline and providing links to content in each of the caves.

Figure 3.4. Members of local group, Save Wemyss Ancient Caves Society dressed up to make one of the films that feature on the 4dwemysscaves.org website.

Figure 3.5. One of the prehistoric wells at Meur being excavated; the structure contained a large amount of organic material.

methodology developed during the Shorewatch project at Cruester (Dawson 2016), a project involving the same Shetland stonemasons was undertaken in 2014.

The initial task was a community excavation to uncover the main elements of the site to be moved: the upright flagstone walls, a paved passageway and a sunken, stone-lined water trough. Erosion meant that more of the site was accessible than during the original dig. This gave access to a prehistoric well, almost 3 m deep and built with internal steps leading to a cistern which contained a large volume of remarkably well-preserved waterlogged organic material, including seeds, stems, leaves, beetles and snails (Fig. 3.5).

Meanwhile, local farmers transported the stonework to the Sanday Heritage Centre. As the dry-stone walling of the well could not be moved, (removing it could destabilise the road), a replica well was built at the reconstruction site. During the process of construction, the stonemasons provided training in dry-stone building techniques.

In addition, the community worked on an interpretation board, with a local artist creating a painting showing the burnt mound when in use. A display was also prepared for the Heritage Centre, giving details on Sanday's eroding heritage, highlighting sites recorded during

ShoreUPDATE surveys, and telling the story of the Meur burnt mound.

Towards the end of the project, an unexpected discovery was made when the large horizontal slab that formed the base of the masonry trough was moved. Additional stonework was revealed beneath, and as this had to be a very early structure, the project team decided that additional fieldwork was required to fully uncover this important discovery. The ability to plan fieldwork projects depending upon need was an advantage of the structure and funding of SCHARP and the ShoreDIGs. A second season of community fieldwork was undertaken in 2015, revealing that the wall was part of an earlier, Neolithic well, from which more organic material was recovered. Analysis of the environmental material is ongoing at Orkney College University of the Highlands and Islands (UHI), and local processing means that the results can be more easily shared with the community (with talks and practical sessions arranged on Sanday).

In addition to providing a tourist attraction and a means of telling a climate story, this community project resulted in many new and unexpected discoveries and will throw new light on past environmental change. This was despite work having already been completed at the site, and the presumed poor condition of the remains, exposed as they were on a beach. It was the fact that the site was being totally dismantled that led to these discoveries, indicating that sometimes more can be learned from eroding sites, which can be fully excavated, than from non-threatened monuments that contain elements that cannot be touched.

Discussion: the role of non-professionals in archaeology

SCHARP has succeeded in bringing together heritage professionals and local communities to work at a severely threatened resource, the coastal heritage of Scotland. Archaeology has been described as one of the few disciplines where it is possible for anyone to make a meaningful contribution (Heyworth 2014, 106) and this recognition has led to discussions on the definition of community archaeology; and on whether projects should be viewed as 'top down' or 'bottom up'.

Richardson and Almansa-Sánchez (2015, 201) present a stark choice, where communities are either the passive recipients of outreach work (top down) or are actively engaged with the process of managing projects (bottom up). Reid (2011) defines community archaeology as 'archaeology by the people for the people,' advocating that all work should be embedded within a local community; Thomas (2010, 6) has even questioned whether projects developed by professional organisations that include volunteers are actually 'community archaeology', wondering if they should be termed 'archaeological outreach' instead.

Certainly, there has been a great variety in top down approaches, and it has been argued that in some cases, community projects may have been vehicles for archaeologists to obtain funding in order to conduct their own research (Simpson and Williams 2008, 71). However, other top down approaches have involved a great deal of thought, and detailed checklists have been produced that outline the elements that should be included in ideal community projects (Moser *et al.* 2002; Tully 2007).

SCHARP is certainly not bottom up, but it recognises that community input is essential to the ShoreUPDATE surveys, and community desire is at the heart of the ShoreDIGs. Neither was a top down approach, employing a pre-determined formula, followed; and projects evolved through dialogue between the local communities and the SCHARP team. In effect, SCHARP adopted a collaborative 'middle path' approach (see Dawson 2015b), recognising that local heritage aspirations can be supported with professional help, especially for specialist elements of projects. The SCHARP team have acted as facilitators, communicating with participants, verifying records, and ensuring that data is exchanged between groups and heritage professionals.

One problem identified by researchers is that interest wanes in some community projects, either during the project or soon afterwards. In some cases, this lack of interest may have been caused by the nature of the sites chosen for investigation, especially when excavation formed part of the project. For example, Moshenska *et al.* (2007, 34) describe community excavations as test pits or evaluation trenches dug on marginal land or at recent sites and usually excavated 'by hand to a shallow depth, aiming to recover artefacts rather than features'. Archaeology has been described as a 'finite and non-renewable resource' (DoE 1990) and it is possible that the organisers of some community excavations fear that this resource could be compromised, and either deliberately choose uninteresting sites, or limit the scale of excavations. Simpson ponders whether the lack of interest in participating in excavations in southern England was due to the nature of the archaeological remains being targeted (Simpson 2009, 57–58). SCHARP has overcome this problem as the sites investigated were nominated by the local community; and the work was undertaken at places in danger of being destroyed, meaning there was a real purpose to fieldwork and local interest in the discoveries. Perhaps the best way to describe the SCHARP excavations is 'community rescue', a concept discussed by Turner in 2005 when he debated the pros and cons of community action at the coast.

Another much discussed topic in community archaeology, and one that also affects SCHARP, is that of sustainability. The nature of grant funding means that projects often have finite timescales and there have been calls for community projects to diversify their funding streams (Belford 2014, 38). SCHARP has been successful because it has created true collaborations, building upon two decades of previous work and thinking about coastal heritage. The approach has benefited from funding which has allowed the project team to coordinate activity and act as a contact between communities and professionals. Individual ShoreDIG projects were planned with sustainability in mind and, as seen at Meur and Wemyss, the community are sustaining their project legacies through their Heritage Centres, by leading events, creating interpretation boards and starring in videos and other online content. Although SCHARP may cease as a project, the results and products will act as a lasting legacy.

Conclusion

The problem at the coast has not been solved, and the methodology adopted by SCHARP, of community empowerment and partnership working, needs to be developed further. This approach is rooted in sustainable development thinking and encouraged at local and national government level. Communities have a key role to play in climate change adaptation and in historic environment management. Much of the Scottish coast remains to be surveyed, and community coastal surveys and continued ShoreUPDATES would help achieve this, contributing vital heritage data. Hundreds more sites would benefit from ShoreDIG style projects, with communities rescuing information from locally-valued sites before they are destroyed. The collaborative working practices developed at the Scottish coast are already being applied in some other countries, and it is hoped that these approaches will both continue in Scotland, and that the benefits of the methodology will lead to them being applied to even more places where heritage is threatened by changing climates.

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References

Ashmore, P. J. 1994. *Archaeology and the Coastal Zone: Towards a Historic Scotland Policy*. Edinburgh, Historic Scotland.

Ashmore, P. J. 2003. Archaeology and the Coastal Erosion Zone. In T. Dawson (ed.), *Coastal Archaeology and Erosion in Scotland*, 1–6. Edinburgh, Historic Scotland.

Belford, P. 2014. Sustainability in community archaeology. *Arqueologia Publica* Special Volume 1, 21–44.

Cassar, M. 2005. *Climate Change and the Historic Environment*. London, University College London.

CCC (Committee on Climate Change). 2016a. *UK Climate Change Risk Assessment 2017: Synthesis Report*. London, Committee on Climate Change.

CCC (Committee on Climate Change). 2016b. *UK Climate Change Risk Assessment 2017: Evidence Report, Summary for Scotland*. London, Committee on Climate Change.

CCC (Committee on Climate Change). 2016c. *UK Climate Change Risk Assessment 2017: Chapter 3, Natural Environment and Natural Assets*. London, Committee on Climate Change.

Davidson, A. and Jones, N. 2002. The Archaeological Survey of the Welsh Coast. In A. Davidson (ed.) *The Coastal Archaeology of Wales*, 18–24. York, Council for British Archaeology Research Report 131.

Dawson, T. 2013. Erosion and Coastal Archaeology: Evaluating the threat and prioritising action. In M.-Y. Daire, C. Dupont, M. Baudry, C. Brillard, J. M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coast*s, 73–80. Oxford, British Archaeological Reports International Series 2570.

Dawson, T. 2015a. Eroding archaeology at the coast: How a global problem is being managed in Scotland, with examples from the Western Isles. *Journal of the North Atlantic: 2010 Hebridean Archaeology Forum* Special Volume 9, 83–98. Steuben, ME, Eagle Hill Publications.

Dawson, T. 2015b. Taking the middle path to the coast: How community collaboration can help save threatened sites. In D. C. Harvey and J. Perry (eds), *The Future of Heritage as Climates Change: Loss, Adaptation and Creativity*, 248–67. London, Routledge.

Dawson, T. 2016. Community rescue: Saving sites from the sea. *Arqueologia Publica: Online Journal in Public Archaeology* Special Volume 2, 5–42.

Dawson, T., Lelong, O. and Shearer, I. 2011. Local community groups and aeolian archaeology: Shorewatch and the experience of the Shetland Community Archaeology Project. In D. Griffiths and P. Ashmore (eds), *Aeolian Archaeology: the Archaeology of Sand Landscapes in Scotland*, 87–105. Edinburgh, Scottish Internet Archaeological Reports Volume 48.

Flatman, J. 2009. A Climate of Fear: Recent British policy and management of coastal heritage. *Public Archaeology* 8(1), 3–19.

Fraser, S. M., Gilmour, S. and Dawson, T. 2003. Shorewatch: Monitoring Scotland's coastal heritage. In T. Dawson (ed.), *Coastal Archaeology and Erosion in Scotland*, 197–202. Edinburgh, Historic Scotland.

Hambly, J., Abbott, M. and Arrowsmith, M. in press. How a community-based digital heritage project may help us imagine the circumstances of symbolic Pictish carvings in the Wemyss Caves, Scotland. In L. Büster, E. Warmenbol and D. Mlekuž (eds), *Between Worlds: Understanding Ritual Cave Use in Later Prehistory.* New York, Springer.

Henson, D. 2011. 'Does archaeology matter?' In G. Moshenska and S. Dhanjal (eds), *Community Archaeology: Themes, Methods and Practices*, 123–30. Oxford, Oxford University Press.

Heyworth, M. 2014. Archaeology for All. *Journal of Community Archaeology and Heritage* 1(2), 105–06.

Highland Council. 2012. *Adapting to the Impacts of Climate Change in Highland.* Updated January 2012. Inverness, Highland Council.

Historic Scotland. 1996. *Coastal Zone Assessment Survey: Historic Scotland Archaeological Procedure Paper 4*. Edinburgh, Historic Scotland.

Historic Scotland. 2012. *A Climate Change Action Plan for Historic Scotland 2012–2017*. Edinburgh, Historic Scotland.

Jackson, T. and Lynch, W. 2011. Public sector responses to climate change: Evaluating the role of Scottish local government in implementing the Climate Change (Scotland) Act 2009. *Commonwealth Journal of Local Governance Issue* 8/9, 112–35.

Moser, S., Glazier, D., Phillips, J. E., el Nemr, L. N., Mousa, M. S., Aiesh, R. M. N., Richardson, S., Conner, A. and Seymour, M. 2002. Transforming archaeology through practice: Strategies for collaborative archaeology and the Community Archaeology Project at Quseir, Egypt. *World Archaeology* 34(2), 220–48.

Moshenska, G., Dhanjal, S., Doeser, J., Phillips, S. and Allen, S. 2007. Community archaeology: Against the odds. *Current Archaeology* 213, 34.

Reid, P. 2011. Performance or participation: The relationship between local communities and the archaeological domain In G. Moshenska and S. Dhanjal (eds), *Community Archaeology: Themes, Methods and Practices,* 18–27. Oxford, *Oxbow Books.*

Richardson L.-J. and Almansa-Sánchez, J. 2015. Do you even know what public archaeology is? Trends, theory, practice, ethics. *World Archaeology* 47(2), 194–211.

Scotland's Environment. 2015. Historic Environment. Available at: http://www.environment.scotland.gov.uk/get-informed/people-and-the-environment/historic-environment/ [accessed 5 August 2016].

Scottish Government. 2009. *Scotland's Climate Change Adaptation Framework*. Edinburgh, Scottish Government.

Scottish Government. 2014. *Our Place in Time – The Historic Environment Strategy for Scotland*. Edinburgh, Scottish Government.

Simpson, F. 2009. Evaluating the value of community archaeology: The XArch Project. *Treballs d'Arqueologia* 15, 51–62.

Simpson, F. and Williams, H. 2008. Evaluating community archaeology in the UK. *Public Archaeology* 7(2), 69–90.

Smith, G. 1995. Aberdaron Bay to the Great Orme. Unpublished GAT (Gwynedd Archaeological Trust) Report 79. Bangor, Wales.

Thomas, S. 2010. *Community Archaeology in the UK: Recent findings*. York, Council for British Archaeology.

Toolis, R. 2009. Excavation of a burnt mound at Meur, Sanday, Orkney. *Scottish Archaeological Journal* 29(1), 31–49.

Tully, G. 2007. Community archaeology: General methods and standards of practice. *Public Archaeology* 6(3), 155–87.

Turner, R. 2005. A credit to archaeology. *Scottish Archaeological News* 49, 1–2.

UNEP (United Nations Environment Programme). 1992. *The Rio Declaration on Environment and Development.* Rio de Janeiro, UNEP.

Woolf, D. and Wolf, J. 2013. Impacts of climate change on storms and waves. *MCCIP Science Review*, 20–26.

Chapter 4

Improving management responses to coastal change: utilising sources from archaeology, maps, charts, photographs and art

Garry Momber, Lauren Tidbury, Julie Satchell and Brandon Mason

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Abstract

The coastal zone that we see today is a dynamic ribbon of land that is in a constant state of flux. Coastal managers face an ongoing battle to moderate impacts from the sea in the face of a changing climate and pressures from human uses of the coastal zone. The challenges that lie ahead are forecast to increase while resources are being forced to go further. This paper looks at the implications of climate change and explores the value of under-used coastal indicators that can be applied as tools to inform long-term patterns of coastal change. These are archaeology, palaeoenvironmental data, works of art, historic maps, charts and photographs. They have been tested against set criteria within the Arch-Manche Archaeology, Art and Coastal Heritage project that demonstrated their worth as tools to inform the scale and rate of long-term coastal change. The western Solent is presented as a case study. With the advent of new technologies, ongoing monitoring would be increasingly valuable, and with the support of the coastal community, it could be very cost effective.

Introduction

In July 2016, the United States National Oceanic and Atmospheric Administration (NOAA) published on their website that this had been the hottest summer on record. They stated that: 'This was also the 14th consecutive month the monthly global temperature record has been broken – the longest such streak in NOAA's 137 years of record keeping' (NOAA 2016). Their global analysis began in 1880 after which their records show a cooling trend that continued for around three decades. This was followed by a gentle, albeit erratic, rise in temperature of around half a degree for the next half century or so; but in the last 40 years, since 1976, this has tripled with a sustained increase in mean temperatures resulting in a cumulative rise of 0.9 ºC (NOAA 2016). It is becoming universally accepted that the cause of this change is an escalation of greenhouse gases that began during the Industrial Revolution. The effects of the increase in global temperature are becoming ever more apparent as the oceans heat up, the northern ice cap is reduced in size each year and glaciers recede. It is argued that these phenomena have brought on a 'rupture' in the natural climatic cycles and heralded a new epoch: the Anthropocene (Crutzen 2002; Hamilton 2016). A date proposed for the beginning of this period is the creation of the Newcomen atmospheric engine in 1712 (Lovelock 2014). Since the onset of the industrial revolution, there has been a lag of over two hundred years before the warming climate was discernible, but now that it has begun the impact will be felt long into the future. 'The chemical compositions of air and ocean have been altered in ways that cannot be undone except on a millennial timescale' (Hamilton 2016, 100).

The lag effect caused by the proposed Anthropocene is something that is not without analogy (Clark *et al.* 2016). Rapid global warming has happened many times before and when it did so it set in train a process of oceanographic, coastal and landscape change that took thousands of years to unfold. This paper will look at the impact of past sea level fluctuations along the coasts of the Channel and southern North Sea that have occurred following the last glaciation. It will show how a record of that change remains along the shoreline within the palaeoenvironmental deposits and the archaeology. It will demonstrate how these can be used along with art and historical records to help us understand patterns of change that have had, and will continue to have, consequences for the coastline.

Long-term climate change and the sedimentary archive

The last major event to have a dramatic impact on the global climate was the Devensian Ice Age (Marine Isotope Stage 2). At the peak of this cold period, glaciers covered the northern hemisphere extending south of the Baltic and across the British Midlands. Sea level was over 120 m lower and most of the European continental shelf was dry land. However, around 22,000 years ago temperatures began to rise and the ice started to thaw. This resulted in the formation of large rivers draining through fast flowing channels that cut deep into the landscape and carried billions of tons of glacio-fluvial material downstream. The Devensian gave way to the Holocene around 11,450 cal BC when the northern hemisphere saw the temperature increase by 5–10ºC in only a few decades (Alley and Clark 1999; Alley 2000; Alley *et al.* 2003). During the early part of the Holocene, aeolian and coastal processes reworked the sand and gravel deposits that were laid down by the Ice Age rivers and cast them onto the foreshore to form beaches. In the later part of the Holocene, the supply of this material stopped. As it is not being replaced, there are areas that will not be naturally recharged once it is dispersed. These are the areas that are now at greatest risk from undercutting and storm damage.

The lack of understanding of these coastal processes at the beginning of the 20th century led to irreparable damage. Hallsands in Devon, England is an example where the beach was eroded away because the shingle below the low water mark had been dredged, resulting in a coastal village being destroyed in 1917 (Fig. 4.1). The developers that took the gravel away did not realise the source material would not be replenished and the result was the loss of 37 houses (Melia 2002). These actions continued with little reflection because there was a general belief that the natural state was in balance. During the last 5000 years, climate and sea level have become relatively stable, making changes between land and sea hard to distinguish on a human timescale. This has provided a sense of permanence that belies ongoing processes.

While the comparatively static sea level has meant fewer areas of land are being flooded, the lengthy still-stand has caused attrition at the land-sea interface. This is eroding soft cliffs at unprecedented rates and stripping beaches permanently of natural material. The response to this instability by coastal managers and engineers has traditionally been to build groynes or hard defences, often without considering the long-term consequences. These only last a limited time before they are undermined and while they are effective at retaining material at one beach they can starve beaches downstream of essential material, which, in turn can accelerate erosion (Fig. 4.2). The need to understand coastal processes on a broader geographical scale was recognised during the latter stages of the 20th century in the UK, and a programme of Shoreline Management Plans was put in place during the 1990s. This initiative benefited from extensive seabed mobility studies, but little effort was made to understand long-term effects on the coastline due to natural changes (Brampton *et al.* 1998). In more recent years, concern about global warming has helped raise awareness of the inevitable changes to come, compelling some coastal managers to start looking at historical records to measure variations through time (NFDC 2014; DEFRA 2009). This is a useful method to detect trends along the coastline and to remind the public and decision makers that some coasts may not retain the same form over a long timeframe. However, authorities seldom look further back in time to fully understand the longer term influences that underpin the changes, and few have recognised the value of archaeology, art, maps and charts to add significant time-depth and detail to studies of coastal evolution.

Archaeology, art, maps and charts as indicators of change

The climatic amelioration of the Holocene attracted humans to northwest Europe who were quick to colonise the increasingly appealing environment (Gaffney *et al.* 2009; Momber *et al.* 2011; Sturt *et al.* 2013). People became established in the landscape and lived there for thousands of years, but always in the context of steadily rising sea levels which followed deglaciation and lasted to around 5000 years ago. They lost their hunting and gathering territories as coastal water levels rose, but they left behind a record of their presence encapsulated within the formerly terrestrial matrix of sediments, and alongside flora and fauna that provide a signature of the environment which they inhabited. As the sea advanced, vast tracts of land would have been washed away while storm-battered coastlines collapsed and retreated, but in more sheltered coastal units – such as bays, below growing estuaries or under beaches –, pockets of the drowned landscape were protected by a covering of sediment (Flemming 2004; Gaffney *et al.* 2007). It is here where palaeoenvironmental and archaeological material has been preserved, and analysis of these deposits can tell us about the transitions that happened as the water rose, together with the rate and scale of change and the impact on humans who had to adapt or move.

The stabilisation of the warm Holocene climate and global sea level around five millennia ago facilitated the growth of civilisations. This led to the growth of coastal settlements with structures along the shoreline, which is fortunate as these can now be used as markers from which to measure change. These monuments to past human endeavours are found from the Neolithic to modern times. Many of the older sites are now submerged, such as the Neolithic trackways that disappear

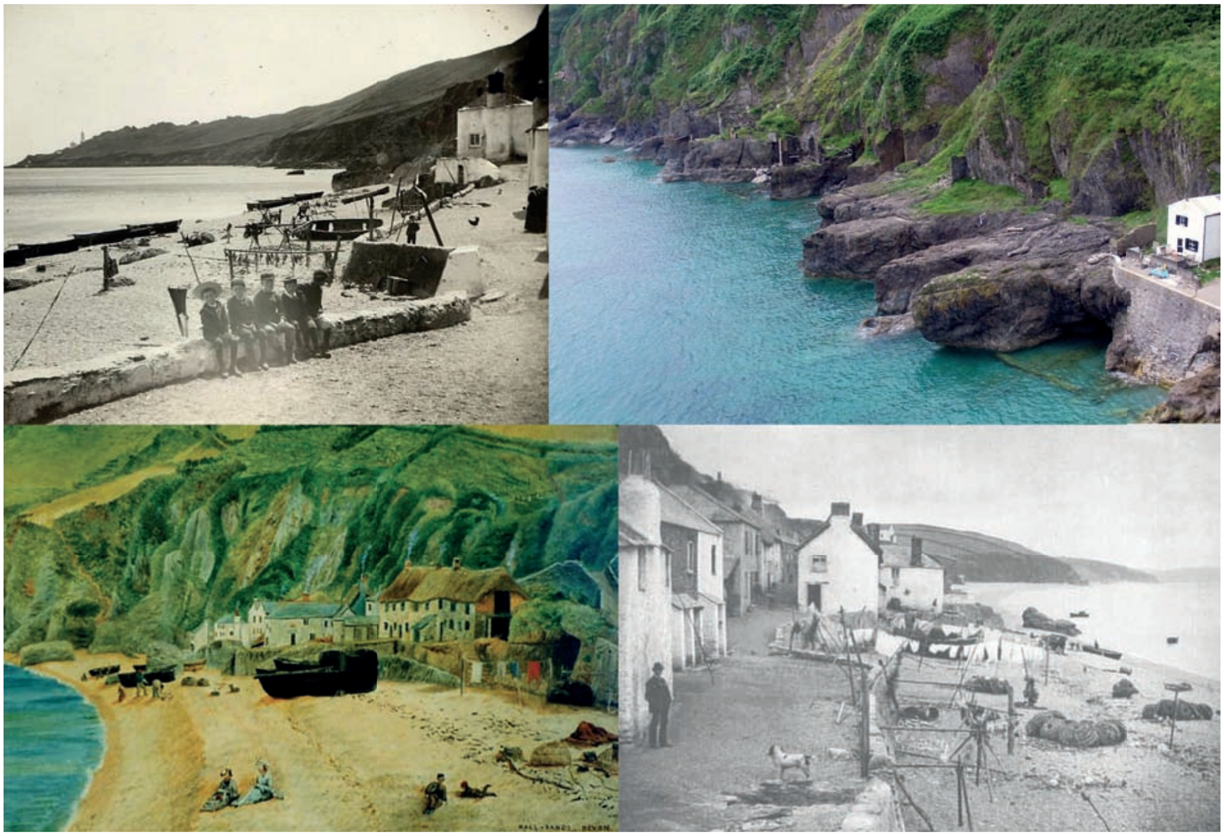

Figure 4.1. Hallsands, Devon UK, before and after the storm. The painting from 1869 by Lidstone (http://www.abandonedcommunities.co.uk/page78.html) (bottom left), the late 19th century image of the foreshore (http://www.abandonedcommunities.co.uk/hallsands.html) (top left), and the 1885 image of the village main street (City of Plymouth Archives and Records) (bottom right) depict an established settlement and a stable beach. The photograph taken in the summer of 2016 by B. Mason (MAT) (top right) shows the beach is gone and only ruins of the 37 houses remain.

Figure 4.2. Unprotected cliff at Barton-on-Sea, Hampshire, UK, showing the loss of WW2 heritage sites. The Dorset seafront to the east is protected by groynes where the cliffs have stabilised (Photo: G. Momber, MAT).

below the low tide mark at Wootton Quarr (Tomalin *et al.* 2012), Roman peat extraction pits off Raversidje in Belgium (Thoen 1978), relatively deeply submerged medieval fish traps at Lannion (Daire and Langouët 2011), or Neolithic megaliths in Morbihan, France (Fig. 4.3). The reasons for their submergence could be rising sea level, tectonic downwarping or coastal erosion, however, their significance lies with their ability to provide accurate dates for their construction and in some cases for their abandonment, therefore enabling us to monitor their positions relative to the sea. These are all sites that were studied in the Arch-Manche project where they were investigated to quantify their value as markers of sea level change. By the time we travel further forward through the historical period, port and coastal structures are common. Harbours or fortifications can have a direct relationship with water and may have been adapted in response to variations in sea level. These can be captured in written records, charts, paintings or even photographs. Such tangible markers can be used to inform coastal managers of past change, and many examples were included in the Arch-Manche project, which was developed to demonstrate the value of coastal heritage for monitoring relative change.

Arch-Manche and tools to monitor change

The Maritime Archaeology Trust has championed the value of art and archaeology as indicators of coastal change for over two decades. With the support of the European Development Fund through the Interreg IVA 2 Seas Programme, we led a project to develop methods and techniques that would apply heritage data to help monitor coastal erosion. The Arch-Manche project was a major undertaking that addressed these issues in four European countries. The other partners were Centre National de la Recherce Scientifique (CNRS) through the University of Rennes from France, Ghent University in Belgium, and the research institute Deltares in the Netherlands. The project aimed to provide innovative tools to improve understanding of the scale and rate of coastal change in the past to help make decisions for the future (Maritime Archaeology Trust 2014). It demonstrated how the application of methods assessing the study of submerged and intertidal archaeology, paleaeoenvironmental evidence, maps, charts, photographs and art can fulfil an important role in Integrated Coastal Zone Management (ICZM) and help share best practice between archaeologists, geologists and palaeogeographers. The project demonstrated how long-term behavioural trends in coastal landforms could be determined by maximising these often-overlooked resources. The results are important for coastal and marine management as they can support the development of sustainable policies for adapting to climate driven coastal change (see the Arch-Manche website: http://archmanche.maritimearchaeologytrust.org/).

Figure 4.3. Er Lannic Stone Circle,Gulf of Morbihan, France, half of which is now submerged by sea level rise. The site provides direct evidence of sea level change (Photo: MAT archive).

The project reviewed five key themes or categories and used them as tools to record change. Firstly, we assessed palaeoenvironmental samples and archive data for evidence of past landscapes from early prehistoric times through to the modern day. Palaeoenvironmental material contains the remains of plants, animals and insects, together with soil types that can indicate whether the environment was dry, damp, wet, saline or brackish. The layers of organic material can be accurately dated allowing for a detailed chronology of events to be charted. This is particularly important when recording changes to local environments, the sea level and for insights into coastal adaptation.

Secondly, we used archaeology as a means of looking at occupation and human interaction along the coastal zone. The position of settlements within coastal areas can help chart the advance or retreat of the sea. In cases such as Langstone Harbour, *in situ* features and related objects underwater or in the intertidal zone can show where people lived when the sea level was lower (Allen and Gardiner 2000; Van de Noort 2013; Evangelinos *et al.* 2014; Satchell and Tidbury 2014). Features like prehistoric trackways that would have crossed marshy areas but are now exposed along the shoreline at low water show adaptations to marine environments and provide markers for sea level rise. Conversely, areas like the Romney Marshes on the south coast of England or the Scheldt Estuary Polders in the Netherlands (Vos and Heeringen 1997) have all been subject to accretion rather than erosion. Here, rates of sedimentation or land advance can be monitored with reference to dated archaeological features that are now located further inland. Studying the archaeological record can also show how humans adapted to their changing environment by constructing defensive structures and in more recent times, how the building of these structures has affected change.

Thirdly we looked at maps and charts. These contain useful qualitative and quantitative data that can help us understand and gauge changes in the coastline and settlement responses to local environmental impacts. The maps can provide a record of territories and boundaries while also reflecting improved techniques and methods for measuring the landscape, coast and seascape. Where you can define a level of confidence in their accuracy, map regression studies can indicate rates of change over time. Detailed depictions of coastal areas on both maps and charts provide interpretable evidence of change from the 16th century to modern day. In cases such as Dunwich in Suffolk, England or Saeftinghe in the Scheldt Polder, the villages have succumbed to coastal erosion, and the rate that the land has been lost can be readily calculated by looking at maps (Brooks *et al.* 2011).

Fourthly, we looked at photographs. These images are particularly useful as they provide three-dimensional views of the coastline that can be compared directly with the present-day seascape, thereby revealing changes to a high degree of accuracy. Coastal views have attracted attention from the earliest examples of photography, and they became increasingly popular as tourist postcards.

Finally, artistic representations in the form of paintings, drawings and prints were considered. The art resources of the Channel coastlines illustrate a rich history of landscape art that can be interrogated to support understanding of long-term coastal change. Parts of the Arch-Manche region were painted more than any other part of Europe's coastline, providing a resource dating back to the 16th century. Images of particular interest were those that depicted specific parts of the coastline with well-defined features, buildings and structures. Prior to photography, these depictions give unique opportunities to examine coastal areas for data related to physical, environmental and social change.

Arch-Manche methodology

To extract results from the datasets that were relevant and useful for coastal managers, methods were developed and presented in ways that could be readily included in coastal management evaluations. However, the quality and detail within archaeological, historical, photographic, map, chart and artistic sources can vary dramatically, and it was therefore necessary to evaluate these resources in terms of their accuracy and reliability prior to using them for coastal research (Jongepier *et al.* 2014; McInnes 2008). A cornerstone of the methodology was a system of ranking where each site or source of information was given a value relative to its benefit for understanding coastal change. These scores were based on different criteria for each category but designed so they could be added together to give composite scores that would be comparable.

The project reviewed current knowledge by conducting a desk-based assessment of 3000 sites that could be scored against the ranking systems. First, the records were inspected for areas that have archaeological or palaeoenvironmental information. These were viewed together and scrutinised to see if they held scientific data that could help tell the story of past change. Features included monuments, intertidal structures, fish traps, shipwrecks and submerged landscapes. The ranking system paid particular importance to the past behaviour of the coastline and to chronological information concerning the nature, scale and pace of sea level rise and coastal change. Data were ranked against the following criteria:

1. Does the site contain evidence of changes in sea level?
2. Does the site provide evidence of environmental change?
3. Does the site contain material that could provide evidence of temporal continuity?

These quantitative assessments complemented qualitative criteria presented in descriptive terms that helped provide a physical and managerial context for the ranked evidence. These included an indication of the site's status, which incorporated their state of preservation or exposure and any relationship with the current or past coastline.

The value of maps and charts could only be quantified as a source of direct data to indicate change once the levels of accuracy could be calculated. To do this, three characteristics were compared. First was the topographic accuracy that looks at the particular coastal features such as estuaries or coastal cliffs. Attention was drawn to the level of detail used to record heights of elevated land or of small features like inlets. Secondly, the geometric accuracy was tested. This was achieved by comparing identifiable distances recorded on a historic map or chart against the true distances as recorded today; the Map-Analyst software package was used to conduct the analysis (mapanalyst.org). The final category to be assessed was chronometric accuracy. This looked at the value of older maps and charts by taking into account the methods used to record relative positions on the map and whether these were clearly annotated. The age of the map and whether it was an original or copy was also taken into consideration. It was noted that copies tend to lose details each time they are reprinted or remade and often develop cumulative errors through distortion during reproduction.

The methodology applied to rank historic photographs used four criteria. A key aspect was the viewpoint. Firstly, it should be a coastal view, and the score would be highest if it showed a clear image of the coastal morphology with identifiable features. Secondly, the inclusion of any heritage features that indicated a relationship to the sea was scored. This could be a Neolithic passage grave that was now partially submerged or a coastal fortress of known date. If the structure had been damaged by the sea, especially if there was a sequence of photographs showing change, then the value would be even greater. The final scoring criterion was the quality of the image and therefore its value as a scientific tool. This related to the fourth non-scoring category where the purpose of the photograph was taken into consideration, as this influenced the narrative and sometimes the detail of the photograph.

Artistic works can be many and varied, each being distinct in style. Images are created for a number of reasons and presented in different formats. To review the value of art as a tool to record true change of the coastline, it was therefore necessary to ask a more detailed list of questions. The category of artistic style had to be addressed first by creating five sub-categories. For the purpose of interpreting the coastline they were divided into caricaturist and genre works, picturesque landscapes, marine and shipping subjects, topographical artworks including beach and coastal scenery, and, finally, topographical artworks including beach and coastal scenery with a Pre-Raphaelite influence. The Pre-Raphaelite influenced painting paid the greatest attention to detail and accordingly warranted the greatest score.

The second category was the medium used for the artwork. This theme was split into six distinct groups: 1) copper plate engravings, 2) oil paintings, 3) oil paintings by Norwich School and Pre-Raphaelite artists, 4) steel plate engravings and aquatints, 5) lithographs, fine pencil drawings and watercolour drawings, and 6) watercolour drawings by Pre-Raphaelite artists and their followers. Our research showed that the levels of accuracy varied incrementally between each medium, copper plate engraving being the least accurate medium while Pre-Raphaelite watercolour drawings were, in general, the most accurate.

The subject matter was also given a value. If the view in the image was general it received a low score, if it showed details of the cliff or beach it scored more, and if it depicted high levels of detail of geology, vegetation patterns and coastal development it scored maximum points. Finally, the date of painting was taken into consideration. The time period reviewed was 1770 to 1930 with the more recent images receiving a higher score.

The ranked scores for each category of evidence were collated and input into the project database. The total scores were normalised to a maximum value of 100 enabling comparison between the ranking systems. The results are presented spatially on a web-based geographic information system (GIS). They are visually presented with distinct coloured shapes for the scores of the different categories: the larger the shape, the higher the score (http://archmanche-geoportal.maritimearchaeologytrust.org/).

Fieldwork case study

The desk-based assessment and scoring identified the most significant sites in the coastal regions that fringed the Channel and North Sea, but there was a need to qualify the results with fieldwork. In particular, the fieldwork interrogated archaeological, palaeoenvironmental and heritage sites where methods were developed to record and monitor change. These included diving archaeological investigation, intertidal survey, archaeological excavation, and geophysical and geotechnical survey. When possible, the project team worked closely with volunteers on fieldwork projects. In particular, volunteers helped with survey and excavation around the coast of Brittany and joined the underwater survey operations in the Solent. Looking to the future, a benefit of the Arch-Manche project is that it has identified methods that could be used to facilitate greater community involvement in the future.

The project supported six large fieldwork investigations that were spread across the partner countries (http://archmanche.maritimearchaeologytrust.org/downloads). The following presents the results of the fieldwork case study from the western Solent, which contains a long sequence of data that demonstrates climate change, sea level rise and subsequent human responses. It is an area with a temporal sequence that stretches back over 8000 years. It contains a range of heritage sites from drowned Mesolithic settlements to historical fortifications to 20th century shipwrecks. These assets lie in varied geomorphological contexts including soft chalk and weak sandstone cliff-lines, coastal landslide systems, shingle and sandy beaches, tidal estuaries, dunes, saltmarsh and mudflats. These areas are subject to cliff erosion, coastal landslides, and the loss of beach material. In particular, it is also an area that is very vulnerable to future change in sea level that could result from the predicted increase in global warming.

The application of the Arch-Manche scoring criteria to the archaeological sites in the western Solent study area resulted in five examples scoring a maximum value of '100', having ranked 'high' in each of the categories for evidence of 1) sea level change, 2) environmental change and 3) temporal continuity. The sites scoring '100' included four sites of submerged prehistoric archaeology and/or palaeoenvironmental evidence, and a Medieval coastal castle. A further seven sites scored '88' (two 'high' scores and one 'medium' across the three categories), these were all examples of prehistoric submerged landscape deposits. These results further demonstrated the high value of areas of preserved relic landscapes for understanding coastal change.

The western Solent: archaeology and palaeoenvironmental remains

The western Solent is now a marine channel running east–west that has been completely reconfigured over the last 3500 years due to rising sea levels; 8500 years ago it was a wooded valley with a river running through it from north to south. It sat on the north side of chalk downs that sheltered it from south-westerly winds and provided good resources of flint for tool making. In 1999, worked flints from the chalk cliffs were found 11 m underwater after they had eroded from a submerged forest. They were covered by a sequence of sediments and peat deposits that developed over the site as the sea rose above it. This site at Bouldnor Cliff was one of the examples to score a maximum of '100' when applying the Arch-Manche ranking criteria.

When seawater first entered the Solent it came up the River Yar from the south. It covered the valley floor and turned it into an estuary. The first signs of marine inundation are recorded in the sediments covering the peat deposits at 10.6 m below Ordnance Datum (OD) that date to 6010–5960 cal BC (SUERC-7560) (Momber *et al.* 2011). When the sea came it forced the inhabitants to adapt and move upslope. Prior to the arrival of the sea, the archaeological evidence shows the occupants had already had to respond to flooding. Timber dated to 6240–6000 cal BC (Beta 249735) had been heated, charred and worked. This was at a depth of 11.5 m below OD, and the wood lay alongside piles and pits of burnt flint. The remains of fallen structural elements, including tangentially split timbers, were also recorded on the old land surface. This horizon was covered by a 0.2 m thick layer of freshwater sediment that was capped by a 0.3 m thick layer of humic material and peat that had built up on top. Once this vegetation had become re-established above the freshwater palaeosediments, signs of occupation appear again. This time they were in the form of a wooden post and a small pile pushed vertically into the ground. It appears people had returned to continue activity in the wetter landscape, but ultimately they would have been forced to retreat inland. This was a period of extensive change in northwest Europe and a time when Britain was separated from mainland Europe (Coles 1998; Momber 2014; Peeters and Momber 2014).

Analysis of the mud flat sediments that built up on top of the submerged forest and the archaeological site revealed a wealth of pollen and mineral data. This not only indicated the changes in the local environment and sea level but also where the inputs came from as the estuary evolved. For over 2000 years after the initial submergence, until 4920–4535 cal BC (Beta-140103), the influx of water continued to enter the system from the south. It rose 5.5 m before land was overtopped to the east and the composition of minerals and flora changed. Despite this the Solent was still an estuary – a peat sample from Hurst Spit to the west at just 2.5 m below OD was dated 1900–1690 cal BC (Beta-270797), indicating that it remained estuarine until that time (Momber *et al.* 2011).

The evidence shows that the Solent did not form as a waterway separating the Isle of Wight from mainland Britain until the second millennium BC. The severance occurred at what is now the Hurst Channel. The initial impact of the breach would have been limited and water would have only passed over it during high tide. It would have remained an isthmus for many years and would have been strengthened by the pebble beach that extended from Christchurch Bay until such time as it gave way to the dominant trend of westerly storms and allowed water to pass through it for good. Indeed, it is these storms that threaten Hurst Spit today. The spit is in continual need of recharge (Fig. 4.4). If it were to breach permanently then the sheltered Solent would be exposed to a much greater impact from storms that would result in an accelerated loss of land. Modelling the risk of this happening is something coastal managers are keen to undertake, and it is something that the study of the submerged landscapes can help to inform. The Arch-Manche ranking system drew further attention to the potential of Hurst Spit for understanding coastal change with the Medieval Hurst Castle sited on the spit scoring a maximum of '100', and core samples from the spit scoring '88'.

Inspection of the seabed west of Hurt Spit has revealed a further area of relict landscape. This has become exposed as the spit moved across it to the east. A sample of peat from the prehistoric land surface collected at *c.* 4 m below OD was dated to 2290–2140 cal BC (Beta-366542). What is of particular note is that the seabed dips at a gentle angle offshore, showing how the spit has been pushed upslope in recent decades. Today Hurst Spit sits at the top of the slope, on what was the crest of the hill that bordered the western Solent valley. The evidence shows how there is an increased risk that the spit can be pushed back and damaged as the resistance provided by the underlying morphology has now diminished.

The formation of the Solent is very recent in geological terms, and our research has shown that the process is not yet complete. At Bouldnor Cliff, we have monitored erosion rates underwater. These are varied and can be up to 0.5 m per year, and many of the exposed submerged trees have been eaten by marine boring organisms. These organic surfaces are robust in comparison to the fine-grained sediment deposits that overlay them, but they can still degrade in a matter of years. This is unfortunate as the sites are rich in archaeology, as well as containing material that can provide a better understanding of coastal evolution. The mud flats and salt marsh that protect the mouth of the Keyhaven and Lymington rivers along the north-west of the Solent are another case in point. With reference to charts and aerial photography, it can be seen how the mud flats have receded. They are now less than a quarter of the size they were when Murdoch MacKenzie first recorded them accurately in 1781. Underwater, beneath the mud flats and at the seaward extremity, we have found a large shelf of peat inlaid with trees. The base of the peat is located at a depth of -4 m OD and is dated to 4470–4240 cal BC (Beta-166477). The drowned land surface is eroding in the same pattern as we witnessed at Bouldnor Cliff. Monitoring surveys have demonstrated that deposits do not have to be exposed for long before they are lost. Accordingly, it demonstrates this area of the seabed has been stable and protected for over 6000 years.

Applying archaeological and palaeoenvironmental knowledge to inform management responses to future change

The specific cause of saltmarsh regression is currently little understood, and a combination of factors including wave action, lack of sediment supply, the effect of hard sea defences, dieback of vegetation, tidal currents and sea level rise have all been considered (NFDC 2014). Whatever the cause, the palaeoenvironmental evidence tells us for certain that the erosion is a product of relatively modern processes. Being informed about these long-term processes can help coastal managers make the right decisions about future management, particularly when there is ongoing consideration of the cost benefits.

Figure 4.4. Hurst Spit, Hampshire, UK, is breached in the winter of 2015. It was quickly reconstructed. Studies of the submerged landscape to the west of the spit have shown how this defensive spit is under increasing threat (Photo: G. Momber, MAT).

These considerations also need to be applied to the coastal heritage. The western Solent hosts Hurst Castle, which is located on the end of the Hurst Spit, and Yarmouth Castle, which sits next to Yarmouth Harbour on the Isle of Wight. Both are Henrician fortifications and are scheduled under the Ancient Monuments and Archaeological Areas Act 1979, and both are threatened by the sea, as it undermines the foreshore and eats away at the foundations. These are designated sites and efforts are made to protect them, but other less obvious structures that do not enjoy statutory recognition are destined to disappear with little or no attention. The post-medieval hard and jetties at Pitts Deep, to the east of Lymington, are examples of important heritage that warrant further attention. The harbour was plotted on Elizabethan Charts during an audit of landing sites in preparation for Spanish invasions in the 16th century and was recorded by Rowlandson as a watercolour when he travelled the region in the 18th century. Today the site is eroding quickly and with each storm, another large section is lost (Fig. 4.5).

Figure 4.5. The old jetties at Pitts Deep, on the Solent, UK that were recorded in the 16th century are now degrading rapidly. Elements of timber structure are now clearly visible (left image) while storms in 2015 exposed new areas of wattle as the protective jetty infill deposits are being dispersed (right) (Photo: G. Momber, MAT).

The western Solent: artistic depictions

Within the western Solent area, the application of the Arch-Manche ranking criteria to historic photographs, maps, charts and historic paintings further illustrated the high potential of this area for analysis of coastal change. A photograph of 'Hurst Castle and Lighthouse' was one of only four images to achieve a score of '100' within the case study area. Within the maps and charts category, the 'Hurst Spit to the Isle of Wight' depiction from 1934 was the highest scoring example with a total map score of '88.6'.

Analysis of these results, alongside the archaeological and palaeoenvironmental ranking within the GIS, provides quantifiable evidence of the importance of this area for the study of the impacts of changing sea level on the coast. The western Solent combines a very rich and diverse archaeological resource, with a valuable archive of artistic material within accessible archives; there is also a long history of the study of the geology and geomorphology of the area. These resources and history of study mean there are a wealth of datasets and reference material within repositories that are available for analysis and reinterpretation to aid coastal management.

Next steps

The application of the different tools within the Arch-Manche project has proven to be very informative at identifying high potential sites and deposits for monitoring past change. These tools now need to be used by coastal managers to better understand the relative responses along different sections of the coastline to sea level rise, erosion and the consequence of human actions. This will provide a baseline from which to interpret patterns of future change in light of the sea level rise and increased storminess to come. It will provide wisdom of hindsight as decision makers see the consequences of past actions.

The threats to coastal heritage should also be addressed. This first needs to be recognised by heritage managers and then procedures should be developed to record the diminishing archive. Methods could be developed to record sites on a regular basis with both digital and traditional methods. These tasks need not be expensive or too onerous if the coastal community is engaged to help with 'incidental monitoring' as they walk the beaches, and a citizen science approach can be employed to capture data, while GIS technologies can store and process the data. However, there will be a need for support infrastructure to coordinate the information that is gathered from the eyes on the waterfront.

Conclusion

The impact of rising sea levels and a receding shoreline is of great concern for settlements near the sea. This is increasingly the case as the populations of coastal cities swell and the climate changes. Studies of long-term climate change have shown how the impact on the coastline can lag behind a rise in global temperatures by centuries and the consequences can last thousands of years (Clark *et al.* 2016). It would appear that the period of grace for modern societies has now passed as the climate is warming rapidly and further rises in sea level are inevitable. This will have an increasingly negative impact on the coastline, on the people that live there and the archaeological heritage.

This paper has shown how we can use and apply archaeological and palaeoenvironmental evidence, maps, charts, photographs and art to assist coastal managers in understanding the rate and scale of past change. It has demonstrated how we can look to the past to understand future trends and identify areas that will be under greatest threat in the years to come. Going forward, we can exploit recent technological innovation to enable high resolution aerial monitoring employing techniques such as drone survey, the modelling and visualisation of key indicators and software analysis on a much finer scale than has previously been possible. All of this can be interpreted effectively with accessible web-based GIS.

Coastal and heritage managers would benefit greatly from an understanding of the unforeseen vulnerabilities that can result from the cumulative effects of processes that have been ongoing for centuries or millennia. If we have the foresight to collect and use this information before it is lost, it could help decipher past patterns of change, identify sites under greatest threat and prioritise informed responses.

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References

Allen, M. J. and Gardiner, J. 2000. *Our Changing Coast: A survey of the intertidal archaeology of Langstone Harbour, Hampshire*. York, Council for British Archaeology Research Report 124.

Alley, R. B. 2000. The Younger Dryas cold interval as viewed from Central Greenland. *Quaternary Science Reviews* 19, 213–26.

Alley, R. B., Marotzke, J., Nordhaus, W. D., Overpeck, J. T., Peteet, D. M., Pielke, R. A., Pierrehumbert, R. T., Rhines, P. B., Stocker, T. F., Talley, L. D. and Wallace, J. M. 2003. Abrupt climate change. *Science* 299, 2005–10.

Alley, R. B and Clark, P. U. 1999. The deglaciation of the northern hemisphere: A global perspective. *Annual Reviews of Earth and Planetary Sciences* 27, 149–82.

Brampton, A. H., Evans, C. D. R. and Velegrakis, A. F. 1998. *Seabed Sediment Mobility Studies West of the Isle of Wight*. CIRIA Project Report 65. Kent, Multiplex Medway.

Brooks, A. J., Bradley, S. L., Edwards, R. J. and Goodwayn, N. 2011. The palaeogeography of Northwest Europe during the last 20,000 years. *Journal of Maps* 7(1), 573–87.

Clark, P. U., Shakun, J. D., Marcott, S. A., Mix, A. C., Eby, M., Kulp, S., Levermann, A., Milne, G. A., Pfister, P. L., Santer, B. D., Schrag, D. P., Solomon, S., Stocker, T. F., Strauss, B. H., Weaver, A. J., Winkelmann, R., Archer, D., Bard, E., Goldner, A., Lambeck, K., Pierrehumbert, R. T. and Plattner, G.-K. 2016. Consequences of twenty-first-century policy for multi-millennial climate and sea-level change. *Nature Climate Change*, 360–69. DOI: 10.1038.

Coles, B. J. 1998. Doggerland: A speculative survey. *Proceedings of the Prehistoric Society* 64, 45–82.

Crutzen, P. J. 2002. Geology of Mankind. *Nature* 415, 23.

Daire, M.-Y. and Langouët, L. 2011. Dater les anciennes pêcheries par les niveaux marins: approche méthodologique et perspectives géoarchéologiques: le Bas Léon, nord Finistère, Bretagne. *Norois* 220/3, 69–93.

DEFRA (Department for Environment, Food and Rural Affairs). 2009. *Adapting to Climate Change. UK Climate Projections (2009)*. London, DEFRA. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69257/pb13274-uk-climate-projections-090617.pdf.

Evangelinos, D., Missiaen, T. and Tidbury, L. 2014. Acoustic Mapping of Langstone Harbour. Unpublished Research Report, University of Ghent.

Flemming, N. 2004. The prehistory of the North Sea floor in the context of Continental Shelf archaeology from the Mediterranean to the Nova Zemlya. In N. C. Flemming (ed.), *Submarine Prehistoric Archaeology of the North Sea*, 11–20. York, Council for British Archaeology Research Report 141.

Gaffney, V., Fitch, S. and Smith, D. 2009. *Europe's Lost World: The Rediscovery of Doggerland*. York, Council for British Archaeology Research Report 160.

Gaffney, V., Thompson, K. and Fitch, S. (eds). 2007. *Mapping Doggerland: The Mesolithic Landscapes of the Southern North Sea*. Oxford, British Archaeological Reports.

Hamilton, C. 2016. The Anthropocene as rupture. *The Anthropocene Review* 3(2), 93–106.

Jongepier, I., Soens, T., Temmerman, S. and Missiaen, T. 2014. Assessing the planimetric accuracy of historical maps (sixteenth to nineteenth centuries): New methods and potential for coastal landscape reconstruction. *The Cartographic Journal*. http://www.maneyonline.com/doi/full/10.1179/1743277414Y.0000000095.

Lovelock, J. 2014. *A Rough Ride to the Future*. London, Penguin.

McInnes, R. G. 2008. *Art as a Tool in Support of the Understanding of Coastal Change in Hampshire and the Isle of Wight. The Crown Estate-Caird Fellowship 2008*. London, The Crown Estate.

Maritime Archaeology Trust. 2014. *Coastal Management: Guide for Using Archaeology, Palaeoenvironments, History and Art*. Southampton, Maritime Archaeology Trust.

Melia, S. 2002. *Hallsands: A Village Betrayed*. Liverton, Forest Publishing.

Momber, G. 2014. Submerged archaeology and cultural responses to climatic amelioration. In A. Evans, J. Flatman and N. C. Flemming (eds), *Prehistoric Archaeology of the Continental Shelf: A Global Review*, 194–212. London, Springer.

Momber, G., Tomalin, D., Scaife, R., Satchell, J and Gillespie, J. 2011. *Mesolithic Occupation at Bouldnor Cliff and the Submerged Prehistoric Landscapes of the Solent*. London, Council for British Archaeology Research Report 164.

NFDC (New Forest District Council). 2014. Saltmarsh Erosion. New Forest District Council website: http://www.newforest.gov.uk/index.cfm?articleid=7182 [accessed 11 August 2016].

NOAA (National Oceanic and Atmospheric Administration). 2016. Global Analysis–June 2016. Available at: https://www.ncdc.noaa.gov/sotc/global/201606 [accessed 11 August 2016].

Peeters, J. H. M. and Momber, G. 2014. The southern North Sea and the human occupation of northwest Europe after the Last Glacial Maximum. *Netherlands Journal of Geosciences* 93, 55–70.

Satchell, J. and Tidbury, L. (eds). 2014. Arch-Manche: Archaeology, Art and Coastal Heritage – Tools to Support Coastal Management and Climate Change Planning across the Channel-Regional Sea: Technical Report. Unpublished Research Report. http://archmanche.hwtma.org.uk/uploads/images/Documents/Arch_Manche_Technical_Report.pdf.

Sturt, F., Garrow, D. and Bradley, S. 2013. New models of North West European Holocene palaeogeography and inundation. *Journal of Archaeological Science* 40(11), 3963–76.

Thoen, H. 1978. *De Belgische kustvlakte in de Romeinse tijd. Bijdrage tot de studie van de landelijke bewoningsgeschiedenis*. Brussel, Paleis der Academiën.

Tomalin, D. J, Loader, R. and Scaife, R. G. 2012. *Coastal Archaeology in a Dynamic Setting: A Solent Case Study*. Oxford, British Archaeological Report British Series 568.

Van de Noort, R. 2013. *Climate Change Archaeology: Building Resilience from Research in the World's Coastal Wetlands*. Oxford, Oxford University Press.

Vos, P. C. and Van Heeringen, R. M. 1997. Holocene geology and occupation history of the province of Zeeland (SW Netherlands). In M. M. Fischer (ed.), *Holocene Evolution of Zeeland (SW Netherlands)*, 3–109. Haarlem, Netherlands Institute of Applied Geoscience TNO.

Chapter 5

Community recording and monitoring of vulnerable sites in England

Eliott Wragg, Nathalie Cohen, Gustav Milne, Stephanie Ostrich and Courtney Nimura

Abstract

Significant archaeological sites along England's sinuous coast and on the foreshores of tidal estuaries are continually eroded by winds, waves and tidal scour. Alarmed by the rate of loss, the location of many of these sites has been noted during the national 'Rapid Coastal Zone Assessment Survey' programme initiated by English Heritage (now Historic England) and also by archaeological groups around the country. But until recently there had been no national standardised system in place to record these vulnerable sites in detail or to regularly monitor their fate over the longer term. *CITiZAN: the **C**oastal and **I**nter**Ti**dal **Z**one **A**rchaeological **N**etwork* provides a systematic national response to natural and anthropogenic forces threatening coastal and intertidal archaeology in England. The project employs similar methodologies to the recording and monitoring of fragile intertidal archaeology as its sister project, the *Thames Discovery Programme,* which has for the last decade monitored the archaeology of the Greater London Thames foreshore.

Both projects employ a system of community-based training and outreach programmes, creating an infrastructure to support a network of volunteers with the skills and systems in place to enable them to monitor and survey the highly significant but threatened archaeological sites around England's coast and foreshores. This paper looks at the evolution of the methodologies employed by these projects, both archaeological and educational, as well as the implementation of standardised recording and monitoring using crowd-sourced data, and presents key findings from this 'citizen science' programme. Coastal erosion can rarely be halted, but the hope of TDP and CITiZAN is to involve the public in such a way that will help ensure archaeological sites can be recorded before they are destroyed.

Intertidal archaeology in England: the evolution of a discipline

If archaeology is a relatively modern practice, then intertidal archaeology is a veritable babe in arms. While antiquarians had long seen the Thames as a source of artefacts, it was Sir Mortimer Wheeler (1928) who first identified archaeological features on the Thames foreshore at Brentford in the late 1920s. The first attempt to systematically record the intertidal archaeology of London was undertaken by Ivor Noel Hume in the 1940s and 50s, conducting walkover surveys and plotting the location of finds and features, his discoveries being published in *Treasure in the Thames* (Noel Hume 1956). In the 1970s and 80s, the Wandsworth Historical Society and the West London Archaeology Group recorded prehistoric deposits in Putney and Barn Elms (Anon. 1971). Further afield, in the Humber Estuary Ted and Will Wright discovered the Ferriby boats from the 1930s to 60s (Wright 1976); in 1970, the Graveney boat was recovered from the Kent mudflats (Fenwick 1978); while valuable work by John Allen, Derek Upton and Martin Bell amongst others at places such as Goldcliff and Redwick led to the formation of the Severn Estuary Levels Research Committee (SELRC) in 1985 (Bell 1991).

It was in the 1990s that the archaeology of the Thames foreshore began to receive the first sustained attention since the days of Noel Hume. In 1993, Institute of Archaeology student Richard Hill (1996) recorded prehistoric peats containing lithics and faunal remains along with post-medieval ship timbers at Chambers Wharf, Bermondsey, while Gustav Milne and Jon Cotton surveyed the remains of a Bronze Age jetty or bridge at Vauxhall (Milne *et al.* 1997; Milne 2002). These discoveries led to the formation of the Thames Archaeological Survey (TAS) by the London Archaeological Research Facility at University College London and the Museum of London. An initial pilot study followed by a more comprehensive survey was undertaken between 1996 and 1999, funded by English Heritage and the Environment Agency. Riparian boroughs in Greater London were divided into 'zones' each with its own site code, which were subject to initial walkover surveys and, where appropriate, subsequent, more detailed recording of individual features. Each feature or deposit was allocated an 'alpha' (identification) number and located on large scale Ordnance Survey maps; more than 2500 such features and deposits were recorded, including Anglo-Saxon fish traps, an Iron Age causeway, post-medieval nautical remains, barge beds, gridirons (frames for supporting a ship in dock), river stairs and causeways. Notable finds included a Neolithic beater or club from Chelsea (Webber with Ganiaris 2004), prehistoric human remains and a Roman intaglio (Fig. 5.1).

A remarkable range of sites and features recorded in the English coastal zone had been identified by the end of the 20th century (Fulford *et al.* 1997), and work by individuals was being undertaken at some of these locations around the country, such as at Langstone Harbour (Allen and Gardiner 2001). By the close of the decade, English Heritage (now Historic England) had commissioned the Rapid Coastal Zone Assessment Surveys (RCZAS; Murphy 2014, xi–xv), which began a systematic cataloguing of the fragile archaeology of the English coast.

In the new millennium, intertidal archaeology has grown exponentially. Organisations such as the Nautical Archaeology Society (www.nauticalarchaeologysociety.org), the Hampshire and Wight Trust for Maritime Archaeology (now the Maritime Archaeology Trust; www.maritimearchaeologytrust.org), and the Maritime Archaeology Sea Trust (www.thisismast.org), as well as independent researchers have worked at sites along the English coast such as Forton Lake (Beattie-Edwards and Satchell 2011) and Bamburgh Castle, and the RCZAS have continued to attempt to quantify the coastal archaeological resource.

Figure 5.1. Roman intaglio discovered on the Southwark foreshore (Photo: © Museum of London).

The success of the TAS led to the creation of the Thames Discovery Programme (TDP; www.thamesdiscovery.org) which received a Heritage Lottery Fund grant in 2008 and was managed by the Thames Estuary Partnership and the Thames Explorer Trust until 2011, since when the project has been hosted by Museum of London Archaeology (MOLA; www.mola.org.uk). Following the methodology of the TAS, the project aims to communicate an understanding and informed enjoyment of the historic waterway to the widest possible audience, whilst also preserving by record the fast eroding archaeology of the River Thames.

Subsequent to the TDP, the three-year Coastal and Intertidal Zone Archaeological Network (CITiZAN) project (2015–17; citizan.org.uk) was set up by MOLA with a grant from the Heritage Lottery Fund, match-funding from the Crown Estate and the National Trust, together with support from Historic England and project partners the Council for British Archaeology (CBA; new.archaeologyuk.org) and the Nautical Archaeology Society (NAS). The initiative owes much to the work of the Scotland's Coastal Heritage at Risk Project (SCHARP) in Scotland (www.scharp.co.uk; Dawson 2015), Arfordir in Wales (www.ggat.org.uk/arfodir), and the TDP and SELRC in England (www.selrc.org.uk). The focus is upon coastal archaeology, those aspects of the national heritage that are (broadly) unique to this dynamic zone, such as coastal industries, coastal defences, wrecked and abandoned ships, boats and barges and palaeolandscapes exposed between the high and low water marks. Sites and features recorded during the pioneering RCZAS form the invaluable data set that underpins the CITiZAN programme. This varied suite of heritage assets is threatened by continuing coastal erosion and tidal scour, natural processes that are both the agents of discovery and agents of destruction. As a consequence, the fate of the majority of these sites currently lies outside the remit of the National Planning Framework, which sets out the UK's Government planning policies and how these are expected to be applied.

The Thames Discovery Programme: community archaeology on London's Foreshore

Twice daily, the low tide of the Thames in the Greater London Area exposes two parallel archaeological sites of extraordinary richness and complexity, divided by the waters of the present-day river yet united by the common themes which emerge across its span. Structures, find scatters and deposits date from the Late Mesolithic to the present day, including prehistoric land surfaces and structures; Anglo-Saxon fish traps and emerging structures as yet unidentified; Medieval jetties and river defences; post-medieval consolidation of the foreshore and barge beds, ship building slipways and structures associated with ship breaking, river stairs, causeways, jetties, river defences and docks (see summaries in Cohen *et al.* 2012; Cohen 2012; Cohen and Wragg 2013). Some of these structures and deposits incorporate masonry, timber and domestic refuse from what would appear to be terrestrial origins, whilst others comprise re-used ship and barge timbers along with exotic types of stone not native to London – presumably brought in as ballast and subsequently used to help consolidate the foreshore.

As it was until recent times the greatest port in the world, London's foreshore at low tide would have been a hive of activity – explaining the myriad finds and structures of archaeological significance – whilst its importance as a source of food, as a trading and communication artery, and thus a place of settlement in prehistory is signified by the plethora of finds and structures so far found dating to this period (*e.g.* Sidell *et al.* 2002). It would seem that for millennia, with some significant exceptions at focal points for transhipment, the Thames foreshore in London has undergone a regime of deposition, be it natural peat formation and alluvial sedimentation or anthropogenic action. In recent years, paradoxically, as the volume of shipping in the river has atrophied, the topographical regime of the foreshore has broadly changed to one of erosion. This can be explained by the foreshore no longer being a workplace, so there is no need for anyone to maintain consolidation; by fewer vessels on the river travelling much faster and thus creating more wash; and by an increased flow of the river itself, caused both by sea level rise and increased rainfall causing more water to flow downstream.

The Thames foreshore today, therefore, is a highly dynamic environment, primarily, but not exclusively, one of erosion. The river is not controlled by archaeologists and it does not erode stratigraphically; one can find that numerous features and deposits of differing type and date may be revealed simultaneously. This then is the challenge for the TDP – not only to try to record features and deposits as they emerge and are soon washed away, but to attempt to identify, synthesise and interpret them.

The TDP, with only a very small staff, could not possibly hope to deal with such a range of archaeological features and deposits, or with the rapidity of their exposure and subsequent disappearance without the stalwart and vital work carried out by their volunteers. To date, almost 600 members of the community have undertaken TDP training, which now comprises a 4-day course including lectures, guided walks and fieldwork sessions. Once trained, the volunteers become members of the Foreshore Recording and Observation Group (FROG) and can form their own smaller groups to take 'ownership' of specific sites along the river. They regularly monitor these, noting the condition and presence or absence of previously known features and deposits and identifying and recording the position of those newly emerged. As a result of this monitoring work, the TDP can arrange centrally run fieldwork weeks to record the newly emergent archaeology in more detail before it is eroded or washed away. The volunteers have also undertaken substantial documentary, cartographic and pictorial research into various sites and themes.

When TDP was in its infancy it soon became apparent that members of the public with no archaeological experience, whilst extremely enthusiastic and very willing to learn, were lacking in confidence without supervision. The monitoring system, therefore, was designed to be, and to feel, as user-friendly and simple as possible. Plans for each zone were drawn up showing the locations of each feature or deposit identified by their identification (alpha) number, while site monitoring packs with a short description and photograph of each feature or deposit were provided. *Pro forma* monitoring sheets were created which on the first page asked a series of basic questions within a table:

1. Predicted height of low tide?
2. Is the feature visible? Yes/No
3. Is it more or less visible? More/Less
4. Has the feature moved? Yes/No
5. Photograph number?
6. Sketch number?

The decision was taken to refer to the visibility of a feature or deposit, rather than its presence or absence, as they may have been covered up by deposition, the tide may not have been low enough, or indeed they may have eroded away. Regarding features, 'more or less visible' was employed to indicate how high they stand out from the foreshore surface, not how big the feature was. For example, a feature could have lost some of its elements due to erosion, but the remainder may have been more exposed. Although there would be less of the feature extant, this would be considered 'more visible'. For deposits, visibility was defined by their extent. For features, 'less visible' therefore indicated deposition in that area of the foreshore, while 'more visible' indicated erosion. For deposits the same conclusion could not be drawn; they may have been 'more visible' due to erosion of overlying deposits or 'less visible' because they themselves were eroding or deposition was encroaching upon them. The reverse of the monitoring sheet comprised an area for free text (comments about specific features encouraged) but had a number of prompts:

1. Has the access changed?
2. Are there any new health and safety issues?

3. Was the tide low enough?
4. Is there erosion or deposition across the zone?
5. Are new features present?
6. Are there any immediate recording priorities?
7. Are the baselines still present?
8. Other comments by alpha number.

The emphasis was placed upon taking photographs of each feature and deposit on every visit, thus creating a pictorial record which could stand alone to document a site regardless of written records.

The system has proved broadly successful with each group depositing the results of each monitoring visit into a 'cloud' (in most cases Dropbox), although, given the sheer number and frequency of features and deposits on the Thames foreshore in London, the amount of paperwork required has at times proved unwieldy on site. This issue is being resolved by the new system developed by SCHARP and adopted for England by CITiZAN, described below. The second challenge – that of understanding the features where several phases or features themselves are revealed simultaneously – can be very difficult to resolve given the general lack of secure context stratigraphy. At the most intensively used sites such as the Tower of London or Old Royal Naval College, Greenwich foreshores (Fig. 5.2), the methodology has been to make yearly plans of the site thus capturing all emerging (and subsequently disappearing) elements, then to amalgamate them all into a master plan and tease out obvious alignments. At the Tower, for example, as the more obvious features were removed from the master plan, hitherto unnoticed alignments revealed themselves – in this case the 17th century consolidation revetments had been obscuring possible medieval river stair bases (Wragg 2015).

Overall the TDP has proved an extremely successful project, the volunteers of the FROG making a major and unique contribution to our understanding of London's past.

CITiZAN: evolving methodologies from the Thames to the sea

CITiZAN evolved out of this successful TDP model, flowing down the tidal Thames out to monitor and record England's coastal and intertidal heritage, from mean low water to 100 m inland from mean high water (Milne 2015a; 2015b). The project not only traces its roots to the community fieldwork and training model of the TDP but also to the innovative interactive digital data collection methodologies

Figure 5.2. FROG monitoring visit to Greenwich (Photo: © Thames Discovery Programme).

of SCHARP (Chapter 3, this volume). With a study area some 8000 km long, the scope of the project encompasses the whole of human occupation of England's coast from palaeolandscapes to 20th century military defences. This large study area also covers a variety of landscapes and dynamic environments, from the more stable rock coastlines of Cornwall to the friable clay cliffs of Suffolk sliding glacier-like into the sea, which all present different potential natural risks to England's heritage.

The project relies on mobilised and motivated groups of volunteers to carry out data collection and research on fragile coastal and intertidal heritage. This is a project focussed on education, providing training to groups already armed with local knowledge to help them to identify, monitor and preserve by record heritage at risk from threats such as erosion, scour or slippage. Just as important however CITiZAN focuses on raising the profile of coastal and intertidal archaeology and increasing awareness of the threats posed to it through an extensive outreach programme, such as guided walks, talks and social events.

CITiZANs – the volunteers – belong to local communities. There are many who were previously interested in archaeology or history before becoming involved in the project, including those already affiliated with other heritage groups or societies. However there are also volunteers with no previous involvement in archaeology who are now active in the project, including those who enjoy being on the coast, enjoy volunteering generally, those who want to learn new skills and those who want to take part in the social aspects of the project (for more information on CITIZAN demographic data, see Gill 2016). In order to manage the expectations of a varied audience and also to meet the research aims of the project, CITiZAN provides several levels of involvement which result in high quality crowd-sourced data collection, research and dissemination and a positive experience for our volunteers, regardless of the time commitment.

Volunteers who would like to be more involved can attend a two-day training course, based on the TDP model outlined above, learning more detailed fieldwork techniques, including measuring and planning, recording using standardised *pro forma* recording sheets (Fig. 5.3), locating features using off-set planning and handheld GPS and taking archaeologically-useful photographs. CITiZANs also learn how to be safe when working on the coastal zone, learning to read tide tables and be aware of risks on site. This is first carried out in a controlled environment not harried by short tide windows or inclement weather on day one, and on day two through practical application on site, recording archaeological features on a number of key training sites across England. These site-trained volunteers learn the skills they need to be self-sufficient and confident in the field, working in groups to monitor local coastal and intertidal archaeology with the support of the national CITiZAN team and network. All attendees receive a training pack containing guidance for future reference (also available to download from the project website), a skills passport confirming the methodologies learned during the course and a continued personal development certificate; all training is compatible with equivalent Archaeological Practice NVQ level 3 requirements (a work-based qualification in England, Wales and Northern Ireland; see http://www.archaeologists.net/learning/nvq).

Figure 5.3. CITiZANs using the timber hulk recording forms (Photo: © CITIZAN).

The training programme is based around key subject themes, designed to focus on four of the unique attributes of coastal archaeology (1–4) and a further two over-arching environmental themes (5–6):

1. Abandoned vessels and vessel fragments remains of boats, barges and ship (Fig. 5.4)
2. Coastal military defence features, *e.g.* forts, observation posts, anti-landing devices
3. Coastal industries, *e.g.* salterns, fish traps, wharves, ferries, flood defences, piers
4. Palaeolandscapes, *e.g.* submerged forests, prehistoric peats, footprints
5. Coastal morphological change, *e.g.* evidence for erosion or deposition past and present
6. Relative sea/river level change, *e.g.* evidence for changes in tidal range or height.

Participation in the project can be a large time commitment for volunteers, not only for the two-day training session but also for the implied future commitment of joining a local monitoring group after having attended a session. However, coastal users or heritage enthusiasts who do not wish to commit to full site training can still participate in the citizen science aspect of the project. CITiZAN has launched a digital recording system using a web-based interactive coastal map and complimentary smartphone app, based on the system in use by SCHARP to monitor heritage at risk in Scotland. Any member of the public, from dog walkers and beachcombers to fully

Figure 5.4. Hulk recording using CITiZAN app, Hooe Lake, Plymouth (Photo: © CITIZAN).

site-trained CITiZAN volunteers, can become an online CITiZAN surveyor and use the map or app to create core feature records and contribute to long-term monitoring of change by submitting survey updates.

Like the TDP, CITiZAN records data on the visibility of archaeology at the feature level, collecting information about archaeology as it is exposed in the intertidal zone. There are two main types of data captured. The first is core feature data, including location, description and period of use. Each feature has one core data record, which can be edited by CITiZAN surveyors. The second is survey update data which captures information about each monitoring visit to a feature or deposit. This includes information on the date of survey, state of the tide, any change observed due to erosion, accretion or other damage and images of the feature and surrounding environment. Each core feature record can have multiple related survey updates. Over time, this will become a vital resource to demonstrate change to not only the archaeological feature but also its surrounding environment, quantifiably and also visually through the photographic record.

CITiZAN surveyors can submit as many or as few core feature records or survey updates as they prefer. Before a CITiZAN surveyor heads out, they can prepare survey update forms for known features or deposits in the area of foreshore or coast they are visiting; these can be downloaded and saved directly in the CITiZAN app and can be accessed on a smartphone even when offline as mobile data coverage on the coast can be unreliable. For those surveyors who do not have a smartphone, these survey update forms can be downloaded from the web-browser-based interactive map and printed as hard copies. Survey information can be noted on these hard copy forms and uploaded via the interactive map when the surveyor next has access to a computer. This tool opens up opportunities for monitoring coastal heritage change to a wide audience.

In this way, data are provided directly from the CITiZAN volunteer to a centralised database and after moderation by project staff from there fed back into the wider heritage sector through deposition with the Archaeology Data Service (a national archaeological archive repository) and other appropriate repositories such as the Historic Environment

Records (HER) that are run by the local county councils. This dataset is supplemented by the more in-depth records created by site-trained volunteers monitoring local key sites across the country. CITiZAN volunteers are picking up where the RCZAS left off and crucially filling the void foretold by Murphy (2014) of long-term monitoring and actively contributing to the creation and dissemination of knowledge of at-risk coastal and intertidal heritage of England.

The future: towards sustainable community archaeology?

Both TDP and CITiZAN have been created with generous grants from the Heritage Lottery Fund. What however happens when the tap is turned off? How does the vital and ongoing work of committed volunteers continue to be organised, results assimilated, quality control assured, and wider dissemination take place?

In the case of the TDP, the project has been adopted by MOLA who generously underwrite the project – a valued contribution to the intertidal archaeology of the Thames and a magnificent commitment to community archaeology in London. TDP staff, in conjunction with the fundraising team at MOLA, has also worked to find other revenue strands. Sadly, there is now a charge for the four-day training programme, but at £100 (£50 unwaged) per course (75 year olds and over excepted), with all subsequent fieldwork and monitoring free of cost, it is hoped that the project can continue to engage with most of the community. Guided public walks of London's foreshore have provided significant income, while the project staff has also undertaken developer-led commercial intertidal work. Grant funding has also been energetically pursued: the City Bridge Trust currently fund a staff post for three years; Tideway, the body constructing the new Thames 'super sewer' are also funding a post for two years; while a one-year staff position was funded by the Council for British Archaeology. Other bodies have generously supported the project, though needless to say, fundraising work is a continuing priority. Current revenue strands, incredibly helpful though they are, do not remotely cover the full cost of the project and it is only to be hoped that other organisations may be as benevolent, appreciative and supportive of the vital work of volunteers in recording and monitoring foreshore archaeology.

The current Heritage Lottery Fund grant award to CITiZAN and match funding from the Crown Estate and National Trust supports the project to the end of 2017, but the survey and monitoring work requires a much longer-term commitment. Clearly a higher public profile would improve fund-raising initiatives, and current efforts should substantially raise the profile of the project, and therefore underpin a more effective fundraising programme, contributing towards its sustainability.

Taking a wider view, CITiZAN is actively seeking commitments from the English university sector for greater direct involvement in coastal archaeology, not least to provide long-term support for aspects of research, fieldwork and monitoring projects as well as in community outreach events and workshops. In addition, two other sustainability initiatives are being progressed. One concerns Managed Realignment Projects: for all future projects concerning major 'managed realignment' works on the coast, a condition should be written into the initial brief that there should not just be a pre-coastal heritage assets survey, but also a regular five-year post-works monitoring survey. This is because any major physical change in the topography of the coast can profoundly affect erosion and scour patterns over a wider area. Both stages of survey work – before and after the realignment – should involve or engage with appropriately trained community teams where appropriate. The second initiative concerns the compilation of 'Best Practice Guidelines' designed for coastal property owners. Since there are no protective measures regarding erosion-threatened coastal archaeology within the National Planning Framework, there is a need for a 'voluntary code of conduct' for the major agencies and institutions that own property on the coast. This could suggest that:

- Coastal property owners should be encouraged to sign up to a positive strategy for consideration of their coastal heritage assets at risk of harm or destruction caused by natural agencies.
- Coastal property owners should be encouraged to compile and maintain a listing of such features (or have demonstrable access to the relevant HER or RCZAS data or similar recent record). The level of detail should be proportionate to the assets' importance and no more than is sufficient to understand the potential impacts of development proposals or threats from natural agencies on their significance. It could take the form of a desk-based assessment and, where necessary, a field evaluation.
- Given the dynamic nature of the coastal environment, such Coastal Heritage Asset Assessments should be updated at least once every three to five years.

Conclusion

It is clear that England's coastal and intertidal zones are home to an incredible palimpsest of archaeologically significant features and deposits, ranging from prehistoric landscapes to WWII defences. This extraordinarily rich resource is being rapidly exposed and subsequently lost due to sea level rise, increased river flows, vessel wash and natural geological changes – some caused by and some exacerbated by climate change. No government agency has the funding to sustainably curate these important cultural resources. The only way, therefore, that such archaeology can be recorded and preserved by record is by engaging with local communities and encouraging them to take long-term 'ownership' of their local heritage. This then is at the heart of the TDP/CITiZAN model – empowering communities to undertake longitudinal engagement with their archaeology, supported by a small number of professional archaeologists based at MOLA, the NAS and the CBA readily available to advise and assist where asked.

The digital technology developed for Scotland by SCHARP, subsequently adapted by CITiZAN for the English coasts, represents a quantum leap in capacity from the paper-based system developed by TDP. Henceforward anybody, be they dog walker, bird watcher, holidaymaker, fisher or poacher can, at the tap of a button on a mobile phone, contribute to this vital work. Simultaneously, this technology will make easier the work of those more dedicated volunteers such as CITiZAN surveyors and TDP FROGs. The future of coastal and intertidal archaeology in England, therefore, is archaeology *by* the community *for* the community, supported by small project staffs. As a recent UK government liked to insist in other contexts and as widely quoted in the media – '*We're all in this together'* and '*There is no alternative*'.

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References

Allen, M. and Gardiner, J. 2001. *Our Changing Coast: A Survey of the Intertidal Archaeology of Langstone Harbour, Hampshire*. York, Council for British Archaeology Research Report 124.

Anon. 1971. Wandsworth mud larking. *London Archaeologist* 1(11), 248.

Beattie-Edwards, M. and Satchell, J. 2011. *The Hulks of Forton Lake Gosport: The Forton Lake Archaeology Project 2006–2009*. Oxford, BAR British Series 536.

Bell, M. 1991. Introduction. In *Severn Estuary Levels Research Committee Annual Report 1990*, 1–4. Lampeter, Severn Estuary Levels Research Committee.

Cohen, N. 2012. Fieldwork on the Foreshore. *London Archaeologist* 13(3), 66–69.

Cohen, N., Milne, G. and Wragg, E. 2012. The Thames Discovery Programme: Public engagement and research on London's foreshore. *Archaeology International* 15, 79–86.

Cohen, N. and Wragg, E. 2013. Post-medieval archaeological remains recorded on the River Thames foreshore in Greater London: Interim results of investigations into burial and ships' timbers. *Post-Medieval Archaeology* 47(2), 378–87.

Dawson, T. 2015. Taking the middle path to the coast: How community collaboration can help save threatened sites. In D. Harvey and J. Perry (eds), *The Future of Heritage as Climates Change: Loss, Adaptation and Creativity*, 248–69. Oxford, Routledge.

Fenwick, V. 1978. *The Graveney Boat*. Oxford, National Maritime Museum Archaeological Series 3.

Fulford, M., Champion, T. and Long, A. (eds). 1997. *England's Coastal Heritage: A Survey for English Heritage and the RCHME*. Swindon, English Heritage.

Gill, E. 2016. CITiZAN: Interim Evaluation Report 2015. Unpublished Report. London, Museum of London Archaeology.

Hill, R. 1996. Archaeological Potential of a Riverine Intertidal Zone: A Case Study from Bermondsey. Unpublished BA dissertation, UCL Institute of Archaeology.

Milne, G. 2002. The Vauxhall Bronze Age piled structure. In J. Sidell, J. Cotton, L. Rayner and L. Wheeler (eds), *The Prehistory and Topography of Southwark and Lambeth*, 29–30. London, Museum of London Archaeology Service Monograph 14.

Milne, G. 2015a. The changing River Thames: Some thoughts from an archaeological perspective. *London Journal* 40(3), 211–17.

Milne, G. 2015b. CITiZAN: Turning the tide. *British Archaeology* 144, 50–55.

Milne, G., Bates, M. and Webber, M. 1997. Problems, potential and partial solutions: An archaeological study of the tidal Thames. *World Archaeology* 29(1), 130–46.

Murphy, P. 2014. *England's Coastal Heritage: A Review of Progress since 1997.* Swindon, English Heritage.

Noel Hume, I. 1956. *Treasure in the Thames*. London, Muller.

Sidell, J., Cotton, J., Rayner, L. and Wheeler, L. (eds). 2002. *The Prehistory and Topography of Southwark and Lambeth*. London, Museum of London Archaeology Service Monograph 14.

Webber, M. with Ganiaris, H. 2004. The Chelsea Club: A Neolithic wooden artefact from the River Thames. In J. Cotton and D. Field (eds), *Towards a New Stone Age: Aspects of the Neolithic in South-east England,* 124–27. York, Council for British Archaeology Research Report 137.

Wheeler, M. 1928. An inventory of historical monuments in London. In M. Wheeler, *Roman London*. London, Royal Commission for Historic Monuments.

Wragg, E. 2015. Tower of London: An Archaeological Foreshore Assessment Report. Unpublished report. London, Museum of London Archaeology 13.

Wright, E. 1976. *The North Ferriby Boats*. Greenwich, National Maritime Museum Monograph 23.

Chapter 6

Challenged by an archaeologically educated public in Wales

Claudine Gerrard

Abstract

Climate change is not a new concept to archaeologists. In Wales, extensive work has been carried out to assess the threat to archaeology posed by climate change – the pan-Wales coastal archaeological surveys carried out by the Welsh Archaeological Trusts is one example of such work. A need to respond to this threat has been identified for some time, and a collaborative approach has been sought. The success of *Archwilio* (Wales's online Historic Environment Record) and the community focussed coastal archaeology recording programme Arfordir has created a public that is increasingly aware of the archaeology on its coastline. The expectation raised by Arfordir (and *Archwilio*) has engendered increased pressure from the public to see a quick response to a disappearing archaeological resource. The lack of an agreed mechanism to deal with these issues is a challenge. Failure to meet expectations poses a serious risk of alienating a currently supportive public as well as resulting in the loss of irreplaceable heritage.

Problems of how work should progress at sites threatened by natural processes, and questions on who should lead such work, are leading to inertia in some quarters, while other organisations, including the National Trust, are facing unrealistic pressures.

Coastal erosion in Wales: an active threat

For millennia, the coast has been a favoured location for human habitation, due to its abundance of food sources; the ease of maritime transport for migration and trade along the coast between Britain, Ireland and the continent; and its strategic position as the first line of defence.

Extreme weather is becoming more common across the UK and one of the results of this is an increase in the rate and severity of coastal erosion. The Welsh Government has identified climate change as one of the biggest threats facing society; importantly it recognised that it can have a direct impact on the historic environment (Murphy and Ings 2013). Much of the physical evidence of past activity on the coast now lies buried and forgotten, but coastal erosion is increasingly exposing remains that tell new stories about the past.

Wales is unique in Britain, as it has a continuous coastal path. Many people in Wales go to the coast to play, relax and connect with the cultural and natural environment. Days at the seaside or walks along coastal cliffs are deeply ingrained in collective memory; the coast is an integral and cherished part of Welsh identity. Although the Wales Coast Path is a great resource, it needs constant maintenance and within six months of opening, a 5.9-mile-long section of the path in Ceredigion was lost following a landslide (BBC News 2014). This is merely one dramatic example of the destruction that is occurring across the Welsh coastline.

Heritage management in Wales

In Wales, heritage management is administered by a number of key bodies. Cadw is the Welsh Government's historic environment service, and amongst other roles, it offers funding to aid in this delivery. The Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW) is the national archive for the Welsh historic environment and also investigates the cultural heritage of Wales. There are also four regional Welsh Archaeological Trusts, which are educational charities with a varied remit including heritage management and maintaining the regional Historic Environment Records (HERs). These records, of over 200,000 archaeological sites in Wales, have recently been made available on a publicly accessible and searchable database *Archwilio* (http://www.cofiadurcahcymru.org.uk/arch/) and through an interactive mobile app.

The National Trust

Working alongside these government bodies is the National Trust – a conservation charity in England, Wales and Northern Ireland and the largest membership organisation in the UK. It is also a major landowner, with an extensive estate comprising both landscapes and individual sites of significance for both natural and cultural heritage. The Trust owns land for the purpose of conservation and works to conserve individual sites and landscapes in its care for the benefit of the public. Its ownership crosses regional and national borders within England, Wales and Northern Ireland.

At the centre of the organisation is an overarching administration for which the regions of the National Trust work. Whilst there is an element of practicality to this regional administration, the Trust operates within a framework of both UK-wide and devolved legislation. Because of this, one needs to consider the impact that this legislation and guidance has on the work of the Trust and its ability to deliver a cohesive strategy for the historic environment and the specific assets in its care.

One of the biggest challenges the National Trust faces for historic environment conservation, and specifically for the recording and investigation of archaeological sites, is the difficulty in being able to target its resources on a single issue. The National Trust has broad conservation aims, and sometimes it can appear that the protection of archaeological assets is overshadowed by larger aspects of the Trust's work, such as nature conservation or visitor access. This broad church of conservation provides a strong foundation for the Trust; however, in order to be able to work on issues such as the destruction of archaeological sites by the sea, it is essential for the Trust to work in partnership with organisations like Cadw, the RCHAMW and the Welsh Archaeological Trusts.

The National Trust as a landowner

The National Trust's landholdings include 775 miles of coast around England, Wales and Northern Ireland. In Wales, just over 25% of the Welsh coastline is in National Trust ownership, and this is home to a large number of archaeological sites.

The Welsh Government's view of climate change as a major threat to society, which will impact on the historic environment, is shared by the National Trust. Sea level rise and an increasing frequency in extreme weather is causing rapid change at the coast, vividly demonstrating the shape of things to come.

As a major landowner and conservation body, the National Trust is often on the front line of change affecting the natural and historic environment and is recognised as a leader in developing thinking around coastal change management in relation to climate change and rising sea levels. This recognition, combined with the Trust's profile as a conservation charity and landowner (and in some cases landlord) can result in an expectation amongst the Trust's partners and within local communities that the National Trust will lead on all aspects of the impact of climate change on the coast (and elsewhere).

Reflecting the importance of coastal and marine issues in the work of the National Trust, a Coast and Marine Issues Group (CMIG) within the Trust brings together a multi-disciplinary team of staff (including archaeologists) to consider key issues affecting the Trust's coastal properties and marine sites. The CMIG takes a multi-disciplinary approach to planning ahead, providing a forum that capitalises on the existing strengths of the Trust and the way that it currently looks after its coastal properties. This group also works to secure funding for the Trust's conservation activities on the coast.

Historically, the National Trust has been successful at promoting its cause and engaging its members and volunteers. Over the past 50 years, the Neptune Coastline Campaign – a project that aims to acquire and care for stretches of coastline – has raised over £65 million (National Trust 2015b, 3). This has enabled the Trust to secure special places on the coast for everyone to enjoy. Hundreds of thousands of people have donated to the Trust's coastal appeals or supported the Trust's work that helps ensure that future generations can enjoy this beautiful, dramatic and diverse landscape. The first site acquired, bought in 1965, thanks to the Neptune Coastline Campaign was Whiteford Burrows on the Gower peninsula in South Wales. The Trust's most recent coastal acquisition was the Great Orme, North Wales, in 2015.

To celebrate the 50th anniversary of the Neptune Campaign, the Trust launched the next phase of its coastal vision and its 2015 Coast Campaign. The key to securing people's support is to ask them directly. Clear messages make the Trust's campaigns successful – in order to engage the public with a cause, it is necessary to tell them tell them what you want to do, how you want to do it, why it is important, and how much it will cost. Sharing a simple statistic as a question, such as, 'Did you know it costs £3000 a year to look after 1 mile of the Welsh coast?' can have a big impact.

The National Trust and coastal change

Internally the Trust has set out a clear vision for the coast for the next 50 years, and climate change is at its heart (Dyke 2014, 1). The National Trust's coastal policy largely mirrors those of Shoreline Management Plans – management documents that provide recommendations for coastal areas based on an assessment of threat – and will, it is hoped, be in line with the forthcoming Welsh Government adaptation plan for climate change and the historic environment.

It is important that the Trust's approach to the coast is based upon a clear set of coastal management principles. These principles can be summarised as favouring adaptive responses to coastal change management and working with natural processes.

The National Trust has stated its coastal management principles as (Dyke 2011, 1–2):

1. The Trust accepts that the coast is dynamic and changing and will work with the natural processes of coastal erosion and accretion wherever possible.
2. The Trust will take a long-term view and will adopt or support flexible management solutions which can enable, or adapt to, the processes of coastal change.
3. The Trust will plan in the context of projected sea level rise and will favour coastal realignment wherever this can reasonably be accommodated.
4. The Trust will only support interference with natural coastal processes where it believes there is an overriding benefit to society in social, economic or environmental terms. This will usually be 'buying some time' in order for a longer-term adaptive solution to be negotiated with other parties.
5. Valued habitats and species of the coastal zone will be conserved and enhanced as far as practicable …
6. Valued cultural features in the coastal zone will be conserved and enhanced as far as practicable, whilst not necessarily seeking to protect them indefinitely. The Trust will ensure such features are properly recorded before they are lost or will consider relocation if that can be justified. The relationship between landscape and seascape and the full meaning of the maritime historic environment will be fundamental to the Trust's management.
7. The Trust will actively promote public access to the coastal zone …
8. Coastal management decisions often impact beyond their immediate location. The Trust will work with other managers, organisations and communities to share experience and knowledge …
9. The Trust will only support development in the coastal zone which has taken proper account of coastal change …
10. The Trust will consider the acquisition of land and property where it is the best option to support these principles …

Perhaps the most relevant of these principles in respect to the historic environment is principle number 6, which states that the National Trust will ensure that 'Valued cultural features in the coastal zone will be conserved and enhanced as far as practicable' and further that the National Trust will 'ensure such features are properly recorded before they are lost'. This is certainly a laudable aim, however, having the means to undertake such a course of action is another matter.

Assessing the resource and the risk

A decade ago the National Trust undertook a comprehensive Coastal Risk Assessment across the UK to investigate how the coastline in its care was likely to change over the next 100 years. Out of this research came the Shifting Shores report (The National Trust/Yr Ymddiriedolaeth Genedlaethol 2005/2007), which held one clear message – as a nation we can no longer build our way out of trouble on the coast. Following this report, the Trust thought that perhaps only 47 coastal archaeological sites or monuments in its care across the entire UK would be affected by climate change within the next 100 years. However, events have shown that this figure needs to be seriously reconsidered. Recent winters have seen a succession of violent storms and extreme tides lead to the levels of erosion and flooding that the Trust thought might happen over the next 5 to 15 years occurring overnight.

A report by Powell *et al.* (2012) for the Historic Environment Group (HEG) examined the potential impact of climate change on the historic environment of Wales (HEG is the heritage advisory group which advises Welsh Ministers and includes members representing stakeholder groups from national and local government, the third sector, owners of heritage assets and heritage funding agencies). The HEG report set out a strategic approach for assessing and addressing the impact of climate change and provided a baseline for the production of a sectoral adaptation plan. This report warns that a huge amount of Welsh heritage could be lost unless steps are taken to adapt to climate impacts; a much larger figure for the potential loss of Welsh coastal historic environment assets was also reached. Somewhat startlingly it indicated that *c.* 12,000 archaeological sites and 5000 listed buildings in Wales alone are vulnerable to flooding, many of which are either near rivers or are situated on the coast at an elevation of less than 1 m above sea level. The UK Met Office has noted that low-lying coastal areas face a significant threat from a predicted rise in sea levels of 0.4 m by 2080 and from an increase in storm surges, which are predicted to be twenty times more frequent by 2100 (Murphy *et al.* 2010). It is evident that whilst not all 12,000 of these archaeological sites will be in the care of the National Trust, the 2005 UK-wide figure of 47 threatened sites is likely to be a serious underestimation. Many Welsh historic towns are partially within this zone, so the potential for damage and loss of individual buildings, together with the overall historic character, is considerable. Foreshore areas and cliff edges are at risk from accelerating rates of erosion making all historic assets in these areas vulnerable, ranging from landscapes such as historically drained coastal farmland to discrete sites such as cliff-top promontories and lime kilns.

Responses to change: defend, hold the line, managed retreat

Traditional responses to coastal erosion have seen an approach of resisting change through the construction of hard defences, often in the form of rock or concrete barriers, or holding the line by maintaining existing defences. Experience has shown, however, the damaging and often unexpected knock-on effects that costly hard engineering can have elsewhere on the coast, either by disrupting and reducing sediment supply, or by deflecting energy onto adjacent sections of the coast where it can exacerbate erosion. Furthermore, hard defences constructed to allow preservation in situ are often inappropriate for heritage sites. Increasingly, 'defence' as the only response looks unsustainable and implausible (The National Trust/Yr Ymddiriedolaeth Genedlaethol 2005/2007, 6).

Instead it is imperative to adapt, taking a longer view. The Welsh coastline in the care of the National Trust is very varied, ranging from sand dunes and saltmarshes to villages and harbours. The management of these diverse landscapes calls for a variety of approaches appropriate to specific areas and conditions.

There will be places where the Trust continues to hold the line and maintain sea defences, but it is clear that it should make use of these structures to buy time to develop more long-term and sustainable approaches to managing the future coastline based on adaptation. By recreating a naturally functioning shoreline, it is possible to be free from the 'sea defence cycle' of construct, fail and reconstruct (The National Trust 2015a, 5). This must surely be more cost-effective in the long run and more desirable in terms of maintaining the coast's natural beauty.

Where managed retreat is the preferred option in the face of coastal change, action is necessary to mitigate this loss. Active coastal management work resulting from the *Shifting Shores* report includes archaeological investigation and recording prior to the loss of historic assets (preservation by record). Beyond the needs of specific heritage sites, and addressing other aspects of the National Trust's broad conservation remit, other strategies include: the creation of compensatory habitats to provide a home for nature prior to the loss of existing habitats elsewhere; the replacement of hard engineered coastal footpaths to ensure adaptation and repair is manageable in the future; and the writing of agreed plans for coastal change at individual properties, which state what will or will not happen in a given location.

Arfordir: a short-term solution for an ongoing problem

Given the scale of the challenge represented by climate change, partnerships working to address its impact on heritage are vital, and the National Trust is already working with communities and organisations to adapt to change. One example of a response to the loss of Wales' coastal heritage to climate change and coastal processes is the Arfordir project, of which the National Trust was a supporter. Arfordir ('coastline' in Welsh) was a Welsh archaeology project that was developed based on the SCAPE Trust's Shorewatch initiative in Scotland (Graham 2011, 5). It was initiated and funded by Cadw, and run at a regional level by three of the four Welsh Archaeological Trusts. The purpose of the project was to work with the local community to gather good records of coastal archaeological sites, especially those under threat of loss, and to respond to those threats at specific sites where possible. The project recognised that the coastline is a dynamic environment that is subject to constant change through the actions of erosion, land-use and climate change. This can in turn reveal and conceal sites of archaeological interest, but can also damage and even destroy them. The involvement of the local community who use the coast every day was therefore central to the regular monitoring of the coastline and the condition of coastal sites.

Arfordir was based on the premise that the people who best know the coast are the ones who are there most often; it was explicit in its view that local residents and regular visitors would be better able to spot changes than someone who visits infrequently. The project aimed to recruit local volunteers and bring them together to record and monitor the coastal heritage of their area. Volunteers received training and support from professional archaeologists, who acted as mentors (Bowden 2013, 5). After receiving training in site identification and recording, volunteers were provided with recording forms and equipment, including tapes, ranging poles, a GPS and a camera, and were asked to record the coastal archaeology emerging on 'their' coast. Completed forms were returned to the regional Arfordir coordinator for incorporation into the Historic Environment Record (HER).

As an example, the Arfordir project in South East Wales focussed on the coastal zone from the Gower Peninsula in the west to the Vale of Glamorgan in the east. This area is under the greatest threat as a result of both natural coastal processes and development pressures, and a large proportion of the land is in the care of the National Trust. In South East Wales, the four-year project was successful in recording sites and actively engaging volunteers – this is exemplified in Table 6.1, which sets out the numbers of volunteers involved in the Arfordir project, the number of newly identified coastal archaeological sites added to the HER, and the number of HER records updated or enhanced.

In addition to the survey and monitoring work undertaken by Arfordir volunteers, specific sites under threat were selected for more detailed follow-up work. During the project's second year, recording, excavation and sampling of an eroding prehistoric trackway on the foreshore of Swansea Bay was undertaken with the local group. In the same year, two hulk-recording training sessions were run in partnership with the Nautical Archaeology Society (NAS) to

Table 6.1. Data extracted from Arfordir project reports (Graham 2011; 2012; Bowden 2013; Huckfield 2014)

Arfordir project year	*Volunteers actively involved*	*New sites added to HER*	*Records enhanced for known HER sites*
2010/11 Year 1	254	125	8
2011/12 Year 2	222	63	8
2012/13 Year 3	125	47	16
2013/14 Year 4	No data	36	No data

survey previously unrecorded wreck sites (Graham 2012). In 2014, the project again partnered with the NAS to carry out a further wreck-recording session of hulks revealed during the storms of that winter (Huckfield 2015), and in the final year of the project, Arfordir partnered with the Gower Landscape Partnership to carry out a geophysical survey of two promontory forts on the coast of the Gower peninsula. Sadly, Cadw's funding for Arfordir came to an end following the fourth year of the project.

In the first two years of the project, there was a strong emphasis on training, face-to-face contact and guided site survey visits with volunteers, both to build a relationship with the group and to develop their confidence and skills to undertake independent fieldwork. Arfordir was successful in creating a cohort of aware volunteers who are passionate about coastal archaeology, evidenced by an increase in reports to the National Trust of change to archaeological sites on the coast. This project also raised expectations in the local community; volunteers have come to expect a timely and proportionate response to their reports. The success of the *Archwilio* website and app has to an extent compounded this by engendering an increased awareness of local heritage sites in the community. The ability to submit information on sites can prompt a public expectation to act on that information.

The National Trust in England

After Arfordir started, the National Trust in England joined with others to support and part-fund CITiZAN: the coastal and intertidal zone archaeological network (Chapter 5, this volume). Mirroring and working with the Scotland's Coastal Heritage at Risk Project (SCHARP, Chapter 3, this volume) in Scotland, and Arfordir in Wales, CITiZAN is a volunteer-based, archaeology-focussed, coastal erosion monitoring project. The fieldwork element of CITiZAN began in 2015 and will continue for three years, and it is envisaged that a handful of the Trust's (English) coastal sites will be the focus of volunteer training. CITiZAN represents a fantastic opportunity for the Trust within England to keep up-to-date with coastal change on its estate, and to allow it to react accordingly. In Wales, however, following the demise of Arfordir, the Trust is now in the challenging position of having an archaeologically educated public with no supported project to feed into.

It is important to distinguish between short-term and long-term monitoring projects. For the National Trust and similar bodies which rely on long-term volunteer support, there is a risk that involvement in short-term projects raises expectations which will lead to volunteer disillusionment if funding for the project ends, even though the volunteers can see that there is more to do. At worst, it may lead to volunteers offering their support to other projects where they feel their contribution will be more valued.

The National Trust in Wales is under increased pressure to fill the gap left by Arfordir. This issue has been created in part by the heritage sector in Wales; volunteers were actively recruited during the Arfordir project and told by heritage professionals that their input was essential in helping the sector record the valuable resource being lost at the coast, yet at the end of the project, the volunteers were left with no real support to continue their work. The same problem may face CITiZAN, funding for which is also time-limited and will come to a close at the end of 2017 (although see the discussion on sustainable public archaeology in Chapter 5). One wonders if at the end of CITiZAN's funding, the situation in England will reflect that which currently exists in Wales, where significant numbers of volunteers are lacking the support to which they had become accustomed. It is important for the National Trust, and the heritage sector more widely, to learn from this situation in Wales and other countries that face similar challenges. This dilemma is one that has been highlighted in various chapters throughout this volume.

The National Trust in Wales: a role in managing loss?

The question now is: how can the National Trust meet the expectations of an archaeologically aware public motivated by Arfordir's call to arms and accustomed to the support of regional project coordinators? The loss of archaeology to coastal processes exacerbated by climate change is an ever-present threat on National Trust properties, but so is the lack of means with which to record those sites.

The following case studies provide examples of threatened sites in the care of the National Trust in Wales (Fig. 6.1). In each case, the example given is of a site that has come to the fore at a time when dedicated support for volunteers monitoring coastal archaeology is no longer available from the Arfordir project. The case studies provide examples of the challenges faced by the National Trust in Wales in meeting the expectations of an archaeologically educated public. The examples are intended to demonstrate that whilst

Figure 6.1. Map of Wales with sites mentioned in the text.

short-term funded projects have their place, the problem of coastal erosion does not go away, and providing a legacy for willing volunteers is critical.

Case studies

Ceibwr Bay, Pembrokeshire

The lime kiln at Ceibwr Bay is gradually falling into the sea (Fig. 6.2), and the site is being monitored through a photographic survey by National Trust rangers supported by the author in her role as the National Trust Archaeologist. The plight of this spectacular lime kiln was brought to National Trust Wales' attention by local residents, who were concerned that this site was disappearing without record. It was decided that regular fixed-point photography, together with annual measured drawing, was a reasonable course of action. Photographing the site from the same fixed points over time allows a comparable record of the kiln to be made. When combined with the annual measured drawings, a record of the structure is being made as it is lost, contributing to its preservation by record. While this photographic record and measured drawing forms a basic record, it is at the limit of the National Trust's resource in this region, as it has many miles of coastline (and other land) to care for across Pembrokeshire. As with all case studies discussed here, the erosion affecting this lime kiln

Figure 6.2. Ceibwr Bay, Pembrokeshire – loss of a lime kiln.

Figure 6.3. Rhossili, Gower – loss of a medieval village.

only came to light following the end of the Arfordir project. Sadly, no surviving Arfordir or other coastal archaeology group exists in this area, and although there had been a number of active groups during the life of the project, these have largely fallen inactive. Were these groups to be resurrected, it might be possible for them to take a lead in creating a far more detailed record of the site, and even excavate the structure.

Rhossili, Gower

Little is known about the medieval village on the dune top at Rhossili (Fig. 6.3), despite having been subjected to a limited excavation in the early 1980s (Davidson *et al.* 1987). Following this, it was included in the list of Scheduled Ancient Monuments (SAM, which provides legal protection to nationally important sites and monuments in the UK) and remained stable until suffering dramatic loss in the winter of 2014. An active Arfordir group had existed in this area prior to 2014, and it was members of this group acting informally who brought the dune collapse and damage to the medieval village to the National Trust's attention. Following their report, the group continued to encourage the National Trust to undertake further archaeological work in this area. To date, National Trust Wales have commissioned a desk-based assessment of existing information alongside geophysical survey and hand augering, which was undertaken with direct volunteer involvement. It is hoped that in the coming years, full excavation and recording of this site will be undertaken prior to its destruction by the natural processes of erosion. However, one challenge for future investigation of the village is that it is legally protected as a SAM, and any investigation will require Scheduled Monument Consent. This requirement means that a case for undertaking any intrusive, or indeed non-intrusive, investigation of a SAM needs to be made carefully, and crucially the funding for any work needs to be in place in advance, and such work will be expensive. In times of financial austerity, funding can be hard to acquire, especially for an organisation like the National Trust which relies on the support of its members for income via membership fees or direct project donations. While bids to bodies like the Heritage Lottery Fund (an organisation in the UK that provides funding to heritage projects and other worthy causes) and to Cadw are possible, the National Trust cannot prepare them if in competition with other National Trust bids that are of a higher priority to the organisation.

Abereiddi, Pembrokeshire

Rapid loss of the coast edge has been evident at Abereiddi since early 2009 when the sea defence was breached by storms (Fig. 6.4). The sea defence at Abereiddi falls within the ownership of the Pembrokeshire Coast National Park, which pursues a policy in this location of managed retreat, and no active intervention where practicable, resulting in the sea defence not being repaired once breached. Although this policy is in line with that of the National Trust, there are a number of historically significant 18th century slate quarry workers' cottages and a buried prehistoric land surface at Abereiddi which had been protected by the sea wall. A former Arfordir group was active here, and it was willing to work with the National Trust and partners at Dyfed Archaeological Trust to record the land surface and cottages. This work has been supplemented by a laser scan survey of the buildings, allowing preservation by record of assets that will eventually be lost.

Cwm Silio, Ceredigion

At Cwm Silio in Ceredigion (Fig. 6.5), someone walking at the coast saw human remains falling out of the coastal cliff on New Year's Day 2015. Although this individual had not been involved in the Arfordir project, his observation and reporting to the National Trust demonstrated the principle behind Arfordir, that regular visitors to the coast are best placed to notice change. A project to exhume, analyse, date and report on these human remains was undertaken by the National Trust in partnership with Dyfed Archaeological

Figure 6.4. Abereiddi, Pembrokeshire – disappearing coast and workers' cottages. Top: the intact sea defence; Bottom: after the sea defence was breached by storms.

Figure 6.5. Cwm Silio, Ceredigion – coastal erosion and exposure of human remains.

Trust. The work was paid for by the National Trust's Neptune fund in order to create a record of the site in the face of imminent loss. In the case of the remains at Cwm Silio it was fortunate that the discovery was made on Trust-owned land at a time when there was both the will to undertake work and funding to carry it out. This may not always be the case for discoveries found outside of the Trust's Estate; even if such finds are made on National Trust land, it is not guaranteed that funding would always be so readily available.

Cwm Ivy, Gower

At Cwm Ivy on Gower (Fig. 6.6), extreme tides in 2014–15 resulted in the breach of a medieval sea wall and the resultant loss of an entire Historic Landscape Character Area (Roberts and Jones 2006; GGAT 2016) from within

Figure 6.6. Cwm Ivy, Gower – coastal realignment and a changing historic environment.

a Registered Historic Landscape, one of the 58 landscapes in Wales identified as of special historic interest (Cadw 2003). The preceding winter, Natural Resources Wales (NRW; the principal body for maintaining, enhancing and using the natural resources of Wales) and the Welsh Government had been in discussion with the National Trust over shared plans to purposely breach the sea wall at Cwm Ivy to allow the area to revert to salt marsh. Cwm Ivy had been identified by NRW as an area where the creation of a salt marsh would compensate for the loss of salt marsh habitat elsewhere within south Wales. However, nature took its own course before any approach was agreed, and the rate at which the landscape changed once the breach occurred was rapid and proved shocking to the local and professional communities alike. A petition from the local community demanded that the National Trust reverse the change and bridge the gap made in the historic sea wall (http://www.ipetitions.com/petition/bridging-the-gap-save-our-seawall-foothpath). Helping the local community to understand the choice not to repair the sea wall and protect the historic landscape was challenging. The National Trust commissioned an archaeological contractor to undertake a programme of recording and investigation of the sea wall and historic landscape, however there was limited opportunity to engage with the local community to share the results of this work. One wonders whether or not the process of change could have been less divisive if an active Arfordir group within the community had facilitated communication. The strong negative public response to the decision to allow the reversion of the landscape to saltmarsh highlights potential future difficulties in working with communities to implement the Trust's policy of coastal realignment and of reinstating a naturally functioning shoreline. The imperative to alter the way coastal assets are managed in the future will demand close communication and partnership working with engaged local communities to ensure change is delivered in as sensitive a way as possible.

Using archaeology to understand current change at the coast

Projects such as Arfordir provide a means by which to begin a conversation with individuals and community groups about change. Engaging with communities and individuals to investigate archaeological remains allow us to discuss climate change today and what impacts that might have on our future coastline. We know that the coast has changed and that many former inland sites are now on the coast. The coastal environment today is different from that of the past, and will be different in the future; there can be no better way of illustrating that point than through the investigation and recording of archaeological remains on the coast.

A future for archaeology threatened by climate change

It is apparent that whilst the National Trust has clear management principles for the care of the coast which make specific mention of the historic environment, resources are limited. In order to ensure that the Trust takes care of special places *for ever, for everyone* it must act pragmatically and accept that not all sites can be protected from the effects of climate change. Where preservation *in situ* is not possible the National Trust is committed, wherever practicable, to record all sites before they are lost. This is good news for coastal archaeology in the care of the National Trust – but what of the remainder of the Welsh coast? Without an agreed approach to the reporting, investigation and recording of archaeological remains, the ability to manage the impact of climate change will be at best patchy and at worst non-existent.

The success of the Welsh online HER *Archwilio* and the Arfordir project has created a public who are increasingly aware of archaeology. The expectations raised by Arfordir have engendered increased pressure from the public to see a quick response to a disappearing resource. The National Trust is a high-profile conservation body, and this has resulted in the expectation that the Trust will fill the gap left by the Arfordir project. While it has been possible, to an extent, to ensure that the coastal archaeology in its care is investigated and recorded, it is not for the Trust to plan for the impacts of climate change on the historic environment for the whole of Wales. The National Trust certainly has a role in helping to develop such a plan, and has contributed to developing a framework (Powell *et al.* 2012), but at present the lack of an agreed mechanism to deal with issues raised by an increasingly aware public is a challenge facing Wales as a whole.

Problems of who should be carrying out work, and how or to what level, are leading to inertia in some quarters, together with unrealistic pressure on organisations such as the National Trust. Although they have an important role, it is the opinion of the author that short-term funded projects are not the solution to the broader problem of climate change and the loss of archaeology, as has been demonstrated by the Arfordir project. It is evident that the public values archaeology and will volunteer to record this finite resource. Those volunteers who were actively engaged by Arfordir are still passionate, however they want to get something back from their experience. Volunteers want their work to be supported and valued by professionals, and do not want to be taught new skills and left to their own devices; they want to be part of a valued team and see that their contribution has an obvious legacy. The expectations of individuals and groups trained to recognise and record archaeology remain unchanged; at the very least they want to preserve by record the archaeology that they care so much about. Failure to meet expectations presents a serious risk of alienating a currently supportive public as well as resulting in the loss of irreplaceable heritage.

Whilst Arfordir's funding has come to an end, the need for such a project remains. There is a pressure on heritage bodies to respond, and this is something that this author has seen many times in a professional capacity. Following the end of Cadw's support for Arfordir, Welsh heritage professionals continue to face a number of challenges in terms of the expectations of volunteers and the wider community. It is hoped that an adaptation plan for climate change and the historic environment in Wales will soon be in place and that such a plan could drive forward support from Cadw and partners in the Welsh historic environment sector to develop a new phase of Arfordir. In the meantime, many archaeological sites remain under threat.

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References

BBC News 2014. Llangrannog to Cwmtydu coastal path repaired after landslide. Available at: http://www.bbc.co.uk/news/uk-wales-south-west-wales-30507033 [accessed 25 Jan 2017].

Bowden, R. 2013. *GGAT 103: Arfordir Coastal Heritage 2012–13*. GGAT Report 2013/022. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Cadw. 2003. Historic Landscapes, Parks and Gardens. Available at: http://cadw.gov.wales/historicenvironment/protection/historiclandscapes/?lang=en [accessed 25 Jan 2017].

Davidson, A., Davidson, J., Owen-John, H. and Toft, L. 1987. Excavations at the Sand Covered Medieval Settlement at Rhossili, West Glamorgan. *Bulletin of the Board of Celtic Studies* 34, 244–69.

Dyke, P. 2011. Coast and Marine Policy Position Statement 2011. Unpublished document. London, National Trust.

Dyke, P. 2014. NT Future Coast Summary. Unpublished document. London, National Trust.

GGAT. 2016. Gower Historic Landscape Characterisation. Available at: http://www.ggat.org.uk/cadw/historic_landscape/gower/english/Gower_005.htm [accessed 25 Jan 2017].

Graham, E. 2011. *GGAT 103: Arfordir Coastal Heritage 2010–11*. GGAT Report 2011/019. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Graham, E. 2012. *GGAT 103: Arfordir Coastal Heritage 2011–12, Including Supplement GGAT116: Emergency Recording and Excavation of Oystermouth Trackway*. GGAT Report 2012/025. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Huckfield, P. 2014. *GGAT 103: Arfordir Coastal Heritage 2013–14*. GGAT Report 2014/024. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Huckfield, P. 2015. *GGAT 103: Arfordir Coastal Heritage 2014–15*. GGAT Report 2015/022. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Murphy, J., Sexton, D., Jenkins, G., Boorman, P., Booth, B., Brown, K., Clark, R., Collins, M., Harris, G. and Kendon, L. 2010. *UK Climate Projections Science Report: Climate Change Projections*. Exeter, UK Meteorological Office Hadley Centre.

Murphy, K. and Ings, M. 2013. Climate Change and the Historic Environment of Wales: A Summary of Potential Impacts. Gloucester, Historic Environment Group Climate Change Subgroup.

The National Trust/Yr Ymddiriedolaeth Genedlaethol. 2005/2007. *Shifting Shores: Living with Changing Coastline/Glannau ansefydlog Byw gydag arfordir sy'n newid*. London/Cardiff, The National Trust/Yr Ymddiriedolaeth Genedlaethol.

National Trust. 2015a. *Shifting Shores: Playing our Part at the Coast (Policy Position Statement)*. London, National Trust.

National Trust. 2015b. *Mapping our Shores: 50 Years of Land Use Change at the Coast*. London, National Trust.

Powell, J., Murphy, K., Ings, M. and Chambers, F. M. 2012. *A Strategic Approach for Assessing and Addressing the Potential Impact of Climate Change on the Historic Environment of Wales*. Report to Historic Environment Group – Climate Change Subgroup. Gloucester, Countryside and Community Research Institute.

Roberts, R. M. and Jones, C. 2006. *Historic Landscape Characterisation: Gower AONB Vols 1 and 2*. GGAT Report No. 2006/052. Swansea, Glamorgan-Gwent Archaeological Trust Ltd.

Chapter 7

The MASC Project (Monitoring the Archaeology of Sligo's Coastline): engaging local stakeholder groups to monitor vulnerable coastal archaeology in Ireland

James Bonsall and Sam Moore

Abstract

Ireland is coming to terms with the almost annual frequency of severe storm events. The National Monuments Service – responding to notifications from members of the public – sends small teams of experts to further investigate storm-related discoveries. Despite the need for a coherent coastal monitoring strategy, funding citizen science schemes is a challenge. Archaeological and environmental staff and students at the Institute of Technology Sligo, acting as local coastal rangers, discovered previously unrecorded archaeological sites on eroding beaches in Co. Sligo during the winter of 2014–15. Our coastal rangers are engaging with local stakeholders who already have a significant presence at vulnerable erosion sites such as Scouting, anti-litter and bird watching groups. Tuition in archaeological recording techniques, including high-resolution photography for later use in photogrammetry, will initiate 'Monitoring the Archaeology of Sligo's Coastline' (MASC), a pilot study for rangers to act as 'first responders' capable of making an informed decision to notify relevant government departments. Coastal hazards and climate predictions suggest an increase in severe cyclones and wave surges in the future which will continue to threaten promontories, intertidal sites, wrecks and monuments located around the Irish coastline. The MASC Project is a citizen science scheme that has been developed to assist archaeological research in the north-west of Ireland by recruiting amateur or non-professional scientists that live, work and use the coastline on a regular basis.

Climatic threat assessment for the coastline of Co. Sligo

On the north-west coastline of Ireland, Co. Sligo is directly under the influence of the North-East Atlantic Ocean. In the prevailing south-westerly wind conditions, waves reach here unimpeded from North America and sea surges are funnelled toward the Sligo coast as waves meet the Porcupine Bank, approximately 200 km to the west. The most severe storms result from hurricanes travelling across the Atlantic from North America (Lozano *et al.* 2004), such as Storm Gertrude, which hit Irish shores on 28–29 January 2016 with recorded gusts of 130 km per hour at Malin Head, Co. Donegal (Met Éireann 2016). Constant improvements to climate prediction modelling indicate an increase in westerly flow at mid-latitudes during winter, extreme storms and precipitation events (*e.g.* Haarsma *et al.* 2013; Nolan *et al.* 2013). Further studies (Wang *et al.* 2008; Olbert and Hartnett 2010) suggest greater numbers of storm surges (more than 30% in some cases) along the west coast of Ireland and a strong seasonal variation of storm activity that indicate increases in winter and spring, and decreases in summer and autumn. Modelling also predicts a greater annual frequency of heavy precipitation events during winter; with increases of up to 20% by 2050 (Sweeney and Fealy 2002; Falaleeva *et al.* 2011; Gleeson *et al.* 2013; Nolan 2015). There are, however, conflicting theories that suggest future storms may decrease in frequency but increase in intensity (Nolan 2015), while others suggest that melting Arctic ice caps would increase the likelihood of cold continental air

Figure 7.1. Discussed coastal sites at risk across Co. Sligo.

outbreaks over Ireland during winter that would actually reduce the possibility of extreme storm events (Semmler 2013). An increase in relative sea levels throughout the 21st century raise the potential susceptibility of low-lying coastal areas to inundation, along with subsequent changes in erosion, deposition and extreme water levels from storm surge events, that will have a significant and lasting impact on the coastal morphology (Fealy and Murphy 2009). Winter mean significant wave height for the Irish Atlantic coast is currently at 5 m, while models predict a decrease of *c.* 0.2 m (for winter mean wave heights from 2031–2060), they also predict more than a 0.2 m increase of mean wave heights specifically for the north-west of Ireland, due to a greater intensity of spring storms (Gallagher *et al.* 2013).

Despite these conflicting predictions, an increase in storm events has recorded extreme wave action in the north-west. In December 2014, the M4 wave monitoring buoy (located 75 km off the Belmullet peninsula, Co. Mayo), registered a 21.5 m wave in a sea state with mean wave heights of approximately 13 m (Sarah Gallagher pers. comm.). These recent data and climate prediction models suggest a general trend of rising sea levels and less frequent but more intense storm activity which lend support to an expectation of increased rates of coastal erosion by 2050.

Sligo's coastal heritage currently under threat

Ireland's National Monuments Service (NMS) records weathering or erosion impacts on archaeology in the Sites and Monuments Record (SMR). These have increased dramatically in recent years, from 7–20 reports per year between 2010–2013 to 90 reports in 2014 (Gleeson 2015). The increase is due in part to the severity of the storms and the increased public awareness and reporting of vulnerable coastal archaeology. Our Co. Sligo study area (Fig. 7.1) contains 3795 archaeological monuments recorded in the SMR. There are 3.9% (n = 147) of archaeological monuments located <20 m from the 195 km long Sligo coastline (of which 132 km is 'soft') and these represent our baseline data of 'vulnerable' monuments threatened by erosion, 87 of which (59%) are located <10 m from the coastline. The MASC Project initiated a monitoring programme in 2015 to assess the condition of these monuments.

In total, 65 sites (44% of those <20 m from the coast) have a direct connection or function related to the intertidal environment (Table 7.1; Fig. 7.2). Of these, 33% are associated with subsistence (middens, burnt mounds of stone and seaweed stands) and 13.6% are defensive sites (multi-period promontory forts, cliff-edge forts and fortifications, medieval sea walls and castles). A further 13.6% are funerary monuments (including Bronze Age wedge tombs and cists, Bronze Age/Iron Age barrows, early Christian *leachta* (stone cairn) and slab-lined burials, as well as post-medieval and 19th century isolated burials or graveyards). The Co. Sligo experience of vulnerable monument types contrasts with the most frequent national losses: burial grounds (and isolated exposed ancient human remains), middens, collapsed masonry remains and previously unrecorded archaeological remains (Gleeson 2015), reflecting both coastal and inland experiences across Ireland.

The majority of coastal monuments are middens (21.1%), followed by seaweed stands (11.5%), enclosures (8.1%) and coastal promontory forts (7.5%). There are also a number of palaeoenvironmental features that have been recorded along the coastline, for example peat shelves or submerged forests exposed by erosional wave action. Whilst these are not recorded in the SMR as archaeological sites, the Underwater Archaeology Unit of the NMS maintains a record of their location.

Table 7.1. Archaeological sites within 20 m of the Co. Sligo coastline that depend upon an intertidal environment

Monument classification	*Number*
Cliff-edge fort	3
Midden	31
Promontory fort – coastal	11
Salt works	2
Sea wall	1
Seaweed stand	17

It is estimated that coastal zone erosion results in a loss of land area of up to 300 ha per year around the Irish coast (Sligo County Council 2011, 150). Increasingly, high energy and frequent storm events impact on heritage sites across Co. Sligo mostly in the form of erosion as well as redeposition. The red brick 19th-century changing huts at Lissadell are currently being undermined by the same erosional activity that is removing prehistoric middens and forts from the coastline (Fig. 7.3). A small number of archaeological sites impacted by climate-induced forces are discussed below for a range of monument types.

Fulacht fia

The stone-lined trough of a Late Bronze Age water heating site, known as a *fulacht fia* (SMR SL008-205), was excavated in August 2014 by the National Museum of Ireland and Institute of Technology Sligo. The site was exposed in the intertidal zone on Coney Island, following storm activity. The excavation and subsequent research (Bonsall and Dowd 2017) mapped the topography of the foreshore and noted the presence of exposed midden material (SMR SL008-204), burnt stones and older beach surfaces within 5–25 m of the stone trough, which were exposed in mid-July 2015 following a monthly high tide, with no storm activity recorded. Despite their proximity to

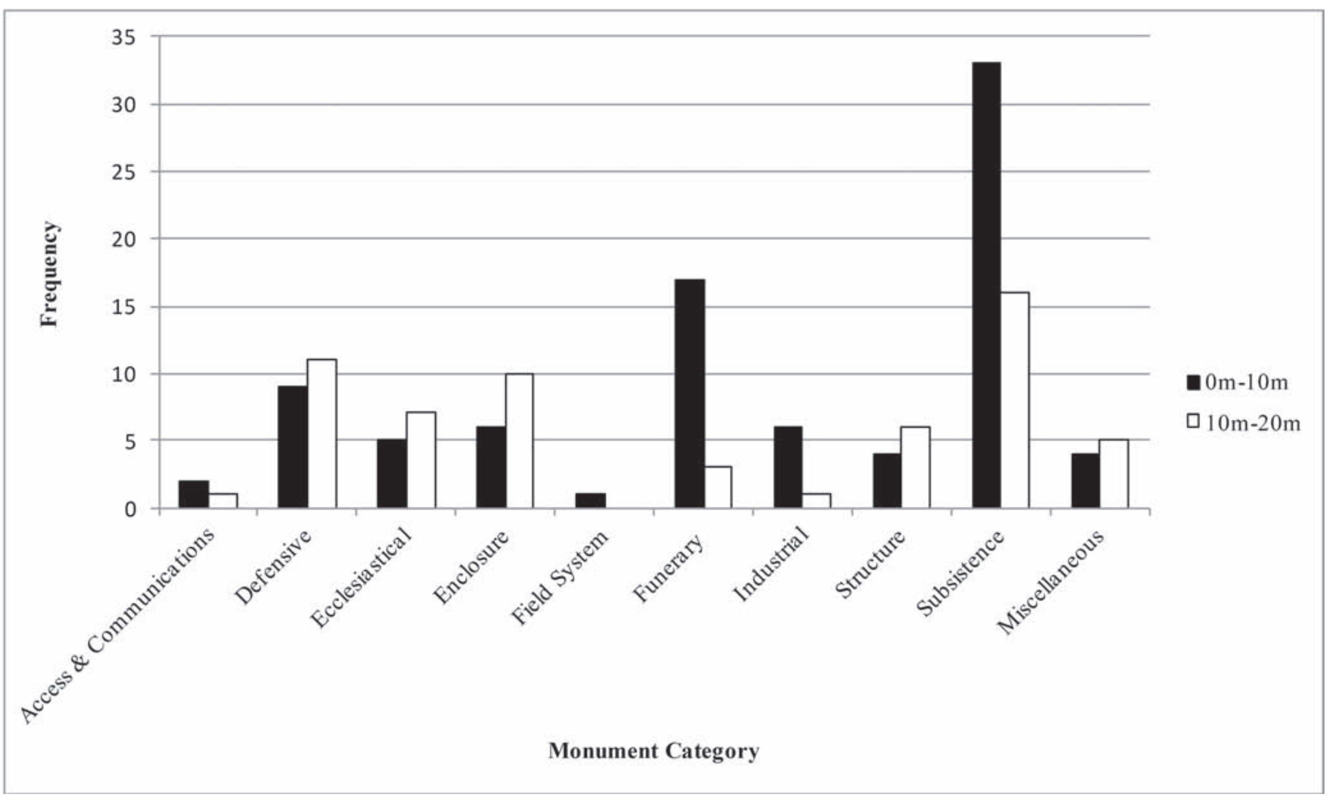

Figure 7.2. Proximity of monument types to the Co. Sligo coastline.

Figure 7.3. The 19th century red-brick beach hut at Lissadell (top) has been substantially damaged by the same tidal forces that erode the prehistoric oyster midden at Culleenamore (base).

Figure 7.4. The Shelly Valley, Carrowdough. A number of substantial and surficial middens are exposed and re-covered on a daily basis by wind blown sands.

the trough, these recently exposed features were covered by tidal sands at the time of the excavation and were not identified. Mapped in detail, archaeologists and citizen scientists witnessed the gradual erosion of the friable midden with each new wave. In the space of 11 months, the dynamic forces at work on the Coney Island coastline had exposed two previously unknown archaeological monuments, and 15 months later had reburied them both to a depth of at least 0.45 m.

Middens

The Shelly Valley, Carrowdough, lies at the base of a large 360 m × 125 m sand dune that was reputedly blown out by a 19th century storm; the dune height is currently recorded by the Ordnance Survey at 39 m (Fig. 7.4). The blowout caused deflation across the valley (which is bounded to the west by the coast and to the east by the large dune); lighter sand particles were blown eastwards into the rapidly accumulating dune leaving behind lag gravels (heavier clasts of sediment and objects) that were not transported by wind energy. In this case, the lag gravels are essentially comprised of a multi-midden complex (SMR SL013-032) as both substantial mounds and laminar surface spreads of exposed cockle, periwinkle, limpet, oyster, mussel, garden snails and white-lipped snails (Napora *et al.* 2016). Every day, the midden complex is covered by windblown sands and subsequently uncovered again, resulting in a valley that changes in appearance diurnally, exposing and re-covering middens and spreads of shells.

Excavations at nearby Culleenamore (SMR SL013-091; see also Fig. 7.3) obtained dates of 3620–3500 cal BC through to AD 800, while the Carrowdough middens (SMR SL013-032) date to 1370–1260 cal BC (Burenhult 1980a; 1980b; 1984; Malmberg 1981; Osterholm 1981; Osterholm and Osterholm 1984). Recent research conducted at the Carrowdough middens employing geoarchaeological and zooarchaeological methods (Napora *et al.* 2016) found that their use also extended to the post-medieval period (1675–1725 cal AD).

Coastal forts

Coastal promontory forts and cliff-edge forts are substantial monuments located across a promontory or cliff-edge to form one or more sides as an enclosing element. Both monument types are defined by one or more banks/walls and/or fosses and tend to enclose other small features such as hut sites. Whilst less friable than discrete midden deposits, the forts are still vulnerable to the impact of high-energy waves. Unlike the middens (which are most frequently identified along the 'soft coastline'), forts tend to occur at locations along the 'hard coastline'. The substantial 70 m × 45 m 'Cahimore' cliff-edge fort at Carrowhubbuck North (SMR SL016-001001), containing four hut sites, is partially eroding out from a west facing cliff-edge on the east side of Killala Bay (Fig. 7.5). Part of a vertical drystone wall (which may form a souterrain SMR SL016-001006),

Figure 7.5. Cahimore Cliff-edge fort at Carrowhubbuck North (SMR SL016-001001). Aerial Photo generously provided by Noel Meehan of Copter View Ireland (www.copterview.ie).

is exposed in the cliff-edge and can be seen 15 m above sea level, demonstrating the substantial erosion that has already occurred. Donaghintraine promontory fort (SMR SL012-011) is also the possible location of Dun-Concreat, a medieval castle belonging to the de Birmingham family (Malcolm 2004). The north-facing promontory measures 20 m × 60 m, is surrounded by the Atlantic to the north, east and west and has been severely eroded and almost destroyed due to storm surges. Aughris cliff-edge fort (SMR SL012-001) faces north-east and has been impacted by severe coastal erosion and human traffic along a coastal path. Ballineden promontory fort at Knocklane (SMR SL007-001001) faces west and is surrounded by the sea on its north, west and south sides. The western end in particular is facing substantial erosion due to storm surges. Comparisons between geo-referenced historic mapping and 2015 aerial photography suggest 25% of the fort has been lost since 1910.

Shipwrecks

Three Spanish Armada galleons – *La Juliana*, *La Lavia* and the *Santa Maria de Visón* – were shipwrecked off the coast of Streedagh, near Grange, in 1588. Over recent years, very large timbers have been discovered by locals on the strand at Streedagh and conserved by the National Museum of Ireland. In September 2014, a 6 m-long rudder was washed ashore, subsequently followed by two more timbers ripped from the wreckage during storm tides (February 2015) and a cannonball (March 2015). A number of disparate sources and unpublished surveys over the last 20 years have failed to address levels of protection and preservation afforded to the Galleons. To mitigate the strong storm tides that continue to threaten the remaining components of the wrecks, the Underwater Archaeological Unit of the NMS carried out a five-week survey and excavation in the summer of 2015, focusing on *La Juliana*, which had been exposed on the seabed following the storms of 2014 and 2015 (Moore *et al.* 2015, 10–15).

Paleoenvironmental sites

Following the removal of vegetation by high-energy erosional storm waves, peat deposits are gradually eroded by both low- and high-energy waves. At Ardtermon, more than 120 m of continuous peat shelves exposed along the coastline were recorded by MASC Project volunteers, as well as small oval shaped 'rugby-ball' sized water-rolled peats. Further *in situ* and exposed peat deposits have been noted within the intertidal zone, more than 100 m from the peat shelves. These demonstrate the presence of a significant drowned landscape that contains important environmental, ecofactual – and potentially archaeological – evidence for the palaeocoastline environment. The Ardtermon peat shelf is adjacent to a localised 'hard engineering' solution – several large storm protection boulders – which diverted high energy waves on to unprotected vegetation and soft sandy deposits overlying the peat shelves.

Beyond archaeology: threats to the tourism economy

Development projects in Sligo are currently restricted between coastal roads and the sea; industrial development is further restricted to resource-based activities that have a clear and demonstrable need (Sligo County Council 2011, 151). The impact of private sector developments, a key driver of archaeological research in Ireland, does not generally occur in the coastal zone in Co. Sligo. Instead, archaeological research in the coastal zone is often reactive to naturally occurring threats, principally destructive erosion waves.

The Sligo County Development Plan explicitly addresses the issues of erosion and heritage, although this is mostly from a tourism perspective. Past aggregate extraction activities from beaches, estuaries and cobble storm berms 'created many problems in the past, resulting in increased levels of erosion and flooding in coastal areas' (Sligo County Council 2011, 48). Further extraction of marine/coastal aggregates, which have the potential to interfere with vulnerable archaeological features located further along the soft coastlines, are assessed for impact upon natural coastal processes. The significant damage caused by coastal erosion in some parts of Co. Sligo motivated policy directions: the protection of infrastructure, the unspoilt beauty of the coastline and an increased interest in heritage is of major importance in ensuring that Sligo's recreational and tourism potential can be fully exploited, which resulted in a need to protect heritage assets and their contexts (Sligo County Council 2011, 53–54). The attraction of tourists to large arenas of natural and built heritage is of increased economic value, but must also be balanced against the potential for damage from pedestrian traffic along coastal paths through fragile and surficial archaeological monuments.

Long-term local studies support the assertion that significant archaeological monuments will be lost due to coastal erosion in the short to medium term. Since 1993 the north-facing severely eroding complex of sites known locally as Staad Abbey, which comprises Agharrow Church (SMR SL005-022001), a souterrain, a cliff-edge exposed midden and a kiln, has been regularly monitored via detailed time-lapse mapping surveys (Beglane and O'Sullivan 2015). The research has suggested that the rapid erosion of the cliff-edge midden is likely to be followed by the loss of the church, currently 3.5 m from the shoreline, within the next generation. Staad Abbey has associations with the Spanish Armada wrecks at nearby Streedagh. As such, it forms part of the Spanish Armada Trail, a significant tourist route for the local area; the predicted loss of Staad Abbey (and associated archaeological features) is expected to also impact on the local tourist industry.

Building networks: engaging citizen scientists to monitor the archaeology of Sligo's coastline

The MASC Project was created as a citizen science scheme to assist archaeological research by recruiting local people who live, work and use the coastline on a regular basis. The principle aim of the MASC Project is to educate and prepare voluntary citizens to recognise, report, record and monitor exposed and threatened cultural heritage sites along the 195 km of coast in Co. Sligo. Based on policy guidelines and recommended outcomes (Kelly and Stack 2009), the MASC Project continues to raise public awareness of natural coastal processes and threats to built heritage. By educating and working with coastal community groups and NGOs in Co. Sligo, the MASC Project has established a system for the identification and recording of sites in vulnerable areas. Public participation in Irish archaeology is very low compared to other European countries, reflecting a robust legislation that requires professional archaeologists to oversee licensed excavations, dive surveys and geophysical surveys, limiting the potential for public participation. 'Public archaeology' in Ireland has, with the exception of fee-charging field schools, been restricted to educational programmes associated with schools or funded (and in some cases, unfunded) research excavations directed by professional archaeologists (Kador and Ruffino 2009; Duffy 2014).

Unlike the UK and other parts of Europe, Ireland has no 'right to roam', meaning members of the public cannot enter private land. For the intertidal zone, members of the public cannot legally access any land beyond the high-water mark. In practical terms, archaeology located in a rapidly eroding cliff-edge can be photographed from the beach, below the high-water mark, but the archaeological site itself cannot be interfered with by a member of the public (*e.g.* finds cannot be removed, excavation is not permitted), nor can a member of public stand on or near the cliff edge, which lies in private land. In fact, only state-employed archaeologists (not those from the private sector or elsewhere) have the 'power-of-entry' to investigate private land.

Despite these regulations concerning roaming and archaeological licensing, Co. Sligo has an impressive history of antiquarianism and amateur archaeological groups, especially since the foundation of the Sligo Field Club in 1946 (Timoney 2002) and the diploma level and degree level courses in archaeology that have been running in the county since 1999. Over half of the coastal archaeological sites reported to the MASC Project in 2015 were from 'archaeologically aware' individuals, predominantly students from the Applied Archaeology degree at IT Sligo who knew how to identify and record archaeological sites. Sligo County Council has a Heritage Officer and a County Sligo Heritage Forum, which recently produced its third County Heritage Plan (County Sligo Heritage Forum 2016). All of these have partnerships and community participation as a key component. Many of the main themes captured in the County Heritage Plan include actions that the MASC Project is actively working towards (raising awareness and promoting the conservation and management of Sligo's heritage; promoting community participation in heritage projects *etc.*). Hence, there is an existing base of 'archaeologically aware' individuals and a concerted effort on behalf of the Local Authority to contribute support towards the aims and ambitions of the MASC Project.

Awareness of the MASC Project and its aims has been raised through local and national media, social media, its website (themascproject.wordpress.com) and word of mouth, but direct contact with stakeholders and coastal communities was a key step in developing our aims. Most coastal communities in Co. Sligo have a local development association, some of which are actively engaged in heritage projects. There are other various groups and societies based along the coast, such as those associated with bird watching, sea-kayaking, surfing, sea-angling, anti-litter groups and Scouting Ireland, all of whom regularly engage with the coast. Furthermore, the MASC Project is a registered organisation with the Sligo Volunteer Centre, part of a national volunteer development agency whose goal is to make sure that anyone who wants to volunteer, can volunteer. With assistance from Sligo County Council Heritage Office, the MASC Project has invited these groups to a series of free workshops that provide instruction on recognising archaeological sites that might be encountered along the coastline; recording these sites, including geo-referencing and understanding the best practice methods for monitoring sites at risk, as well as health and safety and legislative considerations when working in the coastal zone. A series of practical workshops throughout the county at various coastal archaeological sites focuses on photography and standardised recording techniques for non-archaeologists, as well as providing an interactive element to assist with geo-locational data for citizen scientists.

The citizen science experience of discovering an archaeological site

There are 19 coastal Natural Heritage Areas, Special Protection Areas, Special Areas of Conservation, Ramsar Sites and Nature Reserves in Co. Sligo (Sligo County Council 2011, 150), which attract large numbers of people to the area, including ornithologists, whale watchers, anglers, tourists, nature detectives, as well as sports enthusiasts, dog walkers and pedestrians. Sligo markets itself as an outdoor tourist destination and each of these groups have the potential to encounter 'chance' archaeological discoveries along the coast. Sligo's coastal zone tourism policies promote awareness of the sensitivity of the coastal environment among both visitors and residents, through the provision of educational/heritage appreciation programmes, public information boards and other appropriate means (Sligo County Council 2011, 57). The aims of the MASC Project feed directly into this policy. By educating a local and visiting population, we are expanding our citizen science network across (and beyond) Sligo.

Sligo County Council is developing a local forum for five coastal cells along the coastline, involving landowners, local communities and relevant interest groups, to explore and resolve coastal zone management issues specific to each area (Sligo County Council 2011, 151). The MASC Project and citizen scientists can play a key role within each coastal cell to encourage the monitoring and recording of archaeological sites. Our greatest success to date has been the recognition and recording of previously unknown middens by our citizen scientists.

Middens are the most frequent of coastal monuments in Co. Sligo and deserve particular attention. The frequency of shell middens reflects not only the large intertidal environment, but also the derivation of the county name – and before it, the town and castle – of Sligo, which means 'abounding in shells' (Ó Muraíle 2013). There are more middens in Co. Sligo (n = 93) than in any other county in Ireland or Northern Ireland; 25% of the Sligo middens are located within 10 m of the coastline (and a further 8% between 10–20 m). The middens of Co. Sligo are comprised variously of oyster, cockle, limpet, periwinkle, whelk, land snails, charcoal or other burnt deposits and occasional fish or animal bone. In some cases, such as the oyster middens at Culleenamore (SMR SL013-091), they are comprised almost exclusively of one species (Burenhult 1984). These fragile shells are easily eroded by even moderate tidal forces. At the base of the exposed oyster midden section at Culleenamore, the grass-covered soils beyond the high-water mark are littered with eroded and redeposited shells. Despite these variations, middens are easily recognisable when exposed in section along the coastline, due to the presence of often thick layers of bright white shells that contrast strongly with the surrounding sand or soils. As such, these are ideal monument types around which to train citizen scientists that may have no prior archaeological knowledge.

In our experience, a little education can go a long way and has a lasting impact. Shortly after the launch of the MASC Project, we were invited to a Clean Coasts Roadshow – an anti-litter gathering that showcases the work of regional and local Clean Coast sub-groups that regularly remove litter via a rapid beach clean, organised by An Taisce, the National Trust for Ireland. Realising that careful beach cleaners essentially carry out (and regularly repeat) a high-resolution 'walkover survey' to locate and remove coastal litter, we recognised that these same people possessed the skills needed to observe subtle changes along the coastline and that they could be encouraged to recognise, identify and report recently exposed archaeological deposits. The MASC Project now participates in regular Clean Coasts Roadshows, reaching out and educating anti-litter groups about coastal erosion and the potential for archaeological discoveries, with a brief but valuable introduction on 'how to identify a midden'.

Rewarding our citizen scientists: Martina's Midden

High-energy storm waves at Rosses Point in 2015 removed a thick covering of sandy deposits and exposed a large paving of bedrock, at the back of which was located a previously unrecorded and heavily eroded midden. The midden (SMR SL008-203) was recognised as such by an anti-litter group, some of who had attended a MASC Project presentation at a Clean Coasts Roadshow. Once the monument was reported to the MASC Project, we rapidly confirmed that it was a new discovery using our internal database. A site visit was carried out within a few hours which confirmed it as an archaeological feature and the NMS were notified that a previously unrecorded midden had been discovered. The midden was formally recorded by an NMS archaeologist and uploaded to the SMR within 10 days following its discovery by a citizen scientist.

The storm waves that exposed the midden left behind only a thin deposit of oyster shells and an underlying stony subsoil, 32 m inland from the coastline depicted on the 1910 Historic 25-inch Ordnance Survey map. The remaining dense and compact (0.1 m) layer of oyster shells remain exposed and are likely to be removed and redeposited by future erosional waves. For now, a programme of regular monitoring has been established for the remains of the midden, which have also been subjected to detailed (and publicly accessible) photogrammetry and 3-D models by MASC Project volunteers (Davis 2015). The simple photograph – captured by technology available to all – allows us to create a permanent model of fragile and vulnerable archaeological sites that may be lost in the short- to medium-term. The added value of a publicly accessible photogrammetry and modelling archive also allows us to raise awareness within the local community.

The MASC Project builds on our established community networks by giving a sense of 'ownership' of archaeological monuments to those that report a discovery. When formally recorded by the NMS, an archaeological site or monument is given a unique SMR Number, however, via the use of blogs and social media, we offer the discoverer the chance to 'name' their monument. Hence, the midden from Rosses Point, official designation SMR SL008-203, is known amongst the MASC Project citizen scientists as 'Martina's Midden', in honour of the person who reported it to us. By describing the discovery of Martina's Midden as a specific event in a reader friendly blog-entry, we were able to increase local (town and county) awareness about the MASC Project in a rapid and more thorough way than an academic journal. The blog entry (Bonsall 2015) has to date received over 800 views and been shared 249 times across social media (and traditional media) which subsequently attracted many more volunteers to the MASC Project. Archaeologists discover archaeology on a daily basis, but a member of the public rarely gets the chance to discover an entirely unknown archaeological site. The use of blogs and social media to describe these events is key to promoting the aims of the MASC Project and raising awareness of coastal erosion. MASC Project discoveries are normally by-products of another primary activity, be it picking up litter, walking the dog or bird watching. The publicity generated by such chance discoveries allows for a 'buy-in' from local communities which can champion their own local archaeology. Such an approach has already enjoyed particular success for the Irish Heritage Council's 'Adopt a Monument Scheme'. It also allows the MASC Project to 'give something back', to reward those that take the time to report their discoveries whilst engaged in another activity.

The MASC Project has benefited from the enhanced buy-in and reward that we offer to our citizen scientists. We have developed a policy of informing our citizen scientists about 'their' site that essentially works through the following 5 steps of updates and communications:

1. Thank you for your report; we are now investigating it
2. Based on your report/photographs we believe that your discovery may be an archaeological site
3. There are no known archaeological sites in the vicinity of your discovery
4. We have visited your discovery and can confirm that it is a previously unrecorded archaeological site; we are now notifying the state authorities
5. The state archaeologist has visited and verified the site and has included it on the national Sites and Monuments Record.

With this final step (5), we are in a position not only to formally confirm what the site is, but also what type of impact the site has made on our local understanding. For example, in the case of Martina's Midden, we were able to inform the discoverer what a midden is, what periods it might date to, how it would have been used, how many there are within 5 km of that site, how many there are in the county and nationally. We provide images of what such a site would have looked like and what it actually means to us as professional archaeologists. We also offer the citizen scientist the chance to write their own blog entry for the MASC Project website concerning their discovery, how they made it and what it means to them. This is the very essence of our 'buy-in' from the local community – we can give them ownership and a brief but appropriate archaeological education that inevitably leads to them passing on their knowledge to friends and family the next time they walk along the beach: 'You see that midden? I discovered that, let me tell you all about it.' It is an invaluable method of peer-to-peer communication for archaeology among the local community and demonstrates a passion for coastal heritage – and concern for its future – that goes beyond the archaeological profession.

There are challenges for our citizen science experience. The absence of an Irish right-to-roam policy hinders access to many archaeological sites that have been exposed or are under threat. The development of good relationships with landowners can overcome this access issue, which may be made possible through the recruitment of local (land-owning) citizen scientists. A key drawback that we have experienced is an inability to attract funding – the MASC Project is entirely driven by community support and labour and is completely unfunded at present. Twenty-six individuals contributed over 860 hours of voluntary time to the MASC Project in 2015, a huge local investment that has led to real and significant discoveries as well as increased media coverage. However, a lack of funding hinders our ability to host and stage workshops on basic archaeological recording techniques and similarly restricts travel and operating costs to key members of the MASC Project that need to investigate specific discoveries or communicate our findings to professionals and amateurs alike. We continue to overcome these issues by looking for innovative funding methods for low-cost (but high-impact) initiatives.

Conclusion

The loss of archaeological sites to erosion in Ireland is inevitable and unstoppable at both soft and hard coastlines. In Co. Sligo, the MASC Project has made significant inroads to discover and monitor new and previously known archaeological sites in an attempt to maintain an accurate record of coastal archaeology. Our citizen science approach has resulted in the discovery of five monuments that were previously unknown and have added significantly to the sites and monuments record of Co. Sligo in just one year. Our work also attracted attention beyond our study area; we receive reports of site discoveries in neighbouring counties and are frequently approached by members of the public from all parts of the country to consult over their own local archaeology.

We have sought and maintained good avenues of communication both with local community networks and state agencies, to ensure a consistent approach for the mandatory reporting of new archaeological monuments that comply with national legislation. A key area in which we currently suffer is a lack of funding, which restricts our ability to provide workshops and educational material. However, the use of freely available social media, blogs on our website and free open-access software has offset some of these drawbacks and allowed us to communicate directly with a substantial network of volunteers. A vital link for us has been the Clean Coasts anti-litter group, which have a national presence and 51 sub-groups across Co. Sligo, approximately one group per 2.6 km of soft coastline. We share a common agenda with Clean Coasts volunteers that are intimately familiar with their designated coastlines, regularly monitor the same areas and are capable of identifying both small and large 'foreign' or 'anomalous' objects. These participants are an incredible resource of local knowledge for us to interact with and build further networks of citizen scientists. To date, our volunteers account for one person per 5 km of soft Sligo coastline. We need to develop our educational strategy further in the future so that we can coordinate a number of 'key responders' or coastal rangers to rapidly assess discoveries as they are reported.

The lack of funding for our project is mirrored by a general lack of funding for the state archaeologists that have suffered since the economic downturn. In our view, it increases the importance of citizen science projects precisely because of this funding gap. Nationally, the government must find a way to support state archaeologists in their attempts to mitigate the loss and destruction of vulnerable coastal archaeology. Mitigation does not equate to excavation or preservation by record; in most cases, such an outcome is not practical. However, coastal monitoring projects fuelled by local knowledge will assist in the identification of those sites that should be protected or excavated, including those where human remains may be present. The increased resurgence of the post-recession economy has led to larger numbers of development-led projects that are required by legislation (administered by the public sector) to be archaeologically assessed (by the commercial private sector), with enough funding in place to provide for all works including post-excavation, conservation, reporting and archiving. Could a small levy on such projects – from quarries, to infrastructure, to housing and commercial developments – be used to finance rescue and other mitigation works at vulnerable coastal locations? Irish legislation requires detailed (and often lengthy) excavations to accurately record and assess archaeological deposits threatened by developments, yet the state archaeologists are frequently unable to provide the same level of mitigation to sites threatened by natural causes due to funding deficits. An innovative approach is required, one in which citizen scientists across Ireland could play a role.

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References

Beglane, F. and O'Sullivan, J. 2015. A shore chapel at Staad, County Sligo. Conference paper given at the *Weather Beaten Archaeology Conference, 7–8 March 2014, IT Sligo.* Sligo, Ireland.

Bonsall, J. 2015. Martina's Midden: Beach clean results in archaeological discovery by a citizen scientist! *The MASC Project* website: https://themascproject.wordpress.com [published 1 June 2015].

Bonsall, J. and Dowd, M. 2017. Emerging from the waves: A Late Bronze Age intertidal saltwater *fulacht fia* at Coney Island, Co. Sligo. *Journal of Irish Archaeology* XXIV(2015), 79–95.

Burenhult, G. 1980a. *The Archaeology of Carrowmore, Co. Sligo, Ireland. Excavation Seasons 1977–79.* Theses and Papers in North-European Archaeology 9. Stockholm, Institute of Archaeology, University of Stockholm.

Burenhult, G. 1980b. *The Carrowmore Excavation: Excavation season 1980.* Stockholm, Stockholm Archaeological Reports 7.

Burenhult, G. 1984. *The Archaeology of Carrowmore: Environmental Archaeology and the Megalithic Tradition at Carrowmore, Co. Sligo, Ireland.* Theses and Papers in North-European Archaeology 14. Stockholm, Institute of Archaeology, University of Stockholm.

County Sligo Heritage Forum. 2016. *County Sligo Heritage Plan 2016–2020.* Sligo, Sligo County Council.

Davis, C. 2015. Rosses Point Midden. Photogrammetry Model available via Sktechfab. https://sketchfab.com/models/b707c417822c40b987be7713286642b2 [accessed 02 Feb 2016].

Duffy, P. 2014. Grassroots archaeology: An experiment in monument resurrection and suburban identity in North Dublin. *Journal of Community Archaeology and Heritage* 1(3), 193–209.

Falaleeva, M., O'Mahony, C., Gray, S., Desmond, M., Gault, J. and Cummins, V. 2011. Towards climate adaptation and coastal governance in Ireland: Integrated architecture for effective management? *Marine Policy* 35(6), 784–93.

Fealy, R. and Murphy, C. 2009. The likely physical impacts of future climate change on inland waterways and the coastal environment in Ireland. In B. Kelly and M. Stack (eds), *Climate Change, Heritage and Tourism: Implications for Ireland's Coast and Inland Waterways*, 39–54. Kilkenny, The Heritage Council.

Gallagher, S., Tiron, R., and Dias, F. 2013. Predicting the future wave climate of Ireland: 2031–2060. In E. Gleeson, R. McGrath and M. Treanor (eds), *Ireland's Climate: The Road Ahead,* 77–84. Dublin, Met Éireann.

Gleeson, E., McGrath, R. and Treanor, M. (eds) 2013. *Ireland's Climate: The Road Ahead.* Met Éireann, Dublin.

Gleeson, P. 2015. Recent evidence of extreme weather impact on our archaeological heritage. Conference paper given at the *Weather Beaten Archaeology Conference, 7–8 March 2014, IT Sligo.* Sligo, Ireland.

Haarsma, R. J., Hazeleger, W., Severijns, C., de Vries, H., Sterl, A., Bintanja, B., van Oldenborgh, B. J. and van den Brink, H W. 2013. More hurricanes to hit Western Europe due to global warming. *Geophysical Research Letters* 40(9), 1783–1788.

Kador, T. and Ruffino, J. 2009. Doing Archaeology in the Community. *Engage: The Magazine of the Community Knowledge Initiative* 1(May 2009), 4–5.

Kelly, B. and Stack, M. (eds). 2009. *Climate Change, Heritage and Tourism: Implications for Ireland's Coast and Inland Waterways.* Kilkenny, The Heritage Council.

Lozano, I., Devoy, R. J. N., May, W. and Andersen, U. 2004. Storminess and vulnerability along the Atlantic coastlines of Europe: Analysis of storm records and of a greenhouse gases induced climate scenario. *Marine Geology* 210(1–4), 205–25.

Malcolm, J. 2004. Castles and English Lordship in Uí Fhiachrach Muaidhe, *c*. 1235–*c*. 1400. Unpublished MA thesis, National University of Ireland, Galway.

Malmberg, B. 1981. Settlement 15B Culleenamore. In G. Burenhult (ed.), *The Carrowmore Excavation: Excavation Season 1981*, 32–37. Stockholm, Stockholm Archaeological Reports 8.

Met Éireann. 2016. January 2016 weather summary: http://www.met.ie/climate/monthly-weather-reports.asp [accessed 2 Feb 2016].

Moore, F., Brady, K. and Kelleher, C. 2015. Cannons, saints and sunken ships: An Armada wreck revealed. *Archaeology Ireland* 29(4), 10–15.

Napora, K., Bonsall, J. and Rathbone, S. 2016. Geoarchaeology of a Dunefield Shell Midden Site in County Sligo, Ireland. Conference paper given at the *81st Annual Meeting of the Society for American Archaeology, Orlando, Florida, USA, 6–10 April 2016*.

Nolan, P., Gleeson, E. and McGrath, R. 2013. Impact of climate change on surface winds over Ireland. In E Gleeson, R. McGrath and M. Treanor (eds.), *Ireland's Climate: The road ahead*, 71–76. Dublin, Met Éireann.

Nolan, P. 2015. *Ensemble of Regional Climate Model Projections for Ireland (EPA Report no. 159).* Johnstown, Environmental Protection Agency.

Ó Muraíle, N. 2013. Sligeach – The Original and Correct Name of Sligo. In M. A. Timoney (ed.), *Dedicated to Sligo, Thirty-four Essays on Sligo's Past*, 97–102. Keash, Publishing Sligo's Past.

Olbert, A. I. and Hartnett, M. 2010. Storms and surges in Irish coastal waters. *Ocean Modelling* 34(1), 50–62.

Osterholm, S. 1981. Settlement 15A Culleenamore. In G. Burenhult (ed.), *The Carrowmore Excavation: Excavation Season 1981,* 11–31. Stockholm, Stockholm Archaeological Reports 8.

Osterholm, S. and Osterholm I. 1984. The kitchen middens along the coast at Ballysadare Bay. In G. Burenhult (ed.), *The Archaeology of Carrowmore: Environmental Archaeology and the Megalithic Tradition at Carrowmore, Co. Sligo, Ireland,* 326–45. Theses and Papers in North-European Archaeology 14. Stockholm, Institute of Archaeology, University of Stockholm.

Semmler, T. 2013. The impact of vanishing Arctic Sea ice on the climate of Ireland. In E. Gleeson, R. McGrath and M. Treanor (eds), *Ireland's Climate: The Road Ahead*, 85–89. Met Éireann, Dublin.

Sligo County Council. 2011. *Sligo County Development Plan 2011–2017, Volume 1*. Sligo, Sligo County Council.

Sweeney, J. and Fealy, R. 2002. A preliminary investigation of future climate scenarios for Ireland. *Proceedings of the Royal Irish* Academy 102B(3), 121–28.

Timoney, M. A. 2002. Sligo Antiquarian Society, 1945–1946 and Sligo Field Club, 1946–1947, 1954–2002. In M.A. Timoney (ed.), *A Celebration of Sligo: First Essays for Sligo Field Club*, 275–330. Sligo, Field Club Sligo.

Wang, S., McGrath, R., Hanafin, J., Lynch, P., Semmler, T. and Nolan, P. 2008. The impact of climate change on storm surges over Irish waters. *Ocean Modelling* 25(1), 83–94.

Chapter 8

Recovering information from eroding and destroyed coastal archaeological sites: a crowdsourcing initiative in Northwest Iberia

Elías López-Romero, Xosé Ignacio Vilaseco Vázquez, Patricia Mañana-Borrazás and Alejandro Güimil-Fariña

Abstract

The vulnerability of coastal heritage is increasingly coming into focus as thousands of archaeological sites are threatened with destruction around the world – a result of the combined effects of sea level rise, coastal dynamics and human activity. In the north-west of the Iberian Peninsula, the islet of Guidoiro Areoso in Ría de Arousa (Galicia, Spain) is a perfect example of this situation. Several archaeological sites are suffering from rapid erosion and two of them, a Neolithic megalithic chamber and a Bronze Age cist, have recently been destroyed. Local citizens and associations were among the first to warn about the worrying situation facing the islet's natural and cultural heritage. In this context, and as part of a wider project, we recently launched a crowdsourcing initiative with four aims: to recover images and video records of the islet from private archives; to integrate them into a wider monitoring analysis; to engage in a dialogue with local communities; and to regularly provide the communities with information on the advances and results of the project. The initiative has been publicised in a number of ways, including in the media and a variety of social networks, and the public response to requests for information has been a success. In this paper, we summarise the main results we have obtained and discuss how such a small, uninhabited islet can be used as a reference site to bring together researchers, heritage managers and the public in other regions of the globe.

Context and background

A recent paper in the *Journal of Island and Coastal Archaeology* (Fitzpatrick *et al.* 2015) summarised the challenges coastal archaeology is presently facing and pointed out some prospective research and management issues in this field. From a long-term geological, archaeological and historical perspective we are aware that changes and climatic dynamics have always existed, shaping coastal areas and affecting biotopes and human societies. However, from the point of view of present day natural and cultural heritage preservation, research and management, it is necessary to provide responses and create solutions to deal with the various threats prevailing upon this heritage. Medium to long-term predictions prevent us from being optimistic in this matter, as they depict a complex scenario with rising sea levels and an increase of extreme weather events (Stocker *et al.* 2013, 1205).

In Europe, several regions have adopted – at very different times and rates – specific regulations or measures to confront this situation. Local, regional, national or, occasionally, transnational initiatives from different research teams have provided tools to help us to understand, analyse and manage coastal heritage at risk (Ashmore 1994; English Heritage 1997; Welsh Historic Monuments 1999; Daire *et al.* 2012; Dawson 2013; López-Romero *et al.* 2014; Westley and McNeary 2014).

In spite of its varied and rich coastal heritage, these issues have only very recently been raised in some areas of the Iberian Peninsula. Galicia, in North-west Iberia (Fig. 8.1), is the region with the longest coastline in Spain (*c.* 1600 km). It is home to some of the biggest isles and archipelagos in Western Iberia, and is also characterised by the presence of several major estuaries. This region has been the focus of specific research by the authors over the last few years, through the conceptualisation of its coastal heritage as a

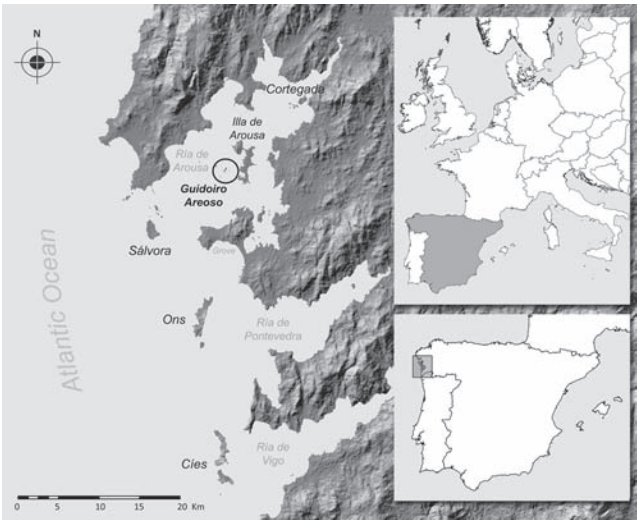

Figure 8.1. Location of Guidoiro Areoso in the context of Western Iberia.

transversal, stand-alone line of research. This has resulted in a substantial increase in our knowledge of its history and vulnerability, both at the qualitative and the quantitative levels (López-Romero *et al.* 2012; Ballesteros-Arias *et al.* 2013; López-Romero *et al.* 2013; Ayán Vila and López-Romero 2014; López-Romero *et al.* 2014).

As is the case in other regions across the globe, there is no specific strategy or regulation for either coastal or intertidal heritage at risk in Galicia. The law that regulates heritage and archaeological activities in Spain is the 16/1985 Heritage Bill (*Ley 16/1985 del Patrimonio Histórico Español*). Since the 1990s, several autonomous regions in the country have adopted their own regulations, using the Heritage Bill as a reference. In Galicia this was the 8/1995 Heritage Bill (*Ley 8/1995 del Patrimonio cultural de Galicia*). In 2016, a new heritage law was approved (*Ley 5/2016 del Patrimonio cultural de Galicia*). This new law makes no explicit mention of palliative measures for cultural heritage at risk – such as urgent archaeological excavation when the risk of destruction is imminent –, something the former law included (Article 58). The situation is therefore similar to heritage regulation issues concerning the coastal and intertidal zone in other European countries (*e.g.* Daire *et al.* 2012, 173).

Galician coastal heritage at risk: Ría de Arousa and Guidoiro Areoso

Galician coastal heritage is rich and varied, but it has traditionally received little attention. Some research projects undertaken during the 1980s and 1990s focussed on several Roman and Iron Age coastal sites, and on Neolithic monuments located on elevated land near the coast. However, the analysis of these occupations was generally conducted using 'inland' theories and methods. As a result, they typically failed to address questions that are essential to our understanding of past and present uses of the coastal zone and the sea, for example the way past societies adapted to changes in a highly dynamic environment (Van de Noort 2013) and the effects these coastal dynamics have on heritage preservation in the present. A good indicator of this situation is that while there was an expansion of studies on palynology and palaeolandscapes in Galicia and the north of Portugal in these decades, only a few of them focussed on the evolution of the coastline and sea level rise (Martínez-Cortizas and Costa-Casáis 1997; Blanco-Chao *et al.* 2002). Only recently has an updated synthesis of these aspects been published (Alonso Millán and Pagés Valcarlos 2010).

This situation overall is quite striking, especially since the acidity of the soil in most northwestern areas of Iberia has prevented the preservation of organic materials. While only a few terrestrial areas and caves in the northeast of Galicia offer favourable taphonomic contexts for preservation, the potential that coastal areas have to provide this type of evidence (resulting from the presence of alkaline sediments) has been largely overlooked. The extreme scarcity of macro-organic remains has often prevented researchers in the region from performing conventional scientific analyses, such as the absolute dating of specific archaeological contexts, the anthropological study of human and animal populations, or the study of non-polynic palaeobotanical records prior to the Iron Age in open-air contexts. The paradox is that these coastal areas occupy a key place in the long-established interpretive models regarding the conception, spread and development of agriculture, pastoralism, monuments and complex societies, not only in Iberia but also across Europe.

Due to present day climatic conditions, the sites most likely to provide this information are at risk. Given this problem, we have been working on different research projects and initiatives that acknowledge the vulnerable situation of this coastal heritage, and have proposed and adapted research solutions and methodologies for its study, dissemination and – where possible – preservation. Special focus has been put on Ría de Arousa, one of the most important estuaries in Galicia, which includes several islands belonging to the Galician Atlantic Islands National Park (*Parque Marítimo-Terrestre de las Islas Atlánticas de Galicia*, created in 2002). A series of dedicated coastal surveys on some of these islands has substantially contributed to our knowledge of their past and recent occupations, and a vulnerability analysis has allowed us to gain a better understanding of the main threats to different types of archaeological sites (Ballesteros-Arias *et al.* 2013; López-Romero *et al.* 2013).

Within this geographical context, the small islet of Guidoiro Areoso (Fig. 8.2) appears as a central feature in the middle of the Arousa estuary. It is not clear when this territory became an island but, following currently available models, it is plausible that this happened after the

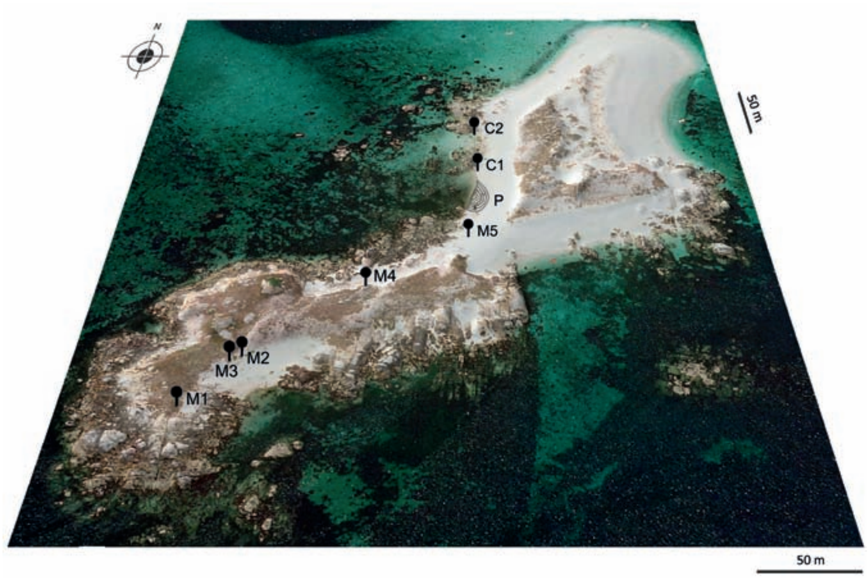

Figure 8.2. Archaeological sites in Guidoiro Areoso.

mid-Holocene (Alonso Millán and Pagés Valcarlos 2010; Rey García and Vilaseco Vázquez 2012).

The islet belongs to the municipality of Illa de Arousa, has a surface of *c.* 8 hectares and is covered by dune sands that are especially active in its northern half. Its highest altitude above sea level is 9 m. Its location and characteristics – low altitude, dune sand sediments – largely contribute to the fragility of its ecosystem and, by extension, of the cultural heritage the islet contains. The emerged land and intertidal sediments are exposed to the winds and tidal regimes, exacerbated in the last few years by the increase in extreme weather events. During the winter 2013–14, an uncommonly intense series of storms (*Dirk, Christina, Nadja, Qumaira, Petra, Ruth, Stephanie, Ulla*) hit the Galician coasts, affecting the Arousa estuary and other areas. Guidoiro Areoso was no exception.

It is primarily due to its cultural heritage that the islet has recently become famous. During the late 1980s, archaeological survey and excavation by J. M. Rey García uncovered three funerary Neolithic megalithic monuments and evidence of Bronze Age occupation. However, coastal erosion in the last 20 years has dramatically increased the number of sites in the island's inventory, with new sites revealed as beaches rapidly lose their sand (more than 70 cm in depth was lost between 2007 and 2013). Two new megalithic monuments, a shell midden, a palaeosoil – containing numerous bones and other organic materials – and two funerary cists have been exposed by the combined action of wave impact, tidal regimes, wind and rainfall. Two of them (Monument 5 and Cist 1) have already been destroyed as a consequence of such events. All of these features were located in the intertidal zone.

Adding to the importance of these sites is the fact that prehistoric funerary monuments dating to the Neolithic and Bronze Age are extremely rare in low coastal areas of Northwest Iberia. While several clusters of monuments are known in the elevated peninsulas near the coast, only a few others (such as Chafé and Eireira in Viana do Castelo, Portugal) seem to have a more direct link with the coastal zone and the sea. This has implications for the understanding of exchange networks of ideas and materiality during European late prehistory, which also seems to be suggested by the ceramic evidence (López-Romero *et al.* 2015).

The archaeological nature of all the sites on Guidoiro Areoso has been detailed elsewhere (*e.g.* Rey García and Vilaseco Vázquez 2012) and this paper will focus on how this small islet has inspired public awareness of natural and cultural coastal heritage in Spain, and what specific actions we have taken to contribute to the social and scientific aspects of this public movement.

The public concern: a fight to preserve local heritage

Local communities in Ría de Arousa are extremely active. Even though the northern and southern shores of the estuary belong to two different administrative units (A Coruña and Pontevedra regions respectively), there is a strong sense of belonging to a single community. As is the case in other coastal regions across the globe, the existence of long maritime and fishing traditions has contributed to shaping this communal sense. Fishers across the estuary are organised into guilds, one of the most important of which is the *Confraría de pescadores da Illa de Arousa* (Arousa Island Fishermen's Guild).

Since 2002, the integration of the isles of Cortegada, Sálvora and Vionta into the Galician Atlantic Islands National Park has contributed to the preservation of areas of natural interest. However, the new legal framework has resulted in some conflicts, and dialogue between managers of the natural park and the local communities has not always been easy.

Specific interest in local history and heritage has also led to the creation of associations aimed at the preservation of material and intangible cultural heritage. The *Pandulleiros* association (http://pandulleiros.blogspot.com.es/), from Illa de Arousa, is one of the most active. Until the construction of a 1.9 km-long bridge in 1985, Illa de Arousa was only accessible by boat. The connection with the mainland by road has resulted in an increase in the number of tourists the island receives, especially during the summer season. Some members of *Pandulleiros* have warned of the negative effects this is having on the preservation of coastal landscapes in the area; this is also a concern for Guidoiro Areoso, more readily accessible now from the western harbours of Illa de Arousa (Pablo Iglesias pers. comm.). Marine traffic has expanded due to some shipping companies that offer a one-day tourist trip to the islet, publicising its 'paradisiacal' beaches and bringing in boats with more than 60 people at a time.

When the erosion of Guidoiro Areoso became apparent in 2010, these associations and local stakeholders were among the first to warn of the fragility of the islet's sand dunes. Fishers also collaborated in the alert, as this is a shellfish harvesting area. One year later, local and regional media published press releases showing images of the eroding palaeosoil and monuments. Awareness of the value of this natural and cultural heritage increased, and managers and scientists were urged to undertake protection measures.

Consequently, in September 2011, when a warning was issued about the fragility of the archaeological sites of the islet, a stone wall was built by the Spanish Ministry of Environment (*Servicio Provincial de Costas de Pontevedra, Ministerio de Agricultura, Alimentación y Medio Ambiente*) and the Galician Heritage Division (*Dirección Xeral do Patrimonio Cultural, Xunta de Galicia*) to protect Monument 4, a highly vulnerable megalithic chamber (Fig. 8.3).

Figure 8.3. Construction of the protection wall around 'Monument 4' (Photo: X. I. Vilaseco Vázquez, taken 5 September 2011).

While this presence in the 'conventional' media played a fundamental role in the early attempts to publicise the situation on Guidoiro Areoso, a different kind of resource boosted the visibility of the islet. In January 2012, journalist Manuel Gago's 14-minute online film *Unha viaxe á illa dos mortos* [*A Journey to the Island of the Dead*] made a great impact. The film presented the nature and erosion of the site through a combination of drone images, extracts of John Boorman's 1981 film *Excalibur*, music and field images. Since its release, local and regional media have been influenced by the idea of the 'island of the dead', and the term has appeared repeatedly in press and radio releases. It was also the title of a song on the 2014 album of the Galician folk group *Tanto nos ten* – track 12, 'Ghidoiro Areoso (A Illa dos Mortos)'. The idea that this was an island of the dead has undoubtedly been enhanced by the funerary character of some of the sites it contains (megalithic monuments and cists), but also by the Galician folklore traditions linking death with the sea. Not far from the Arousa estuary, the island of Ons (also belonging to the Galician Atlantic Islands National Park; see Fig. 8.1) was believed to be the resting place of the *Santa Compaña*, a procession of the dead that, coming from Noalla in the mainland, ended in the cemetery at Ons. Such traditional links are commonplace in other European Atlantic maritime societies (*e.g.* Le Braz 1994, for Brittany, France; Sawyer 2015, for the Isles of Scilly, England). We will discuss later what consequences this perception has had on our attempts to bridge the scientific and social aspects of our initiative.

Added to this presence in the media, local communities – especially the inhabitants of Illa de Arousa – have also engaged in a series of initiatives aimed at inspiring more action from managers, policy makers and researchers. Several boat races, swimming events crossing from Illa de Arousa to Guidoiro and popular meetings have been organised over the last few years to promote the protection of the islet and limit the number of visitors (https://www.facebook.com/pandulleiros).

Engaging the public: the crowdsourcing initiative

As part of our interest in coastal societies, territories and landscapes in Galicia and other areas of the European Atlantic façade, we were familiar with the situation in the Arousa estuary and on Guidoiro Areoso. Since 2013, the islet was included as one of the case studies of the eSCOPES project (*Evolving Spaces: Coastal Landscapes of the Neolithic in the European Land's Ends;* European Commission FP7-People ref. 328753). This project aimed to contribute to the understanding of human dynamics in the coastal landscapes from the Middle Neolithic to the Early Bronze Age in Atlantic Europe (*c*. 4500–2200 BC) through cross-regional analysis of the archaeological evidence and study of the variables affecting the vulnerability of the coast. From a methodological point of view, it used close range photogrammetric techniques as a cost-effective solution to record, model and monitor changes in the architecture of selected case study sites in southwest Britain, western France and northwest Spain (López-Romero *et al.* 2014).

The social demand for action in Guidoiro Areoso aligned perfectly with the objectives and scope of the project, and we decided to engage in a more direct dialogue with local communities. We launched a crowdsourcing initiative called *Guidoiro Dixital* (Digital Guidoiro). It aimed to generate a response from the local community interested in preserving their heritage while contributing to the long-term analysis of site erosion on the islet. Through a public call, we asked citizens to send us any photographs or video footage featuring the natural and cultural heritage of Guidoiro Areoso, pre-dating September 2013 (the date of our first photogrammetry field campaign). Close collaboration with the press division of the Spanish National Research Council (CSIC) in Galicia (http://www.delegacion.galicia.csic.es/actualidad-del-csic-en-galicia), as well as an excellent response from local and regional media, proved essential to publicising the initiative.

In order to facilitate the dialogue between ourselves and the public, we created a series of online tools:

- *HistoryPin* project (http://www.historypin.com/channels/view/54782)
- Blog and informational website (http://guidoirodixital.wordpress.com/)
- *Facebook* page (www.facebook.com/guidoirodixital)
- *Google+* page (https://plus.google.com/118411261666364325005/)
- Sketchfab project (https://sketchfab.com/guidoirodixital)
- Dedicated contact email address (guidoirodixital@gmail.com).

All contributors were requested to complete a form with some basic information (date, conditions in which photographs were taken, type of camera *etc.*) and copyright requirements.

Since this call was launched in May 2014 we have collected (as of February 2016) a total of 677 images from members of the local community, but also from colleagues at Galician Universities and even from the Pontevedra police department. We have also integrated our own photographs taken without a photogrammetric purpose before 2013. The distribution per year is irregular, with almost three-quarters of the dataset covering the year 2011 (n = 479, 70.75% of the total of 677 images). There is a significant difference between this and the second most represented year, 2013 (n = 63, 9.31%). The earliest images date from 1990 (n = 7, 1.03%), and we have no records thus far for the years 1991–2000, 2002–4 and 2008–9. There is also limited coverage for the years 2001 (n = 3, 0.44%), 2005 (n = 4, 0.59%) and 2010 (n = 5, 0.74%). Finally, we could not attribute a date to 36 images (5.32%).

The images range from general views of the landscape to closer details of sites and artefacts. The most photographed place was the already destroyed site, Monument 5 (n = 267, 39.44% of the total 677 images), followed by Monument 4 (n = 179, 26.44%) and by general views of the dune and the landscape (n = 61, 9.01%). Two other monuments have far fewer records: Monument 3 (n = 47, 6.94%) and Monument 1 (n = 25, 3.69%). The information for the destroyed Cist 1 and the palaeosoil in the intertidal area was unfortunately very limited (5 and 10 images respectively).

With the collection of images within the dataset, we were able to extend the temporal span of the analysis for our eSCOPES sites. Three-dimensional reconstructions for the research and conservation of archaeological sites and objects are becoming increasingly common, as laser and photogrammetric techniques are now more readily accessible to non-specialists. Most of these imaging techniques have been applied to sites and objects that can be physically visited, handled, measured or studied in various ways. However, little attention had been paid to the potential of these techniques for obtaining fresh information from destroyed or inaccessible sites and objects. With an awareness of the potential of modern imaging techniques and software, we worked on the hypothesis that this dataset – together with further metric information recovered in 2011 by X. I. Vilaseco – could be used to reconstruct 3-D models of some of the sites in Guidoiro that would allow us to gain a better understanding of their architecture and erosion history. Similar approaches had successfully been applied to other archives of old images (Grün *et al.* 2004; Andaroodi *et al.* 2012; De Reu *et al.* 2013, 1114–16; Aparicio Resco *et al.* 2014; López-Romero 2014). However, we expected that in this case, the results would be limited by the nature of the inputs, which lacked the usual standardisation required in the field data capture phase. As a test case, we attempted to use the 2011 datasets for Monument 4 and Monument 5. [The digital processing of the files was performed with Agisoft Photoscan Professional® 0.9.1. using an Acer Aspire V3-771G computer equipped with an Intel® Core™ i7-3632QM 2.2GHz processor and NVIDIA® GeForce® GTX 730M graphics. In order to model the information, standard Photoscan workflow was followed (http://www.agisoft.ru/tutorials/photoscan).]

In spite of the partial coverage of the sites analysed, the results were satisfactory. A total of 50 images from Monument 5 were successfully aligned and processed to obtain a metric digital model (Fig. 8.4), and the orthostatic chamber of Monument 4 was modelled from a total of 57 images. Digital comparison of this model to a model obtained from images taken during our 2014 field season showed substantial changes to sediments around the site, with erosion noted, together with a re-filling of the area outside the megalithic chamber as a result of the erosion of the dune sediments that covered the structure, and the development of coastal vegetation (Fig. 8.5). We will discuss in detail the methodology and implications of these changes in a forthcoming paper.

The models were subsequently converted to PDF3D files and made freely available on the project's blog and in the Sketchfab digital portal. Complete information on the modelled sites and on the analyses performed was included. A decorated Late Bronze Age pottery fragment discovered on the surface during one of our field campaigns was also modelled and published as a downloadable PDF3D file (Mañana-Borrazás *et al.* 2015).

A review of the activity of the *Guidoiro Dixital* blog and website in February 2016 showed that 97.60% of a total of 9971 visits came from Europe. Not surprisingly, 90.24% of these (n = 8998) originated in Spain. Added to this, 5.02% (n = 501) of the visits were from the United Kingdom, and 2.37% from America (n = 236, corresponding to Canada, USA and Latin America). Finally, we received two visits from Asia (Philippines and Taiwan) and one visit from Africa (Angola). Meanwhile, we currently have 399 followers (likes) on our Facebook page, a good number considering we only post news in Galician concerning aspects of Guidoiro, coastal archaeology and climate change. Most of them (372) come from Spain, but we also have followers from Portugal, the United Kingdom, Uruguay, Argentina, France, Greece, Italy, Sweden and even Malaysia. Some of our posts have reached more than 3000 people.

Considering this was a very local case study in north-west Spain, its relative impact outside the region can be seen as a reflection of the interest that different initiatives dealing with climate change effects on cultural heritage are raising on a global scale. However, while our websites received several visits from European Mediterranean countries (*e.g.* Greece, Italy), we were surprised that we did not receive any from the African Mediterranean and African Atlantic areas (*e.g.* Tunisia, Algeria, Morocco). This is striking, as these are neighbouring countries where similar processes of erosion and human pressure are affecting coastal areas and coastal heritage. We can only speculate that language is an obstacle.

At the time of writing this paper, the initiative remains open. However, having attracted the attention of most of the local public and specialists in the region, we do not expect substantial new additions to our image database. Further analysis to integrate metric 3-D models derived from the images into the erosion monitoring procedures will nonetheless result in a better understanding of the evolution of the sites.

Conclusion

Why has this crowdsourcing initiative been such a success? We believe that a combination of factors has contributed, and there is no straightforward response to that question. The islet is a natural wonder in the middle of the Arousa estuary. This attracts tourists as well as locals, creating a conflict between those who wish to enjoy visiting the island and those who wish to preserve it. This conflict became more virulent when the erosion of the dune sediments and archaeological sites became apparent. At the same time, the existence of local guilds and associations in the Arousa estuary served to channel some of the actions and demands local communities had about their local landscape, economy and heritage. The publicity surrounding the critical situation of the islet would not have been as strong without them, nor without the commitment of local and regional media. In the absence of a prompt response by the competent authorities, several scholars also began – at an early date – to visit the site at their own expense, contributing warnings about the situation. Different interests and sensibilities thus emerged and collided, resulting in several conflicts occurring at different levels: natural, cultural, social and economic. Because of this, Guidoiro Areoso appears to be an exceptional case study within current debates on climate change, public science and the present-day value of heritage sites.

Our initiative has contributed to the merging of these different aspects, bridging the local and scientific interests of the islet, contributing to its international contextualisation, and proposing ways of bringing added value to the image archives compiled by members of the community. These have been seen as positive and adequate responses to some of the demands of the inhabitants of the region.

However, we have encountered difficulties during this process. Some local authorities and several members of the local community do not believe that the main damage to the integrity of the islet is being caused by natural factors such as wave impact. As a result – and against the evidence we and other members of the scientific community have presented – they have almost exclusively insisted upon setting up measures to limit or ban access to visitors. Similarly, the 'romantic' idea that this was an 'island of the dead' is now anchored in the public opinion; this is masking the historical and geomorphological evidence that indicates the islet was probably part of the mainland at the time of occupation, and that this was as much a land of the living as a resting place for the dead.

The focus on Guidoiro Areoso has also meant that discussions about heritage at risk are not reaching a wider, regional area. The threat of erosion and sea level rise is common to all coastal areas in Galicia, and the increase in the frequency of extreme weather events – such as the storms previously referred to – has become apparent. Hundreds of archaeological sites are threatened with destruction across the Arousa estuary and beyond, and there is an urgent need to provide a better framework and dedicated tools for their research and management. Unlike other European

Figure 8.4. 3-D model of 'Monument 5' prior to its destruction. A total of 50 images from 2011 compiled through the Guidoiro Dixital initiative were used for this reconstruction (Agisoft Photoscan Professional v.0.9.1).

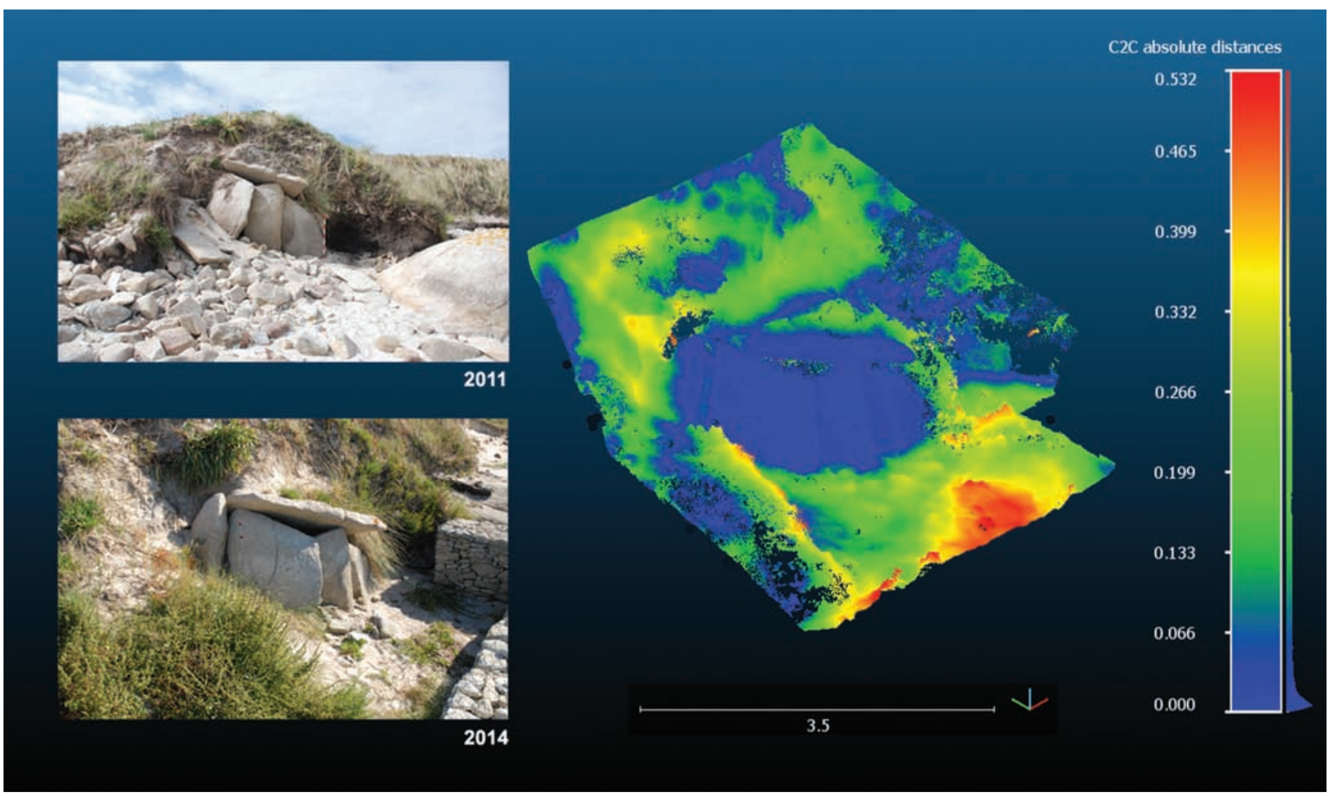

Figure 8.5. Digital modelling of the evolution of 'Monument 4' from images compiled through the Guidoiro Dixital initiative (a subset of 57 images from 2011) and from our fieldwork (2014). Cloud-to-cloud distance (in metres) computed with Cloud Compare v.2.6.0 software (http://www.danielgm.net/cc/).

and American areas, the region lacks a dedicated network of coastal heritage 'watchers' and researchers. This is something that we have not yet managed to achieve, in spite of our efforts, and something that constitutes one of the main challenges we must face in the near future. If we fail to establish a network, we will lose irreplaceable information on past human societies, past landscapes and past uses of the coast and the sea.

Some of the problems we are dealing with in Galicia are common to other regions across the globe, and analysing cultural heritage at risk remains a complex task. Firstly, the integration of heritage into discussions on climate change, sea level rise and erosion do not seem to constitute a priority (the word 'heritage' appears only twice in the 1535 page IPCC 2013 report (Stocker *et al.* 2013), while 'archaeology' or 'archaeological' appears only seven times). Secondly, the current global economic crisis has dramatically reduced the number of people working in scientific and management organisations in a number of countries, limiting their capacity for action and interrupting the consolidation of emerging research teams. Thirdly, knowledge of archaeological heritage is still largely driven by regional and/or national research traditions; to overcome this, more specific international and transnational approaches need to be implemented in the years to come. Lastly, the dialogue between researchers, heritage managers and the wider public remains limited; as we have tried to show here, it is not always easy. If there is a lesson to learn from this edited volume, it is that public concerns about natural and cultural heritage at risk are present everywhere, and they have to be taken into account. We believe there is a need for a more *active* public science approach, for *'activism, like mediation, is an incredibly important part of our work, not only because our way of acting by contributing to the present is to reactivate materialities, sites, landscapes and memories, but also because we must include current, ubiquitous demands for participatory action in our projects*' (Criado-Boado 2016, 6).

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References

Alonso Millán, A. and Pagés Valcarlos, J. L. 2010. Evolución del nivel del mar durante el Holoceno en el noroeste de la Península Ibérica. *Revista de la Sociedad Geológica de España* 23(3–4), 157–167.

Andaroodi, E., Reza Matini, M. and Ono, K. 2012. Post disaster virtual revival: 3D CG manual reconstruction of a World Heritage Site in danger. In X. X. Tang (ed.), *Virtual Reality: Human Computer Interaction*, 261–86. Croatia, InTech. Available at: http://dx.doi.org/10.5772/46406.

Aparicio Resco, P., Carmona Barrero, J. D., Fernández Díaz, M. and Martín Serrano, P. M. 2014. 'Fotogrametría Involuntaria': rescatando información geométrica en 3D de fotografías de archivo. *Virtual Archaeology Review* 5(10), 11–20.

Ashmore, P. 1994. *Archaeology and the Coastal Zone: Toward a Historic Scotland Policy*. Edinburgh, Historic Scotland.

Ayán Vila, X. and López-Romero, E. 2014. Unha viaxe á Artabria: valoración arqueolóxica e patrimonial da franxa litoral este do golfo Ártabro. In V. Alonso, A. R. Colmenero and A. Goy (ed.), *El golfo Ártabro. Fragmentos de historia litoral y patrimonio*, 17–151. Coruña, Universidade da Coruña.

Ballesteros-Arias, P., Güimil-Fariña, A. and López-Romero, E. 2013. *Estudo arqueolóxico do Parque Nacional Marítimo-Terrestre das Illas Atlánticas de Galicia. Prospección superficial e vulnerabilidade*. CAPA 33. Santiago de Compostela, Instituto de Ciencias del Patrimonio (Incipit-CSIC). Available at: http://digital.csic.es/bitstream/10261/74466/1/CAPA%2033.pdf.

Blanco-Chao, R., Costa-Casais, M., Martínez-Cortizas, A., Pérez-Alberti, A. and Vázquez-Paz, M. 2002. Holocene evolution in Galician coast (NW Spain): An example of paraglacial dynamics. *Quaternary International* 93–94, 149–59.

Criado-Boado, F. 2016. Letter from the EAA president. *The European Archaeologist* 47(Winter 2015/2016), 3–7.

Daire M. Y., López-Romero E., Proust J. N., Regnauld H., Pian S. and Shi, B. 2012. Coastal changes and cultural heritage (1): Assessment of the vulnerability of the coastal heritage in Western France. *Journal of Island and Coastal Archaeology* 7(2), 168–82.

Dawson, T. 2013. Locating and prioritising action at eroding coastal sites. In M. Y. Daire, C. Dupont, A. Baudry, C. Billard, J. M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coasts/ Anciens peuplements littoraux et relations Homme/Milieu sur les côtes de l'Europe atlantique. Proceedings of the Homer 2011 Conference, Vannes (France), 27/09–1/10 2011*, 77–84. Oxford, British Archaeological Reports International Series 2570.

De Reu J., Plets, G., Verhoeven, G., De Smedt, P., Bats, M. Cherrette, B., De Maeyer, W., Deconynck, J., Herremans, D., Laloo, P., Van Meirvenne, M. and De Clercq, W. 2013. Towards a three-dimensional cost-effective registration of the archaeological heritage. *Journal of Archaeological Science* 40, 1108–21.

English Heritage 1997. *England's Coastal Heritage: A Statement on the Management of Coastal Archaeology*. London, English Heritage.

Fitzpatrick, S. M., Rick, T. C. and Erlandson, J. M. 2015. Recent progress, trends, and developments in island and coastal archaeology. *Journal of Island and Coastal Archaeology* 10, 3–27.

Grün, A., Remondino, F. and Zhang, L. 2004. Photogrammetric reconstruction of the Great Buddha of Bamiyan, Afghanistan. *The Photogrammetric Record* 19(107), 177–99.

Le Braz, A. 1994. *La légende de la mort*. Coop Breizh, Jeanne Laffite Ed.

Ley 16/1985 del Patrimonio Histórico Español. Available at: https://www.boe.es/buscar/doc.php?id = BOE-A-1985-12534 [accessed 26 Jul 2016].

Ley 8/1995 del Patrimonio cultural de Galicia. Available at: http://www.xunta.es/dog/Publicados/1995/19951108/AnuncioA22E_es.html [accessed 26 Jul 2016].

Ley 5/2016 del Patrimonio cultural de Galicia. Available at: http://www.xunta.gal/dog/Publicados/2016/20160516/AnuncioC3B0-110516-0001_gl.html [accessed 26 Jul 2016].

López-Romero, E. 2014. Out of the box: Exploring the 3D modelling potential of ancient image archives. *Virtual Archaeology Review* 5(10), 107–16.

López-Romero, E., Ballesteros-Arias, P., Daire, M. Y. and Güimil-Fariña, A. 2012. Les Îles Atlantiques de Galice (NW Ibérique). Archéologie et Vulnérabilité. *Bulletin de l'Association Manche-Atlantique pour la Recherche Archéologique dans les Îles* 25, 5–17.

López-Romero, E., Ballesteros-Arias, P., Güimil-Fariña, A. and Daire, M. Y. 2013. Human occupation and formation of the cultural landscape in Galicia's Atlantic Islands National Park. In M. Y. Daire, C. Dupont, A. Baudry, C. Billard, J. M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coasts/Anciens peuplements littoraux et relations Homme/Milieu sur les côtes de l'Europe atlantique*. *Proceedings of the Homer 2011 Conference, Vannes (France), 27/09–1/10 2011*, 285–94. Oxford, British Archaeological Reports International Series 2570.

López-Romero, E., Güimil-Fariña, A., Mañana-Borrazás, P., Otero Vilariño, C., Prieto Martínez, M. P., Rey García, J. M. and Vilaseco Vázquez, X. I. 2015. Ocupación humana y monumentalidad durante la Prehistoria Reciente en el islote de Guidoiro Areoso (Ría de Arousa, Pontevedra). Investigaciones en el marco de las dinámicas litorales atlánticas actuales. *Trabajos de Prehistoria* 72(2), 353–71.

López-Romero, E., Mañana-Borrazás, P., Daire, M.-Y. and Güimil-Fariña, A. 2014. The eSCOPES Project: Preservation by record and monitoring at-risk coastal archaeological sites on the European Atlantic façade. *Antiquity Project Gallery* 088(339). Available at: http://antiquity.ac.uk/projgall/lopez-romero339/.

Martínez-Cortizas, A. and Costa-Casáis, M. 1997. Indicios de variaciones del nivel del mar en la ría de Vigo durante los últimos 3000 años. *Gallaecia* 16, 23–47.

Mañana-Borrazás, P., López-Romero, E., Prieto-Martínez, M. 2015. Pilar Modelo 3D del fragmento de cerámica decorada por boquique y excision localizado en Guidoiro Areoso (Illa de Arousa, Pontevedra). *DIGITAL.CSIC: Spanish National Research Council Repository*. Available at: http://hdl.handle.net/10261/111724 [accessed 26 Jul 2016].

Rey García J. M. and Vilaseco Vázquez, X. I. 2012. Guidoiro Areoso. Megalithic cemetery and prehistoric settlement in the Ría de Arousa (Galicia, NW Spain). In A. Campar Almeida, A. M. S. Bettencourt, D. Moura, S. Monteiro-Rodrigues and Y. M. I. Caetano Alves (eds), *Environmental Changes and Human Interaction along the Western Atlantic Edge/Mudanças ambientais e interação humana na fachada atlântica ocidental*, 243–58. Coimbra, Associação Portuguesa para o Estudo do Quaternário.

Sawyer, K. 2015. *Isles of the Dead? The Setting and Function of the Bronze Age Chambered Cairns and Cists of the Isles of Scilly*. Oxford, Archaeopress.

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P. M. (eds). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, Cambridge University Press. Available at: http://www.ipcc.ch/report/ar5/wg1/ [accessed 26 Jul 2016].

Unha viaxe á illa dos mortos [A Journey to the Island of the Dead]. 2012. Directed by Manuel Gago. Available at: https://www.youtube.com/watch?v = wSF3tHR5pEI [accessed 26 July 2016].

Van de Noort, R. 2013. *Climate Change Archaeology: Building Resilience from Research in the World's Coastal Wetlands*. Oxford, Oxford University Press.

Welsh Historic Monuments. 1999. *Caring for Coastal Heritage*. Cardiff, Cadw: Welsh Historic Monuments with the Welsh Archaeological Trust.

Westley, K. and McNeary, R. 2014. Assessing the impact of coastal erosion on archaeological sites: A case study from Northern Ireland. *Conservation and Management of Archaeological Sites* 16(3), 185–211.

Chapter 9

Coastal erosion and public archaeology in Brittany, France: recent experiences from the ALeRT project

Pau Olmos Benlloch, Elías López-Romero and Marie-Yvane Daire

Abstract

The ALeRT (*Archéologie, Littoral et Réchauffement Terrestre*) project has brought together researchers involved in coastal archaeology and aims to establish an interdisciplinary approach to assessing coastal archaeological vulnerability, site monitoring and heritage management. The scale of the problem and the need for improved field data collection and data management procedures led us to develop a web and mobile application for adding field data and administering users. This reduces the time of data collection in the field and widens the opportunities for collaboration between researchers, heritage managers and the wider community.

Recent extreme weather impacts on coastal archaeology in Brittany has led to a growing interest in public archaeology initiatives and resulted in a huge mobilisation of the local population. As a result of this, a specific training programme in coastal archaeology was developed for coastguards and local communities. The ALeRT network is formed of 30 active members who cover almost the whole coast of the region, and this network has been recently augmented through a partnership with the Conservatoire du Littoral, a public wildlife conservation organisation. In this chapter, we will focus on the results of the collaborative project undertaken in 2014 and 2015, when this citizen science approach was put to the test.

Introduction

Present climatic change and anthropogenic pressures are increasingly affecting the coastal zone across the globe. Hundreds of archaeological sites along the European Atlantic coast are currently threatened by accelerated relative sea level rise, erosion and various anthropogenic modifications to the environment.

The impact of coastal change upon coastal heritage and its vulnerability is now a major European issue, and there are several initiatives that have begun to deal with the problem. In the mid-1990s, the heritage agencies of England, Scotland and Wales all independently started programmes of rapid coastal zone assessments (*e.g.* Fulford *et al.* 1997). Community monitoring programmes have developed from these projects and Shorewatch, launched by Scottish archaeologists in 1997, was one of the first projects to bring together individuals and groups from local communities to save information about archaeological sites before they were lost to erosion (Fraser *et al.* 2003). This was followed by Arfordir and the work of the National Trust in Wales (see Chapter 6, this volume) and SCHARP in Scotland (Chapter 3, this volume). In 1997, English Heritage initiated the national Rapid Coastal Zone Assessment Surveys (Fulford *et al.* 1997), and this work has been followed by CITiZAN (Coastal and Intertidal Zone Archaeological Network), a new national network to monitor, record, and interpret coastal and intertidal sites in England (see Chapter 5, this volume). Some projects to record coastal sites have also been carried out in Ireland (Kelly and Stack 2009; Chapter 7, this volume) and in Spain (Chapter 8, this volume).

Since 2006, the ALeRT (Archéologie, Littoral et Réchauffement Terrestre) project, developed first in France under the coordination of the CReAAH (Centre de Recherche en Archéologie, Archéosciences, Histoire) research team and then in Spain (Institute of Heritage Sciences, Santiago de Compostela), has brought together researchers involved in coastal archaeology and aims to establish an interdisciplinary approach to coastal archaeological vulnerability, site monitoring and heritage management (Daire *et al.* 2012; López-Romero *et al.* 2013; Olmos *et al.* 2014a).

The initial study area covers the West of France (Lower Normandy, Brittany and Pays de la Loire) and examines 2974 km of coastline (Fig. 9.1). Thanks to the active work of regional and local archaeology associations, groupings of professional archaeologists, and local volunteers over the last thirty years, more than 2500 archaeological sites in the study area within 100 m of the shoreline have been shown to be severely threatened. One of the objectives of the ALeRT project is to collaborate with local people and regional authorities to provide tools to assess coastal erosion at archaeological sites. Regular surveys are necessary in order to rank the sites at risk, after which rescue strategies are adapted that take into account regional issues, as the Brittany coastline possesses a great diversity of natural features. The

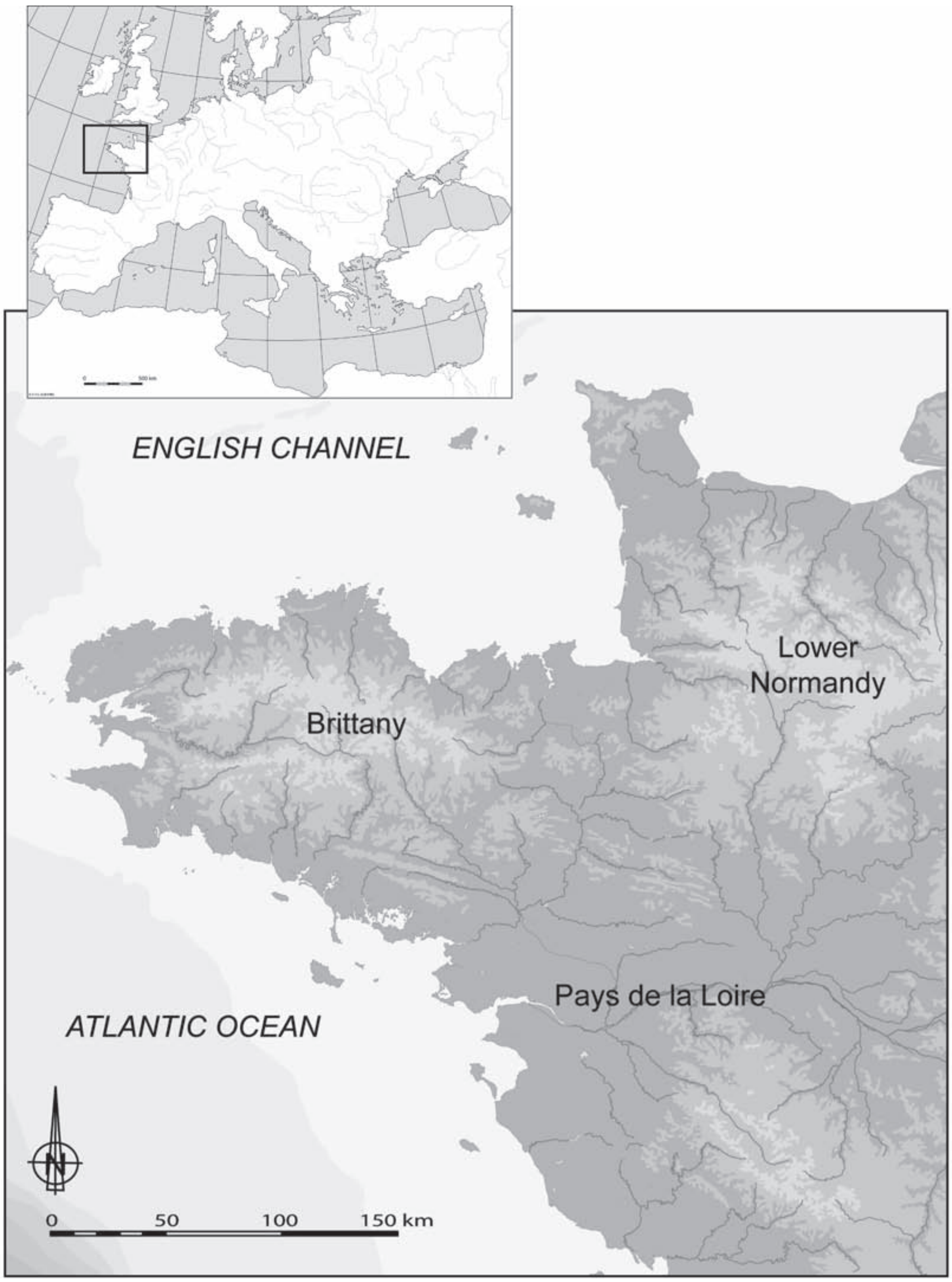

Figure 9.1. Location of the case study area.

geomorphological diversity of the region means that not all the areas appear to face the same erosion problems.

One important point that has been noted is the difficulty in setting up rescue excavation programmes in coastal areas in France. This is largely due to the division of administrative responsibility for projects between the Regional Archaeological Services, who manage terrestrial projects, and DRASSM (*Département des Recherches Archéologiques Subaquatiques et Sous-Marines*), which has a national responsibility for managing underwater projects, even though both divisions report to the Ministry of Culture. Recently, DRASSM established a fund for rescue excavations within the coastal area, but the amount of money available remains insufficient for addressing the scale of the problem.

ALeRT deals with all cultural heritage, including remains or built structures of anthropogenic origin together with materials transformed by human activities, from the earliest settlements up to World War II structures. The sites examined as part of the ALeRT project are representative of this as they belong to a wide range of chronological periods, from the earliest Palaeolithic settlements up to recent coastal installations. Studying this diverse range of sites has shown that different site types do not face equal erosional pressures and other effects of climate changes, due to their form, the raw materials used in construction, *etc.*

Methodology

Specific methodologies were developed for the assessment of the vulnerability of coastal archaeological heritage and for engaging the public.

Assessing the vulnerability of coastal archaeological sites: the VEF tool

Very early on the research group moved towards using an interdisciplinary approach to construct a vulnerability model for coastal heritage, developing assessment and monitoring maps, and assessing the strategies for research and action which could be adapted to local and regional scales. This led to the development of a dedicated tool for the vulnerability assessment of coastal archaeological heritage: the Vulnerability Evaluation Form (VEF).

The VEF provides a standardised grid for recording information aimed at providing a snapshot of the state of preservation of coastal archaeological sites (Daire *et al.* 2012). It considers 10 variables that are measurable on site (see Table 9.1; impacts = A1–A6 and resilience =

Table 9.1. Grids for analysis from the Vulnerability Evaluation Form

Type of variable		*Evaluation of variables*				
A1	Human-made structures	-10 m	-50 m	-200 m	-500 m	+500 m
A2	Activities	-10 m	-50 m	-200 m	-500 m	+500 m
A3	Traffic/frequency of passages	-10 m	-50 m	-200 m	-500 m	+500 m
A4	Distance to the cliff	-10 m	-50 m	-200 m	-500 m	+500 m
A5	Biological erosion	Very strong	Strong	Moderately strong	Weak	Almost inactive
A6	Weathering	Very strong	Strong	Moderately strong	Weak	Almost inactive
B1	Resistance of the remains	Very active	Active	Moderately active	Weak	Almost inactive
B2	Local substrate	Very active	Active	Moderately active	Weak	Almost inactive
B3	Physical protection	-10 m	-50 m	-200 m	-500 m	+500 m
B4	Legal protection	-10 m	-50 m	-200 m	-500 m	+500 m

Type of variable		*Numerical evaluation of variables*				
A1	Human-made structures	1	0.8	0.6	0.4	0.2
A2	Activities	1	0.8	0.6	0.4	0.2
A3	Traffic/frequency of traffic	1	0.8	0.6	0.4	0.2
A4	Distance to the cliff	1	0.8	0.6	0.4	0.2
A5	Biological erosion	1	0.8	0.6	0.4	0.2
A6	Weathering	1	0.8	0.6	0.4	0.2
B1	Resistance of the remains	1	0.8	0.6	0.4	0.2
B2	Local substrate	1	0.8	0.6	0.4	0.2
B3	Physical protection	1	0.8	0.6	0.4	0.2
B4	Legal protection	1	0.8	0.6	0.4	0.2
Total A (Sum of normalised values)						
Total B (Sum of normalised values)						

B1–B4). The impacts measured include: A1) human-made structures, A2) human activities, A3) traffic volume and frequency, A4) distance to the cliff, A5) biological erosion, and A6) weathering. The resilience measurements for each site include: B1) resistance of the remains, B2) local substrate and geomorphology, and existing B3) physical or B4) legal protection (such as nature reserves). Users provide scores based on factors such as distance (*e.g.* distance to the cliff) or intensity (*e.g.* intensity of biological erosion) relating to the hazards and the resilience of each archaeological site.

For each variable of the VEF, the field observation is transformed into a normalised value between 0.2 and 1. The vulnerability score (or index) can then be evaluated by the following method:

- Impacts (threats): A = A1 + A2 + A3 + A4 + A5 + A6
- Resistance: B = B1 + B2 + B3 + B4
- Vulnerability Score: VS = A-B (Daire *et al.* 2012, 179–80).

Resulting values fall between -2.8, which correspond to the lowest vulnerability, and 5.2, which correspond to the highest vulnerability. All of these observations are then integrated into a Geographical Information System, allowing sites to be mapped and ranked accordingly.

Data management: the ALeRT App as a participative approach

The results of the pilot project revealed a need to enhance field collection and data management procedures, leading us to develop a web application for administering users and adding field data. The ALeRT App is a web application accessible on a range of different devices (*e.g.* mobile phone, laptop) and connected to a central online database. The ALeRT App allows the user to type and transmit all relevant information (including the full set of variables considered in the VEF) for each site to a secure server (Barreau *et al.* 2013). It also standardises data collection in the field, improving its quality and widening the possibility of collaboration between researchers, heritage managers and the wider community. The ALeRT App and corresponding explanatory video are accessible online (https://alertarcheo.univ-rennes1.fr/; http://osur.univ-rennes1.fr/page.php?207).

Experiences of the ALeRT project in Western France and further afield

The VEF grid and the ALeRT App have been put to the test at a number of coastal archaeological areas in Western France (Shi *et al.* 2012) and also in North-West Iberia (López-Romero *et al.* 2012; Ayán Vila and López-Romero 2014), demonstrating that it can be successfully used in geographical contexts other than the one for which it was initially created. The first tests of the vulnerability assessment were carried out along Vilaine Bay and the Rhuys Peninsula in southern Brittany. These areas were chosen because various databases contained information on both the geomorphology of the coast and the location of coastal heritage sites.

Assessments of coastal vulnerability were then tested in 2014 after an exceptional run of winter storms that severely affected the Atlantic and Channel coasts of Western Europe. Western France was lashed by a series of storms between December 2013 and March 2014, among which, Storms Xavier, Dirk and Ulla were of unusual intensity, leading to the highest amounts of rainfall since records began in 1910. The combination of heavy rain, strong winds, high waves and high tides caused damage to known coastal sites, but also resulted in the discovery of new archaeological sites and cultural remains. This was not the first time that storms had caused damage; similar weather episodes occurred in March 2008 and in February 2010 (storm Xynthia), with catastrophic – but more localised – effects. Some rescue excavations were undertaken after these earlier storms in Brittany (Daire 2011), thus giving us experience of understanding the importance of planning risk strategies prior to the destruction of sites. The winter storms of 2013–2014 were exceptional however, not only because of the intensity of some of the climatic episodes, but also due to the unprecedented scale of damage to archaeological heritage.

Due to the impossibility of physically preserving all of the threatened sites, our methodology is based on a 'preservation-by-record' strategy. In this, the role of the public, local authorities and coastal managers is essential in order to alert us to the erosion of coastal heritage. Local volunteers and ALeRT reporters quickly reported damage to archaeological sites in the spring of 2014, and subsequently initial assessments of the erosion to coastal sites were undertaken (Olmos *et al.* 2014b).

An intensive fieldwork campaign was carried out in February and March 2014, right after the major winter storms. Work was mainly done in Brittany and fieldwork was systematically prepared in close partnership with local groups. Archaeological surveys were concentrated in different coastal zones depending upon local configurations and the presence of active participants in the area. After each report of damage was received, a detailed documentary study of existing archaeological data concerning each site was carried out. The main data sources used were the:

- *AMARAI* database (*Association Manche Atlantique pour la Recherche Archéologique dans les Îles*, Université de Rennes 1)
- Archives of the *Archéosciences* laboratory (Rennes 1 University)
- *Atlas des Patrimoines* database (Ministry of Culture, France)
- ADRAMAR *Atlas Ponant* underwater archaeology database (Association pour le Développement de la Recherche en Archéologie Maritime).

All the sites within the same geographical sub-area (*e.g.* island, peninsula) were the object of detailed analysis, but only 46 within the whole region were fully investigated, based on their vulnerability and accessibility.

The ALeRT network of coastal monitoring

After the positive experience in Western France and North-West Iberia, the aim of the next phase of the ALeRT project was to increase collaborative work and build awareness of the consequences of heritage loss as a result of climate change and human pressure among coastal communities. Publicity about the effects of recent extreme weather events on cultural heritage has led to a growing interest in public archaeology in Brittany. As mentioned above, this has resulted in the development of the ALeRT network, consisting of about 30 active members led by archaeologists from the Rennes Department of Archaeology and formed of local volunteers (mainly retired people); local and regional historical and archaeological societies; museums; and regional and national authorities.

A specific training course in coastal archaeology was developed, in partnership with the *Conservatoire du Littoral*, for coastguards in the winter of 2015 (Fig. 9.2). This course aimed to strengthen the ALeRT network and to improve the quality of vulnerability monitoring of coastal heritage. The partnership is part of a mid- to long-term strategy of collaboration, as coastguards can alert archaeologists about damage to archaeological sites located within *Conservatoire du Littoral* properties. The outputs of this collaboration can be re-evaluated, especially after subsequent episodes of extreme weather events.

Recently, a survey of volunteers and members of the ALeRT network was launched by Thibaut Peres, a student at Rennes. The sample consisted of 38 respondents, most of whom were experienced volunteers in coastal archaeological survey. The objective of the survey was to identify the behaviour of our volunteers, for example, where they work and what their interests are. Two types of participant were identified: 1) those who undertake coastal surveys in groups for an academic purpose (mainly men who have received a higher education, *e.g.* BA or MA); and 2) amateurs with a long experience of coastal survey, but who work alone or in small groups (mostly retired people with elementary or secondary education). In general, most people visited sites in their local area (up to 50 km away), and most of them complete surveys after every storm. These demographic results have been integrated into our project Geographic Information System and the information will be used as a management tool, allowing us to quickly contact surveyors at times when potential damage may be caused, directing them to survey areas at risk. The review also highlighted some areas where there were no active surveyors, but where coastal features suggest potential damage may be caused, especially in southwest Brittany.

Case study: Roc'h Santec island (Santec, northern Brittany)

After an evaluation of its vulnerability, the small island Roc'h Santec in northern Brittany was selected for an in-depth study. The island has evidence of occupation from the Middle Palaeolithic to the Iron Age and work here demonstrates the role that non-professionals can play in monitoring coastal vulnerability. The area and islands surrounding the Île de Batz, including the island Roc'h Santec, were surveyed and photographed in depth by two locals working in collaboration with regional authorities and archaeologists from the French National Research Centre (CNRS) and the University of Rennes Department of Archaeology (Le Goff and Roué 1999). As the area has a flat coast that is exposed to the north-west, the storms of winter 2014 caused damage to known sites and led to the discovery of new sites and cultural remains.

Thanks to the photos taken by the volunteers of Roc'h Santec between 1995 and 2010, we were able to evaluate its vulnerability. An assessment completed in 2014 provided evidence of major damage to some sites, especially in the

Figure 9.2. Breton's coastguards being trained in archaeological investigation at the Mesolithic site of 'La Torche' (Plomeur, Finistère) in January 2015. Photo: P. Olmos.

Figure 9.3. The Roc'h Santec excavation in March 2015. Photo: M. Monrós.

centre of the island, which had been flooded by high waves. Our survey, when compared with old photographs, showed that a shell-midden had been almost completely destroyed. Due to the interesting archaeological potential on the island – with stratigraphy surviving to more than one-and-a-half metres, which is rare in this region – a rescue strategy was developed. This strategy was adapted to the conditions on the island, where access is difficult and fieldwork can only be undertaken during low tide and is limited to four hours per day. Fieldwork consisted of excavating a coastal section, more than 7 m long, in order to understand site formation (Fig. 9.3). The excavation identified four periods of occupation, the oldest dating to the Middle Palaeolithic, followed by Upper Palaeolithic, Early Mesolithic and a late phase dated to the Iron Age. During fieldwork, and in order to provide an estimation of erosion rates, a 3-D recording project of the island was undertaken. Three-dimensional scans and photogrammetric models can be used to measure

Table 9.2. Results of assessment of the 46 investigated sites A: Threat, B: Resistance; VS Vulnerability Score (A-B)

ID	*Site name*	*Town*	*Type*	*Datation*	*A*	*B*	*VS*
1	Cougn ar Zac'h 1	Santec	Shoreline	Bronze Age	5.2	1.2	3.8
2	Cougn ar Zac'h 2	Santec	Shoreline	Iron Age	5	1.2	3.4
3	Beg ar Bilou	Santec	Shoreline	Bronze Age	5	2.4	2.6
4	Roc'h Croum	Santec	Island	Iron Age	4.2	1	3.2
5	Roc'h Santec	Santec	Island	Iron Age	3	1.2	1.6
6	Enez Glaz	Santec	Island	Indeterminate	2.4	1.8	0.6
7	Dossen	Santec	Shoreline	Neolithic	4	1.6	2.4
8	Corn ar Loa	Santec	Shoreline	Roman	4.8	1.2	3
9	Staol	Santec	Shoreline	Iron Age	5.4	1.2	4.2
10	Sieck 1	Santec	Island	Palaeolithic	4.4	1.4	3
11	Sieck 2	Santec	Island	Mesolithic	4.8	1.4	3.4
12	Tevenn	Plougoulm	Shoreline	Mesolithic	3.6	2	1.6
13	Plage	Saint-Jean-du-Doigt	Shoreline	Iron Age	5.6	1.2	4.4
14	Plage	Plougasnou	Shoreline	Iron Age	5.2	1.2	4
15	Pen ar Bez	Landéda	Intertidal	Neolithic	4.2	1.6	2.6
16	Ile Stérec	Plouezoc'h	Shoreline	Roman	4.2	3.4	0.8
17	Iles de Trévorc'h	Saint-Pabu	Island	Iron Age	3.4	1.6	1.8
18	Ile du Bec	Lampaul-Ploudalmézeau	Island	Iron Age	4.6	1	3.6
19	Letty	Bénodet	Shoreline	Iron Age	5	1.2	3.8
20	Goudoul	Plobannalec-Lesconil	Shoreline	Mesolithic	5	1.2	3.8
21	Grève Blanche	Ile de Batz	Shoreline	Neolithic	4.6	1.2	3.4
22	Penn ar C'hleguer	Ile de Batz	Shoreline	Bronze Age	4.2	2.2	2
23	Kefenn	Ile de Batz	Shoreline	Iron Age	4.8	1.8	3
24	Porz Carn	Penmarc'h	Shoreline	Mesolithic	4.6	1.2	3.4
25	Moulin Rive	Locquirec	Shoreline	Iron Age	5.8	1	4.8
26	Gouffre	Plougrescant	Shoreline	Iron Age	4.8	2.8	2
27	Pors Hir	Plougrescant	Shoreline	Iron Age	5.6	2	3.6
28	Ile Coalen	Lanmodez	Intertidal	Neolithic	3.6	1.2	2.4
29	Ile Tanguy	Trégastel	Island	Neolithic	3	2.8	0.2
30	Beg Crec'h ar Men	Pleumeur-Bodou	Shoreline	Iron Age	4.2	2.4	1.8
31	Enez an Erc'h	Pleumeur-Bodou	Intertidal	Neolithic	2.8	2.2	0.6
32	Enez Vihan	Pleumeur-Bodou	Island	Iron Age	3	1.6	1.4
33	Ile d'Aval	Pleumeur-Bodou	Intertidal	Neolithic	3.2	1.4	1.8
34	Ile d'Aval	Pleumeur-Bodou	Intertidal	Indeterminate	4.4	1.6	2.8
35	Run ar Gam	Trébeurden	Shoreline	Neolithic	2.8	3.6	-0.8
36	Runigou	Trébeurden	Intertidal	Neolithic	3.2	1.6	1.6
37	Toenno	Trébeurden	Intertidal	Neolithic	3.8	1.2	2.6
38	Kermarrec	Groix	Shoreline	Iron Age	4.6	1.2	3.4
39	Pointe des Saisies	Groix	Shoreline	Iron Age	4.4	2.2	2.2
40	Pointe des Chats	Groix	Intertidal	Neolithic	2.8	2.8	0
41	Port Melite	Groix	Shoreline	Iron Age	4.6	2	2.6
42	Camp des gaulois	Groix	Shoreline	Iron Age	4.8	1.8	3
43	Port Blanc	Hoedic	Shoreline	Iron Age	5.4	1	4.4
44	Sterflant	Hoedic	Shoreline	Iron Age	4.2	2.6	1.6
45	Men Rond	Hoedic	Shoreline	Modern	4.2	1.6	2.6
46	Fort des Anglais	Hoedic	Shoreline	Indeterminate	2.8	2	0.8

the rate of loss at a site with great accuracy (López-Romero *et al.* 2016; Chapter 8, this volume) and can also reconstruct the original extent of prehistoric occupation before sea level rise. Repeated surveys of the site over the coming years will allow analysis of the effects of winter storms.

Discussion

Coastal archaeological sites are facing dangers from violent storm surges and anthropogenic pressure. The threats are not new, but there is mounting evidence that climate change is causing an increase in the frequency and intensity of storm events, with harmful consequences for vulnerable heritage (World Heritage Centre 2009).

In Brittany, tests of the assessment of coastal archaeological vulnerability confirmed that the VEF is an appropriate tool for monitoring the coastal record in different contexts. Although the analysis is currently limited to 46 locations, representing a small sample of coastal sites in Brittany, the widespread distribution of these sites along the shore of the region and the diversity of geomorphological contexts allows us to present some conclusions. These will be supplemented by periodic repeat archaeological surveys in order to increase the variability and accuracy of the results.

For each of the 46 sites, a vulnerability score has been calculated, based on values relating to the threat, resistance and vulnerability of each site, as determined from the individual observation sheet database (Table 9.2). The vulnerability score (A minus B) ranges from -0.8 to 4.8 points with an average value of 2.49. The analysis of the vulnerability scores of these 46 sites enabled us to determine three ranks of sites/scores: low vulnerability (-0.8 to 1.1), medium vulnerability (1.2 to 3.1) and high vulnerability (3.2 to 4.8). These results have been integrated into a graduated symbol vulnerability map (Fig. 9.4). Such a vulnerability rank can be helpful in the creation of cultural heritage management policies (thus integrating administrators, local entities, associations, land owners and others), so it is essential to ensure that the output is visually striking and simple to understand. The spatial distribution of dots on the vulnerability map shows that the majority of high-vulnerability values are in western Brittany (Finistère), and 17 of the 27 sites recorded here score higher than the average value. All are located on the shoreline and they score high values for weathering, low values for resistance, and none are legally protected. These high score values are partly the result of a significant retreat of the coastline in this area, and Finistère was the area of Brittany where the impact of the winter storms in 2013–14 was strongest.

The factors threatening coastal heritage mainly result from natural processes. Although the study region features different types of shoreline environments, the most significant damage to archaeological heritage corresponds to sites located along or embedded within soft coastal cliffs and sandy dunes. Winds, waves and salt spray strongly affect the remains, and the structures are destabilised by accelerated cliff retreat due to sea level rise and erosion.

Conclusion

Recent interest in the erosion of coastal archaeology in North-West and Western Europe (France, Ireland, UK, Norway and Spain) demonstrates the potential for international collaborative programmes and the development of common strategies. To date, questions about the effects of coastal erosion on archaeological heritage in France have been delegated to regional authorities. The development of a rescue strategy for coastal archaeology should be an important priority at a national level. We hope that discussion with the Ministry of Culture will lead to new strategies in the future.

Public response to coastal heritage loss has been very positive, but the use of the ALeRT App by the public should be further developed. More training in using the technology has to be undertaken to enhance citizen involvement in coastal heritage conservation issues, and also to integrate young students in vulnerability assessment. It should be noted that the public response to the collaborative project was not always positive, and some experienced volunteers were worried that publicising sites may lead to looting, and therefore preferred not to share their discoveries. This means that new communication campaigns are necessary. During the pilot project, we started to lay the foundations for long-term collaboration between archaeologists and non-professionals. Similar experiences in France (*e.g.* LITAQ project, Université de Bordeaux, http://litaq.huma-num.fr/) have shown that deeper collaborations between teams working with coastal environments are necessary in order to alert national authorities to the importance of developing a national strategy with dedicated funding.

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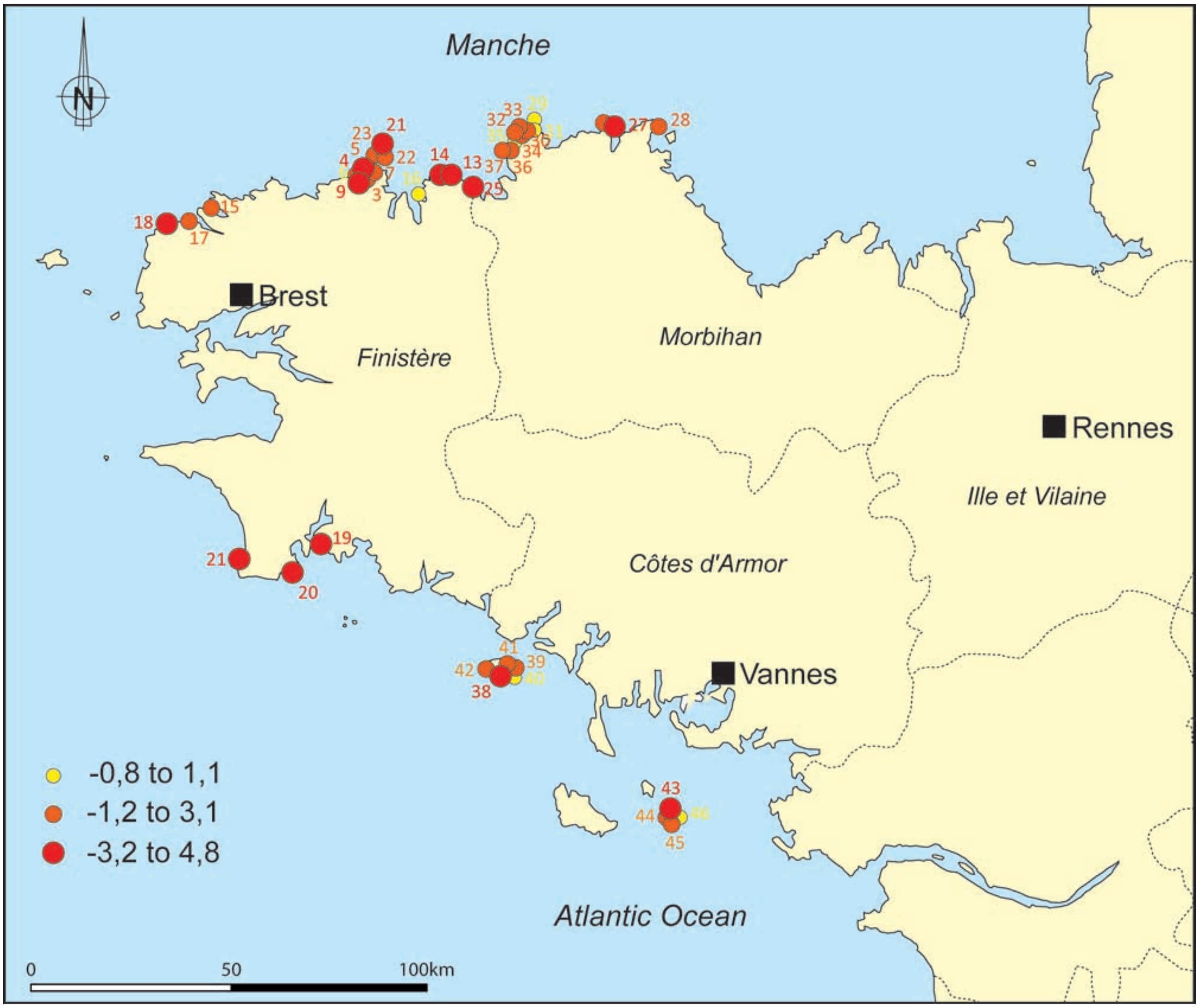

Figure 9.4. Simplified vulnerability map of the archaeological sites of Brittany, as determined in 2014.

References

Ayán Vila, X. and López-Romero, E. 2014. Unha viaxe á Artabria: valoración arqueolóxica e patrimonial da franxa litoral este do golfo Ártabro. In V. Alonso, A. R. Colmenero and A. Goy (ed.), *El golfo Ártabro. Fragmentos de historia litoral y patrimonio*, 17–151. Coruña, Universidade da Coruña.

Barreau, J. B., Sachet, M., López-Romero, E., Daire, M.-Y. and Olmos, P. 2013. ALERT Mobile: managing coastal archaeological heritage in Western France. In *2013 Digital Heritage International Congress*, 611–14. Marseille, Institute of Electrical and Electronics Engineers.

Daire, M.-Y. (ed.) 2011. *Sur les rivages de la Manche ... Le site de l'âge du Fer de Dossen Rouz à Locquémeau-Trédrez (Côtes d'Armor)*. Rennes, Les Dossiers du Centre Régional d'Archéologie d'Alet.

Daire, M.-Y., López-Romero, E., Proust, J. N., Regnauld, H., Pian, S. and Shi, B. 2012. Coastal changes and cultural heritage (1): Assessment of the vulnerability of the coastal heritage in Western France. *Journal of Island and Coastal Archaeology* 7(2), 168–82.

Fraser, S. M., Gilmour, S. and Dawson, T. 2003. Shorewatch: Monitoring Scotland's coastal archaeology. In T. Dawson (ed.), *Coastal Archaeology and Erosion in Scotland*, 197–202. Edinburgh, Historic Scotland.

Fulford, M., Champion, T. and Long, A. 1997. *England's Coastal Heritage*. English Heritage Archaeological Report 15. London, English Heritage/RCHME.

Kelly, B. and Stack, M. (eds). 2009. *Climate Change, Heritage and Tourism: Implications for Ireland's Coast and Inland Waterways*. Kilkenny, The Heritage Council of Ireland Series.

Le Goff, J. C. and Roué, D. 1999. Inventaire archéologique du littoral de la commune de Santec. *Bulletin de l'AMARAI (Association Manche Atlantique pour la Recherche Archéologique dans les Îles)* 12, 5–28.

López-Romero, E., Ballesteros-Arias, P., Daire, M.-Y. and Güimil-Fariña, A. 2012. Les îles atlantiques de Galice (NW Ibérique):

archéologie et vulnérabilité. *Bulletin de l'AMARAI (Association Manche Atlantique pour la Recherche Archéologique dans les Îles)* 25, 5–17.

López-Romero, E., Daire, M.-Y., Proust, J. N., Regnauld, H., Pian, S. and Schaeffer, E. 2013. Le projet ALERT: une analyse de la vulnérabilité du patrimoine culturel côtier dans l'Ouest de la France. In M.-Y. Daire, C. Dupont, A. Baudry, C. Billard, J. M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment Along the European Atlantic Coasts*, 127–36. Oxford, British Archaeological Reports International Series 2570.

López-Romero, E., Mañana-Borrazás, P., Güimil-Fariña, A. and Daire, M.-Y. 2016. Archaeology and coastal erosion: Monitoring change through 3D digital techniques. In H. Kamermans, W. De Neef, C. Piccoli, A. Posluschny and R. Scopigno (eds), *The Three Dimensions of Archaeology. Proceedings of the XVII UISPP World Congress (1–7 September, Burgos, Spain)*, 89–97. Oxford, Archaeopress.

Olmos, P., López-Romero, E., Daire, M.-Y. and Barreau, J. B. 2014a. De nouveaux outils d'observation et de gestion du patrimoine littoral de Bretagne. In A. Henaff (ed.), *Connaissance et compréhension des risques côtiers: Aléas, Enjeux, Représentations, Gestion, actes du colloque international (Brest, 3–4 juillet 2014)*, 234–43. Brest, Université de Bretagne Occidentale.

Olmos, P., Daire, M.-Y., Monrós, M. and López-Romero, E. 2014b. Littoral Breton Prospection Alert. Unpublished report, Rennes.

Shi, B., Proust, J. N., Daire, M.-Y., López-Romero, E., Regnauld, H. and Pian, S. 2012. Coastal changes and cultural heritage (2): An experiment in the Vilaine estuary (Brittany, France). *Journal of Island and Coastal Archaeology* 7(2), 183–99.

World Heritage Centre. 2009. *Case Studies on Climate Change and World Heritage*. Paris, UNESCO.

Chapter 10

Climate change and the preservation of archaeological sites in Greenland

Jørgen Hollesen, Henning Matthiesen, Christian Koch Madsen, Bo Albrechtsen, Aart Kroon and Bo Elberling

Abstract

Archaeological remains can be extremely well-preserved in the Arctic compared to other regions. However, the climate is changing at an alarming rate, accelerating the degradation of archaeological sites. Here we present our ongoing work on understanding the effects of climate change on the preservation of archaeological sites in Greenland. Since 2009 we have investigated preservation conditions and mapped the different threats at a number of archaeological sites located within different climatic zones of southern and western Greenland. Some threats are very visible, such as coastal erosion or changes to vegetation, while others, such as the thawing of permafrost and the gradual microbial deterioration of remains, are less spectacular and may escape attention. Our work shows that it is necessary to consider both types of change in order to evaluate the long-term preservation potential of the sites. At present, it is impossible to predict where and when preservation conditions may worsen. With thousands of sites spread out across one of the most remote areas of the world, the Greenland National Museum and Archives is facing an enormous challenge that requires new methods for locating and managing sites at risk. In our new project, 'REMAINS of Greenland' we focus on developing new models and tools that can be used to pinpoint the most vulnerable areas and thereby help to prioritise and optimise future archaeological investigations.

Introduction

Archaeological sites in Greenland represent an irreplaceable record of unusually well-preserved material remains covering over 4000 years of human history. Sparse populations have limited the human impact on (and possible destruction of) heritage sites. At the same time, a combination of low temperatures and favourable moisture conditions (dry/waterlogged) have limited natural decay, and finds of well-preserved organic materials, such as wood, bone, textile, fur and ancient DNA have been relatively common (Hansen *et al.* 1991; Berglund 2000; Østergaard 2004; Rasmussen *et al.* 2010; Grønnow 2012). Out of the 5500 archaeological sites currently registered in the Greenland Heritage Database, only a very few have been excavated, and it is anticipated that thousands of sites are awaiting discovery in unexplored parts of the country. Thus, archaeological sites in Greenland have a great potential to reveal further spectacular finds and provide novel contributions to our knowledge of the history of both Greenland and the Arctic.

However, it may be only a matter of time before this potential diminishes. The Arctic is warming twice as fast as the global average (IPCC 2013; Schuur *et al.* 2015) with great consequences for organic preservation at archaeological sites. It is therefore urgent to identify, characterise and classify the different threats posed by climate change and to get an overview of where the problems are most urgent in order to prioritise future archaeological investigations. Since 2009, the National Museum of Denmark, the Greenland National Museum and Archives (NKA) and the University of Copenhagen have collaborated in several research projects in order to understand the basic risks currently facing Greenland's heritage sites (Elberling *et al.* 2011; Knudsen *et al.* 2014; Matthiesen *et al.* 2014a). The overall aims of the work are to advance the basic understanding of how climate change can influence the preservation of archaeological sites and organic artefacts, and to develop research-based management tools for locating sites at risk. In this chapter, we give examples of the most important climate change threats to archaeological sites in Greenland and present the main methodologies used in our research projects. Furthermore, we discuss the main results obtained so far and present our future research plans.

Archaeology in Greenland

Greenland (*Kalaallit Nunaat* in Greenlandic) is located between 59° and 83°N, and 11° and 74°W. The total land area is approximately 2,166,086 km^2, of which 80% is covered by the Greenland Ice Sheet (Cappelen *et al.* 2001). Human settlement in Greenland, from the arrival of the first humans *c.* 2400 BC to the present-day Inuit (population *c.* 66,000), has concentrated on the narrow strips of ice-free land along the coast, whereas inland regions have mostly been exploited during seasonal hunts (*e.g.* Grønnow *et al.* 1983; Grønnow 2009). This overall settlement pattern reflects a deep dependence on the richness of the Arctic marine ecosystem, which characterises all the cultures ever to have occupied Greenland. Whether the Stone Age Paleo-Eskimo cultures from *c.* 2400 BC–AD 1300 (Independence I, Saqqaq, Dorset, Independence II, Late Dorset), the medieval Norse farmer-hunters (*c.* AD 985–1450), the expert hunters and whalers of the Thule Culture (*c.* AD 1200–1900) or the European whalers and colonists of more recent history, the seas and fjords have always provided a mainstay of human livelihood, communication, trade and transport (*e.g.* Sandell and Sandell 1991; Ross 1993; Gulløv 2004; Meldgaard 2004; Arneborg *et al.* 2012).

It is therefore no surprise that the vast majority of the 5500 archaeological sites presently registered in the heritage database of the Greenland National Museum and Archives lie relatively close to the sea, the only real exception being the inland caribou areas in West and South Greenland, a place where some of the Norse also settled for a few hundred years (*e.g.* Roussell 1941; Vebæk 1943; Berglund 2000). The heritage sites have been registered over a period of more than 200 years and reflect all aspects of changing livelihoods (and climatic conditions) in the Arctic. Sites range from features related to the hunt (*e.g.* drive systems, traps, shooting blinds, meat caches), transport and communication places (*e.g.* landing sites, boat houses, cairns, *umiaq* (Inuit for a woman's boat) supports), permanent settlements (*e.g.* turf- and stone-built winter houses, Norse farms and outbuildings), brief summer occupation sites (*e.g.* summer camps, Norse shielings *etc.*), features related to life and death (*e.g.* historic place names, graves), and even remains associated with historic power politics (weather stations, military bases *etc.*).

The archaeology of Greenland has provided some highly spectacular finds that provide unique insights into Greenland's cultural history. Among the almost iconic finds are the artistic ivory carvings of the Dorset culture (Fig. 10.1a; Betts *et al.* 2015); the hair of a 4000 year old Saqqaq culture male that allowed, for the first time ever, the decoding of a whole prehistoric genome (Rasmussen *et al.* 2010); the Norse burials at Ikigaat/Herjolfnæs that have provided the largest existing find of everyday European medieval clothes (Fig. 10.1b; Nørlund 1924; Østergaard 2004); the freeze-dried Qilatqitsoq mummies that have perfectly preserved clothing and tattoo styles of pre-Colonial 15th century Thule Culture Inuits (Fig. 10.1c; Hansen *et al.* 1991); and the near complete *umiaq* that lay preserved on the ground at Herlufholms Strand (Fig. 10.1d; Knuth 1951).

Climatic conditions in Greenland

The overall climate in Greenland is Arctic but with a pronounced north/south (cold/warm) gradient in air temperatures, *e.g.* in 2015 the mean annual air temperature at Station Nord in Northeast Greenland was -15.2°C compared to -0.8°C in Qaqortoq in Southwest Greenland (Danish Meteorological Institute 2016). The climatic conditions may vary significantly within relatively small areas depending on the distance to the ice sheet and the sea (Fig. 10.2). Furthermore, local climatic conditions may have a significant influence on both the surface conditions (vegetation and snow cover) and on the conditions in the soil environment (soil temperatures and water content). Thus, archaeological sites located within the same region may be exposed to very different environmental conditions.

Permafrost is found in most parts of Greenland. In the northern parts of the country, the permafrost is characterised as 'continuous permafrost' meaning that it is found extending over more than 80% of the ice-free land area. Further south, the permafrost becomes sporadic and discontinuous (30–80% of the land area) meaning that the permafrost is only in organic-rich wetlands, organic archaeological deposits, in areas with deep, insulating snow cover or in mountainous regions.

Climate change and threats to archaeology

Air temperatures have been increasing quite dramtically in Greenland for the last 20 years, and it is predicted that the mean annual air temperature in 2100 will be 4.0° to 7.0°C warmer than the 1961–1990 mean (Elberling *et al.* 2011). In addition, precipitation patterns are expected to change (IPCC 2013). Permafrost thaw is one of the consequences of a warming climate in Greenland (Hollesen *et al.* 2011; Schaefer *et al.* 2011). The increasing thickness (depth) of the active layer (the upper part of the soil that thaws each summer) is exposing long-frozen deposits to

Figure 10.1. Some of the extraordinary archaeological finds from Greenland: a) Carved figures of bone (Thule, Dorset culture); b) Preserved textiles (Ikigaat, Norse culture); c) human remains (Qilakitsoq, Thule culture); and d) 15th century Thule Culture umiaq *(Inuit for 'women's boat') just after its discovery in 1949, when the layer of covering snow had been brushed off, Herlufsholm Strand, Northeast Greenland. Photos: National Museum of Denmark.*

accelerated erosion, wet/dry and freeze/thaw cycles and microbial activity. This may expose hitherto well-preserved archaeological layers and artefacts to accelerated chemical and physical degradation (Hollesen *et al.* 2015). Increasing temperatures and favourable growing season conditions also lead to more and denser vegetation with deeper roots (Epstein *et al.* 2012; Henry *et al.* 2012) that not only impact the surface energy balance, the nutrient cycling and soil hydrology but may also cause physical damage to buried artefacts and destroy site layering and stratigraphy (Cox *et al.* 2001; Tjelldén *et al.* in press). Changing precipitation patterns can have multiple effects, for example, an increase in precipitation and more melt water from snow, can lead to increased erosion, whereas less precipitation may cause drying of the ground and an increase in the amount of oxygen that diffuses into the ground, impacting the microbial decomposition of organic materials (Hollesen and Matthiesen 2015; Matthiesen *et al.* 2015). Finally, rising sea levels present a great threat for the many archaeological sites located close to the coast, due to the risk of coastal erosion. The overall impact of an increased sea level is expected to vary from region to region, and in areas with a recent thinning of nearby ice sheets and glaciers, relative sea level change at a local scale may be strongly influenced

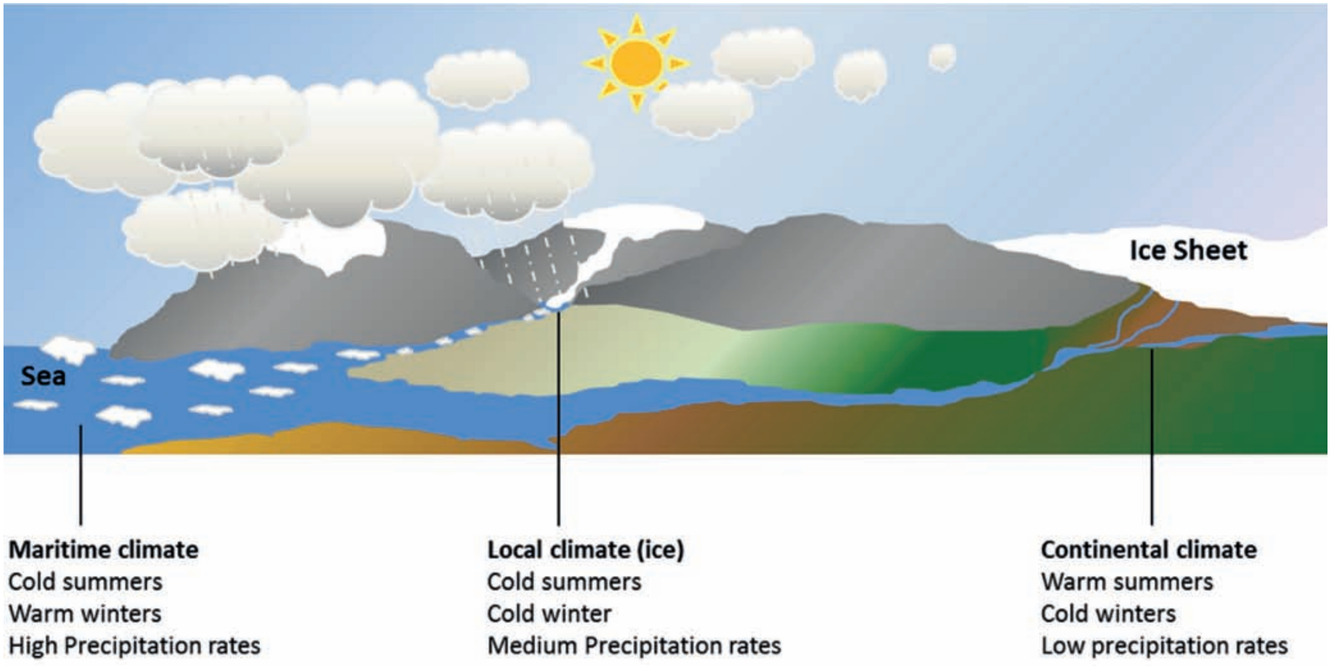

Figure 10.2. Some of the regional climatic variations found in Greenland: from maritime to continental climate and from lowlands to highlands.

Figure 10.3. Pictures from the Qajaa site: a) The midden covers an area of approx. 2900 m² and consists of five separate units which are believed to be the remnants of one single unit. In 2009, monitoring equipment was installed at various depths and was connected to a weather station with a datalogger (Photo: Jørgen Hollesen, National Museum of Denmark). b) The midden at Qajaa is up to 3 m thick and contains remains of the Saqqaq, Dorset and Thule cultures (Photo: Jesper Stub Johnsen, National Museum of Denmark).

by crustal uplift. However, erosion rates are expected to be most dramatic in areas with sedimentary coastlines, and this will further depend on local factors such as wave dynamics, sea ice cover, and the presence of protective dunes or gravel ridges.

Investigations of archaeology and climate change

Between 2009 and 2014, a monitoring and research project was carried out at Qajaa in the Disko Bay area in West Greenland. Qajaa is a key site for the understanding of the prehistory of Greenland. The metre-thick midden layers represent 4000 years of history and contain relics from three different cultures immigrating from the north (Fig. 10.3). Permanently frozen conditions have ensured the excellent preservation of organic artefacts in the midden and even after 4000 years, they look almost pristine (Matthiesen *et al.* 2014b). The purpose of the project at Qajaa was to investigate current preservation conditions through field and laboratory measurements and to evaluate possible threats to the future preservation of the site. Attention was especially given to the relationship between temperature and microbial degradation of organic deposits. The results show that wooden artefacts preserved for more than 4000 years in the permafrost, but exposed to summer thaw following an archaeological excavation in 1982, are now markedly degraded (Matthiesen *et al.* 2014b). Laboratory experiments show that oxic decay (due to the presence of oxygen) of both organic archaeological soils and wooden artefacts is temperature-dependent, with rates increasing 10–15% for each one degree of warming (Hollesen *et al.* 2012; Matthiesen *et al.* 2014b). The microbial decay of the organic and nutrient rich archaeological material produces great amounts of heat which may act as an important positive feedback mechanism that further enhances permafrost thawing and the speed at which organic materials are lost (Hollesen *et al.* 2015). The measured decay rates have been combined with on-site monitoring data in a numerical computer model in order to assess the future thawing and decay of the kitchen midden (Hollesen *et al.* 2015). The model results show that great parts of the midden may thaw within the next century, resulting in a significantly negative effect on the preservation conditions. The results suggest a critical shift from a first phase of relatively slow permafrost thaw, driven by climate change and low heat production, to a second phase of accelerated permafrost thaw, when water is drained and increasing oxygen availability markedly triggers a higher internal heat production. If this tipping point is reached, the heat production can accelerate the decomposition processes and cause the impact of climate change to be significantly enhanced.

A preliminary decay study on samples from two sites in the Nuuk region and from one site in South Greenland indicates that archaeological deposits without permafrost may likewise be highly vulnerable to changes in temperature and soil moisture and also hold the capacity to produce significant amounts of heat. In 2005, the Vatnahverfi-Project was initiated in Tasikuluulik/Vatnahverfi, South Greenland, in order to describe regional settlement patterns, economics, and dynamics in a core Norse settlement area (Madsen 2014). Part of the planned project was the excavation of Norse middens, where excellent preservation conditions for organic materials had been reported around the time of the Second World War (Vebæk 1943; 1992; unpublished field notes in the archives of the National Museum of Denmark). However, test trenching and coring at some of these sites revealed that the state of preservation was so poor that only bone-mush was left. This spurred a programme of systematic test coring of Norse middens across the entire region, during which approximately 90 middens were investigated. Only five of the sites produced well-preserved organic finds, whereas the rest had little or no preservation of organic materials (*e.g.* Arneborg *et al.* 2008; Madsen *et al.* 2009). Following this, nine Thule Culture graves were inspected in South Greenland, where organic materials (mummies, kayaks, hunting implements *etc.*) were reported as late as the 1970s (Mathiassen and Holtved 1936; O. Bak pers. comm. 1967–72; unpublished field notes at the National Museum of Denmark and the Greenland National Museum and Archives). However, the new fieldwork revealed that little or no organic material had survived.

An additional threat, as mentioned above, is that most heritage sites in Greenland are located close to the sea. This makes them especially susceptible to destruction by relative sea level rise, storm surges and coastal erosion. In fact, Greenland is where some of the first scientific reports on such threats to heritage sites were first produced. For example, in 1779, A. Arctander – one of the earliest archaeological surveyors in Greenland – noted that a well-built Norse ruin, located on a small cliff in the Igaliku Fjord, South Greenland was almost completely flooded at high tide; the surveyor deduced that the building had been used for storing fishing and boating implements (Arctander 1793). Some 80 years later, the early scholar C. Pingel was inspired by the same ruin, noting that such an exposed setting to the sea was not a singular occurrence, but could in fact be observed all along Greenland's west coast, which he documented and reported systematically in a paper entitled 'On the lowering of Greenland's west coast' (Pingel 1841, 353).

Although the isostatic and eustatic developments of Greenland's topography have proven extremely complex due to the great dynamics of the Ice Sheet, more recent scientific research has been able to confirm C. Pingel's observations of a relative sea level rise over the last *c.* 1000 years (*e.g.* Sparrenbom 2006; Mikkelsen *et al.* 2007). In contrast, investigations of Paleo-Eskimo sites further north have provided incontestable evidence of an extensive relative sea level decrease, facilitating the beach ridge archaeology that has been key to identifying the chronology of Greenland's prehistory (Knuth 1967; Gulløv 2004). However, while the rate of relative sea level rise may be debated, the ongoing erosion of heritage sites is an indisputable fact that can be observed in many parts of the country (Fig. 10.4a).

In 2012–13 a survey was carried out in the Nuuk region to get a broader overview of the different climate induced threats to archaeological sites (Knudsen *et al.* 2014). The purpose of the survey was to identify threats at different site types located in different environmental settings and to develop and test methods for assessing the vulnerability of sites. The project was based on a combination of rapid surveys and longer site visits. During the project, 30 archaeological sites were visited and described in terms of archaeological significance, state of preservation, and threats to the site. For each site, all available information from previous visits and excavations was collected in order to evaluate the previous state of preservation. A dramatic increase in the natural vegetation cover was observed at several inland sites (Fig. 10.4b) with signs of roots causing physical damage to ruins and buried artefacts and disturbing the site stratigraphy. Human induced changes in vegetation were also observed, and small allotments had been established at some of the nutrient rich archaeological sites, confirming that small-scale farming may become a threat to the archaeology, even at these high latitudes. Finally, the survey demonstrated that sites were not only threatened by coastal erosion but also by fluvial erosion, melt water and soil movement due to freeze-thaw processes.

Methodologies applied

The work in Greenland has been based on a combination of different methods: air photos, satellite images, old maps, previous archaeological surveys and historic photos have been used to detect and quantify recent changes to sites. Small archaeological excavations have been undertaken at study sites in order to evaluate the present state of preservation and to collect soil samples and artefacts for laboratory investigations. During field visits, measurements are taken of pH, depth to permafrost, soil water content, and soil oxygen content at each site. In order to understand the present environment and to study seasonal and year-to-year variations, it is also important to monitor the environmental conditions at sites over longer time periods (Fig. 10.3). Detailed environmental monitoring has been carried out at four sites in Greenland, with measurements taken including meteorological conditions, snow cover, soil thermal properties, soil temperatures and soil water contents. At Qajaa, variations in the snow cover and vegetation cover have been investigated based on pictures taken by an automatic camera every 6 hours over a period of two years.

The physical and chemical conditions within the different archaeological deposits have been investigated through obtaining depth-specific soil bulk samples and volume specific samples. These allow the testing of soil porosity, loss on ignition (LOI), total organic carbon content (TOC), and carbon to nitrogen (C/N) ratios, all of which are important measures in order to understand both the water holding capacity and degradability of the deposits. One of the key parameters controlling the deterioration of archaeological material is oxygen. Its presence, or absence, has a huge effect on the microorganisms and processes that affect deterioration. In recent years, the team has focussed on developing methods to evaluate and quantify ongoing decay in organic archaeological deposits (Matthiesen *et al.* 2014b; Hollesen and Matthiesen 2015; Hollesen *et al.* 2015).

The role that non-professionals play in Greenland

Although sometimes unrecognised in the final academic publications, local informants and observers have always been important to archaeologists working in Greenland. Thus, a large portion of the heritage sites registered in the Greenland National Museum and Archive database were pointed out to visiting researchers by the Inuit hunters and farmers actively using the landscapes (*e.g.* Bruun 1917; Mathiassen 1927). Indeed, a good number of heritage sites in the database have only been recorded through oral information and have neither been investigated archaeologically, nor visited by archaeologists since their initial recording. Besides identifying the location of sites, local informants have often provided information on the use of sites, as well as social and cultural traditions and stories associated with them.

While such information has often only been summarily published (much is preserved only in archived field journals at the Greenland National Museum and Archive or the National Museum of Denmark), research in Greenland has a long tradition for 'participatory-' or 'community-based mapping' and several projects are ongoing (Climate and Society in Greenland 2016; Inuit Pinngortitarlu 2016). Initiating archaeological surveys by informally interviewing locals is also standard practice at the Greenland National Museum and Archive, and was carried out more systematically during a survey in the Nuuk region from 2012–13 (Fig. 10.5) (Knudsen *et al.* 2014). Relying on local informants and participants for the mapping and monitoring of heritage sites has seen commendable use and progress elsewhere (*e.g.* Dawson 2015; this volume), and it is our aim to use the new REMAINS of Greenland project (described below) as a platform for further exploring community inclusion in heritage management strategies, thus helping to support the limited staff at the Greenland National Museum and Archive in their enormous challenge of monitoring enormous and remote geographical areas.

Figure 10.4. a) Cultural layers and building stones of an eroding Norse byre/barn spilling onto the beach at Kangerluarsorujuup Qinngua, South Greenland (Photo: Christian Koch Madsen 2006). b) In 1937, archaeologist Roussell visited several Norse ruin groups in the Austmannadal at the head of the Ameralik fjord in the Nuuk area and described the landscape as 'easily accessible' and dominated by grass. In 2012, parts of the valley and Norse remains were completely overgrown by meter high willow (Upper photo, from Roussell 1941; lower photo: Henning Matthiesen, National Museum of Denmark).

Figure 10.5. An interview situation at the old peoples home in Qeqertarsuatiaat in advance of an archaeological survey in 2012 (Photo: Peter A. Toft, National Museum of Denmark).

Future work

Built on the experiences from previous collaborative projects, the National Museum of Denmark, the Greenland National Museum and Archive and the Center for Permafrost (CENPERM; http://cenperm.ku.dk/) at the University of Copenhagen have initiated a new research project, REMAINS of Greenland. The project runs from 2016–19 and has been initiated as a direct response to the threats that climate change is posing to heritage and to the enormous challenges currently facing the Greenland National Museum and Archive. The overall aims of REMAINS are to:

1. Advance the basic understanding of how climate change influences the preservation of archaeological sites and organic artefacts, and to estimate the rate and magnitude of the destructive impacts.
2. Develop research-based cultural resource management tools for locating sites at risk.
3. Develop strategies for dealing with threatened sites in Greenland.

The project focuses on archaeological sites in the Nuuk region in Southwest Greenland, which is the part of Greenland with the highest density and variety of archaeological sites and where the effects of climate change are already visible. The project involves visits to a number of carefully selected and representative sites. To ensure that the gathered data is comparable between sites and over time, a protocol for site description and sampling is being developed. The protocol:

- will include systematic descriptions of the state of preservation and threats to the site, and allow for preliminary risk assessments to be made in the field;
- will set standards for high precision GPS measurements and Unmanned Aerial Vehicle (UAV) photo documentation of sites;
- is designed to be compatible with the existing NKA heritage site database and online tool; and

- is intended to become a standard that will be used in future archaeological surveys across Greenland.

A Geographical Information System (GIS) risk assessment model will be developed to include coastal erosion, fluvial erosion, periglacial processes, damage from vegetation, as well as decay due to changes in soil temperature and soil moisture content. The impact of threats will be quantified and the likely degree, pattern and rates at which climate change may impact particular areas estimated. Risk assessments will be made for the current conditions and for a selection of future climatic scenarios. The GIS model will be linked to the updated version of the Heritage Database at the Greenland National Museum and Archives with the aim of locating vulnerable hotspots and enabling risk assessments to be made, which will be used as a tool to prioritise future surveys and excavations.

Conclusion

The results obtained so far emphasise that it is urgent that we act now in order to document and manage the archaeological remains in Greenland. At present, it is impossible to predict where and when preservation conditions may worsen. Individual point and site observations of soil temperature and soil water content cannot be carried out at every single site. Thus, methods to upscale from the local to the regional level are needed in order to pinpoint the most vulnerable areas and thereby help to prioritise and optimise future archaeological investigations. Effective management requires the acceptance that not all sites can be saved (Cassar 2005; Murphy *et al.* 2009) and that resources must be guided towards sites of relatively high significance. It is therefore essential to find effective methods to evaluate the significance and potential of sites in order to prioritise those that should be excavated immediately and those that can be saved for future research (when new improved methods and hypothesis can be employed). Excavations are expensive and time consuming, and given the limited resources currently available, it seems inevitable that only parts of the Greenlandic heritage can be saved if the climate continues to change as predicted. Community inclusion in heritage management could help support the limited staff at the Greenland National Museum and Archive in their enormous challenge. Furthermore, in some cases, low-tech remediation actions could be an option to at least slow down the degradation processes. Snow fences could be used to increase the soil water content, soil covers could be used to both insulate the ground surface and buffer against variations in the soil water content, and the backfilling of the many excavation craters left by previous archaeological investigations could prevent erosion and exposure of deeper layers and buried artefacts to atmospheric conditions. It is urgent that work is done to test the efficiency of such actions.

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References

Arctander, A. 1793. Udskrift af en Dagbog, holden i Grønland af Aaron Arctander paa en Rekognoscerings-Reise i Julianehaabs District i Aarene 1777–1779. *Samleren* 6, 1105–242.

Arneborg, J., Hebsgaard, M., Lynnerup, N., Madsen, C. K., Paulsen, C. P. and Smiarowski, K. 2008. Resources, Mobility, and Cultural Identity in Norse Greenland, Vatnahverfi-Project – Report from the Field Work 2008. Unpublished field report. Copenhagen, National Museum of Denmark.

Arneborg, J., Lynnerup, N. and Heinemeier, J. 2012. Human diet and subsistence patterns in Norse Greenland AD *c*. 980–AD *c*. 1450: Archaeological interpretations. In *Greenland Isotope Project: Diet in Norse Greenland AD 1000–AD 1450. Journal of the North Atlantic* Special Volume 3, 119–33.

Berglund, J. 2000. The farm beneath the sand. In W. W. Fitzhugh and E. I. Ward (eds) *Vikings. The North Atlantic Saga*. Washington, Smithsonian Institution Press.

Betts, M., Hardenberg, M., and Stirling, I. 2015. How animals create human history: Relational ecology and the Dorset–Polar Bear connection. *American Antiquity* 80(1), 89–112.

Bruun, D. 1917. Oversigt over Nordboruiner i Godthaab- og Frederikshaab-Distrikter. *Meddelelser om Grønland* 56, 57–147.

Cappelen J., Jørgensen, B. V., Laursen, E. V., Stannius, L. S. and Thomsen R. S. 2001. The observed climate of Greenland, 1958–99 – with climatological standard normals, 1961–90. Copenhagen, Danish Meteorological Institute. Available at: http://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/2000/tr00-18.pdf [accessed 15 February 2016.

Cassar, M. 2005. *Climate Change and the Historic Environment*. London, UCL Centre for Sustainable Heritage.

Climate and Society in Greenland. 2016. http://climategreenland.gl/klimaforskning/samfund.aspx?lang=en and http://marknuttall.com/research/ [accessed 21 March 2016].

Cox, M., Earwood, C., Jones, E. B. G., Jones, J., Straker, V., Robinson, M., Tibbett, M. and West, S. 2001. An assessment of the impact of trees upon archaeology within a relict wetland. *Journal of Archaeological Science* 28, 1069–84.

Danish Meteorological Institute. 2016. Available at: http://www.dmi.dk/groenland/arkiver/vejrarkiv/ [accessed 23 March 2016].

Dawson, T. 2015. Taking the middle path to the coast: How community collaboration can help save threatened sites. In D. Harvey and J. Perry (eds), *The Future of Heritage as Climates Change*, 248–68. London, Routledge.

Elberling, B., Matthiesen, H., Jørgensen, C. J., Hansen, B. U., Grønnow, B., Meldgaard, M., Andreasen, C. and Khan, S. A. 2011. Paleo-Eskimo kitchen midden preservation in permafrost under future climate conditions at Qajaa, West Greenland. *Journal of Archaeological Science* 38(6), 1331–39.

Epstein, H. E., Raynolds, M. K., Walker, D. A., Bhatt, U. S., Tucker, C. J. and Pinzon, J. E. 2012. Dynamics of aboveground phytomass of the circumpolar Arctic tundra during the past three decades. *Environmental Research Letters* 7(1), doi:10.1088/1748-9326/7/1/015506.

Grønnow, B. 2009. Blessings and horrors of the interior: Ethno-historical studies of Inuit perceptions concerning the inland region of West Greenland. *Artic Anthropology* 46(1–2), 191–201.

Grønnow, B., Meldgaard, M. and Nielsen, J. B. 1983. Aasivissuit – The great summer camp. Archaeological, ethnographical and zoo-archaeological studies of a caribou-hunting site in West Greenland. *Meddelelser om Grønland, Man and Society* 5, 5–96.

Grønnow, B. 2012. The backbone of the Saqqaq Culture: A study of the nonmaterial dimensions of the early Arctic small tool tradition. *Arctic Anthropology* 49(2), 58–71.

Gulløv, H. C. 2004. *Grønlands forhistorie*. København, Gyldendal.

Hansen, J. P. H., Meldgaard, J. and Nordkvist, J. 1991. *The Greenland Mummies*. Copenhagen/Nuuk, Christian Ejlers' Forlag/Greenland National Museum.

Henry, G. H. R., Harper, K. A., Chen, W. J., Deslippe, J. R., Grant, R. F., Lafleur, P. M., Levesque, E., Siciliano, S. D. and Simard, S. W. 2012. Effects of observed and experimental climate change on terrestrial ecosystems in northern Canada: Results from the Canadian IPY program. *Climatic Change* 115, 207–34.

Hollesen, J., Elberling, B. and Jansson, P. E. 2011. Future active layer dynamics and carbon dioxide production from thawing permafrost layers in Northeast Greenland. *Global Change Biology* 17, 911–26.

Hollesen, J., Jensen, J. B., Matthiesen, H., Elberling, B., Lange, H. and Meldgaard, M. 2012. The future preservation of a permanently frozen kitchen midden in Western Greenland. *Conservation and Management of Archaeological Sites* 14, 159–68.

Hollesen, J., Matthiesen, H., Møller, A. B. and Elberling, B. 2015. Permafrost thawing in organic Arctic soils accelerated by ground heat production. *Nature Climate Change* 5, 574–78.

Hollesen, J. and Matthiesen, H. 2015. The influence of soil moisture, temperature and oxygen on the oxic decay of organic archaeological deposits. *Archaeometry* 57, 362–77.

Inuit Pinngortitarlu. 2016. http://www.natur.gl/klimaforskningscenter/aktiviteter/samfund/ [accessed: 21 March 2016].

IPCC (Intergovernmental Panel on Climate Change). 2013. Climate Change 2013: The physical science basis exit EPA disclaimer. Contribution of Working Group I. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge/New York, Cambridge University Press.

Knudsen, P. K., Madsen, C. K., Toft, P. A., Matthiesen, H., Hollesen, J., Kroon, A., Møller, A. B., Pedersen, M. W., Allentoft, M., Meldgaard, M., Lennert, A. E., Ledger, P., Møller, K. and Lynge, P. 2014. Unpublished Field report 2012–13 for the pilot project 'People of all times'. Copenhagen/Nuuk, National Museum of Denmark/Greenland National Museum.

Knuth, E. 1951. Et umiak-fund i Pearyland. *Nationalmuseets Arbejdsmark*, 77–87.

Knuth, E. 1967. *Archaeology of the Musk-Ox Way*. École pratique des hautes études-Sorbonne. Sixième section: sciences économiques et sociales. Contributions de Centre d'études arctiques et finno-scandinaves 5. Paris, Sorbonne.

Madsen, C. K., Arneborg, J., Heide, P. B. and Smiarowski, K. 2009. Norse Coastal Farms. Field Report of a Survey in the Southwest 'Vatnahverfi Peninsula' Summer 2009. Unpublished field report. Copenhagen, National Museum of Denmark.

Madsen, C. K. 2014. Norse pastoral farming and settlement in the Vatnahverfi Peninsula, South Greenland. In H. C. Gulløv (ed.), *Northern Worlds: Landscapes, Interactions, Dynamics*. *Proceedings of the Northern Worlds Conference Copenhagen 28–30 November 2012, PNMS 22*, 95–114. Odense, University Press of Southern Denmark.

Mathiassen, T. 1927. *Archaeology of the Central Eskimos. Volumes I–II. Report of the Fifth Thule-Expedition 1921–24*. Copenhagen, Gyldendal.

Mathiassen, T. and Holtved, E. 1936. The Eskimo archaeology of Julianehaab district. *Meddelelser om Grønland* 118(1), 3–141.

Matthiesen, H., Elberling, B., Hollesen, J., Jensen, J. B., and Jensen, J. F. 2014a. Preservation of the permafrozen kitchen midden at Qajaa in West Greenland under changing climate conditions. In H. C. Gulløv (ed.), *Northern Worlds: Landscapes, Interactions, Dynamics*. *Proceedings of the Northern Worlds Conference Copenhagen 28–30 November 2012, PNMS 22*, 383–93. Odense, University Press of Southern Denmark.

Matthiesen, H., Jensen, J. B., Gregory, D., Hollesen, J. and Elberling, B. 2014b. Degradation of archaeological wood under freezing and thawing conditions: Effects of permafrost and climate change. *Archaeometry* 56(3), 479–95.

Matthiesen, H., Hollesen, J., Dunlop, R., Seither, A. and de Beer, J. 2015. *In situ* measurements of oxygen dynamics in unsaturated archaeological deposits. *Archaeometry* 57, 1078–94.

Meldgaard, M. 2004. Ancient harp seal hunters of Disko Bay. *Meddelelser om Grønland, Man and Society* 30, 9–189.

Mikkelsen, N., Kuijpers, A. and Arneborg J. 2007. The Norse in Greenland and late Holocene sea-level change. *Polar Record* 44(228), 45–50.

Murphy, P., Thackray, D. and Wilson, E. 2009. Coastal heritage and climate change in England: Assessing threats and priorities. *Conservation and Management of Archaeological Sites* 11, 9–15.

Nørlund, P. 1924. Buried Norsemen at Herjolfsnes: An archaeological and historical study. *Meddelelser om Grønland* 67(1), 1–270.

Pingel, C. 1841. Om Sænkningen af Grönlands Vestkyst. *Forhandlinger ved de skandinaviske Naturforskeres andet Möde der holdtes i Kjöbenhavn fra dem 3de til den 9de Juli 1840*, 353–63. Copenhagen, Bianco Luno's Trykkeri.

Rasmussen, M., Li, Y. R., Lindgreen, S., Pedersen, J. S., Albrechtsen, A., Moltke, I., Metspalu, M., Metspalu, E., Kivisild, T., Gupta, R., Bertalan, M., Nielsen, K., Gilbert, M. T. P., Wang, Y., Raghavan, M., Campos, P. F., Kamp, H. M., Wilson, A. S., Gledhill, A., Tridico, S., Bunce, M., Lorenzen, E. D., Binladen, J., Guo, X. S., Zhao, J., Zhang, X. Q., Zhang, H., Li, Z., Chen, M. F., Orlando, L., Kristiansen, K., Bak, M., Tommerup, N., Bendixen, C., Pierre, T. L., Gronnow, B., Meldgaard, M., Andreasen, C., Fedorova, S. A., Osipova, L. P., Higham, T. F. G., Ramsey, C. B., Hansen, T. V. O., Nielsen, F. C., Crawford, M. H., Brunak, S., Sicheritz-Ponten, T., Villems, R., Nielsen, R., Krogh, A., Wang, J. and Willerslev, E. 2010. Ancient human genome sequence of an extinct Palaeo-Eskimo. *Nature* 463, 757–62.

Ross, W. G. 1993. Commercial whaling in the North Atlantic sector. In J. J. Burns, J. J. Montague and C. J. Cowles (eds), *The Bowhead Whale,* 511–77. Special Publication Number 2. Lawrence, KS: Society for Marine Mammalogy.

Roussell, Aa. 1941. Farms and churches in the medieval Norse settlements of Greenland. *Meddelelser om Grønland, Man and Society* 89, 3–354.

Sandell, H. T. and Sandell, B. 1991. Archaeology and environment in the Scoresby Sund fjord. Ethno-archaeological investigations of the last Thule culture of Northeast Greenland. *Meddelelser om Grønland, Man and Society* 15, 5–150.

Schaefer, K., Zhang, T. J., Bruhwiler, L. and Barrett, A. P. 2011. Amount and timing of permafrost carbon release in response to climate warming. *Tellus Series B-Chemical and Physical Meteorology* 63, 165–80.

Schuur, E. A. G., McGuire, A. D., Schadel, C., Grosse, G., Harden, J. W., Hayes, D. J., Hugelius, G., Koven, C. D., Kuhry, P., Lawrence, D. M., Natali, S. M., Olefeldt, D., Romanovsky, V. E., Schaefer, K., Turetsky, M. R., Treat, C. C. and Vonk, J. E. 2015. Climate change and the permafrost carbon feedback. *Nature* 520, 171–79.

Sparrenbom, C. J. 2006. *Constraining the Southern Part of the Greenland Ice Sheet since the Last Glacial Maximum from Relative Sea-Level Changes, Cosmogenic Dates and Glacial-Isostatic Adjustment Models*. Lundqua Thesis 56. Department of Geology, Lund University.

Tjelldén, A. K. E., Kristiansen, S. M., Matthiesen, H. and Pedersen, O. 2015. Impact of roots and rhizomes on wetland archaeology: A review. *Conservation and Management of Archaeological Sites* 17(4), 370–91.

Vebæk, C. L. 1943. Inland farms in the Norse East Settlement. *Meddelelser om Grønland, Man and Society* 90(1), 3–119.

Vebæk, C. L. 1992. Vatnahverfi: An inland district of the Eastern Settlement in Greenland. *Meddelelser om Grønland*, *Man and Society* 17, 3–93.

Østergaard, E. 2004. *Woven into the Earth: Textile Finds in Norse Greenland*. Aarhus, Aarhus University Press.

Chapter 11

Gufuskálar: a medieval commercial fishing station in Western Iceland

Lilja Pálsdóttir and Frank J. Feeley

Abstract

Beginning in 2008, rescue excavations at a unique medieval commercial fishing station in the west of Iceland allowed archaeologists to lay the groundwork for collaboration between researchers and local community members. A similar collaboration in the north of Iceland had been successful at not only fostering the community's interest in the past but also leveraging the political power of that community to support continued archaeological research in the area. While the full potential of this partnership has yet to be realised, this paper discusses the archaeological work at the site and the steps taken to initiate this collaboration, as well as our growing involvement in the tourist infrastructure of the region.

Introduction

This chapter presents a project that revolved around the rescue excavation of a critically endangered 15th century commercial fishing station. What follows is a discussion of the site's historical context, excavation, and the steps taken to cultivate a long-lasting and mutually beneficial relationship with the local community. The archaeologists on this project, which include the authors, fostered an integrated partnership between themselves and members of the community in the west of Iceland, following the model of the successful Fornleifaskóli barnanna (The Kids' Archaeology Program) in the north of Iceland (Jóhannesdóttir and Ingason 2009). This model includes a focus on archaeology's role in promoting a dialogue about the past with community members through lectures, roundtable discussions, archaeological site tours, and the introduction of an archaeological module into the school's curriculum. While not a major part of the original programme at Gufuskálar, it was recognised that archaeological sites can have an important role to play in the booming tourist industry in the region, providing an attraction that demonstrates the long history of commercial fishing to the area while educating the public about the problem of coastal erosion.

Historical background

In Iceland around the start of the 15th century a large commercial fishing station was established at a farm called Gufuskálar in the westernmost part of the Snæfellsnes Peninsula (Fig. 11.1). The fishing station consisted of a series of fishing booths or structures, which served as seasonal housing for fishing crews who caught primarily Atlantic cod (*Gadus morhua*) from nearby fishing grounds and processed them into a dried fish product back at the station. Gufuskálar was not the only large commercial fishing operation in Iceland during the 15th century, but was part of a trend responding to a growing demand for dried fish products from European mercantile organisations (Thór 1996). James Barrett's (Barrett *et al.* 2004; Barrett 2016) 9th–11th century 'fish event horizon' in Britain – where marine fish remains begin to show up further inland indicating an increased demand – and Sophia Perdikaris' (1996; Perdikaris and McGovern 2008) proposed system of chiefly provisioning in Arctic Norway – where there are clear signs of early commercial fishing – point to the origins of an eventual North Atlantic-wide trade in preserved marine fish. It is during the 14th and 15th centuries that Mark Gardiner (2016) identifies what he calls 'second-stage commercialisation'. This second stage is marked by the use of large, closed-decked vessels capable of hauling

Figure 11.1. Map of Iceland (inset) and the Snæfellsbær municipality. Modern village names are italicised and the icecap of the glacier Snæfellsjökull and the border of the National Park are outlined.

large cargos over large tracts of open ocean. This is in comparison to first stage commercialisation – a term he uses to characterise the Icelandic fishing operations that used small, open ships and stayed relatively close to the shore.

Historian Björn Þorsteinsson has called the 15th century in Iceland 'The English Age' (Gardiner and Mehler 2007) as it seems that English merchant venture guilds were quite active in both fishing off the shores of Iceland, processing their catch on board their ships and preserving them with salt, as well as trading with local fishers for their air-dried fish (Carus-Wilson 2006). This trade likely began as a casual affair, but the English quickly took root in Iceland and have been credited with the construction of many of the fishing stations, particularly those in the south of Iceland (Thór 1996). However, the English were not Iceland's only trading partners; Dutch merchants, as well as those representing the German-based Hanseatic League, were quite active as well (Gardiner and Mehler 2007).

While these early fishing stations must have been sanctioned by the Icelandic chiefly class, who would have profited from them, there is a later contraction of commercial fishing activities which is somewhat perplexing. It seems as if the entrepreneurial spirit of early 15th century elites gave way to a more conservative view towards international trade (Vésteinsson 2016). The 15th century is still poorly understood as Iceland was experiencing its first brush with Bubonic plague (Hjalmarsson 2007) resulting in Icelandic primary historic sources being scarce. We lack the historical clarity surrounding the 18th and 19th century Icelandic commercial fishing system, and many scholars have uncritically used this later era as a model for 15th century fishing (Edvardsson 2010). Archaeological evidence for big fishing sites is also rare: many of the fishing stations were destroyed as they developed into permanent villages and later into Iceland's first towns, leaving little to no trace of the original structures (Edvardsson 2010). The fishing station at Gufuskálar was abandoned around the 17th century and no town was ever built on top of it, therefore it offers a rare glimpse into a turbulent and pivotal time period in Icelandic history.

The product

The dried fish product produced at fishing stations like Gufuskálar was primarily made from Atlantic cod (*Gadus morhua*). They were targeted because the low oil content in their flesh made them ideal for drying. In a technique imported from Norway, fish could be dried in the open air without the need for salt. It is unclear, however, if this was a universal practice in Iceland. The technique required particular environmental conditions including low humidity and prolonged near-freezing temperatures, which effectively freeze-dried the meat. These environmental prerequisites are met in the area around Gufuskálar during the winter months and these air-drying methods were likely used at the site. The dried fish product then had a shelf life of roughly seven years without the added expense of salt (Perdikaris 1996). Dried fish was a relatively cheap bulk trade good that took advantage of the increased cargo capacity of 15th century ships (Thór 1996) and became an important – if hard to eat – source of protein for many people in Europe (Wubs-Mrozewicz 2009).

While there are a handful of variations in the types of dried fish products, they were all produced in roughly the same manner. Suitably sized Atlantic cod were beheaded and gutted on shore. Their heads were discarded, generating large midden deposits at the production site, which contain a preponderance of cranial osteological elements. Depending on the desired product, the bodies were either split open, spread out and left to dry or were kept 'in the round' and hung in the air to dry. Once dry they were warehoused before being transferred to the purchasing merchant company, probably from a nearby bay, as the Gufuskálar boat landing has a reputation for being difficult and would have likely been intimidating to foreign sailors.

Site description

The farm of Gufuskálar is located along the western coast of the Snæfellsnes Peninsula at the base of the volcanic glacier called Snæfellsjökull (Fig. 11.1). This impressive glacier is well known in classic science fiction circles as Jules Verne's setting for the entrance to the underworld in *Journey to the Centre of the Earth*. The site is within the bounds of the Snæfellsjökull National Park. Geoarchaeological analysis indicates that the farm was founded during the Viking Age (Ian Simpson pers. comm.), and its proximity to rich fishing grounds suggests that the farm was involved, at a minimum, in subsistence fishing, if not in the full Viking Age domestic trade in dried fish products (Perdikaris and McGovern 2008). While the pinnacle of activity at the farm was between the 15th and 17th centuries when it housed the fishing station, the farm was occupied until the mid-20th century when part of it became a NATO radio base.

The site is divided into three main sections. The first section is the farm mound with the remains of numerous farm buildings. While certainly of archaeological interest, the farm mound is not presently under threat from erosion, and government regulations prevent archaeological investigation in parts of the site not under threat. Therefore, our research has been focussed on the fishing station itself; other than surveying the farm mound, little archaeological attention has been given to the farm buildings.

The second section is across the modern road from the farm and consists of fish storage sheds constructed on a lava field (Fig. 11.2). There are approximately 150 of these sheds made out of loose-fitting lava rock, the dry-stone walling containing numerous large voids through which air could pass. While most are in ruins, a few well-preserved examples have a footprint of *c.* 3 m by 7 m and are 2 m tall. There is some discussion as to whether these were used strictly for the storage of dried fish or whether they played a part in the drying process as well. Either way they make use of land that is unsuitable for the grazing of animals or growing of fodder. As with the farm mound, this area has only been archaeologically surveyed, as it is not considered to be under threat from natural forces.

The third section is the fishing station itself, which is positioned right along the coast. At present, it consists of about six fishing booth ruins and associated midden deposits. One historical record from 1465 suggests that there may have been upwards of 14 fishing booths on the property during the 15th century (*Diplomatarium Islandicum*, 444–445), highlighting the serious coastal erosion issue in this area. Associated with the fishing station are two popular tourist attractions which were identified long before the fishing station: the Írskrabrunnur (Irish Well) and Gufuskálavör (Gufuskálar Boat Landing). While the provenance of the Írskrabrunnur is unclear, the boat landing, consisting of deep grooves worn into the stones along the coast by countless boat keels, was likely used during the apex of fishing activities during the 15th century. It was the well-known keel marks at the notoriously dangerous boat landing area together with the fish drying sheds that convinced the Icelandic government to grant official protected status to the site in the 1960s and to incorporate the site into the Snæfellsjökull National Park.

Figure 11.2. A well-preserved fish shed which stands about 2 m high and is made out of loose-fitting lava rock.

Site discovery and excavation

While the fish sheds, Írskrabrunnur, and Gufuskálavör were popular tourist attractions for decades, little recognition was given to the eroding fishing station mounds in close proximity to all three. Despite decades of collecting loose artefacts from the eroding surface, it was not until the 2000s that a concerned villager approached an employee at the national park about the eroding site. The employee then brought this to the attention of Fornleifastofnun Íslands (The Institute of Archaeology, Iceland), which then alerted Minjastofnun Íslands (The Cultural Heritage Agency of Iceland) and surveyed the site and determined that it required protection and research.

In the summer of 2008 archaeologists from Fornleifastofnun Íslands began to clean back the largest erosion scars and record the extent of the site. They found that the site was extremely large, at least 1 km^2, with deep midden deposits. Organic preservation was excellent due to the sandy soil and it was clear that this site warranted further investigation. As with many places in the world it was recognised that coastal erosion was seriously impacting the site, clearly bisecting at least one of the fishing booths. This has been demonstrated by subsequent survey, and since 2009, the archaeologists have measured a loss of 5 m from the coastline in front of the fishing station. Shortly after the initial survey phase, Fornleifastofnun Íslands partnered with archaeologists from the City University of New York and Ian Simpson (Stirling University) through the North Atlantic Biocultural Organization (NABO). From 2011 to 2015 the group carried out extensive excavations at the most endangered portions of the fishing station with funding and assistance from the National Science Foundation (USA), Stirling University (UK), Minjastofnun Íslands (Iceland), The Explorers Club (USA) and Snæfellsjökull National Park (Iceland).

We focussed our excavations on two of the mounds that we felt were most endangered and would yield the most information. The Drottningarhóll, or Queen Mound (Fig. 11.3), is the largest mound on the site. Standing about 4 m high, it had been severely undercut by turbulent winter waters. Here we excavated considerable midden deposits intermixed with multiphase structural remains, including the well-preserved entrance to one of the structures.

We also completely excavated one of the fishing booths which had seen considerable damage from coastal erosion and was additionally under threat of wind erosion (Fig. 11.4). Similar to the Queen Mound, this structure underwent multiple rebuilding periods, and in later phases the building was drastically changed from its original footprint. While the oldest foundations were rectilinear, they later took on a more rounded, organic shape, perhaps as a result of expedient repairs. Aeolian sand deposits between thin floor layers suggest seasonal occupation, and no postholes for a wooden inner framework have been discovered, leaving questions on how these structures were roofed.

Figure 11.3. The erosion face with Drottningarhóll (Queen Mound) on the left and the fishing booth excavation barely visible on the right.

The faunal material recovered from both areas is very well preserved. In total, two tons (*c.* 1814 kg) of faunal material have been recovered and are presently being analysed at Hunter College of the City University of New York. There were also a significant number of artefacts recovered. Some are, as expected, related to fishing, including: iron fish hooks, stone line sinkers, fish hammers, knives, debris from boat repairs, *etc.* There are also many craft, trade, recreational and decorative finds, such as numerous gaming pieces, moulds for copper adornments, imported glass and lead beads, jewellery, and ceramic sherds found in quantities that are rare for 15th century Iceland.

The analysis of the artefactual and faunal remains is still underway, but preliminary results are demonstrating that the people fishing at Gufuskálar were able to access high quality cuts of lamb (Feeley 2012) and expensive imported goods. This suggests that those fishing there – be

Figure 11.4. The fishing booth excavation showing well-preserved walls and the erosion face at the bottom.

they English, Icelandic, or otherwise – were hardly the poor tenant fishers of the 18th and 19th century models of Icelandic commercial fishing.

Public outreach and beyond

The Snæfellsnes Peninsula is a large area with only about 4000 inhabitants, many of who work in the modern fishing industry. The peninsula is also popular with both foreign and Icelandic tourists (Ólafsson and Þórhallsdóttir 2016). Unlike many Icelandic archaeological sites, which are remote or on private property, we had an opportunity to engage with visitors who were originally drawn to the site to visit the fish drying sheds, Írskrabrunnur and Gufuskálavör. As they walked between these, many would stop at our excavation trench and ask questions. Although we were initially focussed on our rescue excavation, we quickly realised that this was an excellent opportunity to engage with the public in a place that strongly demonstrates the damage that coastal erosion can cause to archaeological sites.

In our conversations with these visitors we identified three main categories of stakeholders: 1) general tourists (Icelandic and foreign) who were broadly interested in archaeology; 2) local fishers who were interested in how their work today compares to that in the 15th century; and 3) Icelandic tourists who have roots in the area, but may live elsewhere, and were interested in reconnecting with their ancestry.

After identifying these primary stakeholders, we tried to develop a diverse outreach programme to speak to each group. Our ultimate hope was, and is, to raise awareness about the problem of coastal erosion and the destruction of priceless archaeological sites such as Gufuskálar. Our first task was to let the public know what we were doing, and in addition to a feature in *Archaeology* magazine (Zorich 2012), we actively engaged with Icelandic media outlets. We informed them of recent finds of interest, which generated a number of newspaper articles and TV news stories (Bjarnason 2012; Morgunblaðið 2011a; 2011b; 2014; Skussuhorn 2013; 2014). The Icelandic media is very responsive to stories about the latest artefact finds, and we were able to use this interest to relay our erosion narrative to a national audience. A central part to our narrative is that there is no fixed yearly rate of erosion and that a portion of the coastline that appears stable could see significant damage resulting from a single storm (Dawson 2013). This was, unfortunately, demonstrated during the winter of 2014, when a storm eroded a metre of the Gufuskálar coastline overnight. Our subsequent social media posts garnered the attention of the national press (Morgunblaðið 2014) and helped spark a discussion about how best to preserve Iceland's coastal heritage.

Another outreach activity was site tours, and as mentioned above, Gufuskálar is a common tourist stop. There are parking areas and walking trails for this purpose which led many tourists to pass by our excavation. We encouraged our crews, including the university students, to proactively interact with interested tourists and offer them site tours.

Aside from impromptu site tours we also advertised formal open days during our field season with organised tours of the site and outdoor displays of artefacts, faunal material, and pictures showing the site in various stages of excavation. It was during these open days that we began to interact with local fishers who seemed eager to start a dialogue about fishing. They wanted to compare their methods with those of the past, to know which species were fished and learn about how the fish were processed. Many fishers said that while they knew there were archaeological remains at the site they did not realise that it was a large fishing station; many are now keen to help preserve it. Additionally, not being fishers ourselves, we have learned a lot about commercial fishing from these relationships. We tried to time our open days to coincide with the nearby fishing village's festival, where people who had moved away (usually down to Reykjavik) come up for the weekend for family reunions. Many of these people had personal connections to Gufuskálar and included the descendants of the last farmer to live there and people whose families worked on the NATO base.

To help extend these relationships beyond the site visit and summer fieldwork season we have been active on social media, posting frequent updates during our field season and relevant articles and artefact photos on Facebook (@GufuskalarArchaeology) and the Fornleifastofnun Íslands Instagram (#gufuskalararchaeology). Our growing Facebook presence includes many local followers, as well as other Icelandic people, archaeologists and others from around the world. The comments section has been a great way to continue interacting with people in the nearby villages when we are not in the field. Additionally, as an experiment, we created a geocache related to the site where people are encouraged to find a hidden object (which we ensured was neither buried nor close to the archaeology!) using their GPS units. At the time of writing, over 350 people have visited the site and logged their visit on geocaching.com. While many are visiting the site strictly to find the geocache, our entry on the website acts as a virtual site tour and allows us to present the narrative of the site to people who may not have visited otherwise. An unexpected result of this was that many people attached photos to the log entry of their visit, thereby adding more data and enabling us to monitor the site for erosion damage between field seasons.

Again, in an effort to extend these relationships beyond our summer field season and to develop the interest of permanent residents in archaeology, we have been giving public lectures regarding our work and findings in the local fishing villages. This has greatly increased the dialogue between the archaeologists and local stakeholders.

More than just a one-sided conversation flowing from archaeologists to local villagers, we have entered a two-way relationship, collecting stories and photos of the area from locals and visitors, including those given to us by a woman who, 40 years ago, lived at Gufuskálar and used one of the fishing sheds as her very own doll house. Although her story is much more recent than those that we are trying to learn from the archaeology, it gives us some sense of the link between local people and the site. As with any site, people have been living with the archaeology for a long time and each have their own experience and feelings about it; they bring to the table a different perspective and deepen the interpretation of the archaeology. A site such as Gufuskálar is not isolated, stuck, or frozen in time but is a living place. Its meaning and importance may change through time but its involvement in peoples' lives continues, even when its original purpose is forgotten. This conversation between present and past discoveries holds meaning for the archaeologists working on the site and also for the people who have their own memories and feelings about it. We have found that it has given both parties a deeper appreciation of Gufuskálar and a heightened desire to preserve it.

After a series of these talks, the local elementary schools have begun to integrate our research at Gufuskálar into their curriculum. We hosted the staff of three schools for an extensive tour of the site to prepare the teachers for a class they call *átthagatímar* or 'our local environment'. In these classes, students aged 6 to 15 learned about their environment including archaeology, history, geology, biology, *etc*. The site provides a perfect example of research that encapsulates all of these disciplines right in the students' backyard. As part of this class, the students receive lectures from an archaeologist on the significance of the remains discovered at Gufuskálar, and on erosion and how it affects the archaeological remains. The lessons help to reinforce the relevance of the site to the students' own lives. In addition to being taught how to identify archaeology in a landscape and the appropriate actions to take at an archaeological site, they have also learned about the relevance of archaeological sites and why they should care about preserving them.

Future work

The rescue excavations at Gufuskálar have left us with many questions, primarily about who was fishing at the site. Historical research suggests that in other parts of Iceland there was an English/Continental contingent at big fishing stations such as this (Thór 1996; Carus-Wilson 2006), and our artefact assemblages, particularly the ceramic sherds, are certainly rare for 15th century Icelandic sites. Were the people living at Gufuskálar well-connected Icelanders or foreign agents of large mercantile organisations? If the former, how was this work organised in relation to Iceland's hierarchical political structure? If the latter, what was the nature of the relationship with the Icelandic people? Some fascinating research has been conducted into a similar question regarding the interactions between 17th century Basque whalers and Icelanders in the nearby north-west of Iceland (Edvardsson and Rafnsson 2006; Miglio 2008). Additionally, we wish to explore the social context of 15th century Iceland, with a particular focus on the role of the Bubonic Plague on the formation of these fishing stations.

In an attempt to answer these questions, we have begun to broaden the scope of our excavations. Our hope for future field seasons is to identify farm sites in the area which are contemporary with the fishing station at Gufuskálar. Perhaps comparing artefact and faunal assemblages between these sites and Gufuskálar may give us some clues as to the identity of the fishers at the site.

As for Gufuskálar itself, Minjastofnun Íslands (The Cultural Heritage Agency of Iceland) has dedicated resources to studying the serious issue of coastal erosion and are considering how best to preserve the site.

Finally, we hope to continue our outreach with the community, modelling our work on the successful programme in northern Iceland. The organisation Fornleifaskóli barnanna (The Kids' Archaeology Program) has, since 2007, fostered a successful partnership between archaeologists and local people which has resulted in funding for archaeological projects, integration of archaeology into local school curriculums, and fostered active citizen science organisations in the region (Jóhannesdóttir and Ingason 2009). We feel this model of public and professional interaction can be replicated in other parts of the country, and we look forward to further integration with the communities that dot the Snæfellsnes Peninsula.

References

Barrett, J. H., Locker, A. M. and Roberts, C. M. 2004. The origin of intensive marine fishing in medieval Europe: The English evidence. *Proceedings of the Royal Society* B271, 2417–21.

Barret, J. H. 2016. Medieval sea fishing AD 500–1550: Chronology, causes and consequences. In J. H. Barrett and D. C. Orton (eds), *Cod and Herring: The Archaeology and History of Medieval Sea Fishing*, 250–71. Oxford, Oxbow.

Bjarnason, H. 2012. Fréttaskýring: Fyrsta 15. aldar verbúðin sem grafin er upp í heilu lagi. *Morgunblaðið* 23 July 2012. Available at: http://www.mbl.is/frettir/innlent/2012/07/23/fyrsta_15_aldar_verbudin_sem_grafin_er_upp_i_heilu_/ [accessed 23 July 2016].

Carus-Wilson, E. M. 2006. *Medieval Merchant Venturers*: *Collected Studies*. New York, Routledge.

Dawson, T. 2013. Erosion and coastal archaeology: Evaluating the threat and prioritising action. In M.-Y. Daire, C. Dupont, A. Baudry, C. Billard, J.-M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coasts*, 77–83. Oxford, BAR International Series 2570.

Diplomatarium Islandicum, vol. IV. 1857–1972. Copenhagen/ Reykjavík, Íslenzka Bókmentafélag.

Edvardsson, R. 2010. The Role of Marine Resources in the Medieval Economy of Vestfirðir, Iceland. PhD thesis, Department of Anthropology, City University of New York Graduate Center.

Edvardsson, E. and Rafnsson, M. 2006. Basque Whaling Around Iceland Archeological Investigation in Strákatangi, Steingrímsfjörður. Unpublished field report. Bolungarvík/ Hólmavík, Náttúrustofa Vestfjarða and Strandagaldur ses.

Feeley, F. J. 2012. *Mammal Consumption at the Medieval Fishing Station at Gufuskálar*. NORSEC Zooarchaeology Laboratories Report.

Gardiner, M. and Mehler, N. 2007. English and Hanseatic trading and fishing sites in medieval Iceland: Report on initial fieldwork. *Germania* 85, 385–427.

Gardiner, M. 2016. The character of commercial fishing in Icelandic waters in the fifteenth century. In J. H. Barrett and D. C. Orton (eds), *Cod and Herring: The Archaeology and History of Medieval Sea fishing*, 80–89. Oxford, Oxbow.

Hjalmarsson, J. R. 2007. *History of Iceland: From Settlement to the Present Day*. Reykjavík, Almenna Bokafelagid.

Jóhannesdóttir, S. and Ingason, U. 2009. The Kids' Archaeology Program, Iceland: Goals and activities. Unpublished report for the North Atlantic Biocultural Organization (NABO). Available at: http://www.nabohome.org/projects/kap/fornleifaskolibarnanna1.pdf [accessed 23 July 2016].

Morgunblaðið. 2011a. Halda ekki í við náttúruna. *Morgunblaðið* 15 June 2011. Available at: http://www.mbl.is/frettir/innlent/2011/06/15/halda_ekki_i_vid_natturuna/ [accessed 23 July 2016].

Morgunblaðið. 2011b. Peð bætist í 500 ára gamalt tafl. *Morgunblaðið* 27 June 2011. Available at: http://www.mbl.is/frettir/innlent/2011/06/27/ped_baetist_i_500_ara_gamalt_tafl/ [accessed 23 July 2016].

Morgunblaðið. 2014. Fornleifar á Gufuskálum stórskemmdar. *Morgunblaðið* 21 December 2014. Available at: http://www.mbl.is/frettir/innlent/2014/12/21/fornleifar_a_gufuskalum_skemmdar/ [accessed 23 July 2016].

Miglio, V. G. 2008. "Go shag a horse!": The 17th–18th century Basque-Icelandic glossaries revisited. *Journal of the North Atlantic* 1(2008), 25–36.

Ólafsson, R. and Þórhallsdóttir, G. 2016. *Fjöldi ferðamanna á átta áfangastöðum á Suður- og Vesturlandi 2014 til 2015*. Report for Ferðamálastofa and Háskóli Háskóli Íslands. Available at: http://www.ferdamalastofa.is/static/files/ferdamalastofa/tolur_utgafur/Skyrslur/fjoldi_ferdamanna_13_01_2016.pdf Fjöldi [accessed 23 July 2016].

Perdikaris, S. 1996. Scaly heads and tales: Detecting commercialization in early fisheries. *Archaeofauna: International Journal of Archaeozoology* 5, 21–33.

Perdikaris, S. and McGovern, T. H. 2008. Viking Age economics and the origins of commercial cod fisheries in the North Atlantic. In L. Sickling and D. Abreu-Ferreira (eds), *Beyond the Catch: Fisheries of the North Atlantic, the North Sea and the Baltic, 900–1850*, 41–61. Leiden: Brill.

Skussuhorn. 2013. Landið hverfur undan verbúðinni. *Skussuhorn* 20 June 2013, 12 and 23.

Skussuhorn. 2014. Fornleifarannsóknir á Gufuskálum afhjúpa stórmerkar minjar. *Skussuhorn* 17 June 2014, 33.

Thór, J. T. 1996. Foreign fisheries off Iceland, *c*. 1400–1800. In J. Roding and L. Heerma van Voss (eds), *The North Sea and Culture (1550–1800): Proceedings of the International Conference held at Leiden 21–22 April 1995*, 124–34. Hilversum, Verloren.

Vésteinsson, O. 2016. Commercial fishing and the political economy of medieval Iceland. In J. H. Barrett and D. C. Orton (eds), *Cod and Herring: The Archaeology and History of Medieval Sea Fishing*, 71–79. Oxford, Oxbow.

Wubs-Mrozewicz, J. 2009. Fish, stock and barrel: Changes in the stockfish trade in Northern Europe, *c*. 1360–1560. In L. Sickling and D. Abreu-Ferreira (eds), *Beyond the Catch: Fisheries of the North Atlantic, the North Sea and the Baltic, 900–1850*, 187–208. Leiden, Brill.

Zorich, Z. 2012. Surviving the Little Ice Age. *Archaeology* September/October, 53–60. Available at: http://archive.archaeology.org/1209/letter/iceland_hjalmarvik_irminger_east_greenland_current.html [accessed 23 July 2016].

Chapter 12

Every place has a climate story: finding and sharing climate change stories with cultural heritage

Marcy Rockman and Jakob Maase

Abstract

Cultural heritage is a missing link for understanding climate change. The atmosphere that exists now is the result of all fluctuations on earth to date, and cultural heritage is the record of variations of human behaviour on earth to date. The connections between these two records cannot be replaced by physics or ecosystem models – they are unique in their own right. The US National Park Service (NPS), which is the lead federal agency in the US for cultural heritage, has a role in identifying and sharing these connections. National park rangers, the lead voices within the NPS for disseminating information to the public, are trusted sources of information. But most rangers are not extensively trained in climate science or cultural heritage. The AND-BUT-THEREFORE (ABT) scientific narrative template developed by science communicator Randy Olson (2015) is a useful vehicle for conveying accurate information that leads to a clear and understandable point. The NPS project, Every Place has a Climate Story, brings these issues, needs, and tools together to create ABT narratives for park interpreters to use in connecting cultural heritage, climate change, and parks for visitors.

Introduction

Climate stories are a way of connecting climate change, cultural heritage, and place. They originated as a means to assist US National Park Service (NPS) interpreters in talking about climate change. Currently there are 417 units of the national park system and US national parks have more than 280 million visitors a year, which makes the NPS the largest informal education institution in the country. NPS interpreters do not use scripts. Rather, they are trained in how to enable visitors to connect to the park they are in for the purpose of creating meaningful experiences (Larsen 2003). For several years there have been questions about how to connect visitors and climate change in each park; most parks do not have iconic natural features commonly associated with climate change, such as glaciers, and no parks have polar bears. In turn, one of the authors, Marcy Rockman, was charged with building out the NPS climate change program for cultural heritage. The 'Every Place has a Climate Story' initiative was intended to help bring these issues and needs together.

But the relevance of 'Every Place has a Climate Story' extends far beyond its original remit. In the US, it is often difficult to create policies or indeed make an argument without including an economic focus; cultural heritage struggles with this demand. Heritage does not yet fit well in the natural resources-based approach of ecosystem services (Satz *et al.* 2013). And while heritage tourism does provide economically measurable qualities (see Flatman 2012 for the UK), the potential for tourism does not capture all of the ineffable qualities of heritage and the aspects of identity and knowledge of the past that are lost when heritage resources disappear (UNFCCC 2013).

At the United National Framework Convention on Climate Change (UNFCCC) negotiations leading up to the Conference of the Parties (COP) 21 meetings in Paris in December 2015, Small Island Developing States (SIDS) raised the issue of heritage loss. Although not an economic loss, they wanted the disappearance of places that hold their history and identity to be part of the agreement. US State Department colleagues asked if the NPS could help. The NPS response was, in paraphrase: 'We don't have all the answers yet, but the NPS is the lead federal agency for cultural heritage in the United States and is working on climate change. We currently have some tools and experiences that will hopefully help.' These materials were shared with the State Department, and as of the writing of this chapter, cultural heritage has been proposed as a central theme of discussions for the UNFCCC Warsaw Mechanism for Non-Economic Loss and Damage following from the COP21 agreement. Therefore, climate stories for cultural heritage are not just fun, or interesting, or nice to have. The experiences of the US State Department shows that being able to communicate effectively about heritage, what is happening to it, and why it is important to people around the world, may be a key link in enacting the global agreement on climate change.

The NPS approach to climate change response

To see what climate stories are and how they work within the NPS, it is useful to know more about the overall NPS approach for climate change. The founding document of the NPS Climate Change Response Program, the NPS (2010) *Climate Change Response Strategy,* outlines four components or 'pillars' of climate change response: science, adaptation, mitigation, and communication. Very briefly, these are defined as:

- Science: data, models, observations;
- Adaptation: what to do in response to climate data, models, and impact observations;
- Mitigation: reducing the overall carbon footprint of the NPS;
- Communication: connecting all these pieces and sharing them with the public and partners.

The NPS approach for cultural resources and climate change builds on these pillars. 'Cultural resources' is the NPS term for cultural heritage and includes archaeology, historic buildings and structures, cultural landscapes, ethnographic resources (which include sites, structures, objects, landscapes, natural features, and ecological components of traditional importance to a contemporary cultural group through associations three generations or more in length), and museum collections. Given the connections these resources provide to past lifeways, the NPS has established a two-fold approach for understanding the relationship of cultural resources and climate change: there are climate change impacts *on* cultural heritage and cultural heritage resources themselves also provide the opportunity to learn *from* them.

The impacts of climate change on cultural resources are, and will be, diverse. While environmental forces have always acted on cultural heritage, climate change projections present new risks as environmental forces become more extreme, recombine, and change. Impacts range from the overt and visible, such as sea level rise and storm surges, to subtler or less visible changes that, ultimately, are no less destructive, such as stresses from increased intensity of rainfall to increased freeze-thaw cycles and melting permafrost. A 'snappy' summary of these impacts is the NPS list of 'dread *-ions*': inundation, erosion, deterioration, destruction, conflagration, oxidation, invasion, *etc.* (Table 12.1). A more detailed listing of impacts by climate change phenomena and types of cultural resources to support park managers in preparing vulnerability assessments and other planning documents is available in the NPS *Climate Change Impacts to Cultural Resources* booklet (Morgan *et al.* 2016).

The capacity to learn from cultural resources is familiar to archaeologists and others who manage and work with cultural heritage. As then-National Park Service Director Jarvis (2009, 9) said eloquently during testimony before the US Congress on October 23, 2009:

> One of the most precious values of the national parks is their ability to teach us about ourselves and how we relate to the natural world. This important role may prove invaluable in the near future as we strive to understand and adapt to a changing climate.

This relatively early recognition of the importance of learning in relation to climate change at the highest levels of management within the NPS has influenced and supported subsequent development of climate change policy and guidance for cultural heritage.

This two-fold approach to cultural resources and climate change is now codified as NPS policy in a Director's Policy memo released in 2014, which stated that:

> NPS cultural resource management must keep in mind that (1) cultural resources are primary sources of data regarding human interactions with environmental change; and (2) changing climates affect the preservation and maintenance of cultural resources.

Applying this two-fold cultural approach, (1) Information and (2) Impacts, to the four pillars of climate change response yields a 2 × 4 conceptual framework for cultural heritage and climate change (Table 12.2; for more detail on this framework see Rockman 2015; Rockman *et al.* 2016). In this, there is a science for understanding how climate impacts on cultural resources and a science of learning from them. There is adaptation for managing and addressing climate impacts to cultural resources and there is learning from cultural resources about the past and sharing in such ways that it can assist modern plans for climate adaptation. Division of the mitigation and communication sides between impacts and information is less direct but is still appropriate if 'impacts' is understood to mean practical and technical approaches while 'information' provides content and meaning. Cultural resources, particularly buildings and structures and cultural landscapes, can and should be

Table 12.1. 'Dread -ions': Climate Change Impacts on Cultural Resources. This table incorporates data from Colette (2007) Climate Change and World Heritage *and NPS field observations. A more detailed version is available in Morgan* et al. *2016 and included in Rockman* et al. *2016*

Impact	*Environmental forces*	*Cultural resources affected*	*Rate*
Submersion	Sea level rise (SLR)	AS, B/S, CL, E	Trend
Erosion	SLR, Storm surges	AS, B/S, CL, E	Event, Trend
Inundation	SLR, Storm surges, Flooding	All	Event
Saturation	SLR (rising water tables)	1st: AS, B/S, CL, E 2nd: MC	Trend
Deterioration	Precipitation variation	AS, B/S, CL, E	Trend/event
	Temperature variation	AS, B/S, CL, E	Trend/event
	Wind variation	AS, B/S, CL, E	Event/trend
Dissolution	Temperature increase (permafrost)	AS, B/S, CL, E	Trend
	Ocean acidification	AS (terrestrial, underwater)	Trend
Destruction	Flooding	All	Event
	Storm (rain/wind)	All	Event
Oxidation	Increase atmospheric moisture	B/S	Trend
Depletion	Ecosystem changes due to human development	AS, B/S, CL, E	Event, Trend
Conflagration	Fire (Drought) (Temp. extremes +/- insect effects)	All	Event
Desiccation	Temperature extremes	AS, B/S, CL, E	Event (trend?)
	Drought	AS, B/S, CL, E	Long event
Invasion	Invasive species	AS, B/S, CL, E, MC	Trend
	Mould	BS, MC	Event
Disruption	Loss of species	E	Trend/event
	Loss of access	E	Event/trend
	Looting	AS	Event

Key: AS = archaeological sites, B/S = buildings and structures, CL = cultural landscapes, E = ethnographic resources, MC = museum collections

Table 12.2. Concept Framework for Cultural Resources and Climate Change. This framework applies two climate considerations for cultural resources – the effects of climate change on cultural resources (Impacts) and the capacity to learn about long-term human interactions with environmental and climatic change (Information) – across the four pillars of NPS climate change response: science, adaptation, mitigation, and communication (NPS 2010). The resulting matrix illustrates the broad scope of action needed to address the needs and potentials of cultural resources in relation to climate change. Details about this framework and ways in which it can be used are included in the NPS Cultural Resources Climate Change Strategy *(Rockman* et al. *2016) and Rockman (2015)*

Science		**Mitigation**	
Impacts	*Information*	*Impacts*	*Information*
• Climate science at culturally relevant scales • Cultural resource (CR) vulnerability assessments • CR inventory/monitoring techniques and protocols • CR integrated databases/GIS • Preservation science • Documentation science	• Palaeoclimate/social climatic thresholds • Traditional ecological knowledge • Shifting baselines • Past land use and human impacts on environments • Palaeogenetics	• Integration of historic buildings into energy efficiency plans • Resource conservation through historic or native landscapes • Reduce carbon footprint of management practices	• Past architectural and landscape techniques suited to local environments • Cultural heritage to conserve/re-establish sense of place and community stewardship
Adaptation		**Communication**	
Impacts	*Information*	*Impacts*	*Information*
• Adaptation options • Decision frameworks • Contexts/studies to support decision frameworks • Disaster risk reduction/ response connections • Policies and standards • Scenario planning	• Identifying examples of past social adaptability per environmental change • Traditional ecological knowledge • Relating past adaptability to current issues, methods, and decisions	• Cultural resources climate change (CR-CC) literacy • Dialogue between impacts and information in all pillars • CR-CC links between managers (local-international) • CR-CC links to public	Every Place has a Climate Story: • Change in material culture • Change in experience and lifeways • Insights from past societies • Origins of the modern climate situation

incorporated into energy efficiency planning, and there is also room to learn from past techniques for things such as heating and cooling with lower energy usage (for examples, see Burns 1982). Finally, there are practical approaches to communication and climate change literacy and connections between all the various efforts and levels and partners. And there is the process of creating the content that shares the meaning of cultural heritage in relation to climate change. Climate stories are the means of completing this final piece of concept framework. Climate stories tie everything together.

Climate story themes

Currently, there are four themes for climate stories:

1. Change in the Material World
2. Change in Experience and Lifeways
3. Insights from Past Societies
4. Origins of the Modern Climate Situation

Change in the Material World addresses how we see change happening in the material world around us. These stories are 'climate change made tangible', and show change at a human scale that can be seen and touched. The focus of this theme can include how cultural material items themselves are changing, or how we have come to identify and track this change. Useful references for beginning to understand the impacts of climate change on the material world include the *Atlas of Climate Change Impact on European Cultural Heritage* (Sabbioni *et al.* 2012), the work of the World Heritage Centre (Colette 2007), and the NPS compilation *Climate Change Impacts to Cultural Resources* (Morgan *et al.* 2016; also included in Rockman *et al.* 2016).

Change in Experience and Lifeways discusses how traditional, indigenous, and affiliated communities experience change in their lifeways in relation to traditional knowledge. These stories are the effects of climate change as they are lived and felt. The focus of this theme can include how cultural practices themselves are changing, how these changes are being recognised, and the effects they have on the people and communities that maintain them. An important reference for beginning to understand the interactions of climate change with traditional lifeways and knowledge is *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Nakashima *et al.* 2012).

Insights from Past Societies addresses how past societies and communities responded and adapted, or not, to past climatic and environmental variability. This focuses on the capacity of human societies to recognise change in their surrounding environment and address their behaviour, assumptions, and actions in relation to that environment. The focus of this theme can be past interactions, how we have come to know of and understand those interactions, and ideas for how we might relate information from the past to current climate change issues. There are many potential directions for this topic and correspondingly many publications; starting points include disaster case studies in Cooper and Sheets (2012), climate and social change studies in McIntosh *et al.* (2000), concepts of social vulnerability and resilience (Schoon *et al.* 2011), and connections of archaeology to climate change policy (Rockman 2012).

Origins of the Modern Climate Situation focuses on how the modern climate situation has come to be. These stories address the social, cultural, technological, economic, intellectual, and philosophical trends that have combined over time to create the present day – a present day that includes climate change. The premise of this theme is that understanding how, collectively, as a national and global community, we arrived at this present situation is a fundamental component of finding workable solutions for the future. Work explicitly on this topic appears to be limited; starting points include the climate ethnographic work of Norgaard (2011), and research on the history and anthropology of modern responses to disasters (Hoffman 1999; Hoffman and Oliver-Smith 2002; Rozario 2007).

Working from these themes, any place that has been a home to people at some point in time likely includes at least one topic for a climate story. Likely, there will be many possible stories – the challenge will be selecting which story to tell first.

How to write a climate story

Climate stories are called stories, but they are not fiction. Rather, they are vehicles for scientific information (this recognises that scientific fields related to climate change are developing rapidly, and there are many sources of such data; criteria currently used within the NPS for information used to support decision-making and interpretation is 'best available sound [reliable] science'). Once written, climate stories can be used for interpretation or to support other projects and initiatives. As such, a particularly useful format for writing climate stories is the AND, BUT, THEREFORE – or ABT – method of storytelling as developed by science communicator Randy Olson (2009; 2015; Olson *et al.* 2013).

In this approach, scientific information is organised into a narrative. The organisation is directed toward a point and within that organisation – something happens. As Olson *et al.* (2013, 36) states 'a story begins when something happens'. A climate story is not necessarily about an individual or a set of characters, but it is information that has a beginning, middle, and an end. It can be set up like this:

> AND is where the story starts
> BUT creates the tension
> THEREFORE provides the resolution (Olson *et al.* 2013, fig. 5).

Olson also recommends a writing process called WORD, SENTENCE, PARAGRAPH, or WSP. The word gets at the first commandment of the ABT, which is to know what your story is about. The word captures the concept you are trying to convey. The sentence is phrased as an ABT. It can be a long sentence, but it should have all the parts. The paragraphs expand all the parts of the ABT and can be as long as needed to convey the information.

The first major effort of the NPS 'Every Place has a Climate Story' project took place in the summer of 2015 with one intern, Jakob Maase (co-author), based in Washington, DC. We worked with a set of volunteer parks to research and write a set of climate stories. Together with park staff, Maase conducted original research, identified themes and key words, wrote sentences, and then built out longer paragraph stories.

If you have been reading carefully, you may have noticed that there have been three ABT structures in this paper so far. BUT (the fourth) of course, this is perhaps better explained and more interesting through examples. Therefore, here are the five initial park-based ABT words and sentences.

Catoctin Mountain Park
Theme 1: Material Change
Word: Continuity
Sentence: The Catoctin cabins were built as the first recreational camp for disabled children in the 1930s AND are still in use today as nature retreats, BUT projections indicate increasing temperatures will lead to structural damage from more intense rainfalls; THEREFORE the NPS is researching ways to preserve the historic mortar.

Harper's Ferry National Historical Park
Theme 1: Material Change
Word: Cycles
Sentence: Historic armories such as Harper's Ferry used a lot of wood AND such use led to extensive deforestation, which in turn contributed to extensive flooding. The forests are now regrown BUT the industry spurred by these early factories is now linked through climate change to increases in intensity in rainfall, THEREFORE the threat of flooding in in this area continues.

Sunset Crater Volcano National Monument
Theme 1: Insights from the Past
Word: Innovation
Sentence: Sunset Crater erupted in c. AD 1066 AND covered an area periodically affected by drought with ash AND made agriculture difficult to impossible for several years, BUT the local Sinagua population stayed and developed the technique of cinder mulching, which helps retain soil moisture, THEREFORE providing an example of traditional agriculture that may be useful here and elsewhere in the future as the climate becomes hotter and drier.

Hopewell Culture National Historical Park
Theme 3: Insights from the Past
Word: Resilience
Sentence: The Hopewell people returned to their lands after several centuries of extended flooding AND experienced conflict and competition among themselves for resources, BUT they also developed a combination of new technology, architecture, agriculture, and new exchange patterns of gifts and alliances, THEREFORE the resilience of their culture for the next 500 years can be seen as based on both new ways of doing things and new ways of relating to each other.

Chesapeake and Ohio (C&O) Canal National Historical Park
Theme 4: Origins of Modern Climate Change
Word: Choice
Sentence: Industrial legends Thomas Edison, Henry Ford, and Harvey Firestone camped together along the C&O Canal in 1921 AND noted to each other that if a hydropower dam had been built instead of the Canal, it would have produced more energy, BUT the nature they themselves enjoyed camping in would have been very different, THEREFORE their enjoyment of nature benefited from the choices of previous generations.

Finding a climate story

Once told, the parts of a well-written story can seem obvious. But in the research and writing process, determining what a climate story is about and where it will go can be much less obvious. As cleanly stated by Randy Olson (2015, 134), 'stories, at their core, are about problems posed and solved'. The four story themes provide sparks for inspiration about which problems and solutions the heritage of a particular place may hold. The work of finding a story then comes from using these themes as guides for researching the history and knowledge of that place to identify the pieces that accurately come together to make a story. For example, in this project NPS staff members who had conducted research on cinder mulching at Sunset Crater Volcano National Monument proposed that topic for a story. They then gathered additional research to identify the problem and solution that a cinder-mulching story would convey. Similarly, for C&O Canal National Historical Park, park staff suggested the occasions of Edison, Ford and Firestone camping together. It required detailed research into the records of those camping trips to find the specifics that make up the story. The Hopewell Culture story started somewhat differently, as park staff wanted to tell a story of how modern society can learn from the Hopewell people's experiences. A review and study of archaeological information helped identify what that lesson might be.

Word summaries turned out to be particularly important for connecting with park staff and finding a relevant story. Each park has already identified what are called 'universal themes' that interpreters use to frame the information they share with visitors, topics such as loss, change, home, and choices (Larsen 2003). Such themes are tremendously important for interpretation, as the goal of interpretation is not solely to transfer information, but rather to enable a meaningful experience that connects visitors to a place. Climate stories have the same goal: they are not only about transferring climate information, but also about creating connections within and between information that can in turn bring deeper understanding. Finding a single universal word that summarised the climate story we were trying to write helped the park staff connect the climate story to the work they were already doing.

For example, for the C&O Canal story, the situation of three magnates of industry enjoying camping together struck all of us on the project as superbly ironic – of course this is the subject of a good climate story! But it turned out to be harder than we thought to find the meaningful point of the situation. Irony itself is not a story. Two initial attempts, each of which had a word summary of 'Serendipity', had structurally correct THEREFORE endings but did not work from the perspective of park interpretation. These sentences were:

> Word: Serendipity
> Sentence: Harvey Firestone, Thomas Edison, and Henry Ford tried to find a new renewable source of rubber AND while camping Edison would often look at plants for inspiration, such as goldenrod with which Ford continued to experiment with after Edison's death in 1931, BUT with the advent of WWII synthetic rubber became the norm, THEREFORE the nature-based product of these two industrialists was forgotten.

And:

> Sentence: Thomas Edison, Henry Ford, and Harvey Firestone enjoyed camping in nature AND would often travel by car to reach their campsites, BUT their fame attracted crowds and followers, many of whom soon followed suit THEREFORE the threesome known for their industrial inventiveness also helped inspire increased car transit and outdoor camping.

As noted above, the overall goal of NPS park interpretation is to help visitors have a meaningful experience in a park and find and feel a connection with that place. The first ironic ABT for C&O includes some facts that visitors might find curious or interesting in the moment, but does not provide a launching point for further discussion. The second ironic ABT is classically ironic – love of nature supporting much car use that not only supported their own businesses, but which has ultimately been a notable part of the development of modern climate change. The THEREFORE, however, only led members of this project to feelings of "so now what?" or frustration with the current situation. The final story with the word theme of 'Choice', presented in the first set of story sentences above, provides a much better launching point for interpretation of the history of the canal and the future of all people under climate change.

Connections between climate story and audience

The C&O Canal story also raised issues about audience. The C&O Canal is a long thin park, extending from the western edge of Washington, DC to West Virginia. The communities that surround the park on its eastern end are predominantly well off and liberal. At the western end are communities with generations of history in coal mining that have been affected by downturns in that industry. For interpreters with a mission to help all visitors connect with a park and have meaningful experiences there, it was a matter of not only finding an accurate climate story for their park, but also selecting and sharing a story that would encourage dialogue and understanding between different communities.

Battlefields and parks that commemorate other aspects of conflict bring similar issues. The NPS has 25 battlefield parks, and about 70 parks related in some way to the Civil War. These places preserve distinctive resources and are already connected to powerful stories that are a core reason visitors come to those places.

Researchers at George Mason University have done a series of assessments of what the American public thinks about climate change over the past several years. Results suggest that there is not one American understanding of or reaction to the topic of climate change, there are six – ranging from alarmed to dismissive (Roser-Renouf *et al.* 2015). Initial research on climate change perspectives of visitors to national parks suggests that this range of six views is not evenly represented across park visitors (Davis *et al.* 2012). While this research was not conducted specifically to identify if the 'six Americas' perspective were represented in park visitors, it does raise the need to consider this diversity. Some visitors will be underserved if they do not have a chance to engage with the topic of climate change; others will not be anticipating or desiring of such conversations. Visitors to battlefields tend to include many who are passionate about those battles and military history and who have likely come to hear those stories and not necessarily about climate change or other aspects of the natural environment. This is in contrast with visitors to other parks that emphasise experience of the natural world. So, thinking about climate stories for battlefield parks can be a useful way to practice development of climate stories that emphasise visitor experience with history and potential for engaged discussion about meaning rather than climate information or other scientific findings.

The initial set of five parks that developed climate stories did not include a battlefield, but the 2015 project did craft some approaches to climate change and battlefields for each of the four story themes, as follows.

Theme 1: Material Change

Consider effects of flooding, erosion, oxidation, freeze-thaw stress, and vegetation changes to gravesites, monuments, buildings, forts, munitions, and earthworks. A sample sentence based on previous research by Maase at Big South Fork National River and Recreation Area is:

> The Burke family killed seven Civil War guerrillas during an attack on their farm AND buried them on Big Island, BUT flooding and erosion is re-exposing the bodies, THEREFORE creating a new responsibility for us for these and other impromptu graves.

Theme 2: Change in Experience

Consider how the land has changed since the conflict, the phenology of flowers for memorial days, and how changes in weather have affected festivals or re-enactments. A sample sentence based on non-battlefield-based experiences related to Rockman by the Superintendent of Saint-Gaudens National Historic Site (R. Kendall pers. comm.) is:

> In northern New Hampshire, lilacs have traditionally bloomed around Memorial Day AND in some places lilac festivals were held on that holiday BUT now lilacs are done blooming up to a week earlier, THEREFORE there has been a break in that tradition.

From the time of the project developed with co-author Maase to the date of this publication, it has not been possible to work directly with a battlefield park to develop sample ABT sentence stories for the remaining two themes. Potential directions for battlefield-based climate stories in these themes include:

Theme 3: Insights from the Past

Look at the interaction between weather events and battles or campaigns, or consider how well suited equipment of battle was for the environment in which it was used.

Theme 4: Origins of Modern Climate Change

What innovations or developments have come out of wartime and contributed to modern non-military or civilian lifeways?

Results and the next chapter in the story

At the end of the first round of Every Place has a Climate Story, the story WSPs were again shared with originating parks for use in interpretation planning. The project also connected with the NPS (2016) *National Climate Change Interpretation and Education Strategy* and its online toolkit (https://www.nps.gov/subjects/climatechange/toolkit.htm), which was in preparation at the same time. The online toolkit includes background information on the four story themes, and a brief how-to guide for writing climate stories has been incorporated into the NPS *Cultural Resources Climate Change Strategy* (Rockman *et al.* 2016). Subsequently, this project has been used as the basis of a climate stories training module for the NPS Climate Friendly Parks Program, which is designed to help each park assess and then reduce its carbon footprint. Ultimately, every park may find a climate story.

Climate stories can go much farther and we hope that they do. Connections with the US State Department on non-economic loss and damage following COP21 are exciting for many reasons. Cultural resources are not yet well-integrated into the global efforts to address climate change. This is not due to lack of useful data (for example, see the 'distributed observing network of the past' [IHOPE 2015]), but rather to gaps in how modern society is creating the overarching picture of climate change. The story themes and ABT format go beyond lists of services that cultural heritage can provide to climate change response to clearly connect cultural heritage with parts of climate change problems and potential solutions: this place is where change is being seen and action is needed; here is insight from how past peoples responded to past situations of change; this is how a piece of modern life and climate change has come to be interwoven with how we think and act. The approach and format of climate stories as developed here may seem simple, but what it is able to convey can be profound. Cultural heritage is of the past, and well-researched and grounded cultural heritage information shared in the form of climate stories connects it to the here, now, and future of climate change.

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References

Burns, J. 1982. *Energy Conserving Features Inherent in Older Homes*. US Department of Housing and Urban Development and US National Park Service Report. Washington, DC, US Government Printing Office.

Colette, A. (ed.) 2007. *Climate Change and World Heritage: Report on Predicting and Managing the Impacts of Climate Change on World Heritage and Strategy to Assist States Parties to Implement Appropriate Management Responses*. Paris, UNESCO World Heritage Centre.

Cooper, J. and Sheets, P. (eds). 2012. *Surviving Sudden Environmental Change: Understanding Hazards, Mitigating Impacts, Avoiding Disasters*. Boulder, University Press of Colorado.

Davis, S., Karg, S. and Thompson, J. 2012. *Climate Change Education Partnership Visitor Survey Summary Report.* Fort Collins, CO, Colorado State University (Funded by National Science Foundation, award DBI-1059654).

Flatman, J. 2012. Conclusion: The contemporary relevance of archaeology – archaeology and the real world? In J. Flatman and M. Rockman (eds), *Archaeology in Society: Its Relevance in the Modern World*, 291–303. New York, Springer.

Hoffman, S. M. 1999. After Atlas Shrugs. In A. Oliver-Smith and S. M. Hoffman (eds), *The Angry Earth*, 302–25. London, Routledge Press.

Hoffman, S. M. and Oliver-Smith, A. (eds). 2002. *Catastrophe and Culture: The Anthropology of Disaster*. Santa Fe, NM, School of American Research Press.

IHOPE (Integrated History and Future of People on Earth). 2015. *Global Environmental Change Threats to Heritage and Long Term Observing Networks of the Past*. Posted June 10, 2015 at: http://ihopenet.org/global-environmental-change-threats-to-heritage-and-long-term-observing-networks-of-the-pas/ [accessed 8 November 2016].

Jarvis, J. 2009. Statement of Jonathan B. Jarvis, Director, National Park Service, U.S. Department of the Interior, Before the Senate Committee on Energy and Natural Resources Subcommittee on National Parks, on Climate Change in National Parks. Available at: http://energy.senate.gov/public/index.cfm/files/serve?File_id=9cc4438c-b717-3652-d676-5011376ce474.

Larsen, D. L. (ed.) 2003. *Meaningful Interpretation: How to Connect Hearts and Minds to Places, Objects, and other Resources*. Fort Washington, PA, Eastern National.

McIntosh, R. J., Tainter, J. A. and Keech McIntosh, S. (eds). 2000. *The Way the Wind Blows: Climate, History, and Human Action*. New York, Columbia University Press.

Morgan, M., Rockman, M., Smith, C. and Meadow, A. 2016. *Climate Change Impacts on Cultural Resources*. Cultural Resources Partnerships and Science. Washington, DC, National Park Service.

Nakashima, D. J., Galloway McLean, K., Thulstrup, H. D., Ramos Castillo, A. and Rubis, J. T. 2012. *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*. Paris/Darwin, UNESCO/United Nations University.

NPS (National Park Service). 2010. *National Park Service Climate Change Response Strategy*. Fort Collins, CO, National Park Service Climate Change Response Program.

NPS (National Park Service). 2016. *National Climate Change Interpretation and Education Strategy*. Washington, DC, National Park Service. Available at: https://www.nps.gov/subjects/climatechange/nccies.htm.

Norgaard, K. M. 2011. *Living in Denial: Climate Change, Emotions, and Everyday Life*. Cambridge, MA, MIT Press.

Olson, R., Barton, D. and Palermo, B. 2013. *Connection: Hollywood Storytelling Meets Critical Thinking*. Los Angeles, CA, Prairie Starfish Productions.

Olson, R. 2009. *Don't Be Such a Scientist: Talking Substance in an Age of Style*. Washington, DC/London, Island Press/Covelo.

Olson, R. 2015. *Houston, We Have a Narrative: Why Science Needs Story*. Chicago, IL, University of Chicago Press.

Rockman, M. 2012. *The necessary roles of archaeology in climate change adaptation and mitigation*. In J. Flatman and M. Rockman (eds), *Archaeology in Society: Its relevance in the modern world*, 193–215. New York, Springer.

Rockman, M. 2015. An NPS framework for addressing climate change with cultural resources. *The George Wright Forum* 32(1), 37–50.

Rockman, M., Morgan, M., Ziaja, S., Hambrecht, G. and Meadow, A. 2016. *Cultural Resources Climate Change Strategy*. Washington, DC, National Park Service, Cultural Resources Partnerships and Science and Climate Change Response Program.

Roser-Renouf, C., Stenhouse, N., Rolfe-Redding, J., Maibach, E. W. and Leiserowitz, A. 2015. Engaging diverse audiences with climate change: Message strategies for global warming's six Americas. In A. Hanson and R. Cox (eds), *Routledge Handbook of Environment and Communication*, 368–82. New York, NY, Routledge.

Rozario, K. 2007. *The Culture of Calamity: Disaster and the Making of Modern America*. Chicago, IL, University of Chicago Press.

Sabbioni C., Brimblecombe, P. and Cassar, M. 2012. *The Atlas of Climate Change Impact on European Cultural Heritage: Scientific Analysis and Management Strategies*. London, Anthem Press.

Satz, D., Gould, R. K., Chan, K. M. A., Guerry, A., Norton, B., Satterfield, T., Halpern, B. S., Levine, J., Woodside, U., Hannahs, N., Basurto, X. and Klain, S. 2013. The challenges of incorporating cultural ecosystem services into environmental assessment. *Ambio* 42(6), 675–84.

Schoon, M., Fabricius, C., Anderies, J. M. and Nelson, M. 2011. Synthesis: Vulnerability, traps, and transformations – Long-term perspectives from archaeology. *Ecology and Society* 16(2), 24.

UNFCCC (United Nations Framework Convention on Climate Change). 2013. *Non-Economic Losses in the Context of the Work Programme on Loss and Damage*. UNFCCC Technical Paper 13/2. Geneva, United Nations Office at Geneva.

Chapter 13

Racing against time: preparing for the impacts of climate change on California's archaeological resources

Michael Newland, Sandra Pentney, Reno Franklin, Nick Tipon, Suntayea Steinruck, Jeannine Pedersen-Guzman and Jere H. Lipps

Abstract

Climate change projections for California indicate that even moderate changes in temperature and sea level will have dramatic effects on archaeological resources here. Coastal erosion, inundation, increased fire hazard, and site exposure due to reservoir drawdown threaten California's cultural heritage. Even now, changes in weather patterns and sea level rise have resulted in the destruction of once stable coastal sites. In the forests, severe drought, disease, and past land management policy has led to catastrophic fires. Looting at exposed sites in reservoirs and lakes has drawn national attention. While much of the focus of climate change is on future impacts, climate-caused damage is happening now.

The Society for California Archaeology has launched archaeological surveys of the state's coastal margin. With over 3000 linear km (1900 miles) to look at and little funding, the study has been a massive mobilisation of volunteers coordinated through a handful of dedicated professionals. Fundamental to the project is working closely with tribal communities, each of which has their own views on climate change, archaeology, and long-term land management practices. This paper summarises that effort, with the hope that the methods and goals expressed for this project can be used as a model nationwide and elsewhere around the world.

Introduction

The California coastline is iconic, varying from rocky shores and steep cliffs to open bays, long warm beaches backed by sand dunes, and brackish estuaries teeming with fish, shellfish and waterfowl. Not surprisingly, there are thousands of indigenous and historic-era archaeological sites, many still undiscovered, within the *c.* 3000 km (1900 miles) of coastal land and edges of the Sacramento-San Joaquin delta, which covers some 700 square miles of the heart of California and empties into San Francisco Bay. The Golden State is known for having been one of the most linguistically diverse areas of the world prior to contact, with at least 80 indigenous languages spoken and hundreds of autonomous tribal groups. Many of these tribes have coastal heritage sites. These sites frequently consist of shell midden, the chemical composition of which helps preserve bone and other organic materials representing a cross-section of marine, estuary and coastal upland environs. Many of these sites represent seasonal coastal villages, and contain evidence of ceremonial practices and burial traditions that extend back millennia. The state's maritime heritage, including docks, shipwrecks, submerged cultural resources, and waters-edge historic businesses and residences, are at risk from damage caused by climate change induced sea level rise. The projected rise in mean sea level, in concert with associated storm surges and land erosion, pose a threat to the rich and as-yet sparsely documented and understood cultural heritage.

All of these sites are now simultaneously threatened by climate change. Climate change impacts on the archaeological record is fast becoming a popular research area (Reeder *et al.* 2012; Chiniewicz 2015; Fitzpatrick *et al.* 2015; Van de Noort 2015; Hollesen *et al.* 2016; Naudinot and Kelly 2016 and others), and early adapters of climate change theory have been investigating impacts on archaeological sites since the early 2000s (Erlandson 2008; 2012 and others). Sea level rise and coastal erosion are having, and will increasingly have, devastating effects on coastal sites. Aside from the climate impacts themselves, infrastructure improvements to protect communities from the effects of climate change pose one of the most substantial threats to resources. Upgrading existing facilities to prevent flooding; building or improving sea walls to prevent higher tides and storm surges; and fire-proofing areas all have the potential for destroying historic resources. Forest fire, and the resulting slope erosion and flooding that follow, will completely erode some sites, irretrievably bury others, and destroy the organic remains of others still. No forest stand is immune to this threat.

Many of these impacts can be avoided with proper forward planning with an emphasis on preservation. Multidisciplinary teams including archaeologists, historic architects, historians, engineers and climate scientists have the potential to spearhead forward planning to 'future-proof' communities from the worst effects of climate change without sacrificing historic or prehistoric elements. The time for recording these sites, and planning for the impacts of climate change, is now.

Threats posed by climate change

For the purposes of this chapter, two major impacts of climate change are considered: 1) sea level rise and resulting coastal erosion; and 2) forest fire and resulting soil erosion. Other impacts will occur, but these are more difficult to predict and their footprint harder to delineate. Models of sea level rise and coastal erosion in California, however, exist for different climate change scenarios (IPCC 2007, 45; Heberger *et al.* 2009, 5–6; Kemp *et al.* 2009). The impacts of sea level rise and increased fire risk are discussed below.

Sea level rise and coastal erosion

Sea levels along our coastline have risen 20 cm since 1897, at an average rate of 2.2 mm per year. Sea levels will likely continue to rise at an accelerated rate, to 1.0–1.4 m (4.6 ft) over the next century (NRC 2012, 103). State-wide, the loss of coastline is estimated at *c.* 100 km^2 (41 miles^2), or some 26,000 acres (Heberger *et al.* 2009, xi). A sea level rise of 1.4 m would also flood approximately *c.* 400 km^2 (150 miles^2) of land immediately adjacent to current wetlands (Heberger *et al.* 2009, 3). This is a minimum assessment, and portions of the state remain unassessed. It should be noted that sea level rise modelling south of Cape Mendocino in California is complicated due to significant variations in uplift and subsidence, groundwater withdrawal, tectonic activity, and the effects of isostatic rebound. It is expected that these areas will experience sea level rise of as much as 1.67 m (5.45 ft) over the next 100 years.

While it has been stated that the predicted sea level rise for the western coast of the US is lower than other areas, the increased sea level, in concert with winter storm events, are predicted to cause significant damage across much of the Pacific coastline (NRC 2012). Taking into account the multiple variables on which sea level rise impacts are dependent, the most current planning guidance offered by the California Coastal Commission (2015) recommends local agencies use scenario-based modelling at the local level to assess impacts.

Much of the California coastline consists of sedimentary rock and is highly susceptible to erosion. The projected higher sea levels will accelerate shoreline erosion due to increased wave energy against cliff faces (PWA 2009, 2). Eroded cliff faces will collapse into the ocean, resulting in a progressing strip of coastal retreat, followed by complete wave erosion and removal. In addition, erosion of some sand spits and dunes may uncover previously buried archaeological deposits and expose them to coastal erosion (Heberger *et al.* 2009, 15).

Site destruction accelerated by sea level rise and shifts in wind and storm surges can already be seen on the California coast. Archaeological site CA-SMA-238 (Fig. 13.1), an indigenous shell midden in Año Nuevo State Park, has been stripped down to bedrock by wave action. This erosional process has been further exacerbated by the activity of elephant seals – over the past several years their numbers along the coast have gradually increased, and they have expanded their mating grounds to the site area. Prior to these two events, this site had been stable for millennia, and has been both archaeologically tested and closely monitored over several decades (Hylkema 1991, 362; pers. comm.).

However, 1.67 m does not reflect the worst case of sea level rise should global temperatures increase such that the Greenland, Antarctic, and Arctic ice masses melt (CNRA 2009, 21; Heberger *et al.* 2009, xi). Should abrupt climate

Figure 13.1. Evidence of storm surge across CA-SMA-238, a previously stable archaeological site along the Central California coast, Año Nuevo State Park (Photo: M. Newland).

shifts occur that release the water held in these areas, sea levels could rise 7–14 m (23–40 ft) (CNRA 2009, 21).

For example, Figure 13.2 depicts a 1.8 m (6 ft) sea level rise in the Huntington Beach vicinity of southern California. A rise of 1.8 m would cover or disturb 12 known archaeological sites in this area. There are likely several more undocumented sites in the area, as it was built upon before federal, state and county laws were passed protecting such sites from development. This area is within the ancestral territory of the Gabrielino and Juaneño. Should sea level rise increase beyond 1.8 m (6 ft), there are many more (30+) sites in the immediate area with an elevation between 2.1 m (7 ft) and 15.2 m (50 ft) that would also be in danger of inundation and erosion.

Figure 13.2. Six foot sea level rise projections for the Huntington Beach area, covering some 2 mi² of urban infrastructure. Within this footprint are 12 known archaeological sites (sea level rise data: NOAA 2015).

Increased forest fire risk and soil erosion

Sudden oak death (SOD), bark beetle, and other diseases and parasites likely to have flourished due to ongoing climate changes, have greatly weakened the general health of many mature trees throughout the state. These conditions, combined with federal and state government land management strategies of prohibiting thinning or controlled burns, has led to many of the state's forests becoming tinderboxes.

Recent research has shown that, across the western US, unmanaged old forests have shown dramatic increases in tree mortality. This increase spans elevations, trees sizes, dominant species, and past fire histories. Climate change has been identified as the main cause (van Mantgem *et al.* 2009, 521). As one would expect, the potential for fire, and the size, frequency, and rate of spread, will be greater if the fuel load is high and drought years that dry out accumulated fuel occur in greater frequency. These fires directly threaten indigenous and post-contact archaeological and cultural resources (Fig. 13.3).

A major contributor to fire threats across the western United States is the dramatic increase in bark beetle populations, which are greater than at any time over the past 125 years (Raffa *et al.* 2008, 521). This population boom appears to be directly tied to climate change; once critical stress and climate thresholds are reached, conditions are right for an explosive, and self-sustaining, bark beetle population expansion. While the beetle and similar eruptive species typically only cause minor disruptions in forest biomes, current conditions have negated many of the factors limiting the damage done by these insects (Raffa *et al.* 2008, 515).

Figure 13.3. Hoberg's Resort, an early 20th century mountain recreation area once boasting many cabins and central lodge in Lake County, California, gutted by the Valley Fire in 2016 (Photo: M. Newland).

Disease is also already taking its toll on coastal forests. Sudden oak death is triggered by the fungus-like pathogen *Phytophthora ramorum*, and can strike mature trees of many different species, often resulting in the death of the tree. Bark and ambrosia beetles colonise the open wounds caused by the disease; fungal infections soon follow (Kelly *et al.* 2008 312–313). Tanoaks (*Lithocarpus densiflorus*), an important acorn food source to native peoples along the north coast, are especially susceptible (Nettel *et al.* 2009, 2224). Research by Monahan and Koenig (2006, 151, 154) on SOD and California coastal live oak (*Quercus agrifolia*) has led to algorithmic models predicting the potential future extent of SOD and has concluded that some 17,570 km^2 of California coastline will be potentially impacted. The disease has reached epidemic proportions in coastal oak communities in California and has spread to California black oak (*Quercus kelloggii*), Shreve oak (*Quercus parvula* var. *shrevei*), and over two dozen other tree and shrub species, including Pacific madrone (*Arbutus menziesii*), redwood (*Sequoia sempervirens*), California bay laurel (*Umbellularia californica*) and Douglas fir (*Psuedotsuga menziesii*) (Moritz and Odion 2005, 107; Kelly *et al.* 2008, 312; Kliejunas 2010, 5). Sudden oak death is not as prevalent in areas that have burned in the last 60 years; forest management practices that have not actively included controlled burns may have resulted in forest stands now susceptible to SOD (Moritz and Odion 2005, 106).

This potential for worsening drought conditions, warmer weather, and diseased and infected vegetation communities all increase the chance of fire. The CNRA (2009, 51) has assessed fire studies over the past three decades and now estimates that wildfire occurrence state-wide could increase from 57% to 169% by 2085.

Tribal perspectives on climate change: three views

Climate change is a profoundly spiritual, as well as secular, concern. Many California tribal groups have a spiritual tradition revolving around the Creator, who, in some instances, watches over the world but does not guide the actions of all its inhabitants. One of the primary questions facing tribal groups is, if climate change is indeed occurring – and tribal communities are divided on this – is it the will of the Creator or an act of man? If the former, should the destruction of heritage sites be allowed to continue as a function of the Creator's will? If the latter, what roles should federal and state agencies, tribes, archaeologists, and the larger community play in preventing these sites from being destroyed? Each tribe has a different answer to these questions.

The Society for California Archaeology realises the importance of Native American input in archaeological research. It was decided that Native American tribes across the study area should be consulted to solicit input for the project. The Native American response varied significantly across the state. The San Diego County Native American Tribes responses have ranged from not submitting comment, to full support. One of the tribes has sent volunteers to help with archaeological surveys of threatened areas as part of their training programme to help their Native American monitoring crew gain experience in archaeological survey. Several tribes have requested that we share our survey results with them to help in their preservation planning efforts.

In the northern part of the state, there has been more dialogue on climate change and the impacts to local resources between tribes, archaeologists, and agencies. Three local people working closely on climate change – Reno Franklin, Tribal Chairman of the Kashia Pomo of Stewarts Point Rancheria; Nick Tipon, tribal elder, Federated Indians of Graton Rancheria (FIGR); and Suntayea Steinruck, Tribal Historic Preservation Officer (THPO) for the Tolowa Dee-ni' Nation – were asked to contribute their perspectives to our chapter. They graciously agreed and their contributions to this discussion appear below.

In 2013, two of the authors of this chapter – Michael Newland (2013) and Nick Tipon – worked collaboratively on a report on *Climate Change and Cultural Resources* within Point Reyes National Seashore. Tipon at the time was Chairman of the Sacred Sites Protection Committee for the FIGR, a federally recognised tribe of the Coast Miwok and southern Pomo peoples. Tipon's views are his alone, and he does not speak for his tribe in any official capacity here, but they outline well some of the considerations that tribes face with climate change and public policy. He has prepared the statement below for this current chapter:

> Our resources were often traditionally used during different seasons, their occasional abandonment and reoccupation did not decrease their importance. The land was blessed and sacred to our ancestors and remains so today.
>
> Native people have lived here during many periods of dramatic environmental change that altered their world significantly. As natural resources shifted over the thousands of years, we have migrated to other areas, changed our diets, developed new technologies, and learned to live with what resources nature provided. Adapting to environmental change has always been necessary for our survival. Our ancestors saw sacred areas physically altered or even destroyed by these natural forces. This did not diminish the spiritual significance of the area and the objects revealed by soil disturbance. Environmental changes were part of the natural order of the world.
>
> Today, new forces are emerging that affect our gathering of the natural resources provided by the land and our use of ceremonial or sacred sites. European contact and colonialism forced our ancestors and current Tribal people to move further from their spiritual connection to the land. Prior to

> this, there was a slow adaption over time to changing natural forces. Today, we face a different pace of environmental change that is detrimentally affecting our cultural resources. Modern society has contributed to a climate shift that is causing the physical landscape and weather patterns to rapidly change. Erosion, rainfall, droughts, sea level rise, rise in sea temperatures, and extreme weather patterns have or are about to destroy many of the Tribe's sacred sites. My Tribe must decide how to advise responsible agencies to protect our cultural resources from these threats.
>
> Climate change requires consideration of some modern perspectives of this destructive process. We now can no longer allow natural forces to affect cultural resources in the 'traditional' way. It is no longer only nature that is the cause of climate change. Our traditional ceremonies and ways of interacting with nature cannot be continued because of our industrial society's intervention in the climate process. We can no longer leave artifacts exposed. People are finding, removing, or collecting sacred items exposed by climate change. Our agency partners must, in collaboration with the Tribe, understand the importance of these resources to the long-term health of Tribal members and develop policies and methods for their preservation for future generations of Tribal members. The formation of new public and Tribal policies for the protection of cultural resources from climate change destruction is critical for the Tribe's survival. How to preserve the spiritual nature as well as the physical components of cultural resources, mitigating impacts where feasible, and developing appropriate prayers or ceremonies for what we can no longer protect are some of the cultural challenges the Tribe is facing.

Immediately north of the Coast Miwok are the Kashaya Pomo, whose ancestral territory includes most of coastal Sonoma County. Their reservation lands lie deep within the heart of their ancestral territory. The Kashaya are federally recognised and are represented by the Kashia Band of Pomo Indians of the Stewarts Point Rancheria. As a coastal group, climate change is of great concern to them and the effects are now being seen. Reno Franklin, Tribal Chairman and a former THPO has provided this statement concerning climate change and the cultural heritage of his tribe:

> While much of the country has the choice to ignore or doubt climate change, our Tribe does not share that option. We first saw the evidence of it in our sacred qhamos' (ocean), the duwe'hsa (surf fish) were our first indicator. As the qhamos' temperature rose, the duwe'hsa moved away from their traditional spawning grounds to the cooler water in the traditional lands of a neighboring tribe to our north. This caused a problem for our people and interrupted a Kashaya gathering process that had been going on for more than 12,500 years. Now we are alarmed that our chanama (kelp) beds are in danger of dying. For us, that would be catastrophic. What many others see as potential warning signs of global warming, we see as a sign that global warming is indeed real, and it is already having a dangerous effect on our Kashia way of life.

The north-west corner of California is home to the Tolowa people, whose ancestral territory extends north into Oregon. In California, the Tolowa are represented along the coastline by the Tolowa Dee-ni' and Elk Valley Rancheria, both federally recognised tribes that are interviewing elders and collaborating with agencies to determine what the impacts of climate change are and what they might become. The north-west coast, which sees more severe storms and is characterised by an unstable and highly erosive coastline morphology, will be hit particularly hard by climate change. Two of the authors – Newland and Suntayea Steinruck – are working together with the National Park Service (NPS) to study projected climate change impacts and tribal heritage resources. As the THPO for the Tolowa Dee ni', Steinruck expresses her concerns regarding climate change thus:

> I was raised that it is my responsibility to be a caretaker of the Earth. If we do not treat her right or behave in a way that shows we are grateful she will take things away. In our Tolowa Dee-ni' World Renewal Ceremony we pray for all things and give thanks to show we appreciate all we have been given so that we will then be provided for again. This concept is ingrained in our belief system.
>
> The concept and reality of climate change is very frustrating for my community as well as other tribal communities around the World. In our view of cultural heritage, there is a balance. You never take more than you need and you never take too little or that balance is broken. Every choice has a reaction and it is our Tribal Heritage Preservation Office's duty to look at choices and weigh-out the action that, in-good-faith, makes sure the balance is not disturbed. Climate change has done this. Our World is unhinged and the balance is broken. The poor choices of man and outcome to Mother Earth have resulted in unmeasurable costs and long-term disastrous effects. At the forefront of climate change's wrath are our non-renewable tribal cultural resources. Our heritage has lasted since the beginning of time. Now it is at the mercy of climate change.
>
> Our THPO office is looking at making difficult choices on what actions are necessary to be stewards of our cultural places and tribal resources. It is our duty to know climate change's effects, and what are the best choices to maintain the balance of our ancestral ties to the land, the environment, and traditional ways of life. In the future, our THPO will be working with those that will assist us through these decisions. We plan to move forward in restoring balance to our Earth while always recognizing our ancestors' vital role in being part of the natural environment. It is our responsibility to care for these things.

The archaeological community in California is beginning to understand the breadth of impacts that the tribal community has been tracking for several years. The next sections illustrate two separate efforts conducted by teams working towards addressing climate change and its effects on archaeology.

Preparing for the worst: ongoing research by the Cooper Center

The Dr John D. Cooper Archaeological and Paleontological Center, a partnership of the County of Orange, California and California State University Fullerton has undertaken a research project to identify and document the Native American cultural sites in danger from the impacts of sea level rise along the coast of Southern California. The project area to date includes the coastal areas of Ventura, Los Angeles, Orange and San Diego counties. Hundreds of sites that border the shoreline are threatened or will be threatened in the foreseeable future by rising sea levels.

A survey of the elevations of prehistoric and historic human sites in Southern California reveals the 1.4 m rise in sea level expected by 2100 will impact 194 known archaeological sites. If the ice covering either Greenland or West Antarctica were to collapse or melt into the ocean, sea level would rise some 8 m and impact an additional 295 sites; if both collapsed, it would result in a 17 m rise, with 434 sites inundated. While each of these scenarios has a different time estimate, the collapse of parts of the Greenland and West Antarctica ice sheets could happen quickly, adding their sea level components to the estimates for thermal expansion. Protection of archaeological and historic sites in coastal Southern California should be coordinated and included within efforts to reduce damage to modern infrastructure and buildings from sea level rise.

Mobilising the California archaeological community: ongoing research by the Society for California Archaeology

The Society for California Archaeology (SCA) is a 1000-member strong group of professional archaeologists, avocationalists, and tribal partners. The SCA understands the threats that climate change poses to our state's cultural heritage and has launched efforts to prepare for these threats.

While threats posed by fire are significant, the sheer acreage of our forest lands and unpredictability regarding how fire will play out in these lands makes them less suitable for study. Instead, the SCA has embarked on a study of California's coastal public lands in 2012. The work is ongoing, with a detailed history and technical reports being issued on the SCA website (https://scahome.org/sca-climate-change-and-california-archaeology-studies/).

In summary, the coastline has been divided into mile-long (1.6 km) blocks, with each block extending inland roughly 200 m. Archaeologists are encouraged to adopt a mile-long stretch within public land, where they conduct archaeological survey (consisting of a surface walkover), record any findings, and prepare a brief summary of the results. The survey transects are roughly 30 m apart and the crews use GPS equipment that is borrowed from universities, partner firms, or is privately owned. California has a set of standard recording forms issued by the Department of Parks and Recreation that are used by nearly all archaeologists. To keep the workload of such a project manageable to its participants, we use an organisational structure that spreads the planning responsibilities out to a small group with defined roles. This group consists of a Regional Coordinator, an Archival Coordinator, a GIS Coordinator, a Logistics Coordinator, a Data Management Coordinator, and a Media Coordinator. The group works together to bring the project to completion, including the preparation of final reports and dissemination to agencies, tribes, and redacted versions of the findings to the public (Newland 2014).

Two case studies: Marin and San Diego Counties

Two counties, Marin in the north and San Diego in the south, were chosen as test cases for the project (Fig. 13.4). Both efforts are still underway, with our findings shared with our tribal and agency partners as we proceed. A third foray, into Los Padres National Park in Monterey County, has been conducted by the archaeological field school at Cabrillo College under Dustin McKenzie, with a completed survey report graciously prepared by archaeologist Annamarie Leon Guerrero (2015).

Marin County

Marin County was chosen for pilot studies on climate change, as earlier work there had been done at Point Reyes National Seashore (PORE), related studies were ongoing (Newland 2015; Newland and Engel 2015), and the local agencies and tribe were already aware of many of the issues and were supportive. Between 2012 and 2015, over 80 volunteers, including students, tribal members, and professional archaeologists surveyed *c.* 100 km (60 miles) of coastline, most of it within Point Reyes National Seashore and Tomales Bay State Park. No private property was surveyed. The student turnout was strong, with students representing 12 universities, colleges, and community colleges contributing. Instructors teaching field courses from California State University (CSU) Chico, Cabrillo College, and Foothill College brought their students as part of coursework. The Small Project Internship and Field Internships at Sonoma State University (SSU), taught through the Anthropological Studies Center, also participated. Many graduate students at SSU offered their time and expertise to function as crew chiefs, help serve in coordinator roles, and prepare site records. Paul Engel, PORE Archaeologist, donated several weekends of his own time to the cause.

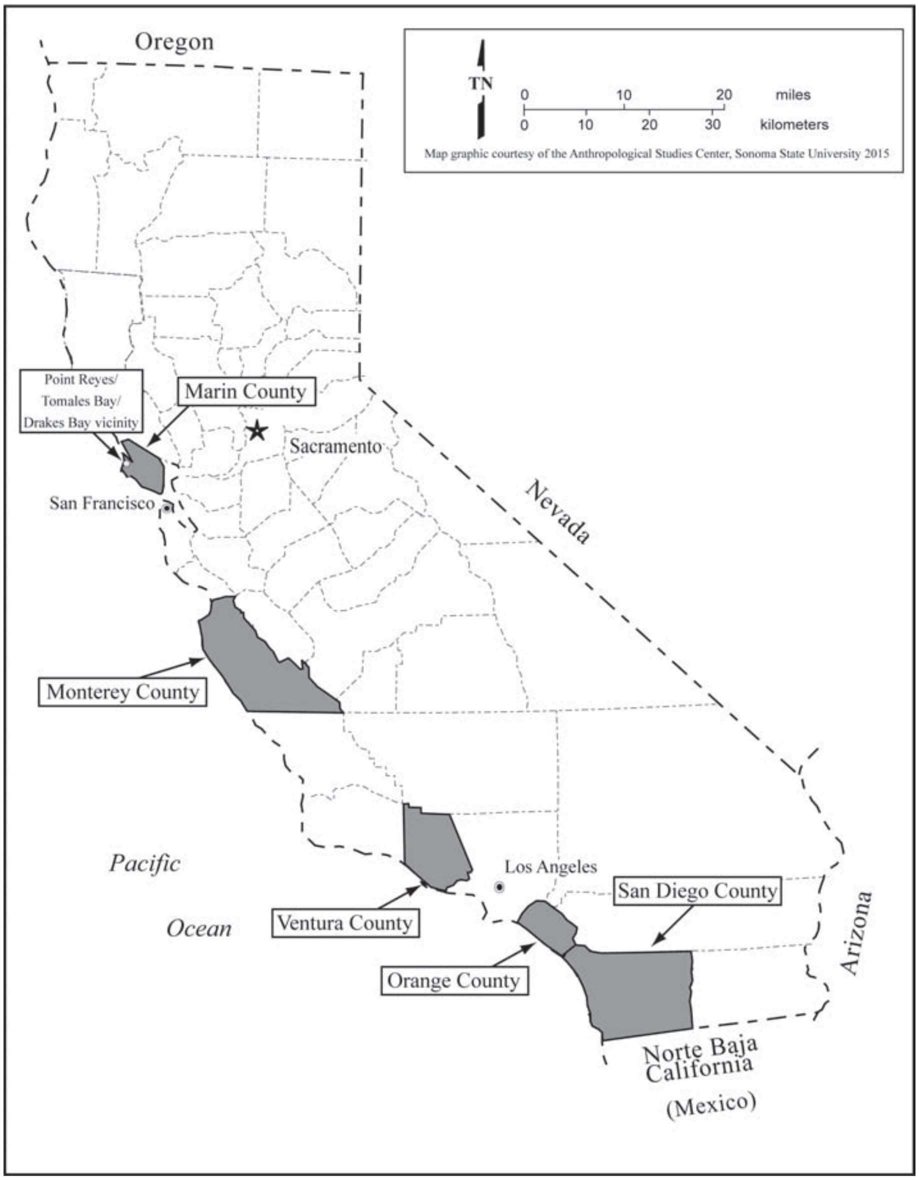

Figure 13.4. Locations of Society for California Archaeology climate change case studies in California.

Results

Drakes Bay and Tomales Bay were some of the earliest archaeologically surveyed areas in the region, and many substantial sites have been found bordering these two bays over the past century (Nelson 1909; Moratto 1974; Compas 1998; Newland 2015). As this area was the focus of so much early work, only a dozen or so new sites have been found, and most of these date to the historic era. The rest – 54 sites in total – had been previously recorded or noted. However, many of these sites had sparse information on them and were last recorded decades ago. Our effort focussed on updating records, establishing site boundaries, and assessing threats. The National Park Service has funded survey and site sensitivity model testing in PORE that has dovetailed with the SCA effort, including inland survey, which has helped tease out Coast Miwok trail routes from interior areas out to the coastal sites.

San Diego County

San Diego County has approximately 18 km (11 miles) of coastline, not nearly as extensive as that of Marin County. However, these 18 km are much more densely developed, and the coastal landscapes of the county vary widely, from high coastal bluffs to a series of ten low-lying estuaries and lagoons. Their margins greatly expanded the geographic reach of the project to 18,000 acres of publicly held lands within our designated sea level rise impact zone. Sandra Pentney has been leading this effort.

To gain access to various types of public land requires consultation and approval from over 60 local public land-holding entities, including state parks, nine separate cities, the County, private land trusts, utilities and roads easements, and the Department of Defense.

Results

These results are preliminary as more survey is underway, but over the past two years, the San Diego team has covered about 4000 acres and found or re-recorded 25 sites. They have worked with 106 volunteers – mostly local students and avocational archaeologists – to accomplish this, most of whom were organised through the San Diego County Archaeological Society.

Discussion

The process of launching such a study, ongoing consultations with tribal representatives, and the continuing evolution of climate change studies has led to a number of conclusions regarding these kinds of studies, and the role that they may play in future work in California and beyond. These are discussed below.

Vegetation

On public coastal lands, vegetation has been allowed to largely grow unchecked. Many of these areas were historically ranches or farms. When the first archaeologists surveyed here, it was predominantly open grazing land, with ranch roads criss-crossing the landscape. This is no longer the case. Many of the known sites were buried under dense vegetation. Clearly, this was not the condition of these sites when they were occupied, and modern land management practices have created a landscape that does not resemble that present at the time of contact. This complicates surveys. Ours will remain a surface effort only so that the permitting requirements – *i.e.* government-issued permits to archaeologists conducting study on public lands – are met easily and the amount of site disturbance minimised. However, those agencies that are serious about doing further good-faith work towards identifying sites likely to be impacted by climate change should include subsurface survey.

Tribal consultation

While several of the tribes welcomed the studies and have participated in them, others did not. In some cases, the tribal governments were not prepared to make decisions about the nature of climate change, did not want archaeologists looking for sites within their ancestral territory, and did not want to put the tribe's own resources towards finding and recording sites. In these instances, no further efforts were made to pursue survey work. In other cases, an informal working relationship with a tribe's cultural staff had to transition to a more formal relationship with the tribal government. In these instances, the work was halted until the Council could weigh in on this; once they did, they approved. In the southern part of the state, a number of the tribes have requested updates on our progress so that they can include our data in their own projects and land-use planning and community outreach efforts. Tribal consultation is a critical component to the success of these studies and we remain committed to collaborative work where it is welcome and to refrain from surveying where it is not.

Climate change and regulatory planning

Cultural resource studies in the United States are largely driven by federal laws and regulations that attempt to mitigate the effects of federal undertakings – those projects funded or permitted by federal government, or that occur on government land – on the nation's cultural heritage. Such undertakings are subject to federal historic preservation laws and regulations. In California, a second set of laws and guidelines govern state-funded or permitted projects. Increasingly, preparing for climate change is becoming part of the planning process. Overall, these preparations are still in their infancy and tend to take into account low sea level rise and little or no coastal erosion. For example, although Channel Islands National Park has been researching sea level rise impacts for some time, most local planning agencies have yet to address these impacts on archaeological resources.

In the future, climate change scenarios should feature more as part of the assessment of an undertaking's effects. Some questions that lead agencies should ask when determining the appropriate treatment of effects include: What climate change impacts are likely to occur at the site over the next century? Are the long-term effects of the undertaking likely to enhance, decrease, or have a neutral impact on climate change damage, and if so, how? What will the preservation of this site be in comparison to others of its type? Do the suggested treatments of the undertaking effects further accelerate or decelerate this damage?

Volunteer climate change studies

By keeping the planning centralised, the SCA hopes that this project will maintain some consistency and still raise awareness within local communities through a grass roots effort. Responses to the opportunities presented have been overwhelming. Our volunteers include tribal members, retired locals, local archaeologists who feel passionately about our cause, and a large contingent of local students who are eager to gain field experience (Fig. 13.5). We have several observations here:

- In California, most of our permits to conduct archaeological work require individuals with a graduate degree and a certain amount of experience to prepare the finished

Figure 13.5. Volunteer field crews surveying the San Diego coastline (Photo: S. Pentney 2015).

survey reports. This results in the quick accumulation of field data with only a handful of people with the qualifications to prepare the report, and those people typically have full time jobs doing other work. Volunteer coordinators must be able to commit to see reporting through to completion.

- Using local volunteer labour comes with risks. In the United States, cultural resources are protected by local, state and federal laws and site looting is a significant issue. Staffing these projects with volunteers can result in potential risks. We train people how to identify archaeological sites and are working to ensure that they will not use this knowledge to loot (which, to date, has not been a problem). We took a three-pronged approach to this risk:
  - o *Training*. All new volunteers undergo a training class before fieldwork or must be enrolled in university anthropology/archaeology coursework. The class lasts 2–3 hours and emphasises the importance of archaeological context and association. It also covers protective laws, their penalties, and what the loss of data means to the scientific as well as the Native American community.
  - o *Confidentiality*. All volunteers are required to sign ethics statements and confidentiality notices before being allowed on a field crew.
  - o *Crew composition*. The field crews contain an appropriate balance of professional archaeologists to volunteers. During survey, the volunteers are spaced in between archaeologists to ensure that there are qualified people to answer questions and provide professional advice on artefact identification.
- Using public volunteers not only helps spread the word about climate change, it also promotes responsible education on the value and sensitivity of archaeological resources. For example, the San Diego County Archaeological Society is a local avocational group of people who want to learn more about archaeology. They organise monthly speakers, publish a newsletter, and have a committee that reviews and provides comment on environmental reports. The SDCAS has worked to educate the public on archaeology and has become a respected voice on local archaeological issues.

Conclusion

Climate change affects us all. The maritime cultural heritage of the world, of all cultures, is currently threatened, as are our ancestral coastal and forest habitation sites. While some have started to address sea level rise impacts upon archaeological sites, the scope of the challenge is unprecedented, its impacts spanning legions of government agencies, private property owners, non-profit organisations, and indigenous communities. The problem is further complicated by the political and economic aspects of the phenomena. In California, the impacts of climate change are already being felt, and over the next century, they may be devastating.

If any field of study is able to understand the impacts of climate shifts on human populations, it is archaeology. The SCA understands this and has committed the time and efforts of its volunteers, in collaboration with tribal communities and government agencies, to begin the process of surveying the areas of California that are likely to be the hardest hit. By bringing awareness to this issue through our ongoing efforts, the significance of the sites being lost, the social implications of climate change, and the responsibility we have as citizens to begin preparing now can be brought to the larger archaeological community and more broadly to the general public.

Acknowledgements

Northern. We would like to thank Jon Erlandson for his generous review of our chapter, and the ongoing support of the Federated Indians of Graton Rancheria, the National Park Service, Tolowa Dee-ni', Elk Valley Rancheria, Kashia Pomo of Stewarts Point Rancheria, the Anthropological Studies Center and student volunteers from Sonoma State University, Dustin McKenzie and student volunteers from Cabrillo College, Kevin Dalton and student volunteers from CSU Chico, Annamarie Leon Guerrero, Dan Curley and student volunteers from Foothill College, Adie Whitaker and staff from Far Western Anthropological Research Group, the Society for California Archaeology, Paul Engel and Mark Rudo of Point Reyes National Seashore, and California Department of Parks and Recreation.

Southern. We would like to thank Atkins, SDCAS, Natalie Brodie, Karen Lacey, Marla Mealey, Sara Shouse, R.D. Schultz, Michael Degiovine, Maximilian Jewett, Nicole Turner, G. Timothy Gross, Marc Cavallaro, Nick Doose, SCIC, California State Parks, California Fish and Wildlife Service, Viejas Band of Mission Indians, Department of Defence, County of San Diego, City of San Diego, City of Oceanside, City of Carlsbad, City of Encinitas, City of Solana Beach, City of Del Mar, National City, City of Chula Vista, San Diego Gas and Electric, and Caltrans.

References

California Coastal Commission. 2015. *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits*. Adopted August 12, 2015. San Francisco, California Coastal Commission.

Chiniewicz, E. 2015. *Potential Effects of Projected Sea Level Rise on Coastal Archaeology at Tolowa Dunes State Park, Del Norte County, California*. North Coast Redwoods District, California State Parks.

CNRA (California Natural Resource Agency). 2009. *California Climate Adaption Strategy*. Sacramento, California Natural Resource Agency. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF [accessed 25 April 2015].

Compas, L. 1998. Research Design, Case Study, and Proposed Management Plan: Post-Contact Coast Miwok Settlement Patterns and Resource Procurement Strategies in Point Reyes National Seashore. Unpublished MA thesis in Cultural Resources Management. Department of Anthropology, Sonoma State University, California.

Erlandson, J. 2008. Racing a rising tide: Global warming, rising seas, and the erosion of human history. *Journal of Island and Coastal Archaeology* 3(2), 167–69.

Erlandson, J. 2012. As the world warms: Rising seas, coastal archaeology, and the erosion of maritime History. *Journal of Coastal Conservation* 16(2), 137–42.

Fitzpatrick, S. M., Rick, T. C. and Erlandson, J. M. 2015. Recent progress, trends, and developments in island and coastal archaeology. *Journal of Island and Coastal Archaeology* 10(1), 1–25.

Guerrero, A. L. 2015. A Cultural Resources Survey of 300 Acres of Pacific Valley Coastline, Los Padres National Forest, Monterey, California. *Society for California Archaeology, Climate Change and California Archaeology Series Technical Report 2*. Chico, Society for California Archaeology. Available at: https://scahome.org/?p=6220 [accessed 1 April 2016].

Heberger, M., Cooley, H., Herrera, P. and Moore, E. 2009. *The Impacts of Sea-Level Rise on the California Coast*. Sacramento, California Climate Change Center.

Hollesen, J., Matthiesen, H., Møller, A. B. and Westergaard-Nielsen, A. 2016. Climate change and the loss of organic archaeological deposits in the Arctic. *Scientific Reports* 6(2016), article number 28690, doi:10.1038/srep28690.

Hylkema, M. 1991. Prehistoric Native American Adaptations along the Central California Coast of San Mateo and Santa Cruz Counties. Unpublished MA thesis. Department of Anthropology, San Jose State University, California.

IPCC (Intergovernmental Panel on Climate Change). 2007. *Climate Change 2007: Synthesis Report*. Available at: http://www.ipcc.ch/organization/organization.shtml# [accessed 11 February 2011].

Kelly, M., Liu, D., McPherson, B., Wood, D. and Standiford, R. 2008. Spatial pattern dynamics of oak mortality and associated disease symptoms in a California hardwood forest affected by Sudden Oak Death. *Journal of Forestry Research* 13, 312–19.

Kemp, A. C., Horton, B. P., Culver, S. J., Corbett, D. R., van de Plassche, O., Gehrels, W. R., Douglas, B. C. and Parnell, A. C. 2009. Timing and magnitude of recent accelerated sea-level rise (North Carolina, United States). *Geology* 37, 1035–38.

Kliejunas, J. T. 2010. *Sudden Oak Death and* Phytophthora ramorum*: A Summary of the Literature*. Albany, CA, United States Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-234.

Monahan, W. B. and Koenig, W. D. 2006. Potential effects of sudden oak death on the oak woodland bird community of coastal California. In S. J. Frankel, P. J. Shea and M. I. Haverty (technical coordinators), *Proceedings of the Sudden Oak Death Second Science Symposium: The State of our Knowledge. General Technical Report PSW-GTR-196*, 195–209. Albany, CA, Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Moratto, M. 1974. *An Assessment of the Cultural Resources within Point Reyes National Seashore*. Report prepared for Arizona Archaeological Center, National Park Service, Tucson, Arizona. San Francisco, Department of Anthropology, California State University San Francisco.

Moritz, M. A. and Odion, D. C. 2005. Examining the strength and possible causes of the relationship between fire history and Sudden Oak Death. *Oecologia* 144(1), 106–14.

NRC (National Research Council). 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Washington, DC, The National Academies Press.

Naudinot, N. and Kelly, R. 2016. Climate change and archaeology. *Quaternary International* (2016), http://dx.doi.org/ 10.1016/j.quaint.2016.02.026.

Nelson, N. C. 1909. Shellmounds of the San Francisco Bay Region. *University of California Publications in American Archaeology and Ethnology* 7(4), 309–56.

Nettel, A., Dodd, R. S. and Afzal-Rafii, Z. 2009. Genetic diversity, structure, and demographic change in Tanoak, lithocarpus densiflorus (Fagaceae), the most susceptible species to Sudden Oak Death in California. *American Journal of Botany* 96(12), 2224–33.

Newland, M. 2013. *The Potential Effects of Climate Change on Cultural Resources with Point Reyes National Seashore, Marin County, California*. Report prepared for the National Park Service. Rohnert Park, Archeological Services Center, Sonoma State University. Available at: https://www.sonoma.edu/asc/publications/pdfs/climate_change_pt_reyes_natl_seashore_draft.pdf.

Newland, M. 2014. Overview and Workplan. In *Society for California Archaeology, Climate Change and California Archaeology Series, Technical Report 1*. Chico, Society for California Archaeology. Available at: https://scahome.org/sca-climate-change-report-volume-1/ [accessed 1 April 2016].

Newland, M. 2015. *The Potential Effect of Climate Change on Cultural Resources within Point Reyes National Seashore, Marin County, California*. Report prepared for the National Park Service, Point Reyes National Seashore, California. Sonoma, Anthropological Studies Center, Sonoma State University.

Newland, M. and Engel, P. 2015. *Indigenous Archaeological Site Predictive Model, Field Testing Program, Point Reyes National Seashore, Marin County, California*. Report prepared for the National Park Service, Point Reyes National Seashore, California. Sonoma, Anthropological Studies Center, Sonoma State University, Rohnert Park, California.

NOAA (National Oceanic and Atmospheric Administration). 2015. *Sea Level Rise and Coastal Flooding Impacts Dataset*. Available at: https://coast.noaa.gov/slr/ [accessed 01 April 2016].

PWA (Phillip Williams and Associates). 2009. *California Coastal Erosion Response to Sea Level Rise: Analysis and Mapping*. Report prepared for the Pacific Institute, Oakland. San Francisco, Phillip Williams and Associates.

Raffa, K. F., Aukema, B. H., Bentz, B. J., Carroll, A. L, Hicke, J. A., Turner, M. G. and Romme, W. H. 2008. Cross-scale drivers of natural disturbances prone to anthropogenic amplification: The dynamics of bark beetle eruptions. *Bioscience* 58(6), 501–17.

Reeder, L. A., Rick, T. C. and Erlandson, J. M. 2012. Our disappearing past: A GIS analysis of the vulnerability of coastal archaeological resources in California's Santa Barbara Region. *Journal of Coastal Conservancy* 16, 187–97.

Van de Noort, R. 2015. Conceptualizing climate change archaeology. *Antiquity* 85, 1039–48.

van Mantgem, P. J., Stephenson, N. L., Byrne, J. C., Daniels, L. D., Franklin, J. F., Fulé, P. Z., Harmon, M. E., Larson, A. J., Smith, J. M., Taylor, A. H. and Veblen, T. T. 2009. Widespread increase of tree mortality rates in the western United States. *Science* 323, 521–24.

Chapter 14

Threatened heritage and community archaeology on Alaska's North Slope

Anne M. Jensen

Abstract

The North Slope of Alaska is home to many coastal archaeological sites. Exceptional preservation is due to the cold climate and, until recently, sites have generally been considered stable. The changing climate has altered this situation. This paper briefly reviews the complex cultural chronology of coastal Northern Alaska. It then describes the situation at some of the significant sites (including two National Historic Landmarks), describing recent work at several of them. Types of information being lost are detailed and reasonable approaches to ameliorate the situation are reviewed, including the role of local communities to help address challenges and seize opportunities.

Introduction

The North Slope Borough of Alaska is a vast area (245,440 sq km), larger in size than 38 of the 50 US states and larger than many European countries (Fig. 14.1). Humans have occupied it since the end of the Pleistocene (Alexander 1974; 1987; Kunz and Reanier 1994; 1995). Archaeological sites occur in a variety of settings, both in the interior, where they tend to be concentrated along rivers and at lakes and overlooks, and on the coast. Thanks to the cold climate, organic preservation at most sites is spectacular. Discarded items often passed through only a few freeze-thaw cycles before being buried deeply enough to remain permanently frozen. Well-preserved artefacts of ivory, bone, baleen, wood, and other organic materials are complemented by nearly intact structures built from wood and bone, caches containing meat so well preserved that they can be identified by sight, and large middens preserving food refuse and manufacturing debris.

Materials dating back 1000 or 2000 years often look as though they were deposited only yesterday. This level of preservation means that, unlike in many regions where organics have long since disappeared from archaeological sites, interpretation need not rest heavily on speculative extrapolation about the nature of the complete assemblage based on discovery of a few stone tools. Zooarchaeological analyses benefit because the actions of many taphonomic forces are slowed to the point that their effects are minimal compared to the situation at sites in temperate climates: partly calcified bone, cartilage, opercula, hair and other similarly delicate tissues are often preserved.

North Slope cultural history

Archaeology in the Arctic has always been difficult and expensive, and so has lagged somewhat behind archaeology in other more easily accessible parts of the world. For that reason, cultural chronologies are not completely understood. Even so, it is useful to present a brief cultural history of the North Slope as context for this paper (Fig. 14.2; for a more extensive review, see Jensen 2014).

Northern Paleoindian, American Paleoarctic and Northern Archaic traditions

The earliest evidence of a Late Pleistocene/Early Holocene occupation of northern Alaska – by peoples using tools similar to those of the Paleoindian cultures known from central North America – is securely dated between *c.* 11,300–8750 cal BC (Smith *et al.* 2013). A Paleoarctic tradition, thought to date between 10,000–7000 years ago, was defined from the Akmak and Kobuk

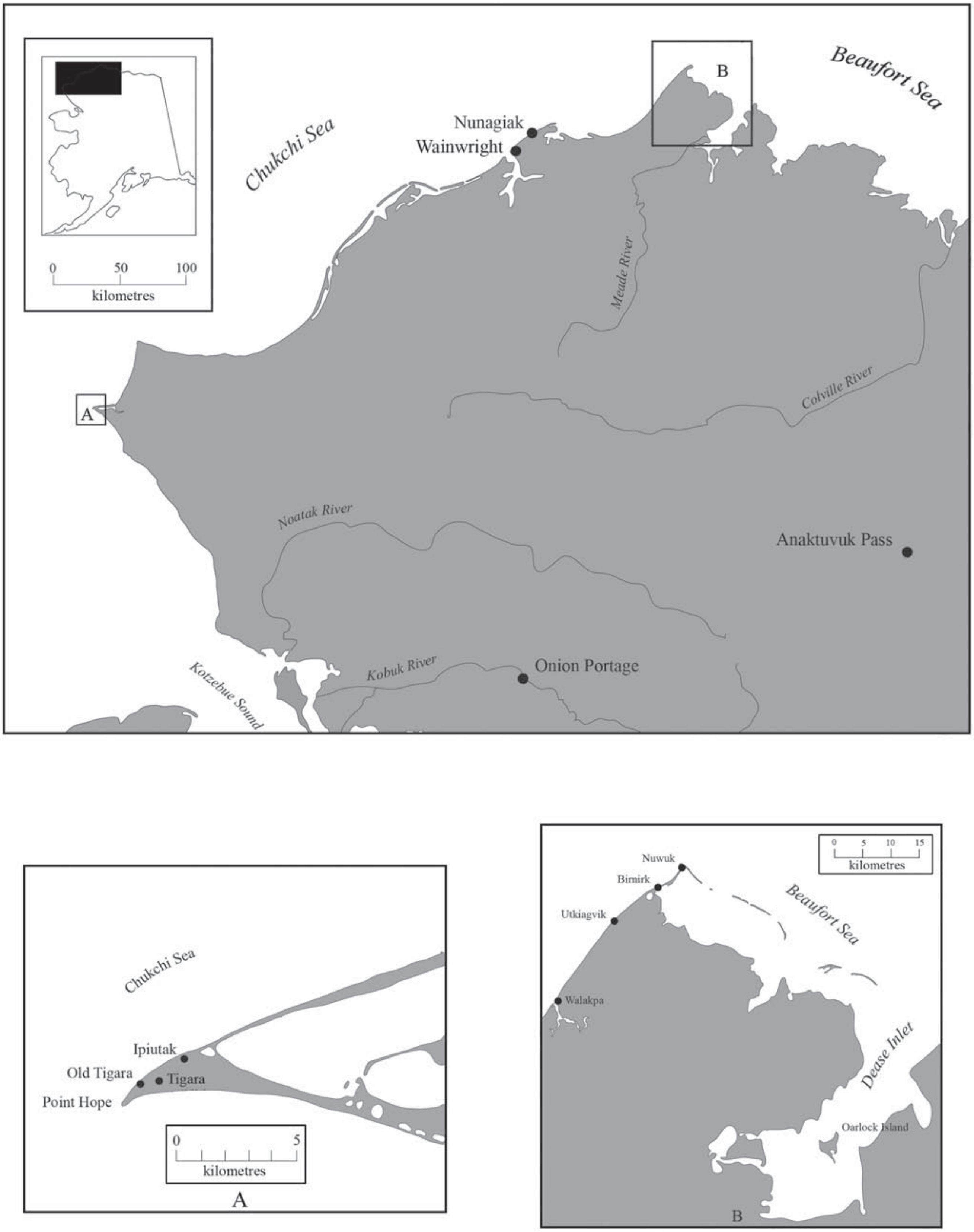

Figure 14.1. Locations of sites mentioned in the text within North and Northwest Alaska.

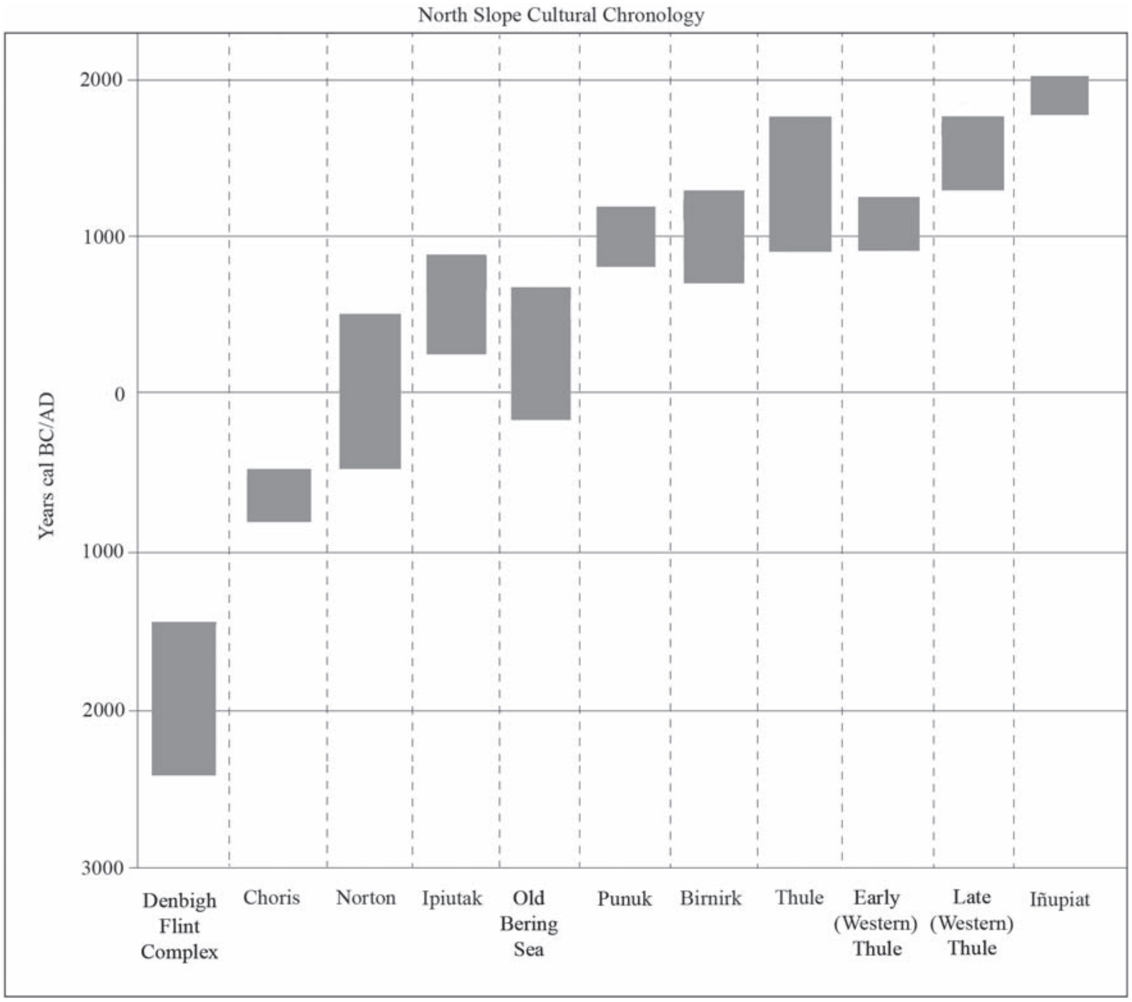

Figure 14.2. Cultural history of North and Northwest Alaska.

complexes at Onion Portage (Fig. 14.1 top) (Anderson 1968; 1988), and some probable Paleoarctic sites are among those recorded by a survey of a relict shoreline bluff south of Wainwright (Gerlach 1982). This was followed by a Northern Archaic tradition, dating to *c.* 6000–3200 cal BC at the coast (Friesen and Mason 2016), also defined from assemblages found at Onion Portage (Anderson 1968). The Northern Archaic tradition appears to have persisted longer in the interior, perhaps as late as 1000 cal AD (Potter 2016).

Arctic Small Tool tradition

In North Alaska, the primary culture representative of the Arctic Small Tool tradition is the Denbigh Flint Complex (2450–1450 cal BC) (Giddings 1951; 1964; Tremayne and Rasic 2016). Denbigh materials have been found at Walakpa, just south of Barrow. Arctic Small Tool tradition cultures that appear related to the Denbigh Flint Complex are found across the North American Arctic, including the Pre-Dorset cultures in Canada, and the Independence I and Saqqaq cultures in Greenland.

The Norton/Paleo-Eskimo tradition: Choris, Norton and Ipiutak cultures

Although some interpretations treat these cultures as part of the Arctic Small Tool tradition, others identify a separate tradition known as the Norton or Paleo-Eskimo tradition. This includes the Choris culture (800–500 cal BC), which features important new artefact types such as pottery and stone lamps (Anderson 1984; 1988; Giddings and Anderson 1986; Friesen and Mason 2016); and the Norton culture (*c.* 500 cal BC–500 cal AD), which continued many of the Choris culture traditions (Friesen and Mason 2016; Mason 2016a). A few large end blades found at Norton sites suggest this group of people may have been casual whalers. Several identified and implied Norton sites have been found between Barrow and Wainwright (Stanford 1976; Jensen 2007).

The Ipiutak culture (250–900 cal AD) is notable for its elaborately carved ivory objects (see Larsen and Rainey 1948; Bowers 2009; Mason 2016a). Surprisingly, the Ipiutak material culture corpus appears to lack the pottery, ground slate, lamps, and whale hunting equipment common to both the earlier Norton and the later Eskimo cultures. Coastal Ipiutak sites show a strong reliance on hunting of marine mammals, particularly walruses, and Ipiutak artefacts have been found in three locations on the North Slope: the type site itself (Larsen and Rainey 1948), a caribou kill or processing site at Anaktuvuk Pass (Mills *et al.* 1999), and Nuvuk, located at the tip of Point Barrow (Jensen 2009a–b).

Neo-Eskimo tradition: Birnirk, Old Bering Sea, Okvik, Punuk and Thule cultures

The Neo-Eskimo tradition (*c.* 250 cal BC–present) has also been referred to as the Northern Maritime tradition. On the North Slope, the Birnirk culture (700–1300 cal AD) is the earliest of the Neo-Eskimo cultures, and its known distribution is exclusively coastal (Mason 2016b; Taylor 1963). Named for its type site near Barrow (Ford 1959; Carter 1966; Stanford 1976), Birnirk sites occur on the north coast of the Chukotsk Peninsula in the Russian Far East, as well as on St Lawrence Island and the north shore of Norton Sound in western Alaska. They also occur along the North Alaska coast at least as far as Point Barrow, although erosion along the Beaufort Sea coastline has most likely destroyed any Birnirk sites that previously existed farther to the east. Birnirk people subsisted on a wide variety of marine mammals, as well as caribou and other land mammals. They were able to take whales, but do not appear to have oriented their entire socioeconomic system toward whaling.

Elsewhere in Alaska, especially on St Lawrence Island along the Bering Sea coast, several other cultures are known to have existed during this period (Mason 2016c). These include the Old Bering Sea (*c.* 200 cal BC–700 cal AD), Okvik (sometimes considered the Old Bering Sea 1), and Punuk (800–1200 cal AD) cultures. They are all characterised by elaborate decorative arts styles and a focus on hunting marine mammals. Old Bering Sea and Punuk material culture has also been found in Siberia. Punuk materials have been recovered from a house at Nunagiak, a coastal site between Wainwright and Barrow (Ford 1959). Technology critical to systematic taking of great whales, including drag float parts, is known from these cultures.

The Thule culture (*c.* 900 cal AD–1750) followed the Birnirk culture (Jensen 2009b) and its tools represent an elaboration and diversification of the Birnirk toolkit. The Thule culture developed somewhere in North Alaska, where the earliest Thule is variously referred to as Early or Western Thule, and spread rapidly across the entire North American Arctic. The Thule were highly successful whalers, who tended to live in larger communities oriented toward whale hunting, although they also hunted the same marine mammals and caribou as their Birnirk forbears. After the initial Thule migration, these people developed more specialised regional cultures, suited to the varying ecosystems from Alaska to Greenland. In Alaska, this regional variant is known as Late Western Thule (*c.* 1300–1750 cal AD), which led directly to the diverse regional late prehistoric Eskimo cultures of northern Alaska (Sheehan 1985; 1990; 1997), and to modern Iñupiat culture (Jensen 2016; Jensen and Sheehan 2016).

Past practices and changing times

Thanks to the cold and the relatively low level of development compared to most other regions, sites in Arctic Alaska have been considered stable by archaeologists. Concerns about their preservation revolved mostly around 'subsistence digging' by local residents, or destruction due to occasional military or industrial development. Since the early exploratory surveys and the excavations of the 1920s to early 1960s, the primary management philosophy for sites on US federal lands has been 'preservation in place'. Budgetary and staff limitations make that an attractive option, but even when university researchers have external funds to conduct excavations, the tendency has been to focus more on coring and test pitting programs, rather than large scale excavation.

This philosophy may have been overly optimistic, particularly for coastal sites and sites on rivers. Oral histories (*e.g.* Ahkivgak and Phillips 1978; Numnik and Neakok 1978) sometimes refer to known sites having been larger in the past, or even to erosion. Nuvuk, at the tip of Point Barrow, was reported by its inhabitants to have been experiencing significant erosion prior to the 1850s (Maguire 1988). Recent archaeological investigations could not locate many of the sites along the Beaufort Sea coastline mentioned in early explorers' accounts (Leffingwell 1919) or oral histories.

The changing climate has altered the situation significantly. Erosion rates have increased tremendously – due to warming permafrost; sea ice retreat, which leads to increasing fetch for fall storms; and longer ice-free seasons, which have quadrupled the average period the coasts are unprotected from wave action. Even for sites that are some distance from the coast, warming has led to a much deeper active layer (the seasonally thawed layer above permafrost). Warming seems to lead to positive feedbacks, with the chemical and bacterial decay processes becoming thermogenic (Hollesen *et al.* 2015). With these changes, we are rapidly losing important sites. Examples are listed below, but these are by no means the only sites on the North Slope that are being damaged by climate change. Some sites, including many along the Beaufort Sea coast, have disappeared entirely. Given the incomplete surveys of the North Slope, even today there are likely unknown, unrecorded sites.

Excavated sites

Nuvuk

Nuvuk is located at the very tip of the Point Barrow spit (Fig. 14.1b). For years it was dismissed by archaeologists as being a contact-era site and therefore uninteresting, although the basis for this belief is unclear. Recently, the Nuvuk Archaeology Project (NAP; Jensen 2009a; 2009b; 2013), which started after the repeated finding of eroding graves, made it clear that the occupation of Nuvuk began long before contact.

The rate of coastal retreat measured at Nuvuk is increasing. McCarthy (1953) measured erosion from stationary points between 1945 and 1951, recording an average rate of approximately 2 m per year. Measurements taken during the NAP (Jensen 2009a; 2009b; 2013) show erosion rates averaging over 6 m a year, with annual loss at some locations exceeding 10 m.

The main focus of the NAP was the excavation of a cemetery that was discovered eroding at Nuvuk (Jensen 2007; 2009a; 2009b; 2012). To date, 85 burials have been excavated from the eroding spit. They range in age from at least the Early to Late Western Thule cultures. Dates range from 810 cal AD–modern (Jensen 2009a; 2009b), although a Bayesian chronological model currently in development suggests that occupation may have begun as early as 530–650 cal AD (A. Krus, pers. comm.). These people are considered to be ancestors by the Iñupiat residents of Barrow, a point of view supported by genetic data (Raff *et al.* 2015; Raghavan *et al.* 2014). The data recovered from the Nuvuk burials fill the last major geographic gap in Arctic North American aDNA (Raghavan *et al.* 2014). Although archaeological excavation is currently outpacing erosion, there are clearly many more burials to be dealt with, including graves with markers as late as the 1920s, which are in danger from erosion in the near term. Because of the close relationship of the community to these grave sites, there is great local concern regarding the recovery of these burials for relocation to a non-eroding location.

Researchers recorded the remnants of two Ipiutak structures – the first evidence of the Ipiutak north of Point Hope – before they eroded (Jensen 2009a; 2009b; 2013; 2014). They were located beneath the Thule and Inupiaq occupations, which were already known at Nuvuk. Nearly a metre of sterile gravel separated these structures from more recent occupation evidence; the beach ridge and sea level were much lower in Ipiutak times (Mason 2010). Recovered items included: lithics, bone, diagnostic antler and wooden artefacts, fish bones (the first from Nuvuk), a crushed egg, a large sandstone grinding slab, a composite jet labret, and a partial box hearth. One of the two loci suggested a catastrophic termination of the occupation by a storm surge, evidenced by a strandline deposit through the middle of the Ipiutak locus. This material is dated to 300–400 cal AD – quite an early date for Ipiutak cultural material. Both loci were exposed in summer (the first in 2008, the second in 2011) and were completely eroded within two months of their discovery.

Another interesting feature is a whaling captain's work area likely from the 1870s or 80s, based on the combination of Euroamerican and traditional whaling gear. It was first exposed during geomorphological work on the erosion face in 2006 and was completely eroded within two years, before which only portions had been excavated. It is the only such feature on the North Slope to be extensively excavated.

Birnirk

Birnirk (Fig. 14.1b), the name given by archaeologists to the settlement known as Piġniq by local Iñupiaq, is the type site of the Birnirk culture, and a US National Historic Landmark. The site has seen extensive excavation during campaigns by James Ford and Wilbert Carter (Ford 1959), all of which appears to have taken place inside the houses, with little or no attention to other types of features or middens. No faunal collection was retained from the site. Much of Carter's work remains unpublished, other than in a few interim reports to funding agencies (Carter 1953a; 1953b; 1962; 1966).

The site appears to have been occupied from the Birnirk period until fairly recently (there were apparently a few families resident there during Carter's work during the early 1950s). There are indications of possible earlier occupations, including an apparent Old Bering Sea harpoon head that Stefánsson reportedly obtained from Birnirk (Ford 1959; Wissler 1916). On a tape made by the North Slope Borough Department of Iñupiat History Language and Culture during a 1993 visit to Birnirk, Carter (1993) stated that a few Ipiutak harpoon heads had been found in the lower levels of one of his excavation units.

Obviously, there may be important information still present at Birnirk. The combination of rising sea level, warming permafrost and saltwater infiltration puts it at risk. Currently water is primarily encroaching from the Elson Lagoon side, while a berm protecting a road and camps from the ocean keeps Chukchi Sea storm surges away from the Birnirk site.

Utqiaġvik

The Utkiavik site (Utqiaġvik in the modern orthography) is made up of the remains of the settlement that developed into modern Barrow (Fig. 14.1b). When Ford mapped the site in the 1930s, most of the house mounds were unmodified (Ford 1959). By the early 1980s, roads had been constructed and buildings erected atop a number of the mounds (Hall and Fullerton 1990); this practice has continued to the present day.

Utqiaġvik was occupied during the Birnirk period, as evidenced by diagnostic artefacts found during the excavation of the ice mummy, Aġnaiyaaq ('little girl'; Zimmerman *et al.* 2001), and by the Birnirk burials at a site located beside the Kugok Ravine (Brower 1990; Ford 1959). Utqiaġvik was also occupied during the Classic Thule period, based on dates retrieved during the Aġnaiyaaq excavation (Zimmerman *et al.* 2001), and the Late Western Thule period through to the present day. This is evidenced by a series of C^{14} dates recently obtained by the author that strongly suggests occupation continued throughout the Thule period.

Utqiaġvik has been suffering the effects of erosion for some time (Hall and Fullerton 1990), although it appears to have accelerated in recent years (Lestak *et al.* 2004). This erosion has led to finds such as the well-preserved frozen individuals known as the 'Frozen Family' (Cassedy *et al.* 1990; Newell 1984) and Aġnaiyaaq (Zimmerman *et al.* 2001), as well as more fragmentary human remains. It has also, however, led to the loss of a great deal of cultural heritage and information about past conditions in the Barrow area.

Figure 14.3. Pre-contact house at Walakpa, viewed from the ESE, exposed on the erosion face in July 2013. Photo: UIC Science LLC.

Figure 14.4. Walakpa in late 2014, viewed from the north. A fall storm had caused the coastline to recede 11 m from where it was in Fig. 14.3, only a year earlier. Photo: Anne M. Jensen.

Walakpa

Walakpa (Ualiqpaa in Iñupiaq) is an iconic, deeply stratified archaeological site on the Chukchi Sea coast of Alaska's North Slope, 20 km south of Barrow (Fig. 14.1b). It is the only site on North Alaska's coastline between Canada and Cape Krusenstern known to contain an entire sequence from Pleistocene deposits to recent occupations. Stanford's 1968–1969 excavations at one corner of the site exposed *c.* 4000 years of stratigraphy from Recent Iñupiat back to Neo-Eskimo and Arctic Small Tool traditions (Stanford 1976).

Until recently, the site was covered by vegetation and appeared to be stable, in contrast to other sites in the region. In summer 2013, however, coastal erosion revealed a house at Walakpa. Limited locally funded salvage took place, and an attempt was made to protect the site with sandbags. Research funding was sought to excavate the structure, but in September 2014, a single intense storm removed over 13 m of the site, including all of Stanford's 'Area A' and the house discovered in 2013 (Fig. 14.3). High waves associated with the storm surge undercut the bluffs where the site is located, causing several large blocks to collapse onto the beach, where they remain (Fig. 14.4). As a result, 2 m of cultural stratigraphy was exposed over a greater than 20 m profile, with shallower exposure extending for an additional 10 m. Most critically, roughly one-third of the cultural features that Stanford (1976) mapped were destroyed in just two years. Even more catastrophically, this appears to include nearly half of the deepest stratigraphy that had the greatest potential to contribute significant data about the Paleo-Eskimo and earlier Neo-Eskimo components.

The landowner funded limited work to evaluate the 2014 damage, stabilise and protect what could be protected, and recover as much in the way of artefacts and information as was possible, given the late season and available resources. In 2015, a small volunteer crew spent less than a week camping at Walakpa and recovered a column sample from the Walakpa profile. Another late fall storm in 2015 did considerable damage to the slump block protecting the remaining site.

A volunteer data recovery effort involving a crew of 27 – including professional archaeologists, their students from nine institutions on two continents, and local residents – took place in summer 2016 under the author's direction. The goals were twofold. First, we wanted to recover additional information and material from Walakpa. This was to ensure that if the site was destroyed, well-provenanced samples large enough to do robust analyses on would be available to researchers. Second, we hoped to recover more detailed information about what remained of the site. This would enable us to write a proposal to fund additional excavation and post-excavation analyses in future years, should the site remain in place that long. During the three-week season, much of it in freezing temperatures, we excavated 33.7 m^3 and recorded 45 m of profiles. This resulted in the recovery of: 181 artefacts, 451 faunal samples (1 sample = multiple bones), 113 bulk sediment samples, 115 flotation samples, 10 ceramic samples, and an intact marine mammal (a mummified ring seal). Analysis of the material is already underway. Twelve radiocarbon dates have been provided by material recovered from Walakpa since 2013, supplementing the eight previously existing dates. The resulting dates are as early as 675–870 cal AD (2σ; Beta-395989). The 2016 work also provided an additional 19 14C samples and 11 samples for Optically Stimulated Luminescence (OSL) dating, including material from the lower cultural levels.

Nunagiak

The Nunagiak site consists of 13 house mounds located on an old beach line separating the ocean from a lagoon at Point Belcher, between Wainwright and Barrow (Fig. 14.1 top). It was partially excavated by Ford in the 1930s. At that time, the bases of the mounds were well above water level, as was the Punuk house that was found in a cut (Ford 1959, pl. 7) at the base of one of the mounds. The water level in the adjacent lagoon, which seems to be closely related to sea level, had risen high enough that the location of the Punuk house was underwater by 2003, when the author most recently visited the site.

Point Hope sites (Ipiutak, Old Tigara, Tigara)

The Point Hope spit, particularly the North side, contains a number of archaeological sites (Fig. 14.1a), including: Ipiutak (type site for the Ipiutak culture and a US National Historic Landmark), Old Tigara (Thule site), and Tigara (Late Western Thule to recent site). Birnirk structures were also present on the Point Hope spit, when first visited by Rasmussen (1927) in 1924. By 1939–1940, when Larsen and Rainey (1948) were working there, the Birnirk structures had disappeared; they were among the 50 or so structures that were destroyed by erosion in the intervening years. Erosion was calculated at 2.7 m per year in 1972 (Hosley 1972, 7), and it continues to remove portions of the Old Tigara and Ipiutak sites in particular (Hosley 1972; Jensen 1997). Although a variety of attempts have been made to slow this process, so far none have been successful.

What are we losing?

A vast quantity of archaeological information contained in sites that are being damaged or destroyed by the effects of climate change is being lost – this is important for both the living descendants of these older cultures and, of course, for science. It directly affects our ability to understand the pre-and post-contact history of the region, as well as the cultural processes that have operated there over time.

Cultural history, past lifeways and cultural process

Archaeologists working in the Arctic are fortunate to be able to address questions of human ecodynamics in a relatively straightforward way compared to researchers working in other areas. Unlike much of the rest of the planet, most of the Arctic never transitioned from a hunting and gathering subsistence base to an agricultural base. The species on which modern subsistence cultures rely are largely the same as those relied on by their predecessors millennia earlier, at least during the Holocene. The modern landscape in most areas is little altered from that experienced by earlier residents. In many areas, there are descendant communities with at least some members who still practice subsistence and/or pastoralism and who therefore can be extremely helpful in understanding how their ancestors lived. The traditional knowledge held in these communities today is directly relevant to understanding and interpreting the information recovered during archaeological investigations.

All of this makes Arctic archaeological sites important for two main reasons. First, they are the building blocks that enable us to define the cultural history of the region. We can reconstruct past lifeways and show how they changed through time, using that information to examine questions of cultural process and resilience in the face of changing climates. Second, they provide an important, if underutilised, analogue for analysing earlier sites elsewhere on the planet. For the vast majority of human evolution, humans were hunters and gatherers, making understanding such peoples critical for examining human history. However, few archaeologists have even minimal experience with such lifeways, presenting serious challenges for those trying to understand hunter-gatherer sites and modes of living (Frison 2004).

Cultural heritage

Of equal importance is that these disappearing archaeological sites are the cultural heritage of the Iñupiat people of the North Slope. The first recorded contact between North Slope Iñupiat people and Europeans took place less than 200 years ago. Today, the dominant Euro-American culture exerts broad influence over many aspects of life, from education of children to religion and language.

While some aspects of contact are welcome (flush toilets and running water are universally praised by those who grew up without them), not all of the results are helpful or benign. The schools teach little about Iñupiat culture and history, in part because most of the teachers come from other regions. The indigenous language is gradually falling out of use, especially among the youth population. Between the spread of wage labour for adults and compulsory education for the young, there is not enough time available for younger people to become skilled in all aspects of hunting or skin sewing.

The tangible evidence of Iñupiat ancestors' presence on the land since 'time immemorial' can be very empowering. Many people are, in fact, trying to retain and revitalise their culture. Some focus primarily on language, some on arts like carving or dancing, and some on subsistence activities. For those who are focusing on carving or sewing, the artefacts recovered from archaeological sites can be sources of guidance or inspiration. For others, the visceral understanding that they come from a long line of intelligent, resilient people who overcame the severe challenges of living in the harsh Arctic environment with their own hard work and ingenuity, and the understanding that can come from learning and seeing the results of archaeological excavations, can be life changing. Iñupiat forebears become a source of pride and are people to emulate, and Iñupiat culture takes its legitimate place on a level with Western culture. One participant in the Nuvuk excavations said that he thought his experience would make him a better father to his children.

Palaeoenvironmental information

Cultural heritage is not the only evidence of past life that we are losing. Zooarchaeological data on species harvested for subsistence are disappearing as the bones and other organics dissolve into unidentifiable mush. Earlier excavators were seldom able – or motivated – to retain faunal collections; it is only recently that retention of faunal remains has become standard practice. It is already possible to construct fairly detailed climate and habitat reconstructions using different sources of palaeoenvironmental data derived from archaeological sites (*e.g.* macrobotanicals) or from other sources such as lake or ice cores. We can begin to reconstruct ecosystems and analyse how they changed through time by combining these data with zooarchaeological data (*e.g.* Sandweiss and Kelley 2012; Harrison and Maher 2014; Nelson *et al.* 2016).

Today, researchers spend large sums of money on collecting tissue samples from marine and terrestrial environments. The samples are returned to home base (*e.g.* a museum) where they are curated and remain available for study. In the past, Arctic people hunted or gathered animals and plants from terrestrial and marine environments. Those plants and animals were returned to a home base (now an archaeological site). Some parts were consumed; other portions were discarded and today remain available for study, often in a near-pristine state thanks to permafrost. The goals of the ancient and modern individuals collecting the items were very different, but the outcomes of their activities – repositories of raw data – were remarkably similar. In effect, one can see archaeological sites with good organic preservation as nodes in a Distributed Observing Network of the Past (DONOP), in many ways analogous to other modern observing networks (this concept is discussed further below).

What can we do? Challenges and opportunities

Challenges

North Slope excavation and post-excavation work are extraordinarily expensive, due to remote locations and the huge volumes of organic materials recovered. Current funding mechanisms, based on competition between carefully thought out research proposals designed to answer specific questions, do not lend themselves to emergent situations. The review and funding process is such that, even in the unlikely event that a successful proposal can be prepared on very short notice to meet a deadline matching the autumn erosion season, funds are not available during the next field season.

With the exception of the National Park Service, which has very little land on the North Slope, cultural heritage is not a significant part of the federal agencies' missions. Their budgets and staffing reflect this reality. Many of the sites are on private land, so no agency has specific responsibility for the heritage resources.

Indigenous land claims in Alaska were settled through the formation of for-profit regional and village corporations with Alaska Natives as shareholders, with title to a portion of the land in Alaska being vested in the corporations. Some of these companies specifically selected known heritage sites as part of their lands; the Arctic Slope Regional Corporation did not, choosing to focus on lands with economic potential. Some of the village corporations, such as Ukpeaġvik Inupiat Corporation (UIC), are successful enough to afford financial assistance for cultural heritage preservation while still providing significant economic benefits to shareholders – others have yet to reach that point. Given the limited economic opportunities for North Slope residents, the corporations' first priority has to be dividends to their shareholders.

One municipal government agency (the Iñupiat History Language and Culture Commission; IHLC) has heritage responsibilities, but it cannot handle the issue alone. It does not have a professional archaeological staff, and the timing of the North Slope Borough budget year does not make it easy to obtain significant funds to support salvage excavation.

The IHLC runs a museum in Barrow, the Iñupiat Heritage Center (IHC). While it is a fine building, with exhibition space, climate control and a traditional room for craftspeople, the facility is short on storage space, creating real issues for the curation of collections. This is particularly true for those items that are not suitable for display, which actually make up the bulk of most collections. This creates a tension between community desires to retain collections on the North Slope and the lack of space in which to store them.

Opportunities

North Slope residents are very concerned about the archaeological sites and are greatly interested in working with people who will help them preserve their cultural heritage. They want a true partnership rather than having someone come and take away information and artefacts, without returning anything to the community.

There are a number of steps that can be, and are, being taken at a variety of different levels to address these challenges. However, because the challenges are extremely urgent, the time for prolonged discussion has passed. The search for the 'perfect' solution can all too easily become the enemy of a 'good' outcome in this situation.

As professionals

Archaeologists can help this process in a few key ways. Firstly, archaeology and heritage groups that are concerned about the effects of climate change on the archaeological and palaeoecological record must continue to expand efforts to collaborate and exchange information. The other papers in this volume highlight the fact that many of the challenges faced on the North Slope exist all over the world. People are attempting to address them in various ways. Information about successes and failures can only help save others time and money, which are both in limited supply.

Secondly, we can adopt language that speaks to other disciplines. Particularly important here are the natural sciences, which tend to be far better funded than the social sciences and heritage research. Some, although by no means all, natural scientists express little concern for heritage issues. In our experience, when they understand that archaeological sites contain data that pertain directly to their particular discipline (data that they can also use to test developing models), their level of interest rises dramatically.

Observing networks, where identical data are collected at multiple stations or nodes, are popular in the natural sciences. The idea is not a new one – everyone is familiar with the networks of weather stations and weather observers established by most countries. The impetus for the First International Polar Year in 1881–1883 was to establish an observing network to obtain data needed to answer research questions that could not be gathered by single-site observations. There are existing networks put together site-by-site by scientists working at various locations, which have proven to be very powerful scientific tools, particularly for problems involving global change. There are now numerous initiatives to construct new observing networks, both terrestrial and oceanic, such as the National Ecological Observatory Network (NEON; Schimel *et al.* 2007; 2013) and the arctic oceanographic Distributed Biological Observatory (DBO; Grebmeier *et al.* 2013). There is even a network of networks, Global Earth Observation System of Systems (GEOSS). Considering archaeological sites as nodes in a Distributed Observing Network of the Past can help facilitate interdisciplinary understanding of the value of archaeological sites. For example, at Walakpa and the Point Hope sites, the archaeological remains are in locations that can extend existing observing networks in both time and space.

The discipline is aided by archaeologists becoming involved in as many interdisciplinary and cross-disciplinary venues as possible. The task of saving a significant quantity of data can succeed once major funding sources consider it a priority. This effort will not take the place of traditional research question-driven archaeology; it needs to be done in addition. Funding for museums and curation is also important here.

With communities

Several avenues for community participation are being developed that provide opportunities for residents of the North Slope to assist in protecting their heritage. Major efforts are being made to inform the general public about the effects that global change is having on important sites. Otherwise, if individuals' subsistence travel routes do not take them past the sites, they may not realise the level of damage that is occurring, and therefore may not understand the urgency of efforts to fund salvage.

It is important to develop ways for the public to update site information. While something like the ShoreUpdate application developed by Scotland's Coastal Heritage at Risk Programme (SCHARP) is the ultimate goal (Chapter 3, this volume), that is some time away on the North Slope. United States law prevents the release of site locational information to the public, so the information could only flow one way. In addition, there is very limited cellular coverage on the North Slope, which imposes its own limitations. Nevertheless, training on how to complete the North Slope Borough's Traditional Land Use Inventory (TLUI) and the State of Alaska's Alaska Heritage Resource Survey (AHRS) site recording forms, both of which are on paper, has been quite popular at Elders/Youth Conferences. An editable PDF combining both forms (many data fields are identical) is under development.

Local individuals are also being trained to participate in fieldwork (Jensen 2012). We have offered numerous student internships, and have provided training opportunities for adults, some of who have been able to put their skills to use on cultural resource management projects. While few people have the free time to learn to be volunteer excavators, more people are interested in helping for a day or two with activities such as screening (sieving) under supervision. We have had a number of people, both local residents and visiting scientists (of whom Barrow has a considerable supply), who have volunteered in the laboratory on weekends or the poor-weather days that frequently shut down work on the North Slope. Some local residents contribute their time to conduct condition checks and photo documentation of sites they frequently encounter while hunting or traveling to subsistence cabins.

The local village corporation in the North Slope provides access to equipment needed for salvage projects, and has also provided professional assistance, including archaeologists, land surveyors and health and safety professionals. Other local organisations, notably IHLC and the Native Village of Barrow (the local tribal government), have assigned staff members to participate and assist with various aspects of salvage and reporting. This helps to build capacity in these organisations so that they are better equipped to respond in the future.

Public outreach

We have a variety of ways to reach out to North Slope residents who are not directly participating in archaeological activities. This outreach has proven equally effective at reaching those who live elsewhere. Both broadcast and print media have covered aspects of the problems of eroding sites on the North Slope (*e.g.* Kintisch 2016). North Slope residents utilise social media heavily, so both the Nuvuk Archaeological Project and the Walakpa Archaeological Salvage Project have Facebook pages. The author maintains an Arctic archaeology-focussed blog 'Out of Ice and Time' (https://iceandtime.net/), as well as sends out notifications on Twitter and Tumblr. New distribution channels are added as they gain popularity. The blog also has links to many web-focussed Arctic science outreach programs and education portals.

Conclusion

North Alaskan sites have great potential to supply both archaeological and palaeoecological data, as well as forming an irreplaceable part of the cultural heritage of Iñupiat people. These sites are at great risk of disappearing. The threat is real and the problem is urgent: it is a matter of years, of a severe storm or two, not a matter of decades. The response must be equally urgent. While there is much to discuss about how best to proceed, we can no longer conduct business as usual. We must rapidly develop priorities and then continue to 'talk while digging', rescuing data from vanishing sites while developing a prioritisation scheme and determining how to distribute effort to maximise the return in salvaged information. We cannot permit the search for a perfect solution to this problem to become the enemy of the implementation of good solutions, or we will wind up with far less data fifty years from now.

Such sites contain information on how people have adapted to climate changes in the past. As humans attempt to adapt to the effects of climate change, it could be immensely helpful to know what approaches were fruitful enough to have left evidence in the archaeological record. North Alaskan sites have the potential to show what actually did and did not work, but this information must come from analysing many sites. The more sites that are lost before archaeologists and other scientists are able to study them, the less informed we will be at this critical juncture.

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References

Ahkivgak, O. and Phillips, S. 1978. *Interview*. Barrow, AK, North Slope Borough Iñupiat History Language and Culture Commission.

Alexander, H. L. 1974. The association of Aurignacoid elements with fluted point complexes in North America. In S. R. A. P. Schledermann (ed.), *International Conference on the Prehistory in Paleoanthropology of Western North American Arctic and Subarctic*, 21–31. Calgary, University of Calgary Press.

Alexander, H. L. 1987. *Putu: A fluted point site in Alaska*. Burnaby, B.C., Dept. of Archaeology, Simon Fraser University 17.

Anderson, D. D. 1968. A Stone Age Campsite at the Gateway to America. *Scientific American* 218(6), 24–33.

Anderson, D. D. 1984. Prehistory of North Alaska. In D. Damas (ed.), *Handbook of North American Indians, Volume 5: Arctic*, 80–93. Washington, D.C., Smithsonian Institution.

Anderson, D. D. 1988. Onion Portage: The archaeology of a stratified site from the Kobuk River, Northwest Alaska. *Anthropological Papers of the University of Alaska* 22(1–2), i–163.

Bowers, P. M. (ed.) 2009. *The Archaeology of Deering Alaska: Final Report of the Village Safe Water Archaeological Program*. Report for the Native Village of Deering, the City of Deering, Alaska Department of Environmental Conservation and the Alaska State Historic Preservation Office. Fairbanks, AK, Northern Land Use Research, Inc.

Brower, L. 1990. Mounds 24, 25, and 27—The Kugok Ravine Excavations. In E. S. Hall Jr. and L. Fullerton (eds), *The Utqiaġvik Excavations: Vol. I*, 31–43. Barrow, AK, The North Slope Borough Commission on Iñupiat History, Language and Culture.

Carter, W. 1953a. *Archaeological Survey of Eskimo, or Earlier, Material in the Vicinity of Point Barrow, Alaska*. *Status Report: 1953 Field Activities*. Submitted to Office of Naval Research.

Carter, W. 1953b. *Archaeological Survey of Eskimo, or Earlier, Material in the Vicinity of Point Barrow, Alaska. Final Report: 30 April 1953*. Submitted to Office of Naval Research.

Carter, W. 1962. *Archaeological Survey of Eskimo, or Earlier, Material in the Vicinity of Point Barrow, Alaska. Status Report: 1 January 1962*. Submitted to Office of Naval Research.

Carter, W. 1966. *Archaeological Survey of Eskimo, or Earlier, Material in the Vicinity of Point Barrow, Alaska. Final Report: 31 January 1966*. Submitted to Office of Naval Research.

Carter, W. 1993. *Carter Visits Barrow*. Edited by J. Harcharek and D. Edwardsen. Barrow, AK, The North Slope Borough Commission on Iñupiat History, Language and Culture.

Cassedy, D. F., Dekin, A. A., Kilmarx, J. N., Newell, R. R., Polglase, C. R., Reinhardt, G. A. and Turcy, B. L. 1990. *Excavation of a Prehistoric Catastrophe: A Preserved Household from the Utqiagvik Village, Barrow, Alaska*. In E. S. Hall Jr. and L. Fullerton (eds), *The Utqiaġvik Excavations: Vol. III*. Barrow, AK, The North Slope Borough Commission on Iñupiat History, Language and Culture.

Ford, J. A. 1959. *Eskimo Prehistory in the Vicinity of Point Barrow, Alaska*. New York, Anthropological Papers of the American Museum of Natural History 47(1).

Friesen, M. and Mason, O. K. 2016. Introduction: Archaeology of the North American Arctic. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 1–24. Oxford, Oxford University Press.

Frison, G. 2004. *Survival by Hunting: Prehistoric Human Predators and Animal Prey*. Berkeley, CA, University of California Press.

Gerlach, S. C. 1982. Small site archaeology in Northern Alaska: The Shoreline Bluff Survey. *Anthropological Papers of the University of Alaska* 20(1–2), 15–49.

Giddings, J. L. 1951. The Denbigh Flint Complex. *American Antiquity* 16(3), 193–203.

Giddings, J. L. 1964. *The Archaeology of Cape Denbigh*. Providence, RI, Brown University Press.

Giddings, J. L. and Anderson, D. D. 1986. *Beach Ridge Archaeology of Cape Krusenstern National Monument*. Washington, US Government Printing Office.

Grebmeier, J. M., Moore, S. E., Cooper, L. W., Frey, K. E. and Pickart, R. S. 2013. *The Distributed Biological Observatory (DBO): A Change Detection Array in the Pacific Arctic Region*. Available at: arctic.cbl.umces.edu [accessed 08 August 2017].

Hall, E. S. Jr. and Fullerton, L. (eds). 1990. *The Utqiaġvik Excavations 2*. Barrow, AK, The North Slope Borough Commission on Iñupiat History, Language and Culture.

Harrison, R. and Maher, R. A. (eds). 2014. *Human Ecodynamics in the North Atlantic: A Collaborative Model of Humans and Nature through Space and Time*. Lanham, MD, Lexington Books.

Hollesen, J., Matthiesen, H., Møller, A. B. and Elberling, B. 2015. Permafrost thawing in organic Arctic soils accelerated by ground heat production. *Nature Climate Change* 5(6), 574–78.

Hosley, E. H. 1972. *Point Hope Beach Erosion, Point Hope, Alaska*. Anchorage, Alaska District Army Corps of Engineers.

Jensen, A. M. 1997. An Archaeological Field Survey in Connection with Proposed Construction at the Ipiutak Site and Old Town Site, Point Hope, Alaska. Unpublished report by Ukpeaġvik Iñupiat Corporation (UIC) Real Estate Science Division (Barrow, Alaska) for LCMF, Inc.

Jensen, A. M. 2007. Nuvuk burial 1: An early Thule hunter of high status. *Alaska Journal of Anthropology* 5(1), 119–26.

Jensen, A. M. 2009a. Nuvuk: Point Barrow, Alaska: The Thule cemetery and Ipiutak occupation. Unpublished PhD Thesis, Bryn Mawr College.

Jensen, A. M. 2009b. Radiocarbon dates from recent excavations at Point Barrow, Alaska and their implications for Neoeskimo prehistory. In B. Grønnow (ed.), *On the Track of the Thule Culture from Bering Strait to East Greenland: Proceedings of the SILA Conference 'The Thule Culture, New Perspectives in Inuit Prehistory', Copenhagen, Oct. 26–28, 2006: Papers in Honour of Hans Christian Gulløv*, 45–62. Copenhagen, SILA.

Jensen, A. M. 2012. Culture and change: Learning from the past through community archaeology on the North Slope. *Polar Geography* 35, 211–227.

Jensen, A. M. 2013. Point Barrow area sites: Nuvuk, Utqiaġvik and Birnirk. In S. E. A. Prentiss (ed.), *Encyclopedia of Global Archaeology*, 767–772. New York, Springer.

Jensen, A. M. 2014. The archaeology of north Alaska: Point Hope in context. In C. E. Hilton, B. M. Auerbach and L. W. Cowgill (eds), *The Foragers of Point Hope: The Biology and Archaeology of Humans on the Edge of the Alaska Arctic*, 11–34. Cambridge, Cambridge University Press.

Jensen, A. M. 2016. Archaeology of the Late Western Thule/Iñupiat in North Alaska (A.D. 1300–1750). In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 511–535. Oxford, Oxford University Press.

Jensen, A. M. and Sheehan, G. W. 2016. Contact and Postcontact Iñupiat Ethnohistory. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 631–650. Oxford, Oxford University Press.

Kintisch, E. 2016. History is Melting. *Hakai Magazine*, January 20, 2016. Available at: www.hakaimagazine.com/article-long/history-melting.

Kunz, M. L. and Reanier, R. E. 1994. Paleoindians in Beringia: Evidence from Arctic Alaska. *Science* 263, 660–662.

Kunz, M. L. and Reanier, R. E. 1995. The Mesa site: A paleoindian hunting lookout in Arctic Alaska. *Arctic Anthropology* 32(1), 5–30.

Larsen, H. and Rainey, F. G. 1948. *Ipiutak and the Arctic Whale Hunting Culture*. New York, Anthropological Papers of the American Museum of Natural History 42.

Leffingwell, E. de K. 1919. *The Canning River Region, Northern Alaska*. Washington, DC, US Government Printing Office.

Lestak, L. R., Manley, W. F. and Maslanik, J. A. 2004. Photogrammetric analysis of coastal erosion along the Chukchi coast at Barrow, Alaska. *Berichte zur Polar- und Meeresforschung* 482, 38–40.

Maguire, R. 1988. *The Journal of Rochfort Maguire, 1852–1854: Two Years at Point Barrow, Alaska, aboard HMS Plover in the Search for Sir John Franklin*. Works issued by the Hakluyt Society. London, Hakluyt Society.

McCarthy, G. R. 1953. Recent changes in the shoreline near Point Barrow, Alaska. *Arctic* 6(1), 45–51.

Mason, O. K. 2010. Geologic Records from the Nuvuk Beach Ridges: Draft Report on Geoarchaeological Research conducted in conjunction with the ECHO Nuvuk Project, 2003–2009. Anchorage, AK. Unpublished manuscript in possession of the author.

Mason, O. K. 2016a. From the Norton culture to the Ipiutak cult in Northwest Alaska. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 443–467. Oxford, Oxford University Press.

Mason, O. K. 2016b. Thule origins in the Old Bering Sea Culture: The interrelationship of Punuk and Birnirk cultures. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 489–512. Oxford, Oxford University Press.

Mason, O. K. 2016c. The Old Bering Sea florescence about Bering Strait. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 417–42. Oxford, Oxford University Press.

Mills, R., Gerlach, S. C., Bowers, P. M. and MacIntosh, S. J. 1999. *Final Report to the Cultural Resources Mitigation of the 1998 Anaktuvuk Pass Runway Realignment Project*. Report prepared for LCMF, Inc. Fairbanks, AK, Northern Land Use Research Alaska, LLC.

Nelson, M. C., Ingram, S. E., Dugmore, A. J., Streeter, R., Peeples, M. A., McGovern, T. H., Hegmon, M., Arneborg, J., Kintigh, K. W., Brewington, S. and Spielmann, K. A. 2016. Climate challenges, vulnerabilities, and food security. *Proceedings of the National Academy of Sciences* 113(2), 298–303.

Newell, R. R. 1984. The archaeological, human biological, and comparative contexts of a catastrophically-terminated Kataliqaaq House at Utqiaġvik, Alaska (BAR-2). *Arctic Anthropology* 21(1), 5–52.

Numnik, I. and Neakok, A. 1978. *Nuvuk*. Edited by G. Kean. Barrow, AK, The North Slope Borough Iñupiat History Language and Culture Commission.

Potter, B. 2016. Holocene Prehistory of the Northwestern Subarctic. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 537–561. Oxford, Oxford University Press.

Raff, J. A., Rzhetskaya, M., Tackney, J. and Hayes, M. G. 2015. Mitochondrial diversity of Iñupiat people from the Alaskan North Slope provides evidence for the origins of the Paleo- and Neo-Eskimo peoples. *American Journal of Physical Anthropology* 157(4), 603–614.

Raghavan, M., DeGiorgio, M., Albrechtsen, A., Moltke, I., Skoglund, P., Korneliussen, P. S., Grønnow, B., Appelt, M., Gulløv, H. C. and Friesen, T. M. 2014. The genetic prehistory of the New World Arctic. *Science* 345(6200), 1255832.

Rasmussen, K. 1927. *Across Arctic America: Narrative of the Fifth Thule Expedition*. New York, G. P. Putnam's Sons.

Sandweiss, D. H. and Kelley, A. R. 2012. Archaeological contributions to climate change research: The archaeological record as a paleoclimatic and paleoenvironmental archive. *Annual Review of Anthropology* 41(1), 371.

Schimel, D., Hargrove, W., Hoffman, F. and MacMahon, J. 2007. NEON: A hierarchically designed national ecological network. *Frontiers in Ecology and the Environment* 5(2), 59.

Schimel, D. S., Asner, G. P. and Moorcroft, P. 2013. Observing changing ecological diversity in the Anthropocene. *Frontiers in Ecology and the Environment* 11(3), 129–137.

Sheehan, G. W. 1985. Whaling as an organizing focus in Northwestern Alaskan Eskimo societies. In T. D. Price and J. A. Brown (eds), *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity,* 123–154. New York, Academic Press, Inc.

Sheehan, G. W. 1990. Excavations at Mound 34. In E. S. Hall, Jr. and L. Fullerton (eds), *The Utqiaġvik Excavations 2*, 181–353. Barrow, AK, The North Slope Borough Commission on Iñupiat History, Language and Culture.

Sheehan, G. W. 1997. *In the Belly of the Whale: Trade and War in Eskimo Society*. Aurora, Alaska Anthropological Association Monograph Series VI. Anchorage, Alaska, Alaska Anthropological Association.

Smith, H., Rasic, J. T. and Goebel, T. 2013. Biface traditions of Northern Alaska and their role in the peopling of the Americas. In K. E. Graf, C. V. Ketron and M. Waters (eds), *Paleoamerican Odessey*, 105–123. College Station, TX, Texas A&M University Press.

Stanford, D. J. 1976. *The Walakpa Site, Alaska: Its Place in the Birnirk and Thule Cultures*. Washington, DC, Smithsonian Contributions to Anthropology, Smithsonian Institution.

Taylor, W. E. Jr. 1963. Hypotheses on the origin of the Canadian Thule culture. *American Antiquity* 28, 456–464.

Tremayne, A. H. and Rasic, J. T. 2016. The Denbigh Flint Complex of Northern Alaska. In M. Friesen and O. K. Mason (eds), *The Oxford Handbook of the Prehistoric Arctic*, 349–70. Oxford, Oxford University Press.

Wissler, C. 1916. Harpoons and darts in the Stefansson Collection. In *Anthropological Papers of the American Museum of Natural History*, Vol. 14, 397–443. New York, NY, Trustees of the American Museum.

Zimmerman, M., Jensen, A. M. and Sheehan, G. W. 2001. Aġnaiyaaq: The autopsy of a frozen Thule mummy. *Arctic Anthropology* 37(2), 52–59.

Chapter 15

Cultural heritage under threat: the effects of climate change on the small island of Barbuda, Lesser Antilles

Sophia Perdikaris, Allison Bain, Rebecca Boger, Sandrine Grouard, Anne-Marie Faucher, Vincent Rousseau, Reaksha Persaud, Stéphane Noël, Matthew Brown and July Medina-Triana

Abstract

Extreme weather and the decline in preservation of archaeological sites on the small island of Barbuda in the Lesser Antilles, has brought together an international team of researchers that have been collaborating in the rescue excavation and preservation efforts of sites ranging from the Archaic Age (3000–1000 BCE) to the late 1800s. Through archaeology, zooarchaeology, archaeobotany, palaeoecology, geospatial technology and citizen science, investigations on long-term human ecodynamics in Barbuda are revealing a complex interplay between culture and environment that has persisted in one form or another for several thousands of years. Barbuda, unlike its sister island of Antigua and other volcanic islands of the Lesser Antilles, never faced the ecological devastation of areas used for sugar production. This means that archaeological sites that predate sugar production are mostly preserved. However, current climatic changes and modern development of the island have had detrimental effects on all Barbudan sites. The team of natural and social scientists are working closely with local experts to document, understand, and find solutions to the pressing social and environmental challenges that threaten the cultural heritage of the island and are working towards preservation and conservation of Barbuda's rich archaeological past.

Introduction

Barbuda is a semi-arid, relatively flat limestone island of 161 km^2 located midway along the island chain known as the Lesser Antilles, and is at the outer curve of the Leeward Islands about 50 km northeast of its sister island, Antigua (Fig. 15.1). Barbuda has seen successive economic and environmental transformations, beginning with initial human settlement by Archaic Age hunter-fisher-foragers (*c.* 3000–1000 BCE), continuing with Ceramic Age agricultural villagers (*c.* 100 BCE–CE 1500), Colonial British plantation economy of enslaved Africans (*c.* CE 1650–1834), and post-emancipation, a Barbudan economy combining hunting, fishing, agriculture, and wage labour (1834–present).

Barbuda, like many other Caribbean islands, faces many challenges – food security, coastal erosion, storm surges, water quality and quantity, and limited economic opportunities that result in a 'brain drain' of young, educated people migrating off the island. These interconnected challenges intensify and become increasingly urgent as sea level rises and climate changes cause fluctuations in temperature and precipitation patterns, including the intensity and frequency of storm events. Farming is on a decline due to droughts, erosion and nutrient depleted soils, and fishing can no longer sustain the population, partly as reefs are bleached and dying, hence depleting the near-shore fish stocks. Coastal erosion, frequency and intensity of storms, and land development are the major threats to the island's cultural heritage. As a result of severe storms and sea level rise flooding coastal areas, archaeological sites are eroding. Furthermore, the lack of strong legislation concerning heritage resources in Antigua and Barbuda leaves archaeological sites both unknown and unprotected (Murphy 2011). Unfortunately, other Caribbean nations face

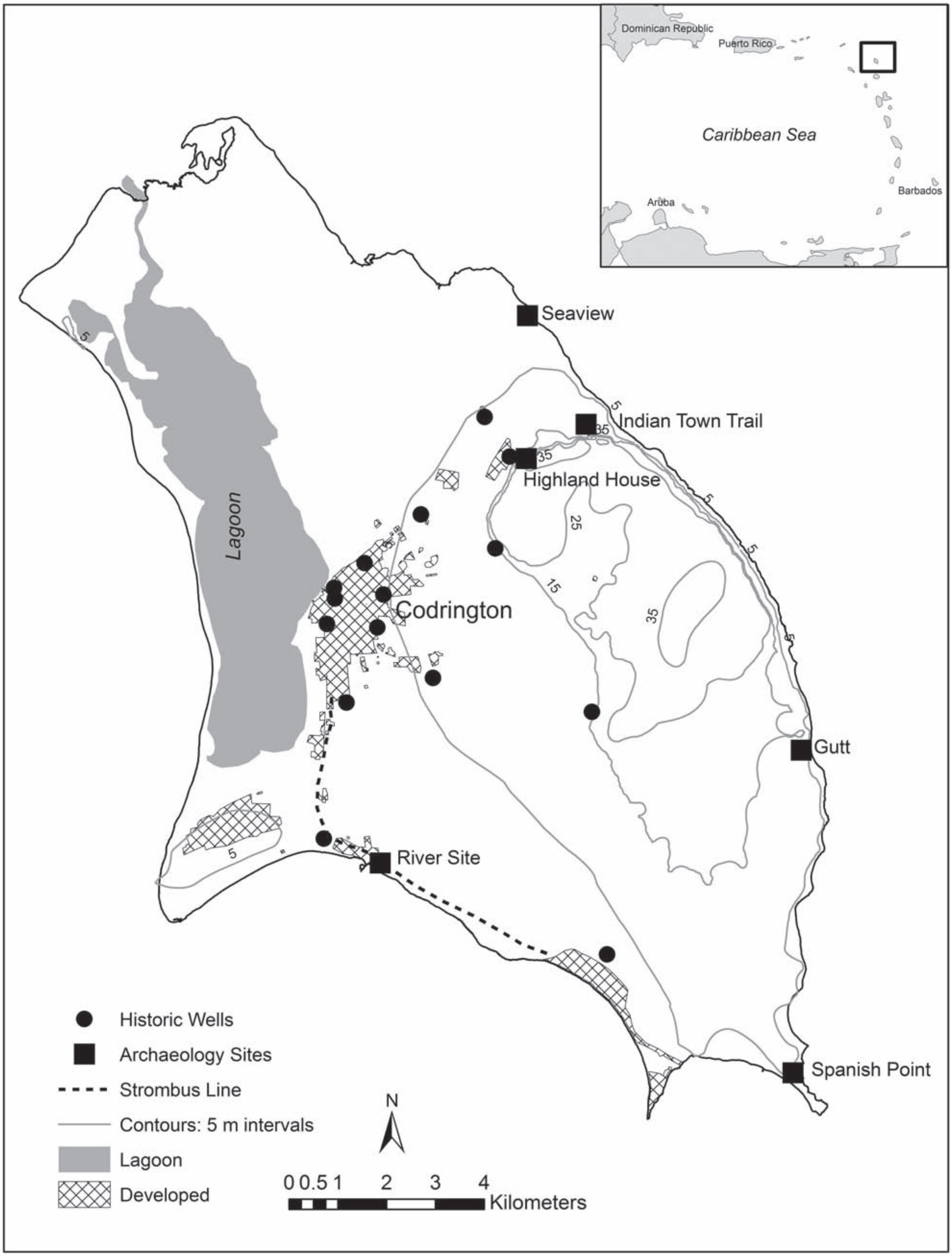

Figure 15.1. Location map of Barbuda showing the archaeological sites including the historic wells. Source: R. Boger and J. Medina-Triana.

similar challenges (Fitzpatrick and Keegan 2007; Siegel and Righter 2011; Siegel *et al.* 2013; Reid *et al.* 2014; Hofman 2015).

As climate change, environmental degradation, population growth and other factors threaten the sustainability and resilience of communities in the Caribbean and worldwide, the need for accessible human-ecodynamics research has never been greater. One of the advantages of working in Barbuda is that, as an island, it is geographically bound, thus forming a semi-closed system of society and environment. This helps facilitate the study and understanding of interactions that shape people-environment relations through time. Yet even within a semi-closed system, science research is often conducted in such a way that each researcher sees only one piece of a larger puzzle. Bringing together natural sciences, social sciences, humanities, arts, Traditional Ecological Knowledge (TEK) and citizen science in a dialogue of knowledge and discovery promotes an integrated systems approach to studying human-environmental interactions, and this approach is central to Barbuda's survival. For the past 10 years, a multidisciplinary[1] team of researchers has been conducting archaeological, environmental and ethnographic work on the island.

Collaborating with the Barbuda Research Complex (BRC), a local NGO, work on Barbuda focuses on linking the arts, humanities, natural and social sciences in the preservation and conservation of archaeological sites and in assisting with sustainability strategies for the present and future. Through educational initiatives, community stakeholders and international academics are working as a team. With cooperation from the Barbuda School System and the Barbuda Council, the local governing body, this collaboration has been exceptionally productive not just in archaeology, but also in paleoecology, marine biology, ethnography, climate history, and international transdisciplinary investigation of long-term island ecodynamics.

Our primary objective in Barbuda is to empower and collaborate in solution-based science to embrace a sustainable resilience model. By sustainable resilience we suggest that societies live sustainably within their dynamic ecosystems. Disturbances, such as hurricanes and drought, naturally occur and shape how people conduct their lives. People-environment interactions are therefore dynamic. Archaeological research suggests that since the first island occupants of the Archaic Age, the diverse populations on Barbuda have successfully navigated the climate and ecology of Barbuda, resulting in vibrant livelihoods (Boger *et al.* in press; Rousseau *et al*. 2017). Even under recent changes in the newly defined Anthropocene, archaeological sites can be monitored and secured and when necessary, excavated. The newly established Barbuda Museum will be the caretaker and repository of data and artefacts so that they will not be lost to future generations who will continue to create and maintain an ethnographic cultural record of life on the island through time. This intergenerational dialogue on ethnicity, identity and transition is what preserves meaningful cultural heritage. A sustainable approach to Barbuda is appropriate for this small island faced with dynamic changes and challenges.

Geography, climate and climate change scenarios

According to Cooper (2013), key aspects of climate change that affect humans include changes in temperature, precipitation, humidity, wind speed and wind direction. These may result in flooding, prolonged droughts, dramatic sea level rises and intense periods of hurricane activity. Recent years have seen an increase in climate change research in Caribbean archaeology (see review in Cooper and Peros 2010). Two of the most important and easily visible threats are rising sea levels (Cooper and Peros 2010) and coastal erosion (*e.g.* Fitzpatrick 2012; Fitzpatrick *et al.* 2006). Ongoing effects of climate change had and will continue to have major impacts on Barbuda and other islands in the Caribbean (Cooper 2013; USAID 2007).

In the Caribbean, relatively predictable trade wind and precipitation patterns are interspersed with more extreme weather events (Cooper 2013). These storms damage both coastal and terrestrial resources, and Barbuda lies directly in the pathway of significant annual cyclone and hurricane activity. There has been significant increase in the magnitude and frequency of North Atlantic tropical cyclones since 1995 (Goldenberg *et al.* 2001).

Much of the low-lying areas of the Caribbean are threatened by rising sea levels, and some sites may already be submerged (Fitzpatrick 2012). As most of Barbuda is low lying and less than 3 m above sea level, it is particularly vulnerable to rising seas, which have already damaged marine resources and archaeological sites. The Intergovernmental Panel on Climate Change (IPCC 2013) scenario projections indicate that temperatures will increase by 0.4 to 2.1°C by the 2060s and 0.9 to 3.5°C by the 2090s, and annual and seasonal rainfall will decrease. Satellite observations and tidal gauges since the early 1990s indicate a rate of sea level rise globally at 3 mm/yr (NOAA). IPCC predictions for the Caribbean range between 1.6–1.7 mm/year (McSweeney *et al.* 2016), although there is considerable local variability in the Caribbean, and observed rates range between 1.92 mm/yr to 7.88 mm/yr (Davis *et al.* 2012). Additionally, although global climate models poorly predict tropical cyclones, increased frequency and intensity are predicted in this region. While a decrease in precipitation would lead to less available water, increased intensity of heavy rain events causes rapid runoff, flash floods, and accelerated soil and coastal erosion (Christensen *et al.* 2007; IPCC 2013). In order to better assess local potential impacts due to sea level rise on Barbuda, a computer-based modelling system, SimCLIM 2013, was used to examine the effects of climate

Table 15.1. SimCLIM 2013 results (RCP = Representative Concentration Pathways)

	Sea Level Rise per year (metres) in Barbuda Island			
Scenarios	*2040*	*2060*	*2080*	*2100*
RCP 2.6	0.1811 m	0.2809 m	0.3798 m	0.4708 m
RCP 8.5	0.1992 m	0.3537 m	0.5496 m	0.7918 m

variability and change by creating scenarios for sea level rise. The scenarios, called the Representative Concentration Pathways (RCP), follow the example of greenhouse gas emission scenarios used by the IPCC Fifth Assessment Report (AR5; IPPC 2013). For each SimCLIM scenario, low, mid and high projections are provided for global mean changes in temperature, sea level (thermal expansion only) and sea level (total, including ice melt). The corresponding values for atmospheric concentrations of carbon dioxide are also provided (CLIMsystems 2013).

Table 15.1 shows the SimCLIM model results for the best-case scenario RCP2.6 and the worst-case scenario RCP8.5 for the years 2040 and 2100. This gives an approximate window of what to expect for Barbuda in the near future and within one or two generations. For the best-case scenario, the sea level will rise about 0.18 m in 2040 and about 0.5 m by 2100. For the worst-case scenario, the sea will rise about 0.2 m by 2040, and 0.8 m in 2100.

The results from the SimCLIM 2013 best-case and worst-case scenarios were then added to a Digital Elevation Model (DEM) of Barbuda in ArcGIS to estimate which areas in Barbuda would be most impacted by the sea level rise, shown in Figure 15.2. In both scenarios, the low-lying marshes around the lagoon to the northwest will disappear and likely move landward as the sea rises. The village of Codrington will be impacted immediately and become increasingly inundated and exposed to storms. The southwest of the island, where the River Site is located, will be flooded by 2040 (see Fig. 15.1 for archaeological sites in discussion). The Atlantic side of the island, more exposed to hurricanes and other storm events, also houses many heritage sites along the coast. The Seaview site, which is already experiencing the impacts of sea level rise, will be completely inundated by 2040 even in the best-case scenario. Likewise, Indian Town Trail will be increasingly exposed to storms and threatened by winds, rain and storm surges. This type of modelling highlights the potential threats in specific locations and thus allows for a proactive evaluation of priorities for the threatened heritage resources.

The archaeology of Barbuda and threats from climate change

Archaeological work on Barbuda aligns with the tenets of historical ecology, which may also be termed human eco-dynamics (McGovern 1994; Crumley 1994; 1998; Balée 1998). Historical ecology has been defined as landscape history, or the study of past climates and ecosystems, (Crumley 1994, 6). By undertaking local and regional long-term studies of human-environment interactions, historical ecology is incorporated into a comprehensive, interdisciplinary framework reflecting the contributions of social, physical, and biological scientists (Crumley 1994). The papers included in Redman *et al.* (2004) note that archaeologists should not differentiate between environmental and cultural processes; it is our responsibility to observe how human strategies and environments have co-evolved, each interacting to shape the characteristics of the other. Conventional archaeological studies have focussed primarily on the direct relationship between economic strategies and environmental resources or how climate change affected habitats and led to changes in regional settlement systems (Redman *et al.* 2004). This deterministic approach is superficially applicable to many regions; however, humans react to local changes and this must be appropriately contextualised through interdisciplinary studies which can produce localised, sensitive results. In place of a deterministic model, an appropriately ecological approach is in order. Barbuda houses rich heritage resources from pre-Columbian, colonial and post-colonial periods, most of which can be found along the southern and Atlantic coasts (Fig. 15.1). The lack of intense economic development over the past centuries has been advantageous to archaeologists, as several large archaeological sites have been left intact. The practice of communal land tenure (Potter and Sluyter 2010) also precluded the extensive development of Barbuda's southern and Atlantic coasts. Coastal erosion, increasing tropical cyclone activity, tourism and human pressure conjointly threaten the island's heritage resources (Perdikaris and Hejtmanek in press).

David Watters (1980) extensively surveyed the archaeological resources of the island in the 1970s, resulting in a fairly comprehensive catalogue of Barbudan archaeological sites (see also Watters *et al.* 1991; Watters 2001). Work since 2005 has been undertaken by CUNY Brooklyn (Hambrecht and Look 2009; Hambrecht *et al.* 2011; Perdikaris *et al.* 2008; 2009; 2013; 2017) and Université Laval (Faucher *et al.* 2011; 2017; Rousseau 2014; Noël *et al.* 2016; Bain *et al.* 2017; Rousseau *et al.* 2017), and the Muséum d'histoire naturelle (Grouard *et al.* 2012; 2013). The following paragraphs discuss heritage areas (Strombus Line, Seaview, Indian Town Trail and Highland House) currently at risk due to both climate change and anthropic factors. These areas, along with historic wells (see Boger *et al.* 2013) are the key to citizen science initiatives in cultural heritage.

Strombus Line

In the Lesser Antilles island chain, Barbuda was part of a highly mobile marine-oriented subsistence strategy and was

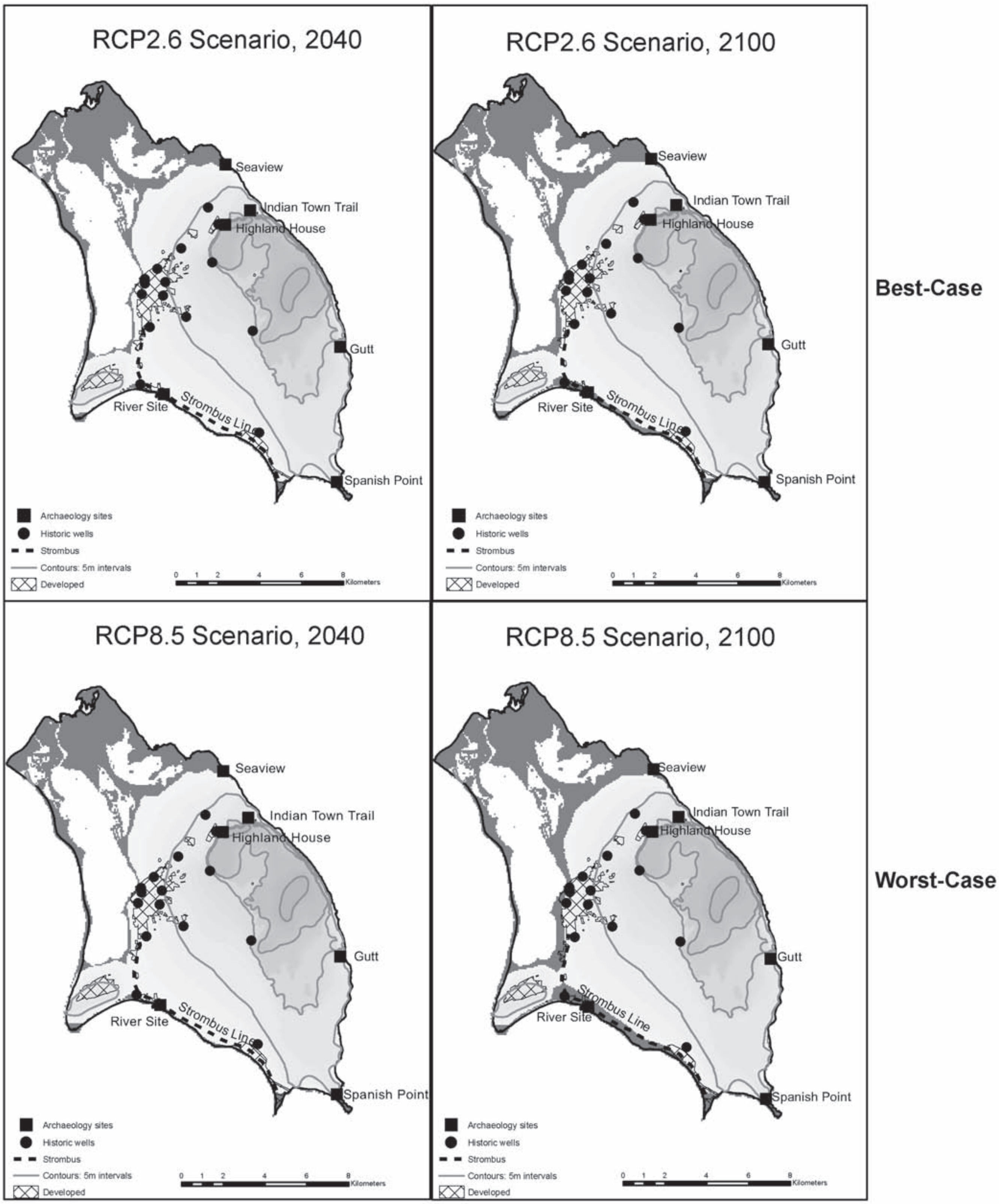

Figure 15.2. Sea level rise scenarios for Barbuda using SimCLIM. Elevation contours in all four maps are based on current elevation. Source: J. Medina-Triana and R. Boger.

specifically exploited for conch (Rousseau 2014; Rousseau *et al.* 2017). The south-eastern shore of Barbuda houses several prehistoric sites dating to the Archaic Age, related to the rich beds of Queen Conch (*Lobatus gigas*) a few metres off the southern shore. Extensive conch harvesting is suggested by fragments of exogenous stone tools and worked shells, the overwhelming majority of which are Queen Conch found on Barbuda's Archaic Age sites. Conch harvesting and the disposal of the shells resulted in the creation of an impressive linear shell midden several metres wide and up to 3 km in length, the Strombus Line, which followed the prehistoric coastline or palaeoshoreline (Brown and Look 2007; Rousseau 2014). A detailed survey project of the Strombus Line began in 2011 (Friðriksson *et al.* 2011; Vésteinsson 2011) and highlighted the fact that much of this feature has already been destroyed during construction and farming activities.

Seaview

The rugged landscape and seascape of the Atlantic Coast of Barbuda deter modern development and other anthropic threats to the archaeology of this specific area (see Fig. 15.3). Intense hurricane activity and rising water levels, however, have been and continue to be significant threats contributing to the erosion and loss of many of the Atlantic Coast archaeological sites on Barbuda (*i.e.* Spanish Point and Gutt; Fig. 15.1). Similar to the Archaic Age sites along the southern coast (River Site, Burton's Field, Cattle Field) Seaview will be largely inundated by 2040, even in the best-case scenario.

Seaview, a large Ceramic Age site (100 BCE–CE 650) is located within this specific area of risk (see Fig. 15.2). It has been affected by erosion and hurricanes for over two decades, resulting in a significant loss of portions of the site. Rescue excavations on the erosion face undertaken from 2007–2012 shed light on the occupants of Seaview, indicating the production of distinctive and at times highly decorated pottery (Kendall *et al.* 2011), and a mixed economy based on the exploitation of plants, hunting, and fishing (see also Grouard *et al.* 2013). This is confirmed by a stable isotope study undertaken on a skeleton washed out during Hurricane Georges in 1998 at Seaview, which dates to *c.* CE 450 (Perdikaris *et al.* 2008). According to Tamara Varney (pers. comm.) the stable carbon and nitrogen isotopic values obtained show that this individual consumed a mixed marine and terrestrial diet, suggesting the exploitation of multiple ecological niches.

Figure 15.3. Cliff face of Seaview showing extensive coastal erosion. Photo: R. Boger.

These results contrast with a shift found later in the Ceramic Age which might be related to 14th century climatic shifts (see below). Stable isotopic analysis is a powerful tool when combined with zooarchaeological, archaeobotanical and archaeological data, and has the potential to add significantly to our understanding of resource exploitation and sustainability relating to long-term climate change on Barbuda. Testing behind the dune area shows that the site extends beyond the erosion face. Charcoal obtained from a posthole located in test pit excavation in the area behind the dune dates to 100 BCE (Perdikaris *et al.* 2008). While the CUNY team carried out some dune stabilisation in 2008, it is nowhere near the scale of protection required for this site. Seaview provides one of the earliest dates for the appearance of the Ceramic Age in the northern Lesser Antilles, but the site is currently eroding and is partially underwater.

Indian Town Trail

The site of Indian Town Trail (Fig. 15.1) is further inland than Seaview. It spreads over at least 1 km^2, and dates to *c.* CE 900–1600 (Brown and Look 2007). There are numerous middens, burials and camp areas across the site (Look 2009). Through the analysis of faunal remains, Indian Town Trail provides invaluable information about climatic shifts, wetter conditions and increased storminess during the European 'Little Ice Age' time period (Grouard *et al.* 2011). The most imminent threats to the site are primarily anthropic (road cutting, quarrying), although in the decades to come, it will become increasingly exposed to rising sea levels and storm events. Indian Town Trail is the only site in Barbuda that has the potential to shed light on the time period connecting Barbuda's prehistoric and historic horizons. Recent preliminary analyses of pottery from the 2016 field season may suggest a Taino Amerindian presence in this part of the Lesser Antilles, and further work on this is forthcoming (Reginald Murphy and Reaksha Persaud pers. comm.).

Highland House

Changing weather patterns and threats from climate change are also affecting the sites dating to the Colonial and Post-Colonial periods, such as Highland House (Fig. 15.1) which is one of the most important sites for the development of heritage tourism. The main house at this complex of a dozen buildings was likely built between 1720 and 1730 and was originally intended as a retirement residence (Tweedy 1981). Archaeological survey and investigations at the site over the last three decades have helped define the boundaries of the site (Watters 1980; Watters and Nicolson 1982; Hambrecht and Look 2009), while excavations in recent years have focussed on identifying the function and phases of occupation of several of the crumbling limestone structures (Hambrecht and Look 2009; Noël *et al.* 2016).

Since 2009, Barbuda Research Complex (BRC) staff and collaborators have assessed and monitored the structures at Highland House. Clearing vegetation for the purpose of documentation by archaeologists may have impacted the site as it altered the site's vegetation (see Celesti-Grapow and Blasi 2004). However, recent drought periods, followed by wetter than normal seasons, appear to have accelerated plant growth, impacting extant structures. Particularly destructive root systems – such as that of the agave family plant, locally known as century plants – grow on many stone walls at Highland House and their roots feed on the mortar holding the limestone masonry together resulting in collapsing and shifting walls. The weakened structures are thus less able to withstand hurricane activity. Using archival sources, Berland (2015) documented 42 occurrences of tropical cyclones' winds of varying intensity from 1770–1895 on the nearby island of Antigua, while Charles William Day (1852, 286) specifically mentions that Highland House was already in ruins in 1850 due to hurricanes and earthquakes. Recent palaeoecological research by team members also indicates that strong El Nino-like activities affected Barbuda during the historic period (1720–1775 CE, 1820–1850 CE and 1975–2010 CE; Burn *et al.* 2016). This data suggests that storm events and climate contribute to the collapse of structures at Highland House.

If the Highland House site is not stabilised soon, it will eventually be reduced into unrecognisable ruins; its loss will be of significant detriment to Barbuda's heritage, eliminating one of the most important potential sources of tourism revenue. BRC is spearheading a research programme at Highland House where team members are systematically photographing and recording the structures, and strategic small-scale testing has also begun in order to better document the site's history. This will allow the identification of different building phases and support the local community in the development of interpretive tools such as panels, displays and publications.

Citizen science approaches to Barbuda's cultural heritage monitoring

Since the team began working in Barbuda, Barbudan scholars and youth have collaborated closely with visiting researchers. During the summer of 2012, a research team that included faculty and students from the City University of New York, the Barbudan secondary school, and Barbudan scholars, began to explore the topics of water resources and subsistence agriculture in backyard gardens. Research on food and water included various expertise and disciplinary methodological approaches from anthropology, geography, geology, and botany. Multiple methods such as aerial kite photography, Geographical Information Systems (GIS), water and soil testing, ethnographic semi-structured interviews, surveys and observations to gain multiple perspectives on these topics were used (Boger *et al.* 2013; Perdikaris *et al.* 2013). More recently, mobile apps and story maps as data collection tools and sharing of data online on various platforms are being used. We use ESRI products, mainly the Collector for ArcGIS and Snap2Map apps for ArcGIS Online (AGO). The Collector application allows users to create easy data entry portals that can be downloaded to smartphones, while the Snap2Map allows us to create visually exciting stories with maps, photos, videos, and text (see Fig. 15.4 for an example of a map story). With this approach, a water-monitoring program of the historic wells has begun, mapping the wells and examining how these important cultural sites are changing above and below ground (Fig. 15.1). This closely-knit collaboration of learners and teachers with varied expertise now forms the core of the research approach.

Central to the success of these projects is the partnership with Barbudan community scholars. They accompany the U.S. scholars and students on interviews, help navigate cultural intricacies (*e.g.* translating and transcribing from the Barbudan Creole English to Standard American English), and provide essential input. Barbudan scholars play an important role in the design, implementation, analysis and application of the research data and findings. This approach also serves as a way for the young people of Barbuda to connect with and learn from their elders, as this was a common mode of knowledge transmission in the past. The secondary school students learn about traditional practices and apply them to their own education in agriculture science back in the classroom. This collaborative endeavour also serves to document Barbudan elder knowledge about past sustainable resilience practices – or as they call it, 'living from the land' for future generations – since this knowledge is rapidly disappearing with the passing of the older generations.

People are the experts in their communities and through participation in data gathering and observation as citizen scientists; it shifts the nexus of authority from scientists to the community members themselves. Citizen science is emerging as a critical public engagement phenomenon in the United States and elsewhere (*e.g.* Fore *et al.* 2001; Ebersole 2003; Pattengill-Semmens and Semmens 2003; Lepczyk 2005; Bonney *et al.* 2009). In Barbuda, analytic data derived from scientific instruments are combined with Traditional Ecological Knowledge and Local Ecological Knowledge. The combination has the potential for an engaged citizenry

Figure 15.4. Screen shot of a map story. Source: R. Boger.

to make informed decisions as they face the impacts of climate change.

Conclusion

Multidisciplinary approaches aimed at understanding long-term climate and environmental changes and their effects on human populations are key to understanding the causes of climate change as well as how humans respond to them over thousands of years. Scientific teams collaborating with citizen scientists are key to the rescue, preservation and conservation of cultural heritage, not just in Barbuda but globally. As foreign scholars, we can help inform Barbudans of all ages of the potential impacts of climate change. However, going from knowledge to action requires engaging people in the present. For many people in the United States and elsewhere, climate change, as reported in the media, is described as too far away in time (>50 years) and too abstract (global impacts, far away) to connect with the hearts and minds of the majority of people. Furthermore, the problem is too remote, both spatially, and temporally, to motivate individuals to significantly change their behaviour. However, in Barbuda, people are already feeling impacts, and people must currently navigate the challenges of rising sea levels, saltwater intrusion, and more unpredictable weather patterns.

Gathering data provides us with climatic scenarios that will enhance our understanding of climatic variability and responses of both people and environment in specific time horizons helps to understand Barbuda in a circum-Atlantic perspective. While Barbuda residents struggle with daily resilience to a constantly changing environment and socio-economic challenges, learning about the past is a crucial exploration of self that grounds and connects people to places. This connection serves to strengthen cultural identity and may inspire communities to look towards a shared and possible future.

As the work in Barbuda continues, more and more light is shed on Barbudans of the past. As a young island nation, archaeology is one of the few tools allowing Barbudans to document their history. Citizen science is a way forward to maximise the efforts of making this happen. Climate change is having, and will continue to have, devastating effects on these narratives. Developing proactive approaches through the use of visual aids from climatic model applications helps us prioritise the direction of future research and preservation activities. None of this is possible without members of the local community who live on the island year-round, not just when there is interest or funding, and must survive the coming changes. For them, heritage loss is identity loss.

Note

1 We define interdisciplinary research as research that integrates separate disciplinary perspectives through the development of connections between them and transdisciplinary research as research that integrates perspectives beyond disciplinary

perspectives to incorporate knowledge outside of academia. Multidisciplinary research combines separate perspectives under a common theme without identifying connections between them (Hampton and Parker 2011; Pennington *et al*. 2015). The research approaches in Barbuda vary and include all three types. For the purposes of this paper, we use the term multidisciplinary for simplicity, realising that there may be a combination of one or more approaches.

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References

Bain, A., Faucher, A.-M., Kennedy, L. M., LeBlanc, L. R., Burn, M. J., Boger, R. and Perdikaris, S. 2017. Landscape transformation during Ceramic Age and Colonial Occupations of Barbuda, West Indies. *Environmental Archaeology*. https://doi.org/10.1080/14614103.2017.1345115.

Balée, W. (ed.) 1998. *Advances in Historical Ecology*. New York, Columbia University Press.

Berland, A. J. 2015. Extreme Weather and Social Vulnerability in Colonial Antigua, Lesser Antilles, 1770–1890. Unpublished PhD thesis. Department of Geography, University of Nottingham.

Boger, R., Perdikaris, S., Potter, A. E., Mussington, J., Murphy, R., Thomas, L., Gore, C. and Finch, D. 2013. Water resources and the historic wells of Barbuda: Tradition, heritage and hope for a sustainable future. *Island Studies Journal* 9(2), 327–42.

Boger, R., Perdikaris, S., Potter, A. and Adams, J. in press. Sustainable resilience in Barbuda: Learning from the past and developing strategies for the future. *The International Journal of Environmental Sustainability*.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V. and Shirk, J. 2009. Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience* 59(11), 977–84.

Brown, M. and Look, C. 2007. Island Ecodynamics: Four Thousand Years on Barbuda. Unpublished report by Barbuda Research Complex, Antigua and Barbuda.

Burn, M. J., Holmes, J., Kennedy, L. M., Bain, A., Marshall, J. D. and Perdikaris, S. 2016. A sediment-based reconstruction of Caribbean effective precipitation during the 'Little Ice Age' from Freshwater Pond, Barbuda. *Holocene* 26(8). doi: 10.1177/0959683616638418.

Celesti-Grapow, L. and Blasi, C. 2004. The role of alien and native weeds in the deterioration of archaeological remains in Italy. *Weed Technology* 18, 1508–13.

Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C. G., Räisänen, J., Rinke, A., Sarr, A. and Whetton, P. 2007. Regional Climate Projections. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (eds), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, 849–926. Cambridge, Cambridge University Press.

Cooper, J. 2013. The climatic context for Pre-Columbian archaeology in the Caribbean. In F. Keegan, C. L. Hofman and R. Rodríguez Ramos (eds), *Oxford Handbook of Caribbean Archaeology*, 47–58. Oxford, Oxford University Press.

Cooper, J. and Peros, M. 2010. The archaeology of climate change in the Caribbean. *Journal of Archaeological Science* 37(6), 1226–32.

Crumley, C. L. 1994. Historical ecology: A multidimensional ecological orientation. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, 1–16. Santa Fe, NM, School of American Research Press.

Crumley, C. L. 1998. Foreword. In W. Balée (ed.), *Advances in Historical Ecology*, ix–xiv. New York, Columbia University Press.

CLIMsystems. 2013. http://www.climsystems.com/simclim/ [accessed 25 March 2016].

Davis, D., Sutherland, M., Jaggan, S. and Singh, D. 2012. Determining and monitoring sea level in the Caribbean using satellite altimetry. Paper presented at *FIG (International Federation of Surveyors) Working Week*, *Rome, Italy 6–10 May 2012*. Available at: https://www.fig.net/resources/proceedings/fig_proceedings/fig2012/papers/ts08d/TS08D_davis_sutherland_et_al_6024.pdf [accessed 25 March 2016].

Day, C. W. 1852. *Five year's Residence in the West Indies, vol. 2*. London, Colburn and Co.

Ebersole, R. 2003. Adventures afield: Volunteers tune in to frog talk. *National Wildlife* 41, 18–19.

Faucher, A.-M., Bain, A. and Grimes, V. in press. First archaeological evidence for Old World crops in the Caribbean: The presence of barley on the island of Barbuda. *Historical Archaeology* 51(4).

Faucher, A.-M., Guay, E.-A. and Bain, A. 2011. Archaeobotanical Studies on Barbuda: Preliminary Results from 2011. Unpublished report by Barbuda Research Complex, Antigua and Barbuda.

Fitzpatrick, S. M. and Keegan, W. F. 2007. Human impacts and adaptations in the Caribbean Islands: An historical ecology approach. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* 98(1), 29–45.

Fitzpatrick, S. M., Kappers, M. and Kaye, Q. 2006. Coastal erosion and site destruction on Carriacou, West Indies. *Journal of Field Archaeology* 31(3), 251–62.

Fitzpatrick, S. M. 2012. On the shoals of giants: Natural catastrophes and the overall destruction of the Caribbean's archaeological record. *Journal of Coastal Conservation* 16(2), 173–86.

Fore, L. S., Paulsen, K. and O'Laughlin, K. 2001. Assessing the performance of volunteers in monitoring streams. *Journal of Freshwater Biology* 46, 109–23.

Friðriksson, A., Gudmunsson, G., Feeley, F., Rousseau, V., Vésteinsson, O., Vobornik, J. and McGovern, T. 2011. Investigations at the River site (BAA 004), Field Report, Barbuda. Unpublished report by Barbuda Archaeological Research Center, Barbuda Research Complex, Antigua and Barbuda.

Goldenberg, S. B., Landsea, C. W., Mestas-Nuñez, A. M. and Gray, W. M. 2001. The recent increase in Atlantic hurricane activity: Causes and implications. *Science* 293.5529(2001), 474–79.

Grouard, S., Bain, A., Perdikaris, S. and Persaud, R. 2012. Stingray Cave and Cat and Dog Cave, The Highlands, Barbuda. Report survey field 08/01/2012-12/01/2012. Unpublished report for Muséum National d'Histoire Naturelle, AASPE, Barbuda Archaeological Research Center, Human Ecodynamics Research Center (HERC), Global Human Ecodynamics Alliance, Universite Laval, CUNY Brooklyn College.

Grouard, S., Perdikaris, S. and Debue, K. 2013. Dog burials associated with human burials in the West Indies during the early pre-Columbian Ceramic Age (500 BC–600 AD). *Anthropozoologica* 48(2), 447–65.

Grouard, S., Perdikaris, S. and Persaud, R. 2011. Fishing practices characterization of the Precolumbian sites in the West Indies: Do the Pre-Columbian overfished the doctor-fish? Sizes of Acanthuridae through time from the sites of St Martin, Barbuda, Antigua, Guadeloupe, and Martinique. Paper presented at the *16th Meeting of the ICAZ (International Council for Archaeozoology) Fish Remains Working Group, Oct. 23–31 2011, Jerusalem and Eilat, Israel*.

Hambrecht, G. and Look, C. 2009. Highland House Survey Report for the Barbuda Historical Ecology Project. Unpublished report by Barbuda Archaeological Research Center, Barbuda Research Complex, Antigua and Barbuda.

Hambrecht, G., Hicks, M., Djuknic, B., Khalsa, S., Williams, L., Witter, L., Riggle, R., Plummer, J., Olavarria, G. and Adkins, R. 2011. Preliminary Report of the January 2011 Excavations at Highland House, Barbuda, Antigua/Barbuda. Unpublished report by Barbuda Archaeological Research Center, Barbuda Research Complex, Antigua and Barbuda.

Hampton, S. E. and Parker, J. N. 2011. Collaboration and productivity in scientific synthesis. *BioScience* 61, 900–10.

Hofman, C. L. 2015. The Caribbean challenge. Fernweh: Crossing borders and connecting people in archaeological heritage management. In M. van den Dries, S. van der Linde and A. Strecker (eds), *Archaeological Heritage Management*, 105–09. Leiden, Sidestone Press.

IPCC (Intergovernmental Panel on Climate Change). 2013. *Climate Change 2013: The physical science basis*. Working Group I Contribution to the IPCC 5th Assessment Report: Changes to The Underlying Scientific/Technical Assessment (IPCC-XXVI/Doc.4). Available at: http://www.ipcc.ch/report/ar5/wg1/#.UnpRAiRTvjE [accessed 25 March 2016].

Kendall, A. Manigault, N., Guðmundsson, G., Djuknic, B., Schreiner, A., Khalsa, S., Williams, L., Witter, L., Riggle, R., Plummer, J., Olavarria, G. and Adkins, R. 2011. Preliminary Report of the 2011 Excavation at Seaview, Barbuda, Antigua/Barbuda. Unpublished report by Barbuda Research Complex, Antigua and Barbuda. Available at: www.barbudaresearchcomplex.weebly.com/researchandscholarship [accessed 27 April 2016].

Lepczyk, C. A. 2005. Integrating published data and citizen science to describe bird diversity across a landscape. *Journal of Applied Ecology* 42, 672–677.

Look, C. 2009. Barbuda Historical Ecology Project 2009: Assessment for qualitative field analysis of phosphates on Barbuda. Unpublished report by Barbuda Research Complex, Antigua and Barbuda. Available at: www.barbudaresearchcomplex.weebly.com/researchandscholarship [accessed 27 April 2016].

McGovern, T. 1994. Management for extinction in Norse Greenland. In C. Crumley (ed.), *Historical Ecology: Cultural knowledge and changing landscapes*, 127–54. Santa Fe, NM, School of American Research Advanced Seminar Series.

McSweeney, C., New, M. and Lizcano, G. 2016. *UNDP Climate Change Country Profiles: Antigua and Barbuda*. Available at: http://journals.ametsoc.org/doi/pdf/10.1175/2009BAMS2826.1 [accessed 25 March 2016].

Murphy, R. 2011. Antigua and Barbuda. In P. E. Siegel and E. Righter (eds), *Protecting Heritage in the Caribbean*, 73–79. Tuscaloosa, University of Alabama Press.

Noël, S., Ladouceur, M.-E. and Bain, A. 2016. CUNY-Brooklyn College Historical Archaeology Field School 2015, Excavations at Highland House (BA-H1), Barbuda (Antigua and Barbuda). Unpublished report by Barbuda Research Center, Antigua and Barbuda.

Pattengill-Semmens, C. V. and Semmens, B. X. 2003. Conservation and management applications of the reef volunteer fish monitoring program. *Environmental Monitoring and Assessment* 81, 43–50.

Pennington, D., Bammer, G., Danielson, A., Gosselin, D., Gouvea, J., Habron, G., Hawthorne, D., Parnell, R., Thompson, K., Vincent, S. and Wei, C. 2015. The EMBeRS Project: Employing model-based reasoning in socio-environmental synthesis. *Journal of Environmental Studies and Sciences* 6(2), 278–86.

Perdikaris, S., Bain, A., Grouard, S., Baker, K., Gonzalez, E., Hoelzel, A. R., Miller, H., Persaud, R. and Sykes, N. 2017. From icon of empire to national emblem: The fallow deer of Barbuda. *Environmental Archaeology*. http://dx.doi.org/10.1080/14614103.2017.1349027.

Perdikaris, S. and Hejtmanek, K. in press. The sea will rise, Barbuda will survive: Environmental and time consciousness. In M. Kilker, R. Hennig and S. Hartman (eds), *Environmental Consciousness Conference Proceedings*. Sundsvaal, Brill.

Perdikaris, S., Hejtmanek, K., Boger, R., Adams, J., Potter, A. E. and Mussington, J. 2013. The tools and technologies of transdisciplinary climate change research and community empowerment. *Anthropology News: In Focus* 54(2), e13–e44. doi:10.1111/j.1556-3502.2013.54202.x.

Perdikaris, S., McGovern, T., Brown, M., Look, C., McGovern, D., Pálsdóttir, A. and Smiarowski, K. 2008. Field Report, Barbuda Historical Ecology Project. 2008. Unpublished report. Antigua and Barbuda National Parks Department/City University of New York.

Perdikaris, S., McGovern, T., Hambrecht, G., Look, C. and Manigault, N. 2009. Field Report, Barbuda Historical Ecology Project 2009. Unpublished report by Barbuda Research Center, Barbuda Research Complex, Antigua and Barbuda.

Potter, A. and Sluyter, A. 2010. Renegotiating Barbuda's commons: Recent changes in Barbudan open-range cattle herding. *Journal of Cultural Geography* 27(2), 129–50.

Redman, C. L., James, S. R., Fish, P. R. and Rogers, J. D. (eds). 2004. *The Archaeology of Global Change: The Impact of Humans on their Environments*. Washington DC, Smithsonian Books.

Reid, B., Hofman, C. L., Gilmore III, G. and Armstrong, D. V. 2014. *Introduction*. In B. Reid and G. Gilmore III (eds), *Encyclopedia of Caribbean Archaeology*, 1–30. Gainsville, FL, University of Florida Press.

Rousseau, V. 2014. Un pied-à-terre sur Barbuda, Le Strombus Line et l'archaïque des Petites Antilles du Nord. Unpublished Masters thesis, Université Laval, Québec.

Rousseau, V., Bain, A., Chabot, J., Grouard, S. and Perdikaris, S. 2017. The role of Barbuda in the settlement of the Leeward Islands: Lithic and shell analysis along the Strombus Line shell midden. *Journal of Caribbean Archaeology* 17, 1–25.

Siegel, P. E., Hofman, C. L., Bérard, B., Murphy, R., Hung, J. U., Rojas, R. V. and White, C. 2013. Confronting Caribbean heritage in an archipelago of diversity: Politics, stakeholders, climate change, natural disasters, tourism, and development. *Journal of Field Archaeology* 38(4), 376–90.

Siegel, P. E. and Righter, E. (eds). 2011. *Protecting Heritage in the Caribbean*. Tuscaloosa, University of Alabama Press.

Tweedy, M. T. 1981. A History of Barbuda Under the Codringtons, 1738–1833. Unpublished PhD thesis, History Department, University of Birmingham, Alabama.

USAID. 2007. Possible storm surge impact on Codrington and breaching of sand dunes. Unpublished report by Chemonics International Inc. for USAID.

Vésteinsson, O. 2011. *Reconnaissance of a Prehistoric Shell-Ridge in Barbuda, West Indies*. Reykjavik, Fornleifastofnun Ísland Ses/Icelandic Institute of Archaeology.

Watters, D. R. 1980. Transect Surveying and Prehistoric Site Locations on Barbuda and Montserrat, Leeward Islands, West Indies. Unpublished PhD thesis, University of Pittsburgh.

Watters, D. R. 2001. Preliminary report on the correlation of Archaic-Age localities with a Paleoshoreline on Barbuda. In *Proceedings of the Nineteenth International Congress for Caribbean Archaeology*, *Oranjestad, Aruba, July 22–28, 2001,* 102–09. Oranjestad, Archaeological Museum of Aruba.

Watters, D. R., Donahue, J. and Stuckenrath, R. 1991. Paleoshorelines and the prehistory of Barbuda, West Indies. In L. Lewis Johnson and M. Stright (eds), *Paleoshorelines and Prehistory: An Investigation of Method*, 15–152. Boca Raton, FL, CRC Press.

Watters, D. R. and Nicholson D. V. 1982. Highland House, Barbuda: An 18th century retreat. *The Florida Anthropologist* 35(4), 223–42.

Chapter 16

Archaeological heritage on the Atlantic coast of Uruguay: heritage policies and challenges for its management in coastal protected areas

Camila Gianotti, Andrés Gascue, Laura del Puerto, Hugo Inda and Eugenia Villarmarzo

Abstract

Archaeological coastal sites are an important source of information about human–environment relationships. The information they can provide is particularly significant given current predictions of global changes to coastal environments, mainly as a consequence of increasing sea levels attributed to global warming. In addition to climatic threats, there are strong pressures on coastal environments related to anthropic activities, such as urbanisation, tourism, agriculture and industrial production, which can further impact upon archaeological heritage. Although strategies to deal with the loss and destruction of archaeological sites have not always been included in public heritage policy, recent conservation policies associated with the management of protected areas in Uruguay have begun to integrate this heritage. This paper presents information about archaeological heritage on the Atlantic coast of Uruguay within three conservation areas, each providing a different category of protection. It will show how archaeological heritage has been integrated into conservation policies and will highlight future challenges for cultural heritage management and how they should be included in sustainable, participatory frameworks. The paper will also discuss the potential for prehistoric coastal occupation to shed light on past adaptations to environmental change.

Archaeological heritage management in national public policies for nature conservation

Over the last 15 years, public policies affecting Uruguay's heritage have developed and broadened, increasing links with biodiversity conservation and land planning. In 2001, the *National System of Protected Areas* (Sistema Nacional de Áreas Protegidas [SNAP]) created three national categories of protection: *Protected Landscapes, Sites of Protection* and *National Parks*. The new system replaced the old heritage law (No 14.040/1972) which had protected (but not effectively managed) heritage as *National Historic Monuments*. The former law had been criticised as being inadequate due to diverse socio-economic developments in the country over the last 15 years. This contrasted with certain national regulations that had progressively included cultural heritage protection and management, such as:

- Law 16.466/1994: Environmental protection through archaeological impact studies
- Law 18.308/2008: Land planning and tourism through departmental guidelines, master plans and local plans
- Law 17.234/2000: Biodiversity management and nature conservation through protected areas and their management plans
- The declaration of Ramsar sites protected by the Ramsar Convention on Wetlands Preservation (1971) and the

creation of Biosphere Reserves (through UNESCO's Programme on Man and Biosphere).

Integrating archaeology into biodiversity conservation policies has provided a favourable contextual and systemic framework in which to consider the management of heritage sites alongside the environmental units and ecosystems that contain them. It has also allowed for the development of participatory work as part of protected areas governance, where different forms of public archaeology can be adapted to the socio-economic characteristics of the protected territories (Caporale 2010; Brum *et al.* 2011; Lamas *et al.* 2013; Blasco *et al.* 2014; Gianotti *et al.* 2015a; Gascue *et al.* 2016). However, nature conservation policies have been criticised for their bias towards preserving living species and ecosystems, and for not paying enough attention to other elements of ecological systems (including archaeological, geological, and palaeontological heritage; Toledo 2005). They are also criticised because they have not incorporated the long-term responses of ecosystems to natural or anthropogenic changes (Waldhardt 2003). This was identified as a problem during the implementation of SNAP in Uruguay (Gianotti *et al.* 2016). The situation, however, is beginning to improve in some protected areas due to integration into management plans (Laporta and Sarroca 2014), especially when a landscape approach is incorporated (SNAP 2014-Project URU/13/G35; Gianotti *et al.* 2015a).

Some consideration is being given to large-scale processes and changes in national climate change adaptation policies (Bidegain *et al.* 2012). These also take into account the impacts of climate change on vulnerable socio-economic and environmental systems (cf. FAO 2013; 2014). Projected global climate models for the region forecast a rise in mean temperature of about 2–3°C and a rise of 10–20% of annual rainfall by the end of the 21st century (Bidegain *et al.* 2012). This could lead to the destruction of some of the archaeological heritage. However, the impacts of climate change on archaeological heritage – which can act as either a key indicator for conservation and management or as an example of past resilience – have not been explicitly included in national climate change adaptation policies. This situation is somewhat understandable given the historic vicissitudes of identity formation within Uruguay (Caetano and Rilla 2005; Criado-Boado *et al.* 2006). Heritage is not considered a key factor in the nation's economic and cultural development or as a priority for national policies.

Some recent initiatives have focussed on two main areas of archaeological heritage management in vulnerable coastal areas. Archaeology has made contributions to the integrated management of heritage, including projects which have a participatory or public dimension (Gianotti *et al.* 2007; 2015a; 2015b; López *et al.* 2007; Brum *et al.* 2011; Brum 2013; Gascue *et al.* 2016). In addition, interdisciplinary studies have enabled an understanding of the long-term, natural variability of coastal systems and the effects of human modification upon the environment. Combined, these help to show the effects of natural dynamics and the vulnerability of coastal sites from a time before more recent changes and anthropogenic pressures (Inda 2009; del Puerto 2011; del Puerto *et al.* 2011; Inda *et al.* 2011). Such studies have the potential to influence our thinking about the integration of archaeological investigation into policies orientated towards evaluating vulnerable socio-ecological systems. They can also inform our understanding of the impacts of, and the mechanisms of resilience against, climate change. This potential is evidenced by some European projects that have assessed the vulnerability and risk of archaeological sites prior to recent climatic changes, and have shown how these aspects are key when designing integrated heritage management measures (Daire 2008; Daire and López-Romero 2008; Ballesteros *et al.* 2013).

The Atlantic coast of Uruguay as a territory of change: archaeology's contributions to the study of human-environment relationships

On the Atlantic coast of Uruguay, climatic and environmental evolution has been approached with different multi-proxy analyses, as well as topographic and stratigraphic-sedimentological surveys (*e.g.* del Puerto *et al.* 2011; 2013). Archaeological surveys and excavations have been carried out as part of specific studies to understand prehistoric subsistence systems, changes in occupation patterns, and strategies for natural resource collection and use (*e.g.* Inda *et al.* 2006; 2011; López *et al.* 2009a).

Archaeological and palaeoenvironmental data have shown that settlement of the region took place *c.* 11,000–10,000 years ago, at a time when the coastline was significantly different and the sea was between 30 and 50 m below its present-day level (Inda *et al.* 2011). Subsequent sea level rise has inundated many of the archaeological remains of that period, leading to a lack of information on the early human occupation of the Atlantic coast (Inda *et al.* 2011). During the Holocene maximum transgression (4050–2550 BC), the sea was *c.* 4–6 m above present day levels, and evidence shows that human groups settled rocky promontories and the shores of gulfs and bays which would later develop into coastal lakes (Inda *et al.* 2006; López *et al.* 2009a).

A subsequent period of sea level regression led to humans following the retreating coastline. However, climatic oscillations between 2000 and 1000 years BC, including arid periods when there was significant aeolian movement of sand exposed by the retreating sea, created less favourable conditions for coastal occupation, thus

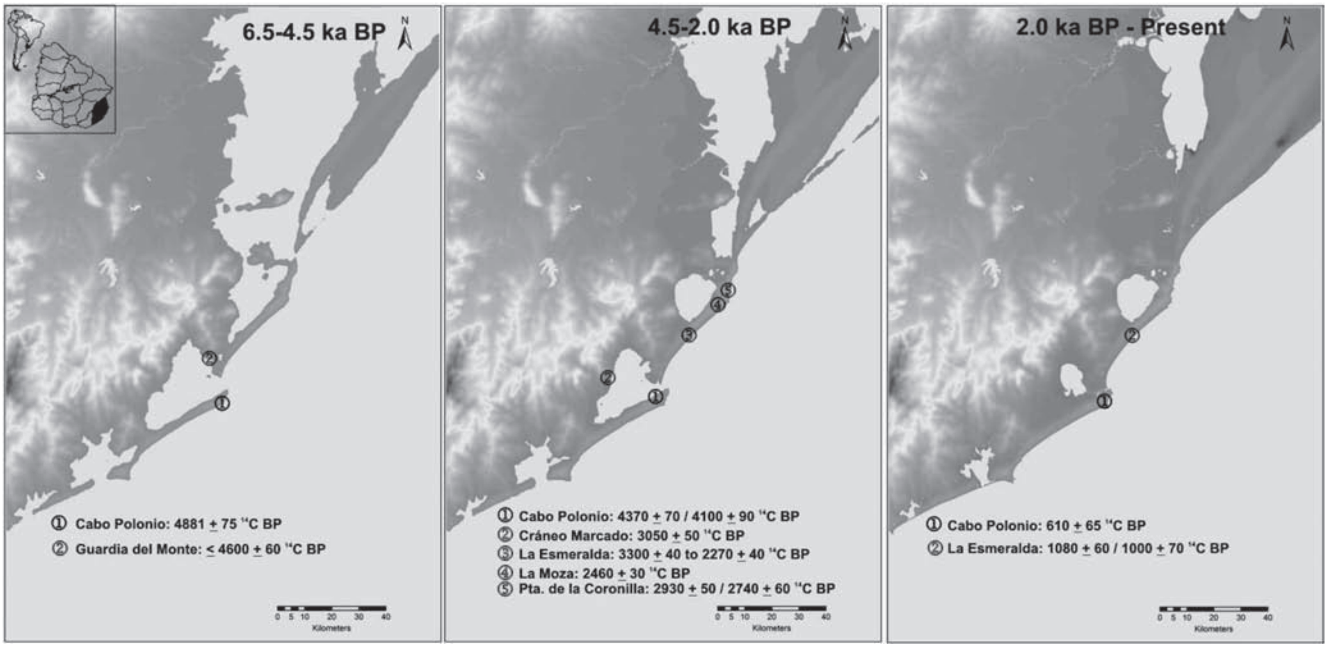

Figure 16.1. Evolution of the coastline of the study area (Department of Rocha) and location of archaeological sites divided by time period.

prompting new strategies for environment and resource management (Inda *et al.* 2006; Castiñeira *et al.* 2010; Villarmarzo 2010). Evidence of these changes has been recorded at archaeological sites such as La Esmeralda shell mound and Cráneo Marcado I (Fig. 16.1).

From 550 BC (dated by geomorphological location and relative chronologies), the environment was similar to today. Many sites were abandoned, although indigenous mound structures have been recorded in coastal areas from this period (López *et al.* 2009b).

From the 18th century, a new wave of human occupation occurred with the arrival of European settlers. Anthropic pressures emerged in coastal ecosystems – amplified by the start of production activities on newly settled fields and initiatives such as wetland drainage and afforestation – and modified both landscapes and the archaeological sites contained therein. The coastal urbanisation process and the development of towns and cities was exacerbated by the *Populated Centres Law* of 1939.

Promoting approaches that combine palaeoenvironmental, archaeological and historical information to understand coastal change processes is therefore an important challenge for heritage and conservation policymakers. The following three case studies highlight different actions that were taken to plan the management and conservation of coastal archaeological heritage. As the study area contains a large number of protected areas, an additional challenge was to develop strategies that promote integrated heritage management. These projects included the addition of a public archaeology approach to heritage management, and a participatory and multi-vocal dimension as an essential foundation of the management plans.

Archaeological heritage management in three protected areas on the Uruguayan Atlantic coast: planning for conservation and socialisation

In the last 20 years, socio-economic and land-use changes in the Uruguayan coastal territory have had a significant impact on the natural and cultural heritage of the region. These transformations took place at a time when National Parks were being supplemented by the creation of protected areas for the conservation of natural heritage and biodiversity.

The Department of Rocha contains two National Parks and five Protected Areas forming part of SNAP. The heritage management approaches employed have varied according to the legal status of the area, to the type of work being undertaken, and to the technical abilities of the teams.

Management plans have set out the processes for protected area planning, organising all relevant information so that it can be analysed to establish a set of sustainable management guidelines and actions based on conservation criteria. Criteria and methodologies published in SNAP project guidelines (SNAP 2012; Mejía 2012) have been used with other tools, including the Conservation Action Planning (CAP) methodology for the conservation of sites (TNC 2007), the Open Standards for Conservation Practice (CMP 2007), the IUCN Guide for Planning and Management of Protected Areas (IUCN 1994; Dudley

2008), and the Management Effectiveness Tracking Tool (METT; World Bank/World Wildlife Fund). Each of these established different mechanisms for promoting participatory governance strategies.

The creation of the management plans discussed below show a bias of the methodologies towards the biological and ecological aspects of conservation, and this has, at times, generated challenges for integrating, analysing, and assessing the cultural dimension of heritage (Gianotti *et al.* 2015a; 2016). Also, there are no pre-established planning guidelines used in the National Parks that are not managed by SNAP. The administration of each park has followed different processes as the technicians involved with each park have determined the methodologies used.

Cerro Verde and La Coronilla Islands Protected Area

The Cerro Verde and La Coronilla Islands Protected Area is a marine coastal area comprising 7000 ha of marine territory and 1700 ha of land located between Santa Teresa National Park and La Coronilla seaside resort (Fig. 16.2). The area is co-administered by the Ministry of Housing, Land Management and Environment (MVOTMA) and the Ministry of National Defence (MDN). This Protected Area entered SNAP in August 2011 as a *Habitat and Species Management Area*. Although its organisational structure was formed immediately, the management plan is still under development. From the outset, a key goal was collaboration, and the aim of the management plan is

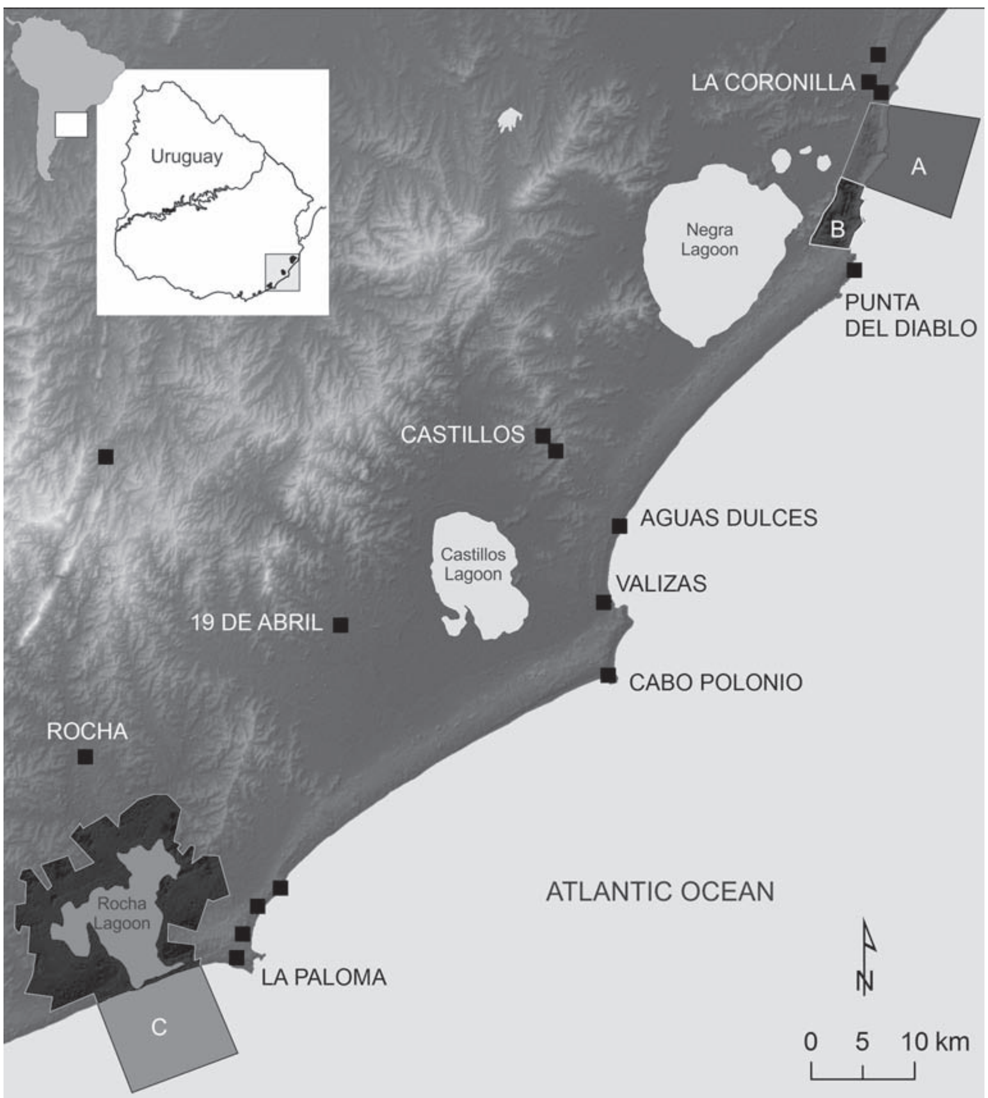

Figure 16.2. General location of the geographical area in Uruguay with the specific location of the three case studies: A) Cerro Verde and La Coronilla Islands Protected Area, B) Santa Teresa National Park, and C) Laguna de Rocha Protected Area.

to: 'research, restore and preserve biological and cultural diversity, respecting the high degree of naturalness of the marine-coastal landscape and providing opportunities for the population of La Coronilla within a framework of regional sustainable development' (Laporta and Sarroca 2014, 3).

Before the area was protected, archaeological sites dated *c.* 550 BC (López 1995) found on outcrops inspired the development of a conceptual and instrumental approach that promoted the integration of archaeological heritage and its management (Gianotti *et al.* 2007). The work involved cataloguing the archaeology of the area, thus increasing the number of known sites; analysing their conservation state; identifying the main threats and pressures; and defining a set of measures to promote better conservation of the heritage (Gianotti *et al.* 2007).

In 2014, during the development of the management plan, the opportunity arose to establish a specific strategy to integrate management of cultural heritage together with other assets in the area. Conservation *targets* – species, ecosystems, processes, or other important aspects of biodiversity and archaeological and cultural heritage – were defined as entities that needed to be preserved (Granizo *et al.* 2006). Of these, *archaeological zones, sites* and *movable property* with cultural or heritage value were identified separately from other resources relating to ecosystems, environmental processes and flora and fauna. Archaeological zones and sites comprise structures, groups of material and/or evidence of activities that indicate human use and occupation over time. Movable property refers to collections of palaeontological, archaeological and historical materials collected or otherwise sourced within the boundaries of a protected area (Laporta and Sarroca 2014). Two zones and five sites of cultural and heritage value (including prehistoric, historic and ethnographic sites) were recorded, together with some private archaeological collections (Laporta and Sarroca 2014; Table 16.1; Fig. 16.2).

An evaluation of the conservation state of the archaeological zones and sites allowed us to recognise that the majority of threats and pressures came from activities related to tourism (including motor or animal-drawn vehicles and tourist traffic), followed by looting, vandalism and a late 19th century forestry initiative that included the extensive introduction of exotic tree species. These pressures can directly alter or destroy heritage resources and can also generate the loss of vegetation cover and increase run-off, affecting the physiochemical action of natural agents. Other problems included aeolian weathering, intense rainfall, wave action and corrosion (Table 16.1).

Table 16.1. General characterisation of archaeological zones and sites of the protected area Cerro Verde and its main pressures and threats for conservation

Heritage entity & # on map	*Name*	*Site typology*	*Chronology*	*Pressures due to anthropic agents*	*Pressures due to natural agents*	*Present damage assessment*
Zone 1	La Coronilla I	Stratified with surface materials	Pre-Hispanic	Tourist development (pedestrian, motor or animal-drawn vehicle traffic), pillage, afforestation (sand dunes fixation)	Loss of vegetation cover, run-off, sediment erosion, insolation, aeolian dynamics	Moderate
Zone 2	Cerro Verde	Stratified with surface materials	Pre-Hispanic	Tourist development (pedestrian, motor or animal-drawn vehicle traffic), pillage, signage and wooden structures, afforestation (sand dunes fixation)	Loss of vegetation cover, run-off, sediment erosion, insolation, aeolian dynamics	Moderate
Site 3	La Coronilla II	Stratified with surface materials	Pre-Hispanic	Tourist development (pedestrian, motor or animal-drawn vehicle traffic), pillage, afforestation (sand dunes fixation)	Loss of vegetation cover, run-off, sediment erosion, insolation, aeolian dynamics	Moderate
Site 4	Olla-Isla Verde	Place of memory, historic site	Historic – ethnographic	Arrival of tourist boats, pillage	Weathering, corrosion	Moderate
Site 5	La Porteña	Underwater site	Historic – ethnographic	Pillage	Waves, corrosion	Very Severe
Zone 6	El Pesquero	Place of memory, historic site	Historic – ethnographic	Vandalism, abandonment	Waves, corrosion	Very Severe
Zone 7	Refugio Punta La Coronilla	Place of memory, historic site	Historic – ethnographic	Vandalism, abandonment	Weathering	Moderate

Following the evaluation, measures aimed at minimising harmful activities were integrated into the management plan. These included a ban on motor or animal-drawn vehicles in vulnerable areas and the use of rangers to control looting. In order to evaluate these measures, a monitoring plan was developed that included raising heritage awareness among the local population within a broader environmental and cultural education programme (Laporta and Sarroca 2014).

Santa Teresa National Park

The *c.* 3000 ha Santa Teresa National Park (PNST) lies adjacent to the Cerro Verde and La Coronilla Islands Protected Area, and receives *c.* 30,000 visitors annually. The Park has many cultural and natural assets, including: Santa Teresa Fortress (a National Historic Monument), dozens of archaeological sites (Gascue *et al.* 2016), and natural attractions including sandy beaches separated by rocky peninsulas, trails, and exotic and native flora and fauna.

The park is managed by the Army's Service of Parks (SEPAE) and the Museum of Santa Teresa Fortress is run by the Department of Historical Studies under the Army's management. Recently the Ministry of Tourism has shown an interest in participating in the Park's management by developing a *Master Plan for Santa Teresa National Park,* which includes aspects of heritage (Roche and Somaruga

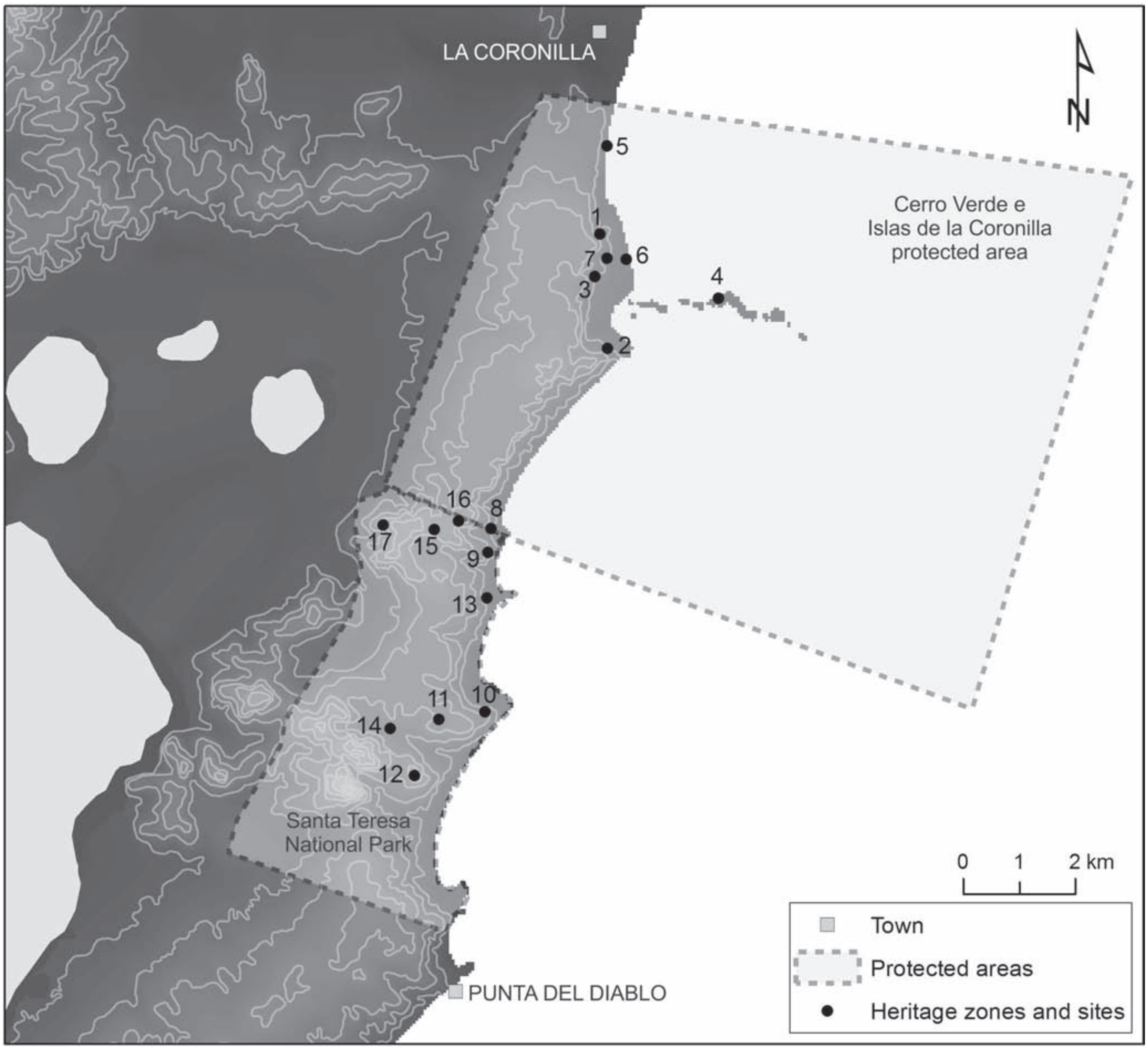

Figure 16.3. Delimitation of Cerro Verde and La Coronilla Islands Protected Area and Santa Teresa National Park with zones and sites of cultural and heritage value (site characterisation in Table 16.1 and Table 16.2).

2015). This is already being implemented in collaboration with the School of Architecture, University of the Republic.

An increase in socio-environmental transformations have created pressures and threats to heritage assets, and these can be traced back to the reconstruction of the Santa Teresa fortress and the reconversion of the area for tourism in the 1920s (Arredondo 1943). The main impacts include the afforestation of the mobile sand-dune system with exotic species, the damming of natural drains (Laguna de Peña), the introduction of exotic animal species, and an increase in tourism. The latter is exemplified by the expansion of infrastructure, equipment and services, including the construction of a network of roads and tourist buildings. Although tourism related improvements have had positive economic impacts, the changes have had a negative impact on the physical and biotic environment and on archaeological heritage.

These problems motivated the development of a management project, directed by Andres Gascue and funded by the Sectorial Commission for Scientific Research (CSIC), University of the Republic. The *Integrated Management of Prehistoric Cultural Heritage of Santa Teresa National Park* project aimed to identify and catalogue cultural assets, assessing and assigning significance to them and increasing public accessibility (Gascue *et al.* 2014). Twenty-four locations with concentrations of prehistoric material were identified through archaeological survey. Archaeological findings were grouped into seven zones and three isolated sites, which in turn related to different environmental units (Atlantic shore, Laguna de Peña and highlands) (Fig. 16.3 and Table 16.2). Recommendations were then made to integrate cultural assets into park management strategies (TNC 2003).

Each zone or site had been negatively impacted by tourism development and/or improvements to the park (Table 16.2). The evaluation identified the causes of degradation, providing the data needed to design management strategies that could safeguard unaltered areas that have a high scientific or heritage potential.

The first conservation strategy included the development of a public archaeology programme in an attempt to relay

Table 16.2. General characterisation of archaeological zones and sites of Santa Teresa National Park and its main pressures and threats for conservation

Heritage entity & # on map	*Name*	*Site typology*	*Chronology*	*Pressures due to anthropic agents*	*Pressures due to natural agents*	*Present damage assessment*
Zone 8	La Mocita-Cerro Bobo	Stratified with surface material	Pre-Hispanic	Buildings, motor vehicle and pedestrian traffic, pillage, absence of storm water management, afforestation with exotic species	Insolation, aeolian dynamics, run-off	Very severe
Site 9	La Moza	Stratified with surface material	Pre-Hispanic	Tourist development (roads, sports-recreational infrastructure construction, pedestrians), sediment removal (cell phone antenna, observation tower for whales)	Insolation, aeolian dynamics, run-off	Moderate
Zone 10	El Barco	Surface	Pre-Hispanic	Roads, pedestrians	Insolation, aeolian dynamics, run-off	Severe
Zone 11	Barco Alto	Stratified with surface material	Pre-Hispanic	Roads, heavy machinery traffic, afforestation with exotic species, pillage	Insolation, aeolian dynamics, run-off	Severe
Zone 12	Cerro Árido	Surface	Pre-Hispanic	Afforestation with exotic species, fires, pillage	Erosion, insolation, run-off	Severe
Site 13	Achiras	Stratified with surface material	Pre-Hispanic	Afforestation with exotic species	Erosion, insolation, run-off	Severe
Zone 14	Laguna de Peña	Surface	Pre-Hispanic	Afforestation with exotic species, sediment removal	Insolation, run-off	Severe
Zone 15	Cuartelillo	Stratified	Pre-Hispanic	Tourist development- road development, recreational use (camping zone), sediment removal for camping and drinkable water service, afforestation with exotic species	Run-off	Very severe
Site 16	Antena	Stratified with surface material	Pre-Hispanic	Roads, buildings (cell phone antenna base), afforestation with exotic species	Run-off	Moderate
Zone 17	Fortaleza and Pueblo de Santa Teresa	Architectural complex	Historic	Touristic reconstruction, afforestation with exotic species, roads	Weathering	Low

archaeological knowledge beyond the scientific community, and to help prevent the degradation of cultural assets due to negligence or ignorance (Saucedo 2006). The activities were focussed on local inhabitants and tourists with the intent to promote education and awareness of cultural heritage in terms of archaeological site preservation, together with a vast array of cultural resources that could foster local economic development. Three strategies were proposed/employed (Gascue *et al.* 2014):

- Archaeological trails, site signage and the design of display boards for the dissemination of research results and the promotion of community best practices for the preservation of cultural heritage.
- New exhibitions and designs for the archaeological exhibitions within the Santa Teresa museum, including the addition of new objects and scientific information based on recent research.
- A proposal developed for local school children and teachers with the aim of promoting a leisure-related experience and improving awareness of the importance of preserving cultural heritage. The proposal included a guided tour of ongoing excavations and experimental workshops for manufacturing and using prehistoric artefacts (Bortolotto *et al.* 2010).

These activities have helped turn Santa Teresa's pre-Hispanic heritage into assets that generate profitability by incorporating them as additional attractions offered to tourists by the Park.

Laguna de Rocha Protected Area

Laguna de Rocha Protected Area is located about 11 km from the city of Rocha and is very close to the seaside resort of La Paloma. Towards the west, it borders Laguna Garzón Protected Area. It has a total surface of 35,700 ha, which includes rural properties (18,425 ha), the lagoon water surface (7512 ha) and a portion of marine territory (9762 ha). Recently, the whole area was designated as a Protected Landscape by SNAP, the result of over 20 years of collaborative work involving different institutions, agencies and the local community (Vitancurt 2016). The development of the management plan began in 2011 and was finished two years later (Rodríguez-Gallego *et al.* 2012), although it is still awaiting approval by SNAP.

Initially there was a limited understanding of the Protected Area's cultural assets (Thompson 2006), which resulted in a project to identify, catalogue, and enhance the archaeological heritage of the area (Gianotti and Villarmarzo 2011; Rodríguez-Gallego *et al.* 2012). At the same time, new initiatives were started to create a general overview of the cultural heritage of the lagoon (Tiscart *et al.* 2014; Lagos 2016; Vitancurt 2016). Palaeoenvironmental and geomorphological studies contributed key information for understanding the relationship between human occupation and environmental changes in the course of the lagoon's evolution over the last 10,000 years (Inda 2009).

In 2012, interdisciplinary workshops began with the intention of reaching an agreement about the main aspects of a management plan (Rodríguez-Gallego *et al.* 2012). This resulted in a proposal to define Laguna de Rocha as a *cultural landscape* with a set of *focal targets*. The Laguna de Rocha Cultural Landscape is an area shaped by anthropogenic coastal practices – the population see themselves as part of the environment in which they live, and certain historical forms of territorial occupation continue today, reflecting strong links with marine-lacustrine biodiversity (see Gianotti *et al.* 2015a).

Six focal targets were identified for the conservation of biodiversity – five ecological and one cultural. Five main components were also identified: 1) visual, 2) aural, 3) historical-archaeological, 4) living heritage, and 5) physical. Each focal target and its components were defined by key attributes that could be monitored (Gianotti *et al.* 2015a; 2016). These data allowed a revision of the governance model, and six operational programmes (tourism, education, conservation, agricultural management, cultural heritage management, and monitoring) were presented to create the management plan (Rodríguez-Gallego *et al.* 2012).

The historical-archaeological component is formed of eight archaeological zones, seven sites and three private archaeological collections (see Fig. 16.4 & Table 16.3). The condition and conservation pressures on the sites were documented. In general, the degradation of archaeological heritage in the area is moderate. The main threats are the loss of vegetation cover from farming activities (crops, afforestation, cattle raising) and the action of natural agents on soils (weathering, insolation, aeolian dynamics *etc.*). To a lesser extent, looting and abandonment are also factors (Gianotti and Villarmarzo 2011; Rodríguez-Gallego *et al.* 2012; Gianotti *et al.* 2015a).

Archaeological work within the protected area has been carried out with a participatory approach. Projects have:

- activated, visualised and discussed the multi-vocal heritage narratives belonging to the community, institutions and technicians within the area;
- bridged the gap between traditional conceptions of 'heritage' at different institutional levels (university, local government, technicians, area administration), and what local actors consider 'their heritage'; and
- made visible the discussions of the ongoing process of heritage protection at Laguna de Rocha Protected Landscape, showing both conflicts, interests and asymmetries, but also confluences and agreements (Blasco *et al.* 2014; Gianotti *et al.* 2015a; 2016).

Some of the conservation measures implemented were based on the application of an inclusive approach, with the aim of raising awareness about the role of cultural heritage assets in

Table 16.3. General characterisation of archaeological zones and sites of the protected area Laguna de Rocha and its main pressures and threats for conservation

Heritage entity & # on map	*Name*	*Site typology*	*Chronology*	*Pressures due to anthropic agents*	*Pressures due to natural agents*	*Present damage assessment*
Zone 18	Loma Santa Carmen	Stratified with surface material	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Loss of vegetation cover, run-off	Moderate
Zone 19	Virazón-Barra Vieja	Stratified with surface material	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Loss of vegetation cover, run-off, weathering (insolation, aeolian dynamics)	Moderate
Zone 20	Zanjón de la Virazón	Stratified with surface material	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Loss of vegetation cover, run-off, weathering (insolation, aeolian dynamics)	Moderate
Zone 21	Lomada Zanja Honda	Stratified	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Loss of vegetation cover, run-off, weathering (insolation, aeolian dynamics)	Moderate
Site 22	Arroyo Zanja Honda	Stratified	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Run-off	Moderate
Site 23	Estancia Zunini	Architectural complex	Historic	Farming activities, buildings	Loss of vegetation cover, weathering	Moderate
Zone 24	Cañada Bellaca	Stratified with surface material	Pre-Hispanic	Farming activities (cattle raising), pillage	Loss of vegetation cover, erosion, weathering (insolation, aeolian dynamics)	Moderate
Zone 25	Arenal de La Garita	Stratified with surface material	Pre-Hispanic	Farming activities (crops and cattle raising), pillage	Loss of vegetation cover, run-off, weathering (insolation, aeolian dynamics)	Moderate
Site 26	La Garita	Architectural complex, place of memory	Historic-ethnographic	Absence of maintenance	Weathering (insolation, aeolian dynamics, rainfall)	Low
Site 27	Cerrito Tropicalia	Mound	Pre-Hispanic	Farming activities (crops and cattle raising)	Loss of vegetation cover, erosion	Moderate
Site 28	Tapera Laguna de las Nutrias	Architectural complex	Historic-ethnographic	Abandonment	Weathering (insolation, aeolian dynamics, rainfall)	Severe
Zone 29	Laguna de las Nutrias	Surface	Pre-Hispanic	Farming activities (crops and cattle raising), afforestation	Loss of vegetation cover, run-off, weathering (insolation, aeolian dynamics)	Moderate
Site 30	Carbonera Los Noques	Productive place	Historic-ethnographic	Farming activities (crops and cattle raising)	Loss of vegetation cover, erosion.	Low
Zone 31	Cañada de los Noques	Stratified with surface material	Pre-Hispanic	Farming activities (crops and cattle raising)	Loss of vegetation cover, erosion, weathering (insolation, aeolian dynamics)	Moderate
Site 32	Carbonera Sauce de Rocha	Productive place	Historic-ethnographic	Farming activities (crops and cattle raising)	Loss of vegetation cover, erosion	Low

the creation, promotion and conservation of biodiversity. The activities were carried out in collaboration with local people and examples included participatory archaeological surveys (Gianotti and Villarmarzo 2011); interviews to document oral history and local memory (Gianotti *et al.* 2016); social cartography workshops to record representations of the lagoon and its values (Blasco *et al.* 2014); activities in rural schools (Vienni *et al.* 2012); exhibitions and dissemination publications (Gianotti *et al.* 2015b); the presentation of the Laguna de Rocha Protected Landscape at the international photography exhibition *Diversa* organised by Incipit (Institute of Heritage Sciences, Spanish National Research Council; http://www.agenciasinc.es/Agenda/Exposicion-Diversa.-Arqueoloxia-dende-o-Incipit-alen-Europa); and scientific exchange through the incorporation of this protected area as a case study within the international study programme *Red TRAMA3* (Gianotti *et al.* 2016; Lagos 2016; Rodríguez-Gallego and Nin 2016; Vitancurt 2016; http://www.cyted.org/?q=es/detalle_proyectoandun=862).

Reflections and perspectives

The three case studies have shown how the management of cultural heritage in Uruguay's coastal Protected Areas have considered the relationship between climate change and human occupation of Uruguay's Atlantic coast together

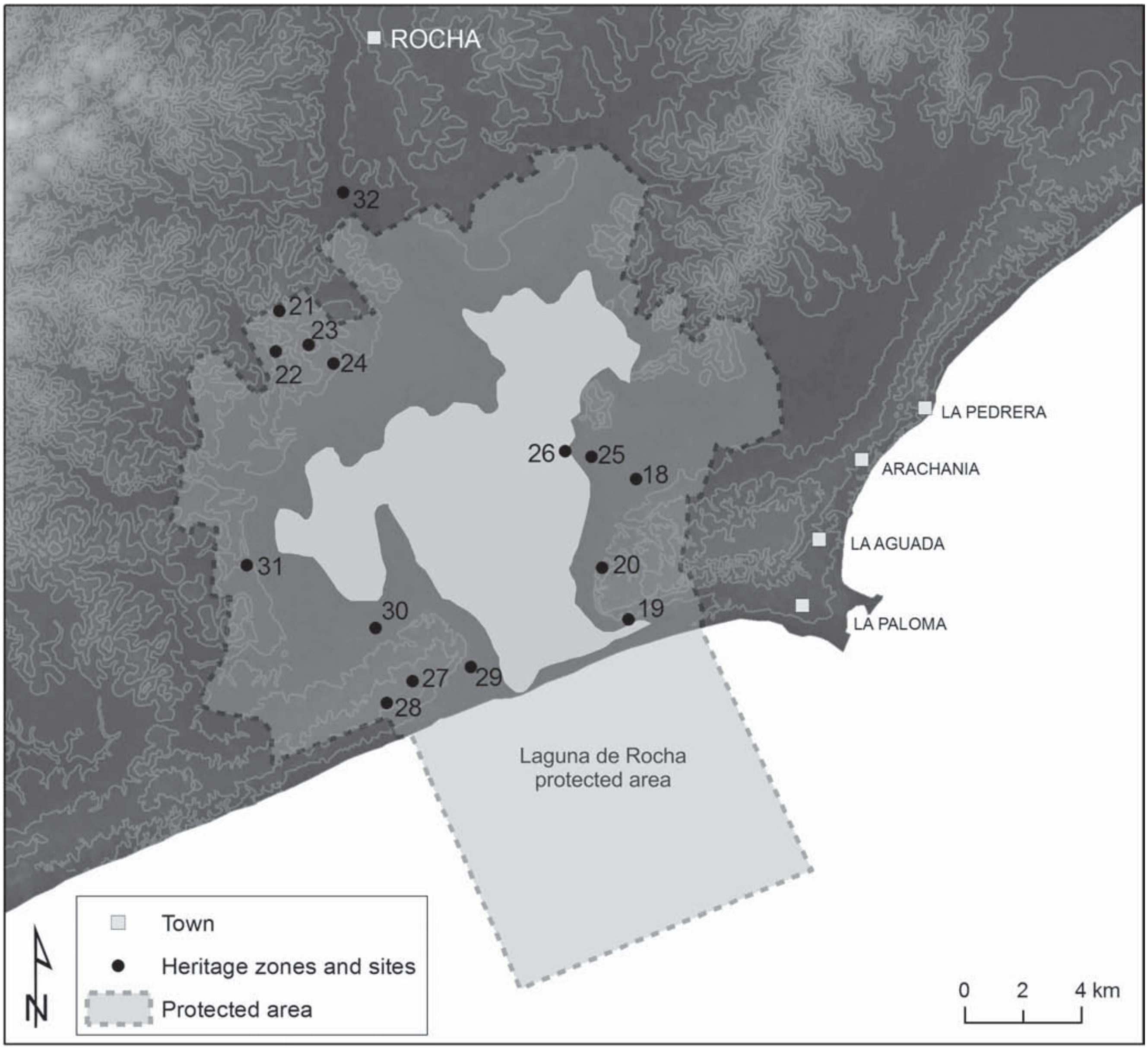

Figure 16.4. Delimitation of Laguna de Rocha Protected Area with zones and sites of cultural and heritage value (site characterisation in Table 16.3).

with the state and vulnerability of archaeological heritage in coastal Protected Areas. Consideration of these topics has been incorporated into national conservation and heritage policies within SNAP, and has directed thinking about future challenges, thereby strengthening heritage management practices.

Palaeoenvironmental and archaeological studies contribute evidence of successful prehistoric adaptations to environmental change, providing a long-term historical perspective. Modelling the formation of different coastal ecosystems indicates that some archaeological sites, especially the older ones, are now underwater (Inda *et al.* 2011). Those that are currently above mean sea level are located in different and varied landscapes, showing how human occupations adapted to these changes in terms of the spatial rearrangements of site allocation patterns (del Puerto *et al.* 2011; 2013).

We have also seen that much of the archaeological heritage in the three protected areas is extremely vulnerable, with different pressures affecting their integrity and conservation. Most pressures are exacerbated by an increase in human activity along the coastal strip (especially tourism, urbanisation, farming activities and afforestation). These can trigger erosive processes, enhanced by climatic factors that further damage heritage. This can lead to the rapid destruction of some sites, while others are exposed and are, in turn, rapidly affected by erosion, leading to the movement or loss of archaeological materials. Some structures are damaged or collapsed, and there has been an increase in looting (Gianotti and Villarmarzo 2011; Laporta and Sarroca 2014; Gianotti *et al.* 2015a; Gascue *et al.* 2016).

It has become necessary to consider heritage vulnerability (and its causes) explicitly in order to implement conservation plans at different levels (analysis, scenario prediction, decision making). We believe that integrating threats into heritage and environmental public policies and planning processes for biodiversity conservation will help minimise damage in the future. It is also essential to initiate monitoring programmes that identify and assess the real impacts of climate change on heritage to help protect and safeguard assets. In this regard, some progress has been made. The three case studies show how, for the first time, heritage management is being incorporated into conservation planning at Uruguay's coastal Protected Areas.

There is still more to be done, including refining methodologies and work protocols to better integrate cultural asset management within Protected Areas. In addition, we must design cross-disciplinary strategies that consider the perceptions and representations of the different actors involved; and utilise the framework of public archaeology (Matsuda 2004; Silverman 2011). Implementing participatory and multi-vocal approaches should be goals for the future.

From the planning and management perspective, integrative approaches – including the landscape perspective – will need to be developed and implemented as main objectives of future management strategies. This will help overcome prevailing sector-based ideas that rely on the conservation of natural and cultural heritages in disparate ways. The challenge is to protect the human processes that shaped landscapes and cultural heritage by introducing best management practices to ensure the sustainable and long-term preservation of these resources. From this perspective, National Parks and Protected Areas and Landscapes are more than just units for management policies, they are spaces where we can think creatively and critically about heritage, territory and sustainability.

References

Arredondo, H. 1943. Parque Nacional de Santa Teresa. *Revista Turismo en el Uruguay* VIII(33), 18–36.

Ballesteros-Arias, P., Güimil-Fariña, A. and López-Romero, E. 2013. *Estudo arqueolóxico do Parque Nacional Marítimo-Terrestre das Illas Atlánticas de Galicia. Prospección superfi ciale vulnerabilidade*. CAPA 33. Santiago de Compostela, Instituto de Ciencias del Patrimonio (Incipit-CSIC). Available at: http://digital.csic.es/bitstream/10261/74466/1/CAPA%20 33.pdf.

Bidegain, M., Crisci, C., del Puerto, L., Inda, H., Mazzeo, N., Taks, J. and Terra, R. 2012. *Clima de cambios: Nuevos desafíos de adaptación en Uruguay*. Project report URU/3302. Rome, Food and Agriculture Organization (FAO)/Ministerio de Ganadería, Agricultura y Pesca (MGAP).

Blasco, J., Lamas, G., Gentile, B., Villarmarzo, E. and Gianotti, C. 2014. Aprendiendo de nuestras prácticas. Cartografía social en Laguna de Rocha. In L. Berrutti, M. Cabo and M. J. Dabezies (eds), *Apuntes para la acción III. Sistematización de experiencias de extensión universitaria*, 33–46. Montevideo, CSEAM UdelaR.

Bortolotto, N., Gascue, A., Baeza, J., Gómez, J., Lemos, J. and Duarte, C. 2010. Extendiendo la Arqueología. Valorización del patrimonio cultural prehistórico en la enseñanza secundaria. In *Proceedings of III Jornadas de Investigación.* Montevideo, Facultad de Humanidades y Ciencias de la Edicación (FHCE), Universidad de la Republica, Uruguay. Available at: http://www.fhuce.edu.uy/jornada/2010/PONENCIAS/BORTOLOTTOetal.PDF [accessed 1 April 2016].

Brum, L., Cervetto, M., Chreties, C., Gorostiaga, J., Iriondo, L., Leicht, E., Roberto, C. and Rodríguez, L. 2011. Plan piloto de manejo costero integrado en área de oportunidad Punta Colorada-Punta Negra, Maldonado. In D. Conde (ed.), *Manejo Costero Integrado en Uruguay: Ocho ensayos interdisciplinarios*, 153–86. Montevideo, UDELAR/CIDA.

Brum, L. 2013. Gestión del patrimonio arqueológico en el litoral oeste del departamento de Maldonado (Uruguay). La investigación como práctica integral. *Revista del Museo de La Plata* 13(87), 417–28.

Caetano, G. and Rilla, J. 2005. *Historia contemporánea del Uruguay*. Montevideo, Fin de Siglo.

Caporale, M. 2010. La gestión del patrimonio arqueológico en el marco de los programas de Manejo Costero Integrado. El área protegida 'Humedales del Santa Lucia', región metropolitana de Uruguay. In R. Barcena and E. Chiavazza (eds), *Arqueología Argentina en el Bicentenario de la Revolución de Mayo*, 497–502. Mendoza, Universidad Nacional de Cuyo, CONICET-Zeta Eds.

Castiñeira, C., Panario, D., Bracco, R. and Gutiérrez, O. 2010. Concheros en la costa atlántica uruguaya y su vinculación con la dinámica litoral. XIV Congreso Nacional de Arqueología Argentina. In F. Oliva, N. de Grandis and J. Rodríguez (eds), *Arqueología Argentina en los inicios de un Nuevo Siglo*, vol. 3, 635–43. Rosario, Laborde Libros.

CMP (Conservation Measures Partnerships). 2007. *Open Standards for Conservation Practice*. Available at: http://cmp-openstandards.org/wp-content/uploads/2014/03/CMP_Open_Standards_Version_2_Spanish.pdf [accessed 1 October 2016].

Criado-Boado, F., Gianotti García, C. and López Mazz, J. M. 2006. Arqueología Aplicada al Patrimonio cultural: la cooperación científica entre Galicia y Uruguay. In G. Muñoz and C. Vidal (eds), *Actas del II Congreso Internacional de Patrimonio Cultural y Cooperación al Desarrollo*, 165–83. Valencia, Universidad Politécnica de Valencia.

Daire, M. Y. 2008. *ALERT (Archaéologie, littoral et réchauffement terrestre)*. Rapport d'activité Bretagne. Bretagne, UMR 6566, CReAAH, AMARAI.

Daire, M. Y. and López-Romero, E. 2008. Des sites archéologiques en danger sur le littoral et les îles de Bretagne: Chronique

2007–2008. *Bulletin de l´Association Manche Atlantique pour la Recherche Archéologique dans les Îles* 21, 91–104.

del Puerto, L. 2011. *Silicofitolitos como indicadores paleoambientales. Bases comparativas y Reconstrucción paleoclimática a partir del Pleistoceno tardío en el SE del Uruguay*. Berlín, Editorial Académica Española.

del Puerto, L., García-Rodríguez, F., Bracco, R., Blasi, A., Inda, H., Mazzeo, N. and Rodríguez, A. 2011. Evolución Climática Holocénica para el Sudeste del Uruguay: Análisis Multi-Proxy en Testigos de Lagunas Costeras. In F. García-Rodríguez (ed.), *El Holoceno en la Zona Costera del Uruguay*, 119–56. Montevideo, UCUR-UdelaR.

Dudley, N. (ed.) 2008. *Guidelines for Applying Protected Area Management Categories*. Gland, Switzerland, International Union for Conservation of Nature.

FAO (Food and Agriculture Organization of the United Nations). 2013. Clima de cambios. Nuevos desafíos de Adaptación en Uruguay. Available at: http://www.mgap.gub.uy/media/content/audio/source0000000011/AUD000002000002810.pdf [accessed 1 April 2016].

FAO (Food and Agriculture Organization of the United Nations). 2014. Adaptación al cambio climático en Uruguay. Available at: http://www.fao.org/climatechange/84982/es/ [accessed 1 April 2016].

Gascue, A., Baeza, J., Bortolotto, N., del Puerto, L., Inda, H., Lemos Zito, J., Gómez Trincabelli, J., Fleitas, M. and Mazarino, J. 2014. Gestión Integral del Patrimonio Cultural Prehistórico del Parque Nacional Santa Teresa. Unpublished Final Report Project 256. Montevideo, Comisión Sectorial de Investigación Científica, Universidad de la República.

Gascue, A., Baeza, J., Fleitas, M., Bortolotto, N. and Gómez, J. 2016. Catalogación y Contextualización Cronológica – Estratigráfica de los Bienes Culturales Prehistóricos del Parque Nacional Santa Teresa. *Revista Intersecciones en Antropología*, 3, 95–106.

Gianotti, C., Cacheda, M. and Dabezies, J. M. 2007. *Bases para la gestión del Patrimonio Arqueológico dentro del Área Protegida Cerro Verde*. Technical Report. Montevideo, SNAP (MVOTMA) y CPCN (MEC-Uruguay). Available at: http://digital.csic.es/bitstream/10261/32005/1/Documento%20t%C3%A9cnico_Bases_gestion_PA_Cerro_Verde.pdf [accesed April 2016].

Gianotti C. and Villarmarzo E. 2011. Identificación y valoración de elementos culturales de conservación del Área Protegida Laguna de Rocha. Informe técnico. In L. Rodríguez-Gallego and M. Nin (eds), *Avances del plan de manejo del área protegida Laguna de Rocha*, 60–98. Montevideo, Futuro Sustentable Srl.

Gianotti, C., Villarmarzo, E., Blasco, J., Lamas, G., Gentile, B. and Bica, C. 2016. Paisaje y Patrimonio como espacios de construcción multivocal en el Área Protegida de Laguna de Rocha. In C. Gianotti, D. Barreiro and B. Vienni (eds), *Patrimonio y Multivocalidad. Teoría, prácticas y experiencias en torno a la construcción del conocimiento en Patrimonio*, 161–77. Montevideo, CSIC–UdelaR.

Gianotti, C., Villarmarzo, E., Piazza, N., Nin, M., Rodríguez-Gallego, L. and Lembo, V. 2015a. El Paisaje Cultural Laguna de Rocha como objeto focal de conservación: propuesta para su integración dentro del plan de manejo de un área protegida. In M. Medina (ed.), *Paisaje, patrimonio, proyecto, desarrollo local. Paisajes culturales en Uruguay*, 13–31. Montevideo, CSIC-Biblioteca Plural.

Gianotti, C., Villarmarzo, E. and Blasco J. (eds). 2015b. *Una Laguna muchas Lagunas. El Paisaje Cultural de Laguna de Rocha* 15. Montevideo, Laboratorio de Arqueología del Paisaje y Patrimonio (Facultad de Humanidades y Ciencias de la Educación), Universidad de la República.

Inda, H. 2009. Paleolimnología de cuerpos de agua someros del sudeste del Uruguay: Evolución holocénica e impacto humano. Unpublished Masters thesis. Programa de Ciencias Básicas, Facultad de Ciencias, Universidad de la República.

Inda, H., del Puerto, L., Bracco, R., Castiñeira, C., Capdepont, I., Gascue, A. and Baeza, J. 2011. Relación Hombre-Ambiente para la Costa Estuarina y Oceánica del Uruguay durante el Holoceno: Reflexiones y Perspectivas. In F. García-Rodríguez (ed.), *El Holoceno en la Zona Costera del Uruguay,* 231–57. Montevideo, UCUR-UdelaR.

Inda, H., del Puerto, L., Castiñeira, C., Capdepont, I. and García, F. 2006. Manejo prehistórico de recursos costeros en el litoral atlántico uruguayo. In R. Menafra, L. Rodríguez-Gallego, F. Scarabino and D. Conde (eds), *Bases para el Manejo y Conservación de la Costa Uruguaya,* 661–67. Montevideo, Vida Silvestre.

IUCN (International Union for Conservation of Nature). 1994. *Guidelines for Protected Areas Management Categories*. Gland, Switzerland and Cambridge, UK, International Union for Conservation of Nature.

Lagos, X. 2016. Cultura de la Pesca en Laguna de Rocha. Enfoque cultural para el manejo integrado del patrimonio costero. In C. Gianotti, D. Barreiro and B. Vienni. 2016. *Patrimonio y Multivocalidad. Teoría, prácticas y experiencias en torno a la construcción del conocimiento en Patrimonio*, 135–48. Montevideo, CSIC–UdelaR.

Lamas, G., Blasco, J., Bica, C., Gentile, B. and Gianotti, C. 2013. La cartografía social como herramienta para la co-construcción del patrimonio cultural en laguna de Rocha. In D. Barrios, N. Marrero and G. Iglesias (eds), Memorias del Congreso de Extensión de la Asociación de Universidades Grupo Montevideo, 6 a 9 de noviembre de 2013, 1–13. Unpublished report. Montevideo, Universidad de la República. Available at: http://www.academia.edu/12309235/La_Cartograf%C3%ADa_social_como_herramienta_para_la_co-construcci%C3%B3n_del_patrimonio_cultural_en_la_Laguna_de_Rocha [accessed 4 April 2014].

Laporta, P. and Sarroca, M. 2014. Objetos focales de conservación en el área protegida Cerro Verde e Islas de la Coronilla. Unpublished technical report. Montevideo, Sistema Nacional de Áreas Protegidas/Dirección Nacional de Medio Ambiente/ Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente.

López, J. M. 1995. El fósil que no guía y la formación de los sitios costeros. In M. Consens, J. M. López and C. Curbelo (eds), *Arqueología en el Uruguay de Hoy: 120 años después*, 92–105. Montevideo, Editorial Surcos.

López, J. M., Gascue, A. and Villarmarzo, E. 2007. Diagnóstico arqueológico del area proteigda marino costera de Cabo Polonio y aportes para el diseño de su plan de gestión. Unpublished technical report. Montevideo, Dirección Nacional de Ordenamiento Territorial /Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente.

López, J. M., Moreno, F., Villarmarzo, E. and Gascue, A. 2009a. Apuntes para una arqueología costera y del Cabo Polonio. In

J. M. López and A. Gascue (eds), *Arqueología prehistórica uruguaya en el siglo XXI*, 39–66. Montevideo, Bibloteca Nacional y Facultad de Humanidades.

López, J. M., Gascue, A. and Moreno, F. 2009b. Arqueología de los Cerritos Costeros en el Sitio Estancia La Pedrera. In J. M. López and A. Gascue (eds), *Arqueología prehistórica uruguaya en el siglo XXI*, 67–84. Montevideo, Bibloteca Nacional y Facultad de Humanidades.

Matsuda, A. 2004. The concept of 'the Public' and the aims of public archaeology. *Papers from the Institute of Archaeology* 15(2004), 66–76.

Mejía, P. 2012. Directrices para la Planificación de Áreas Protegidas de Uruguay. Documento de Trabajo No 28 Versión Borrador. Montevideo, Dirección Nacional de Medio Ambiente. Available at: http://www.mvotma.gub.uy/ciudadania/item/10006145-documento-de-trabajo-n-28.html [accessed 1 April 2016].

Rodríguez-Gallego, L., Nin, M., Suárez, C. and Conde, D. 2012. *Paisaje Protegido Laguna de Rocha, propuesta de plan de manejo*. Montevideo, Futuro Sustentable Srl.

Rodríguez-Gallego, L. and Nin, M. 2016. Propuesta de plan de manejo del paisaje protegido Laguna de rocha: conservación del patrimonio natural versus patrimonio cultural. In C. Gianotti, D. Barreiro and B. Vienni (eds), *Patrimonio y Multivocalidad. Teoría, prácticas y experiencias en torno a la construcción del conocimiento en Patrimonio*, 149–60. Montevideo, CSIC, UdelaR.

Roche, I. and Somaruga, R. 2015. Lineamientos generales del plan director Parque Santa Teresa: Informe preliminar; antecedentes y marco referencial. Unpublished technical report. Montevideo, Facultad de Arquitectura, Universidad de la República. Ministerio de Turismo.

Saucedo, D. 2006. Arqueología Pública y su aplicación en el Perú. *Revista Electrónica de Arqueología PUCP* 1(1), 2–12.

Silverman, H. 2011. Perspectives on community archaeology. *Historical Archaeology* 45(1), 152–66.

SNAP. 2014. *Documento técnico No 2; Fortalecimiento de la efectividad del Sistema Nacional de Áreas Protegidas incluyendo el enfoque de paisaje en la gestión*. Technical report URU/13/G35. Montevideo, Dirección Nacional de Medio Ambiente/Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente. Available at: http://www.mvotma.gub.uy/publicaciones-de-areas-protegidas/item/10007135-documento-de-proyecto-n-2.html [accessed October 2016].

Tiscart, M., Brochier, T., Timor, J. and Vitancurt, J. 2014. Use of local knowledge in marine protected area management. *Marine Policy* 44, 390–96.

TNC (The Nature Conservancy) 2003. *Planificación para la conservación de áreas. Metodología para la integración de recursos culturales tangibles*. Guatemala, The Nature Conservancy.

TNC (The Nature Conservancy). 2007. *Conservation Action Planning Handbook: Developing Strategies, Taking Action and Measuring Success at any Scale*. Arlington, VA, The Nature Conservancy.

Thompson, D. 2006. *Historias de ayer y de hoy. Comunidad de pescadores de la Laguna de Rocha.* Available at: http://www.casaseneleste.com/paseos/laguna-de-rocha.html [accessed April 2016].

Toledo, V. 2005. Repensar la conservación: ¿áreas naturales protegidas o estrategia biorregional? *Gaceta Ecológica* 77, 67–83.

Vienni, B., Villarmarzo, E., Gianotti, C., Blasco, J., Bica, C. and Lamas, G. 2012. Ciencia Pública en construcción: El Programa de Educación patrimonial y Ciencia Pública del LAPPU (FHCE). Paper presented at *IV Jornadas de Investigación, III Jornadas de Extensión de la Facultad de Humanidades y Ciencias de la Educación, Udelar*. Available at: http://www.fhuce.edu.uy/jornada/2011/Ponencias%20Jornadas%202011/GT%2035/Ponencia%20GT35%20Vienni%20et%20al.pdf [accessed 4 April 2014].

Villarmarzo, E. 2010. Arqueomalacología del sitio La Esmeralda, Uruguay. *Comunicaciones de la Sociedad Malacológica del Uruguay* 9(93), 215–30.

Vitancurt, J. 2016. La gestión del paisaje protegido Laguna de Rocha como proceso participativo, de diálogo y construcción de confianzas. In C. Gianotti, D. Barreiro and B. Vienni (eds), *Patrimonio y Multivocalidad. Teoría, prácticas y experiencias en torno a la construcción del conocimiento en Patrimonio*, 125–34. Montevideo, CSIC – UdelaR.

Waldhardt, R. 2003. Biodiversity and landscape: Summary, conclusions and perspectives. *Agriculture, Ecosystems and Environment* 98, 305–09.

Chapter 17

Australian Indigenous rangers managing the impacts of climate change on cultural heritage sites

Bethune Carmichael, Greg Wilson, Ivan Namarnyilk, Sean Nadji, Jacqueline Cahill, Sally Brockwell and Deanne Bird

With contributions by Victor Rostron, Patricia Gibson, Jonathan Nadji, Jeffrey Lee, Fred Hunter, Jimmy Marimowa, Natasha Nadji and Kadeem May

Abstract

Over 100 Australian Indigenous ranger groups manage a significant proportion of Australia's natural and cultural resources. Two Indigenous ranger groups in Australia's monsoonal far north are concerned about a perceived escalation of impacts on cultural heritage sites arising from climate change, variation and extremes. A preliminary version of a tool to assist them in managing these impacts was synthesised from other community-based climate adaptation tools. It contained phases for scoping, risk analysis and options analysis. In the testing and further development of the tool, rangers identified risks to shell mounds and middens (remains of shellfish meals that have accumulated over time), earth mounds (mounds of earth that contain cultural material) and rock art (paintings and engravings found in caves and open sites) caused by more frequent and extreme sea level rise events, and inland river flooding events. They set goals, considered barriers and assessed the availability of appropriate resources. During the tools risk analysis phase, rangers sought to prioritise sites with the greatest exposure and sensitivity to not only the identified climate impacts but also a range of other threats such as fire and feral animals. While the risk analysis phase used a modified field survey approach, it sought to complement the original model with a cultural-value assessment methodology that would allow further prioritisation on the basis of site significance. To date, over 100 sites have been assessed with the tool and allocated one of five possible management priorities. In considering adaptive options, rangers confronted limits to climate change adaptation for the prioritised heritage sites. For sites most in peril from climate extremes, digital documentation was chosen over salvage or physical protection. However, rangers were concerned that confinement of sites to a database would undermine their ongoing use of them in traditional cultural practice. They therefore considered the possibility of combining photogrammetry-derived 3-D models with augmented-reality applications to re-experience lost sites in their original non-virtual locations. Validation of ranger group organisational capacity to use the climate change planning tool bodes well for its use by other Indigenous ranger groups.

Introduction

In 2015, 108 Australian Indigenous ranger groups managed 70 Indigenous Protected Areas (IPAs) covering some 63 million ha of land (Pew Charitable Trusts 2015). (Indigenous landowners nominate their estates as IPAs, which are subsequently recognised as part of the National Reserve System and attract government resourcing.) A significant number of Indigenous rangers are also employed in Australia's national and state parks. Ranger work involves addressing a host of environmental issues, such as wildfires, weeds and feral animals, but also managing tourism operations, quarantine services, and monitoring and reporting illegal commercial fishing. Indigenous Protected Areas and national parks contain an extensive range of cultural heritage sites also managed by rangers (Department of Environment 2013). Importantly, these sites are vital to ongoing traditional cultural practice.

A limited number of studies have investigated the impacts of climate change on Indigenous communities in Australia and elsewhere. Indigenous communities experience great social and economic disadvantage and various studies document heightened vulnerability because of poor service delivery and a lack of political participation (Ford *et al.* 2006; Altman and Jordan 2008; Green 2009). In this context, some scholars have concluded that while Indigenous Australians are worried about ecological change, it is a peripheral concern for a dispossessed people struggling with poverty and social dislocation (Petheram *et al.* 2010). Notwithstanding this, Australian studies are increasingly engaging local Indigenous stakeholders in discussions around climate change impacts and adaptation needs (*e.g.* Bird *et al.* 2013; Leonard *et al.* 2013) and have successfully elicited participation in the writing of formal adaptation plans (Memmott *et al.* 2013; Nursey-Bray *et al.* 2013). McIntyre-Tamwoy *et al.* (2013) found that many of the concerns Indigenous people had about climate change were related to cultural values, places and landscapes, and concluded that there remains an urgent need for processes and systems to be developed to promote knowledge sharing and action in this regard.

In considering climate change impacts on Indigenous cultural heritage sites, we focus on the potential role and capacity of Indigenous ranger groups. Ranger groups not only have responsibilities for cultural heritage sites, but they also represent a positive step towards addressing some of the issues underlying Indigenous disadvantage. The benefits of ranger programmes to Indigenous people are many, well-documented and promoted by Indigenous communities and representative bodies. Rangers earn wages in remote locations where unemployment is high; become community role models; engage in work that is meaningful to them; and are highly motivated because the work underpins cultural maintenance (DPMC 2015). Ranger groups address Indigenous poverty and increase health and wellbeing (WalterTurnbull 2010).

The project described here was originally motivated by the idea of developing a decision tool to guide rangers in addressing climate change impacts on cultural sites. While a growing literature on climate change adaptation offers many insights and principles, there tends to be something of a gap between this theoretical work and practice on the ground. For this reason many decision tools have been developed to aid governments, organisations, businesses and communities which undertake adaptive action. They are particularly useful for supporting local level organisations conducting participatory or bottom-up planning for climate change. While frameworks for cultural heritage risk assessment are now emerging (*e.g.* Bickler *et al.* 2013; Daly 2014), none are expressly aimed at non-professionals or a bottom-up planning context.

Stakeholder-led or bottom-up planning is routinely characterised as fundamental to climate change adaptation (Dessai and Hulme 2004; Wilby and Dessai 2010; Raiser 2014). Studies already cited echo the same point (Bird *et al.* 2013; Green *et al.* 2012; Nursey-Bray *et al.* 2013; Memmott *et al.* 2013; McIntyre-Tamwoy *et al.* 2013; Leonard *et al.* 2013). The Intergovernmental Panel on Climate Change (IPCC 2014, 87) notes, too, that climate change adaptation planning benefits from combining western science and traditional Indigenous knowledge.

Rangers are also a good fit in this regard. Bottom-up participatory planning is fundamental to their work. Indigenous Protected Areas involve rangers in rigorous, facilitated natural resource management planning each year, which involves extensive consultation with the Traditional Owners of given lands. (The Aboriginal Land Rights Act [1976] describes 'traditional Aboriginal owners' as local descent groups with primary spiritual responsibility for sites and land.) Indeed, the majority of rangers are themselves Traditional Owners (Djelk Rangers 2014). The same is true of Indigenous rangers in national parks, where joint management by Traditional Owners and the Australian Government takes place (Kakadu Board 2014).

Before developing a decision tool geared to support Indigenous site management of climate change impacts, we needed to establish whether or not rangers believed climate change to be an issue for cultural heritage sites, and if so, whether addressing the issue with a tool was a priority need for them. To this end three diverse ranger groups in Arnhem Land in the Northern Territory were approached. In the two more mature groups, senior rangers expressed very strong views as to the impact of climate change on cultural sites, and they welcomed the opportunity to undertake a project aimed at developing and testing a tool to address these impacts (Carmichael 2015).

Senior rangers, some with up to 30 years' experience, were adamant that sea level rise and sea level rise extreme events such as storm surges were increasingly impacting coastal shell middens, that salt water intrusion combined with extreme precipitation was increasingly inundating floodplain-fringing rock art and earth mounds, and that inland riparian rock art was being washed away by more frequent and higher floods. Senior rangers from both of these groups explicitly stated that addressing these impacts was a priority need for their groups.

These perceptions may have been influenced by popular representations of climate change in the media, by ranger attendance at climate change symposiums over the years,

Table 17.1. Climate projections for the monsoonal north (Moise et al*. 2015)*

Climate change aspect	*Projection*
Average temperatures will continue to increase in all seasons	Very high confidence
Numbers of hot days and warm spells will increase	Very high confidence
Total rainfall changes are possible but unclear	Unknown
Intensity of extreme rainfall events will increase	High confidence
Mean sea level will continue to rise	Very high confidence
Height of extreme sea-level events (storm surge) will increase	Very high confidence
Tropical cyclones will be fewer but more intense	Medium confidence
Natural variability in the climate system can act to either mask or enhance any long-term human induced trend, particularly in the next 20 years and for rainfall	Unknown

or by the presence of climate change research in their domains. However, these perceptions are also consistent with documented trends in sea level rise for northern Australia, current issues with vegetation death from saltwater intrusion into low lying freshwater flood plains, and climate change projections. Very significant sea level rise has been observed in the monsoonal north of Australia since the 1960s. Furthermore, there is a ‘high confidence’ in future sea level rise and extended extreme sea level rise events (*i.e.* extreme storm surges), in more extreme precipitation events (*i.e.* riparian inland flooding), and ‘moderate’ confidence in more intense cyclones (Table 17.1).

The aim of the project described in this paper was to propose and then test a preliminary decision tool. Testing by rangers would shed light on its usefulness – or otherwise – and inform its further development. The preliminary model was synthesised from generic climate change adaptation decision tools on the one hand, and recent attempts by heritage managers internationally to develop methods to address the issue on the other. This synthesis was further modified in light of findings from Indigenous adaptation studies, as well as the particular needs of Indigenous rangers. The tool encompasses five distinct phases:

1. *Scoping*: Rangers design their project.
2. *Cultural heritage risk analysis*: Rangers determine and prioritise sites most at risk.
3. *Cultural heritage options analysis*: Rangers prioritise adaptation options for sites.
4. *Document and implement*: Rangers write and execute a plan.
5. *Monitor and review*: Rangers assess progress and update their plan.

For this chapter we will explore the development of the scoping, risk analysis and options analysis phases alone.

The rangers

The two ranger groups engaged in the project are from Kakadu National Park (KNP), and the Djelk Indigenous Protected Area (Djelk IPA), both in Arnhem Land, Northern Territory, Australia. The climate is tropical with a short but intense wet season followed by a longer rainless dry season.

Kakadu National Park is centred on the Alligator Rivers region (Fig. 17.1) and is World Heritage listed. The Park’s cultural values include a record of habitation stretching back 50,000 years, exceptional rock art, and the living knowledge of Aboriginal Traditional Owners. Indigenous rangers from Kakadu National Park (Kakadu Rangers) are a cohort that constitute roughly one third of Park rangers. The Park is managed by Parks Australia in conjunction with Traditional Owners through a board of management, which has a majority of Indigenous members. Final management decisions must be ratified by Parks Australia.

The Djelk IPA is centred on the Blyth and Cadell rivers (Fig. 17.1) and contains comparable cultural values to those of Kakadu National Park. Djelk Rangers employs an entirely Indigenous ranger staff, and operates under the auspices of the Bawinanga Aboriginal Corporation (BAC), which is directed by a wholly Indigenous executive committee.

The scoping phase of the tool

The scoping phase of the tool consists of seven elements:

1. Analysing the problem
2. Setting goals
3. Selecting a methodology
4. Conducting a stocktake of resources
5. Conducting a stocktake of barriers or obstacles to action
6. Considering leadership
7. Considering ownership

The seven elements contain a further extensive list of questions designed to help rangers consider each element as thoroughly as possible. Here we consider the responses of both groups to each of the scoping phase’s seven elements. The preliminary results of the study are presented here. A more comprehensive discussion of the results is presented in Carmichael *et al.* (2017).

Analysing the problem

In this phase, rangers considered the types of site currently being impacted by climate change, the nature of the impacts and the areas on their estates where these impacts were being felt. Whether the rangers’ perceptions are of climate ‘change’, climate ‘variation’ or climate ‘extremes’ is less important than the need to protect sites from the resulting impacts. This paper takes the view, recommended by the IPCC (2014, 31), that because it may not be possible to

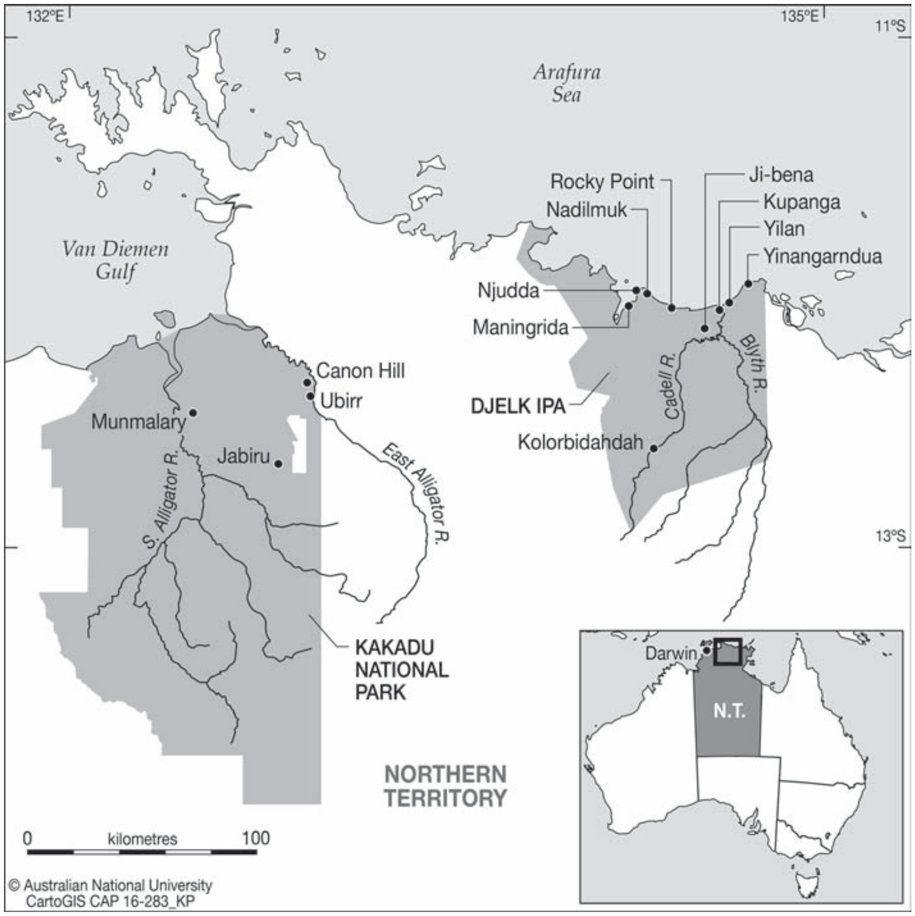

Figure 17.1. Map of case study areas.

differentiate climate change from climate variation and extremes, 'a first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate'. Ranger perceptions of 'climate change' were nonetheless consistent with previously published climate change projections made by Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Australian Bureau of Meteorology (BoM) for the monsoonal north (CSIRO and BoM 2015; Moise *et al.* 2015), the region taking in their territories (Table 17.1).

Extreme wetland flooding

Kakadu National Park Rangers report unprecedented flooding of the East Alligator River area in recent decades. The onset of the monsoonal wet season has become less predictable and when rain does come it is extreme, with wetland impacts accentuated even further when the rain coincides with a high tide. One ranger says:

> We're getting heavier rain: used to be more spread out; but now we're getting it all at once. Then we get that water rising really quickly … when you get the king tides, and you get a big rain on top, there's nowhere for that water to get out, so it just backs all up onto the floodplains. … That's when these sites are going underwater.

In 2006, there were two extreme flood events, one associated with Cyclone Monica and another unrelated to a tropical cyclone. Rock art in the Canon Hill area and the area around Ubirr was impacted by flooding (Fig. 17.1). Rangers were able to explore the Canon Hill area by boat at the time and witnessed what were for them unprecedented water levels. During the following dry season, they observed resulting damage and watermarks at rock art sites. One ranger says:

> It's not normal. It's getting worse. The old people, our ancestors, would not have put it [burial sites and rock art] there if it was going to go under water.

Rangers also expressed concerns for stone artefact scatters, earth mounds and shell middens on the South Alligator River floodplains. One ranger sums up:

> Climate change is really huge! A lot of people talking about it. Things might change, site might have gone … where's all the things, tools and everything? Nobody, nothing ... I break

> down ... I see that long history there from our ancestors, and it's hard. I don't want to see it gone.

Extreme coastal flooding

According to Djelk Rangers, the IPA has changed dramatically over their lives but sea level rise is particularly pronounced. Rangers relate childhood memories of low tides being significantly lower than today. One ranger notes:

> I can tell you about when I was young. Everything was there, but now it's changed. The tide has changed; the weather has changed. When I was a boy, the low tide used to go right out. Now it goes out about halfway.

One ranger explains this as the result of:

> Pollution … sea level is up, because of those icebergs melting.

Rangers reported observing the wholesale loss of shell middens after Cyclone Nathan on 23 March 2015. Djelk Rangers identify the entire coast of the IPA as a hazard zone for shell middens, earth mounds, sacred billabongs, sacred trees and ceremonial grounds. Areas around the Blyth River entrance (near Kupanga), Rocky Point, Maningrida and east of Njudda (Fig. 17.1) are highlighted as particularly vulnerable for shell middens. Earth mounds in the Jibena floodplain area are also said to be vulnerable. These nominations are based on observations of vegetation loss over time, changes in tidal extents, channel expansion and erosion, wholesale loss of sites to receding beaches and saltwater intrusion into sites that previously contained freshwater exclusively.

Extreme inland flooding

Djelk Rangers are also observing unprecedented riparian flooding in escarpment country away from the coast. Rivers are increasingly flooding outstations, and evacuation by helicopter is becoming a more regular occurrence. Djelk Rangers report more erosion and the formation of new creeks and channels. They identify the upper Cadell River (Fig. 17.1) as a climate change hazard zone, specifying six rock art sites they perceive as impacted by unprecedented flooding (Fig. 17.2). This is pointedly described as not being the result of an overall increase in rainfall but of more extreme rainfall events. One ranger observes:

> Not more rain, but bigger floods!

In one instance the total obliteration of rock art was observed by way of dry season visits over a period of several years. One ranger explains:

> One year we went to the Cadell, right on the IPA border, for ceremony; there were really old paintings there; on a second visit the paintings were damaged; on a third visit they were gone; water marks were there … when we are on country we record things with our mind.

Rangers also have concerns for unspecified ceremony grounds, burial and Dreaming sites (during the Dreaming, ancestor spirits created the world then changed into trees, the stars, rocks, watering holes or other land forms). These concerns are held on the basis of observations of damage to and loss of sites resulting from flooding and associated algal growth on rock art.

Setting goals

Establishing goals for protection of sites from the start is important to ensure all participants have a shared understanding of the project and what its outcomes should be. There was no disagreement here: Djelk and Kakadu Rangers hope the project will be able to keep their sites 'healthy', 'safe' and 'strong'. One Djelk ranger echoes the feelings of his colleagues in stating:

> We want them to be safe! Safe! To be safe!

Asking rangers 'why are sites important?' was a unifying experience for both groups. Their identities as Aboriginal people are bound up with their sites. One ranger says:

> They're in our blood, all those sacred sites … our body and spirit.

Responses are often heartfelt when their loss is contemplated:

> That damage makes me cry inside … I ask myself, 'What am I going to do?'

Often it is the impacts on cherished culture that represent the greatest motivation for climate change adaptation (Adger *et al.* 2012).

Selecting a methodology

The tool does not take it as a given that a biophysical risk analysis is the ideal approach to take. It is presented as one among three options, which also include organisational capacity building and individual ranger capacity building. Both ranger groups were initially adamant, however, that a biophysical risk analysis was the most appropriate approach. Djelk and Kakadu Rangers favoured the prioritisation of sites according to (a) proximity to hazard, (b) sensitivity to hazard and (c) significance. One Kakadu Ranger concludes:

> That's the good one: risk analysis … for future generations; [Traditional Owners] can pass that information on to … kids.

Focusing on capacity building alone is rejected.

> We couldn't just stop worrying about the sites … we have to look after those sites, it's what the old people say needs to happen.

Figure 17.2. Ranger Ivan Namarnyilk uses the field survey to conduct a risk analysis of flood damaged rock art. Stranded flood debris is evident on a rock outcrop level with the painting. Upper Cadell River, Djelk IPA.

Later in the Kakadu Ranger workshop, however, when rangers discussed barriers to adaptation, they raised issues around not spending enough time maintaining sites. As a result, they revised their decision on methodology, opting for a mixed approach encompassing both risk analysis and organisational policy change. They insisted that a resulting adaptation plan should not shy away from 'the problems' they have with the Park's provision of resources for site maintenance. Similarly, Djelk Rangers were ultimately concerned to modify BAC policies as well as conduct a risk analysis, in order that perceived governance issues be resolved.

The scoping phase's 'selecting a methodology' element contains a particularly long list of further discussion points. These points aim to ensure the selected methodology fits in with current work practices; is culturally appropriate; benefits the community as a whole; and can have its effectiveness scrutinised. Discussion points also explore the need for a communication plan as well as an appropriate time frame for the method's application.

Among the responses to these questions, it is important to mention here that risk analysis is seen to be culturally appropriate only insofar as consultation with Traditional Owners and *djunkai* (traditional custodians) takes place throughout its application. The method should be flexible enough that Traditional Owners are able to require that sensitive sacred sites not be entered onto maps if needs be. For this reason, this article cannot reproduce the mapping outputs generated during the testing of the risk analysis phase.

Conducting a stocktake of resources

For Djelk Rangers, data is an issue: apart from Brandl (1988) and Meehan (1982), no extensive formal surveys of rock art and other archaeological sites have been conducted in the Djelk IPA. While around 130 sites are scheduled for maintenance, these are potentially a fraction of sites in the IPA. Conducting a risk assessment might ultimately serve to populate a database, albeit one adhering to strict administrative protocols negotiated with Traditional Owners. Certainly, the skills and resources needed to obtain data are available.

For Kakadu Rangers, decades of scientific recording in the Park have produced a vast data set of rock art and other archaeological sites (*e.g.* Gillespie 1983; Jones 1985). More resources, however, are needed in order to extend site maintenance significantly. Indeed, a climate change adaptation project might be a catalyst for this, insofar as it alerts authorities to the climate threats facing the World Heritage listed Park.

Conducting a stocktake of barriers

Governance barriers potentially exist. Some Kakadu National Park Traditional Owners favour a wholesale change to Park governance, proposing Aboriginal Corporations manage ranger groups rather than Parks Australia. Djelk, however, have some issues with this very model, alluding to the potential for planning and consultation outcomes to be circumvented by a corporation's non-Indigenous administrative officers. Such barriers, however, were not judged to be insurmountable for the climate change adaptation project.

Considering leadership

An adaptation project might fail without individuals motivated to take on leadership roles. There is no shortage of leadership within Kakadu and Djelk ranger groups. However, the need for consultation suggests a leadership that is shared, more communal and consensual. This notion of leadership lends itself well to the tool's bottom-up approach.

Considering ownership

Studies of Indigenous community adaptation emphasise the need for formal legal agreements ensuring Indigenous control over research outputs (Leonard *et al.* 2013). This draws only a neutral response from Djelk and Kakadu rangers, because all research on their lands takes place only after research permits are issued by the Northern Land Council (which represents Indigenous landholders) and Kakadu National Park. If the tool is used in a context lacking such overseeing authorities this issue may be more pressing. On the other hand, it is important to rangers that research outputs formally recognise their contribution.

The cultural heritage risk analysis phase

The initial construction of a risk analysis phase considered lessons from (1) climate change adaptation literature; (2) archaeological climate change risk assessment studies; and (3) the particular needs of rangers. The preliminary results of the study are presented here. A more comprehensive discussion of the results is presented in Carmichael *et al.* (2017).

Lessons from climate change adaptation literature

Climate change adaptation studies emphasise many key considerations. The value of stakeholder participation, using local experience of current extremes as a starting point for climate change adaptation, and using Indigenous knowledge have all been mentioned above. Another important principle is mainstreaming. To increase the likelihood of adoption by an organisation, a climate change risk analysis needs to be combined with the management of other risks to the system, not just those related to climate (Huq and Reid 2004; Smit and Wandel 2006, 285). In assessing risk, it is also important to consider either the consequence or the sensitivity of the system to the given impact under consideration (Füssel 2007). Finally, in the face of uncertainty and a lack of fine scale climate change data, establishing a monitoring programme should be an early initiative of those wishing to adapt (Rowland *et al.* 2014).

A synthesis of existing approaches to archaeological risk assessment

Archaeological risk assessment methods to date have largely relied on desktop, GIS-based analysis of the probability of site exposure to a hazard, based on a range of geospatial data and/or climate change projections (Westley *et al.* 2011; Johnson *et al.* 2015; Reeder-Myers *et al.* 2015). The threat considered was typically sea level rise but has also included forest desiccation and wind damage (Dupont and Van Eetvelde 2013). While the GIS approach has mainly considered probability of exposure, the consequence of exposure has also been factored in (Bickler *et al.* 2013).

Other approaches have sought to incorporate stakeholder consultation. Dawson's (2015) GIS-based analysis was reviewed and amended by local stakeholders. Daly's (2014) non-GIS approach combined secondary research and climate change projections with local stakeholder interviews.

Many of these approaches are, however, dependent on a high degree of technological or archaeological expertise. Our approach therefore seeks to extend Marie-Yvane Daire *et al.*'s (2012) field survey approach to risk assessment because it can be conducted by non-specialists rather than expert professional heritage managers. The survey is based on the *in situ* recording of data on a range of exposure and sensitivity variables and resembles a questionnaire. Furthermore, the survey differs from the above approaches in that threats other than climate change are also included. The survey produces a risk score for each site. Finally, the collection of largely quantitative data on the ground means that the survey can act as a monitoring system; future re-assessment can deduce areas of change or otherwise.

What is missing from the field survey, however, is further prioritisation based on significance or cultural heritage value. Other methods note the value of significance assessment

(Bickler *et al.* 2013; Daly 2014), and Dawson (2013, 78) incorporates a significance assessment into prioritisation based on criteria of 'rarity', 'period', 'condition', 'group value' and 'potential'.

Including significance assessment in a field survey approach is challenging. Collecting data relevant to Dawson's (2013) criteria requires skills not available to rangers. Bowdler (1984), assessing significance in Australian archaeology, considered a site's ability to 'answer timely and specific research questions' and its 'representativeness'. In the Djelk IPA no comprehensive survey of each site type has been undertaken to date. This makes reference to 'representativeness' and 'timely and specific research questions' difficult.

Our solution is for rangers to ask Traditional Owners (if they themselves are not the Traditional Owner for the site) to determine significance according to their values, and then later consider inviting archaeologists to contribute their perspectives to the results. The approach adheres to a major concern highlighted by ICOMOS (2013, article 12): that conservation of a place should be based on 'a consideration of cultural significance' and 'the participation of people for whom the place has significant associations and meanings'.

As noted, rangers who are all Traditional Owners were asked during the scoping phase why cultural sites are important. The rangers provided explanations broadly in line with ICOMOS indicators of significance. Their explanations of significance pertain to: social identity value (*e.g.* 'Sites are who I am'); historic value (*e.g.* 'The stories [in rock paintings] are about how we lived off the land, and some of them may point to how we still need to care for the land'); or spiritual value (*e.g.* 'We have to look after those Dreaming sites and the stories that go with them, or the country will die') (Carmichael *et al.* 2017). Accordingly, the questions developed for the significance assessment tool record the significance of sites in terms of social identity value, historic value, and spiritual value. Importantly, the resulting schema (Table 17.2) assumes *all sites* are significant from the outset: social identity value is taken as a given for all archaeological sites, and is the default position.

Exposure and sensitivity variables

Rangers using the tool are prompted to record values for (1) exposure variables for sites and (2) sensitivity variables. Each variable has a set of alternative value options from which rangers are required to choose, and each value has a corresponding numerical score. Likelihood of loss or damage is determined by subtracting the total score for sensitivity from the total score for exposure, in the manner pioneered by Daire *et al.* (2012). After multiple iterations based on ranger trial and error, the field survey risk assessment tool's likelihood of loss or damage element requires rangers to choose values for the following exposure and sensitivity variables.

Exposure variables

Direct human induced impacts: recorded by selecting a value option for the proximity of (a) road types, (b) settlement types and (c) activities.

Climate change impacts: recorded by selecting a value option for (a) proximity to the edge of the tidal zone or centre of a river; and (b) vertical distance above tidal zone or river in recognition of slope variance in sea shore and river banks in the study areas. Rangers' observation of impacted sites also led to the inclusion of a variable gauging (c) proximity to geomorphological hazards. This requires rangers to record if the rock art site is in a gorge (where a bottleneck effect can accentuate flooding); the proximity of a floodplain midden to a channel (where water moves at greater speed); or the proximity of a coastal midden to a river mouth (where salt water flooding can be accentuated by fresh water flooding).

Large-scale biological impacts: recorded by selecting a value option for (a) the degree of damage done by feral animals such as pigs and buffalos. Rangers felt strongly that the tool should account separately for biological threat types with greatly differing impact magnitude. The impacts of feral animals, such as buffalos and pigs, are a highly destructive problem in both study areas (Meehan *et al*. 1985; Jambrecina 2010; Saafield 2014), and are therefore distinguished from those of birds and insects. Rangers also wanted the threat of (b) vegetation conflagration, also highly destructive to rock

Table 17.2. Assessing Indigenous significance

Value type	*Questions for traditional custodians*	*Significance*
Social-identity Value Site connects us with ancestors and country.	**No questions:** Social-identity Value is a given for all middens and rock art sites.	Class one
Historical Value Site shows us how ancestors lived.	**Does the site have, or contain:** A traditional or modern name; tools; depictions of hunting and gathering; paintings that inform current painting practice?	Class two
Spiritual Value Site shows us ancestors' ideas about the world.	**Does the site have:** An associated religious story; a burial; a ceremony site; depictions of spiritual themes or practice?	Class three

art (Lambert and Welsh 2011), to have a dedicated variable based on the degree of vegetation build up at the site.

'Erosion' impacts: recorded by selecting a value option for (a) rain and wind damage (degree of fading in rock art and degree of deflation for a midden); and (b) values for the mechanical impacts of native flora and fauna.

Sensitivity variables

Built and legal protection: recorded by selecting a value option for (a) the degree of legal protection pertaining to the site; and (b) whether or not a midden or rock art site has a fence or a rock art site has had a protective silicon dripline installed (for the history of this measure, see Gillespie 1983).

'Weathering' sensitivity: recorded by selecting a value option for (a) the nature of the substrate (rock hardness for rock art, and soil type for a midden – i.e. clay, soil or sand); (b) the nature of the remains (ochre type for rock art, and structure characteristics for middens); and (c) natural protection (the degree of rock shelter overhang for rock art, and the degree of protective tree-root consolidation for middens – rangers observe that middens with trees growing in them are usually the most intact).

Preliminary results

Combining assessments of likelihood of loss or damage *and* significance for each site allows for site risk to be expressed in a classic risk matrix, giving rise to five possible management priorities: 'very low', 'low', 'medium', 'high' or 'very high'.

As an example (Table 17.3), rangers assessing a site near a creek in the Canon Hill area of Kakadu National Park gave it a 'high' management priority. Firstly, its risk rating is 2.2, or 'high', because of: close proximity to a creek, and only moderate height above it; moderate weathering; high fire-hazard proximity; and very close proximity to a settlement.

Table 17.3. Management priority assessment for an unnamed site in the Cannon Hill area of Kakadu National Park. The management priority was assessed as 'high' due to a 'high' risk score, and a Class 2 significance rating.

		Management priority		
Likelihood of loss or damage	High	***medium***	***high*** ✓	***very high***
	Medium	***low***	***medium***	***high***
	Low	***very low***	***low***	***medium***
		Class 1	Class 2	Class 3
		Consequence (Significance)		

These factors are offset to some degree by: a good rock-shelter overhang; hard rock; and red, more durable, ochre. Secondly it is assessed as being in Significance Class Two, due to paintings depicting traditional hunting and gathering. 'High' likelihood of loss or damage and Significance Class Two converge on a 'high' management priority in the tool's management priority matrix.

Across the two case studies, of over 100 sites so far assessed by rangers approximately 10% were rated as being a 'very high' management priority and 19% a 'high' priority. These preliminary results are a very small fraction of total sites needing assessment within each ranger group's domain. The majority of the shell middens assessed have been formally recorded for the first time.

The cultural heritage options analysis phase

Throughout the testing of the preceding phases of the tool, both ranger groups continually identified adaptation options for sites. These were collected and presented back to rangers for analysis at options workshops and in individual discussions. An additional option, concerned with developing an augmented reality application, was proposed by the lead author. The adaptation options nominated were concerned with either capacity building or delivering adaptation actions directly to sites.

Rangers reviewed each option against seven criteria adapted from generic adaptation planning tools (*e.g.* UKCIP 2013):

1. *Is it 'proper way'?* Will our old people think it is culturally appropriate?
2. *Will it help Aboriginal people in other ways?* Does it meet other community goals?
3. *Could it be done quickly?* How soon could it be started and completed?
4. *Is it easy to do?* Or is it too complicated and requires unavailable skills?
5. *How costly is it?* Is it too expensive?
6. *Will it meet our goals of 'safe', 'strong' and 'healthy' sites?* Or will it lead to other counter-productive problems?
7. *Is it flexible?* Will it still work if climate change happens more quickly or is worse than expected?

There is unanimity around the benefits of digitising the risk assessment field survey for use in GPS-based field monitoring devices, such as I-Tracker (NAILSMA 2014), which are used by rangers to collect management data. Doing so would make the survey integral to heritage maintenance programmes.

Attitudes to other options sometimes reflect the differing circumstances of each group. For example, Kakadu rangers are concerned with introducing more gates across roads to keep tourists away from sites, while for Djelk a low tourist presence means this is not a priority. Buffalo culling is not of primary importance to Kakadu Rangers given buffalo numbers were drastically reduced by a major cull in the 1990s (Petty *et al.* 2007). Numbers are, however, increasing again and pigs are a major issue.

In terms of salvage, moving shell middens or earth mounds and rock art is dismissed as impractical, too costly and culturally inappropriate by both groups. Building flood barriers is generally considered in similar terms, though some feel an earthen bank with consolidating vegetation to protect floodplain sites could be engineered in a culturally appropriate way. As risk assessment progresses, barriers might conceivably be revisited as a viable option for the cream of 'very high' priority sites in amenable locations. In Kakadu, a simple earthen 'causeway' was built in the 1970s to ameliorate saltwater intrusion at Canon Hill, and before falling into disrepair it reportedly had some success (Thiele 1987, 28).

Salvage ultimately comes down to cultural data salvage; that is ensuring sites most in peril are fully documented for posterity. Photogrammetry-based three-dimensional (3D) modelling techniques are surprisingly inexpensive and have been used to record vulnerable coastal heritage (López-Romero *et al.* 2014) and remote Indigenous rock art (Bourke 2014). For Kakadu Rangers, storing such documentation in a museum is more appealing than in a database with its attendant problems of access and privacy, though Djelk do not preference one over the other.

A central plank in the national rock art strategy proposed by Taçon and Marshall (2014, 7) is to develop 'new database systems, innovative ways of using 3D and other new technology'. They propose that 3D records could be used for detailed recording and to provide virtual access to sites via museums and online, and conceive of virtual reality 'walk-throughs'. Virtual reality (VR) technologies have been applied in the cultural heritage field for decades, and heritage professionals have set out guidelines for enhancing their applicability and usability (Luchia *et al.* 2010).

However, the concept of cultural data salvage of imperilled sites for posterity's sake causes great despondency among rangers, and even virtual reality applications may not attend to the particular needs of Indigenous custodians. Significant sites continue to be used in cultural practice and are important for the 'learning on country' undertaken with young people. Digital salvage might allow the maintenance of cultural identity, but it could not facilitate perpetuation of a way of life. Indigenous people see sites as connected to the land, and want to interact with them in their original spatial reality. As one Djelk Ranger says:

> The Djomi Museum [local museum in Maningrida] is really good, taking photos and getting information, but in my way I want to see it 'live'; paintings, right there.

In the spirit of Taçon and Marshall's (2014) call for innovative ways of using 3D and other new technology, we conceive their use in augmented reality applications. An augmented reality (AR) device overlays a virtual world on the real one. In this sense, it is unlike virtual reality, which entirely replaces the external world with a virtual one. Instead, AR embellishes the real world.

AR ocular headsets, such as those now produced by Microsoft, might conceivably allow observers *in situ* to experience a 3D model of a lost rock painting superimposed on its original, non-virtual rock face. For rock art already damaged, the image capture used to generate the 3D model might conceivably incorporate 'DStretch' enhancement (Harman 2016). When rangers were shown promotional video for the Microsoft ocular headset (Microsoft 2016), their response was one of intrigue and excitement. Assessing an unproven technological solution against the seven assessment criteria was pure speculation. However, while the functionality of the imagined concept is unknown, AR would almost certainly pose a more realistic option than moving sites or building sea walls.

Discussion and conclusion

In the 1990s, archaeologist Michael Rowland (1992; 1996; 1999) proposed that Indigenous cultural heritage was in peril from climate change and sea level rise, and noted that a necessary priority would be to, 'discuss with Aboriginal owners the potential impact of greenhouse changes on coastal sites' (Rowland 1992, 31). We document Aboriginal owners' openness to such discussions. Their closeness to, and deep understanding of, their natural environment directly informs them of significant impacts now affecting cultural heritage.

Rowland (2010) argued that climate change was one of among many critical impacts on cultural heritage, and he and others (Rowland 2008; Rowland and Ulm 2012; Rowland *et al.* 2014) focussed in particular on the issue of monitoring of impacts on sites to determine the real impact of climate change on cultural heritage. Assessing risk with a field survey approach fulfils the dual purpose of both risk assessment and monitoring. Its inclusion of non-climatic threats allows for an integrated approach and therefore greater likelihood of adoption.

Given the right tools, planning autonomy and adequate resources, Indigenous ranger groups have the organisational capacity to confront the issues related to climate change and its impact on cultural heritage. In fact, few other organisations are as well equipped to do so. Their local presence and traditional knowledge, the highly consultative nature of their planning and leadership styles, their willingness to combine their insights with western science, and above all their deep affinity with and care for their cultural heritage will potentially place Indigenous rangers at the forefront of cultural heritage adaptation efforts worldwide.

The risk analysis methodology described here constitutes an ongoing monitoring programme that will, over time, build a body of data supporting informed adaptation actions. Heritage sites are highly valued in terms of Indigenous cultural identity. Their destruction represents the loss of places vital to Indigenous people's historical understanding of themselves as well as their understanding of the world and their place in it. Incorporating these values into risk assessment allows prioritisation on the basis of the magnitude of consequence, making for a risk assessment that recognises sites as 'living' cultural entities.

Indigenous rangers are embracing innovative technical solutions in their management of serious environmental problems. GPS-based field monitoring devices allow them to collect data vital to fire and weed management. Rangers hope to digitise and incorporate the risk assessment field survey tested here into these devices. This is an important next step that would allow the mainstreaming of climate change adaptation into rangers' daily work practice.

Rangers welcome other potential technological solutions as well. Traditionally, Aboriginal artists undertook rock art repainting as works faded. The use of augmented reality devices might one day constitute 'digital rock art repainting'. Rangers are interested in investigating further the potential of VR and the glimmer of hope it offers for overcoming the enormous challenge of salvaging sites prioritised as the most in peril.

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References

Aboriginal Land Rights (NT) Act 1976 (Cth), s. 3(1).

Adger, N. W., Barnett, J., Brown, K., Marshall, N. and O'Brien, K. 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3(2), 112–17.

Altman, J. and Jordan, K. 2008. *Impact of Climate Change on Indigenous Australians: Submission to the Garnaut Climate Change Review*. Canberra, Centre for Aboriginal Economic Policy Research, Australian National University.

Bickler, S., Clough, R. and Macready, S. 2013. *The Impact of Climate Change on the Archaeology of New Zealand's Coastline: A Case Study from the Whangarei District.* Wellington, Australian Policy Online.

Bird, D., Govan, J., Murphy, H., Harwood, S., Haynes, K., Carson, D., Russell, S., King, D., Wensing, E., Tsakissiris, S. and Larkin, S. 2013. *Future Change in Ancient Worlds: Indigenous Adaptation in Northern Australia.* Gold Coast, National Climate Change Adaptation Research Facility.

Bourke, P. D. 2014. Novel Imaging of Heritage Objects and Sites. Paper given at the *20th International Conference on Virtual systems and Multi-media, December 2014, Hong Kong*.

Bowdler, S. 1984. Archaeological significance as a mutable quality. In S. Sullivan and S. Bowdler (eds), *Site Significance Assessment in Australian Archaeology*, 1–9. Canberra, Department of Prehistory, Research School of Pacific Studies, Australian National University.

Brandl, E. 1988. *Australian Aboriginal Paintings in Western and Central Arnhem Land: Temporal Sequences and Elements of Style in Cadell River and Deaf Adder Creek Art.* Canberra, Australian Institute of Aboriginal and Torres Strait Islander Studies.

Carmichael, B. 2015. Supporting Indigenous rangers' management of climate-change impacts on heritage sites: Developing an effective planning tool and assessing its value. *The Rangeland Journal* 37, 597–607.

Carmichael, B., Wilson, G., Namarnyilk, I., Nadji, S., Cahill, J. and Bird, D. 2017. Testing the scoping phase of a bottom-up planning guide designed to support Australian Indigenous rangers manage the impacts of climate change on heritage sites. *Local Environment* 22, 1–20.

Carmichael, B., Wilson, G., Namarnyilk, I., Nadji, S., Brockwell, S., Webb, B., Hunter, F. and Bird, D. 2017. Local and Indigenous management of climate change risks to archaeological sites. *Mitigation and Adaptation Strategies for Global Change* 2017. Available at: http://link.springer.com/article/10.1007/s11027-016-9734-8 [accessed 1 February 2017].

CSIRO and BoM. 2015. *Climate Change in Australia Projections for Australia's NRM Regions*. Available at: http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=MNWCandpopup=trueandtooltip=true [accessed 8 July 2015].

Daire, M.-Y., López-Romero, E., Proust, J.-N., Regnauld, H., Pian., S. and Shi, B. 2012. Coastal changes and cultural heritage (1): Assessment of the vulnerability of the coastal heritage in Western France. *Journal of Island and Coastal Archaeology* 7(2), 168–82.

Daly, C. 2014. A framework for assessing the vulnerability of archaeological sites to climate change: Theory, development, and application. *Conservation and Management of Archaeological Sites* 16(3), 268–82.

Dawson, T. 2013. Erosion and coastal archaeology: Evaluating the threat and prioritising action. In M.-Y. Daire, C. Dupont, A. Baudry, C. Brillard, J.-M. Large, L. Lespez, E. Normand and C. Scarre (eds), *Ancient Maritime Communities and the Relationship between People and Environment along the European Atlantic Coasts*, 77–83. Oxford, BAR International Series 2570.

Dawson, T. 2015. Taking the middle path to the coast: How community collaboration can help save threatened sites. In D. Harvey and J. Perry (eds), *The Future of Heritage as Climates Change: Loss, Adaptation and Ccreativity*, 248–69. Oxford, Routledge.

Djelk Rangers. 2014. *Djelk Rangers Annual Report 2013–14*. Maningrida, Bawinanga Aboriginal Corporation.

DPMC (Department of Prime Minister and Cabinet). 2015. *Australia's Indigenous Protected Areas*. Canberra, Department of Prime Minister and Cabinet, Australian Government.

Department of Environment. 2013. *Working on Country*. Canberra, Commonwealth of Australia. Available at: http://www.environment.gov.au/indigenous/workingoncountry/publications/pubs/fs-woc.pdf [accessed 5 September 2016].

Dessai, S. and Hulme, M. 2004. Does climate adaptation policy need probabilities? *Climate Policy* 4, 107–28.

Dupont, L. and Van Eetvelde, V. 2013. Assessing the potential impacts of climate change on traditional landscapes and their heritage values on the local level: Case studies in the Dender basin in Flanders, Belgium. *Land Use Policy* 35(0), 179–91.

Ford, J. D., Smit, B. and Wandel, J. 2006. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16(2), 145–60.

Füssel, H. 2007. Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change* 17(2), 155–67.

Gillespie, D. 1983. The practice of rock art conservation and site management in Kakadu National Park. In D. Gillespie (ed.), *The Rock Art Sites of Kakadu National Park: Some Preliminary Research Findings for their Conservation and Management*, 191–213. Canberra, Australian National Parks and Wildlife Service.

Green, D. 2009. Opal waters, rising seas: How sociological inequality reduces resiliance to climate change among Indigenous Australians. In S. A. Crate and N. Mark (eds), *Anthropology and Climate Change: From Encounters to Actions*. Walnut Creek CA, Left Coast Press.

Green, D., Niall, S. and Morrison, J. 2012. Bridging the gap between theory and practice in climate change vulnerability assessments for remote Indigenous communities in northern Australia. *Local Environment: The International Journal of Justice and Sustainability* 17(3), 295–315.

Harman, J. 2016. DStretch. http://www.dstretch.com/index.html [accessed 1 June 2016].

Huq, S. and Reid, H. 2004. Mainstreaming adaptation in development. *IDS Bulletin* 35(3), 15–21.

ICOMOS. 2013. *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance*. Burwood, Australia ICOMOS Incorporated International Council on Monuments and Sites.

IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Technical Summary*. Cambridge, Cambridge University Press.

Jambrecina, M. 2010. *Kakadu National Park Landscape Symposia Series 2007–2009. Symposium 5: Feral Animal Management, 3–4 December 2008, Jabiru Community Centre, Kakadu National Park. Internal Report 568*. Darwin, Supervising Scientist.

Johnson, A., Marrack, L. and Dolan, S. 2015. Threats to coastal archaeological sites and the effects of future climate change: Impacts of the 2011 tsunami and an assessment of future sea-level rise at Hōnaunau, Hawai'i. *Journal of Island and Coastal Archaeology* 10(2), 232–52.

Jones, R. (ed.) 1985. *Archaeological Research in Kakadu National Park*. Canberra, Australian National Parks and Wildlife Service.

Kakadu Board. 2014. *Kakadu National Park Draft Plan of Management.* Canberra, Director of National Parks.

Lambert, D. and Welsh, B. 2011. Fire and rock art. *Rock Art Research* 28(1), 45–48.

Leonard, S., Mackenzie, J., Kofod, K., Parsons, M., Langton, M., Russ, P., Ormond-Parker, L., Smith, K. and Smith, M. 2013. *Indigenous Climate Change Adaptation in the Kimberley Region of North-western Australia. Learning from the Past, Adapting in the Future: Identifying Pathways to Successful Adaptation in Indigenous Communities*. Gold Coast, National Climate Change Adaptation Research Facility.

López-Romero, E., Mañana-Borrazás, P., Daire, M.-Y. and Güimil-Fariña, A. 2014. The eSCOPES Project: Preservation by record and monitoring at-risk coastal archaeological sites on the European Atlantic façade. *Antiquity* 88(339). Available at: http://antiquity.ac.uk/projgall/lopez-romero339/ [accesssed 16 August 2016].

Luchia, M., Mancusoc, S., Muzzupappaa, M., Brunoa, F., Brunoa, S. and Sensib, G. D. 2010. From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition. *Journal of Cultural Heritage* 11, 42–49.

McIntyre-Tamwoy, S., Fuary, M. and Buhrich, A. 2013. Understanding climate, adapting to change: Indigenous cultural values and climate change impacts in North Queensland. *Local Environment: The International Journal of Justice and Sustainability* 18(1), 91–109.

Meehan, B. 1982. *Shell Bed to Shell Midden*. Canberra, Australian Institute of Aboriginal Studies.

Meehan, B., Brockwell, S., Allen, J. and Jones, R. 1985. The wetland sites. In R. Jones (ed.), *Archaeological Research in Kakadu National Park*, 103–53. Canberra, Australian National Parks and Wildlife Service.

Memmott, P., Reser, J., Head, B., Davidson, J., Nash, D., O'Rourke, T., Gamage, H., Suliman, S., Lowry, A. and Marshall, K. 2013. *Aboriginal Responses to Climate Change in Arid Zone Australia: Regional Understandings and Capacity Building for Adaptation*. Gold Coast, National Climate Change Adaptation Research Facility.

Microsoft 2016. HoloLens. https://www.microsoft.com/microsoft-hololens/en-us [accessed 1 June 2016].

Moise, A., Abbs, D., Bhend, J., Chiew, F., Church, J., Ekström, M., Kirono, D., Lenton, A., Lucas, C., McInnes, K., Monselesan, D., Mpelasoka, F., Webb, L. and Whetton, P. 2015. *Monsoonal North Cluster Report*. In M. Ekström, P. Whetton, C. Gerbing, M. Grose, L. Webb and J. Risbey (eds), *Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*. Australia, Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology.

NAILSMA. 2014. I-Tracker. *Northern Australia Indigenous Land and Sea Management Alliance*. Available at: http://nailsma.grasslands.net/hub/programs/i-tracker [accesssed 1 June 2014].

Nursey-Bray, M., Fergie, D., Arbon, V., Rigney, L.-I., Palmer, R., Tibby, J., Harvey, N. and Hackworth, L. 2013. *Community*

Based Adaptation to Climate Change: The Arabana, South Australia. Gold Coast, National Climate Change Adaptation Research Facility.

Petheram, L., Zander, K., Campbell, B., High, C. and Stacey, N. 2010. 'Strange changes': Indigenous perspectives of climate change and adaptation in NE Arnhem Land (Australia). *Global Environmental Change* 20(4), 681–92.

Petty, A., Werner, P., Lehmann, C., Riley, J., Banfai, D. and Elliott, L. 2007. Savanna responses to feral buffalo in Kakadu National Park, Australia. *Ecological Monographs* 77(3), 441–63.

Pew Charitable Trusts. 2015. *Working for our Country: A Review of the Economic and Social Benefits of Indigenous Land and Sea Management*. Available at: http://www.pewtrusts.org/~/media/post-launch-images/2015/11/economicandsocialbenefitsindigenouslandwhitepaper.pdf [accessed 3 December 2015].

Raiser, W. K. 2014. Adaptation to climate change: Inciting yet another top-down/bottom-up debate. *Climate Exchange*. Available at: http://climate-exchange.org/2014/02/24/390/ [accessed 2 November 2015].

Reeder-Myers, L. 2015. Cultural heritage at risk in the Twenty-First century: A vulnerability assessment of coastal archaeological sites in the United States. *Journal of Island and Coastal Archaeology* 10(3), 436–45.

Rowland, M. 1992. Climate change, sea-level rise and the archaeological record. *Australian Archaeology* 34, 29–33.

Rowland, M. J. 1996. Climate change and its impact on Australia's cultural heritage. In L. Smith and A. Clarke (eds), *Issues in Management Archaeology*, 128–35. Tempus 5. St Lucia, Anthropology Museum, University of Queensland.

Rowland, M. J. 1999. Accelerated climate change and Australia's cultural heritage. *Australian Journal of Environmental Management* 6(2), 108–18.

Rowland, M. J. 2008. Saving the past for the future. *Historic Environment* 21(1), 19–29.

Rowland, M. J. 2010. Will the sky fall in? Global warming – an alternative view. *Antiquity* 84, 1163–71.

Rowland, M. J. and Ulm, S. 2012. Key issues in the conservation of the Australian coastal archaeological record: Natural and human impacts. *Journal of Coastal Conservation* 16(2), 159–71.

Rowland, M., Ulm, S. and Roe, M. 2014. Approaches to monitoring and managing Indigenous Australian coastal cultural heritage places. *Queensland Archaeological Research* 17, 37–48.

Saafield, K. 2014. *Aerial Survey of Buffalo Distribution and Abundance at Djelk IPA: Survey results*. Darwin, Northern Territory Government.

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16(3), 282–92.

Taçon, P. and Marshall, M. 2014. Conservation or crisis? The future of rock art management in Australia. In Y. Zhang (ed.), *A Monograph of Rock Art Research and Protection*, 119–41. Beijing, Zhong Guo Zang Xue Chu Ban She/China Tibetology Publishing House.

Thiele, C. 1987. *Ranger's Territory: The Story of Frank Woerle as Told to Colin Thiele*. North Ryde, Angus and Robertson.

UKCIP. 2013. *UKCIP Adaptation Wizard – Identifying Adaptation Options*. UK Climate Impacts Programme. Available at: http://www.ukcip.org.uk/wizard/getting-started/ [accessed 11 June 2014].

WalterTurnbull. 2010. *Working on Country Evaluation Report*. Canberra, Department of the Environment, Water, Heritage and the Arts. Available at: http://www.environment.gov.au/indigenous/workingoncountry/publications/woc-evaluation.html [accessed 5 February 2014].

Westley, K., Bell, T., Renouf, M. and Tarasov, L. 2011. Impact assessment of current and future sea-level change on coastal archaeological resources – illustrated examples from northern Newfoundland. *Journal of Island and Coastal Archaeology* 6(3), 351–74.

Wilby, R. L. and Dessai, S. 2010. Robust adaptation to climate change. *Weather* 65(7), 180–85.

Chapter 18

Perception of the relationship between climate change and traditional wooden heritage in Japan

Peter Brimblecombe and Mikiko Hayashi

Abstract

In Japan, much monumental historic architecture is built from wood. When considering the pressures likely to arise under a changed climate, we are presented with some problems that are different to those found in countries where stone has been such an important material. Additionally, the open design of Japanese temples results in a close connection between outdoor and indoor climate parameters, such as temperature and relative humidity. There are likely to be increases in temperature, shifts in rainfall patterns and a decrease in relative humidity over the coming century. There may also be more surface water and floods that threaten structures, and drier summers that increase the risk of forest fires. Warmer temperatures can create a potential for enhanced insect infestation, while altered humidity may affect the seasonal distribution of mould attack. Climate changes will advance the arrival of spring blossoms and delay autumn colours, potentially affecting the ways in which visitors choose to use important sites, influencing their appreciation of the site and its relation to the surrounding landscape. This paper presents a review of the effects of climate change on Japan's heritage sites and explores the level of public engagement with this heritage.

Introduction

Japan has a wealth of wooden heritage. Although wood is an excellent material for buildings and portable items, it is sensitive to climate and other environmental parameters. There is a long history of maintenance and restoration of wooden buildings in Japan, which developed from religious and cultural values and technical knowledge. Despite an emphasis on the skills required to maintain Japan's wooden heritage, an understanding of the importance of climate change as a novel threat to heritage has grown only recently. In parallel, although there is public awareness about changing climates, and about the need to protect heritage for future generations, these ideas are not often linked. This paper reviews the ways in which climate change may affect Japan's heritage sites and explores the level of public engagement with this heritage.

Climate and climate change in Japan

Japan is an island nation: an archipelago which extends more than 3000 km in the latitude band 20–45°N (Fig. 18.1). Although the climate is generally temperate, it ranges from the subarctic zone of the most northerly island of Japan, Hokkaido, where the average annual temperature is 6–10°C to the subtropical zone of the southern island, Okinawa, where the average annual temperature is more than 20°C. Japan has four distinct seasons, but there is a large difference in climate between the sides of the country facing the Pacific Ocean and the Sea of Japan. This is because the southeast monsoon blows from the Pacific Ocean in the summer, and the northwest monsoon blows from the Asian continent during the winter. Since the mountains of Japan run longitudinally, the area where the monsoons deliver precipitation and dryness leads to a rain shadow across the mountain spine. Thus precipitation is higher in summer than winter on the Pacific side, while the reverse is true on the Sea of Japan side. The rainy season begins in early summer and lasts around one and a half months in most of the country, except Hokkaido. Additionally, a large amount

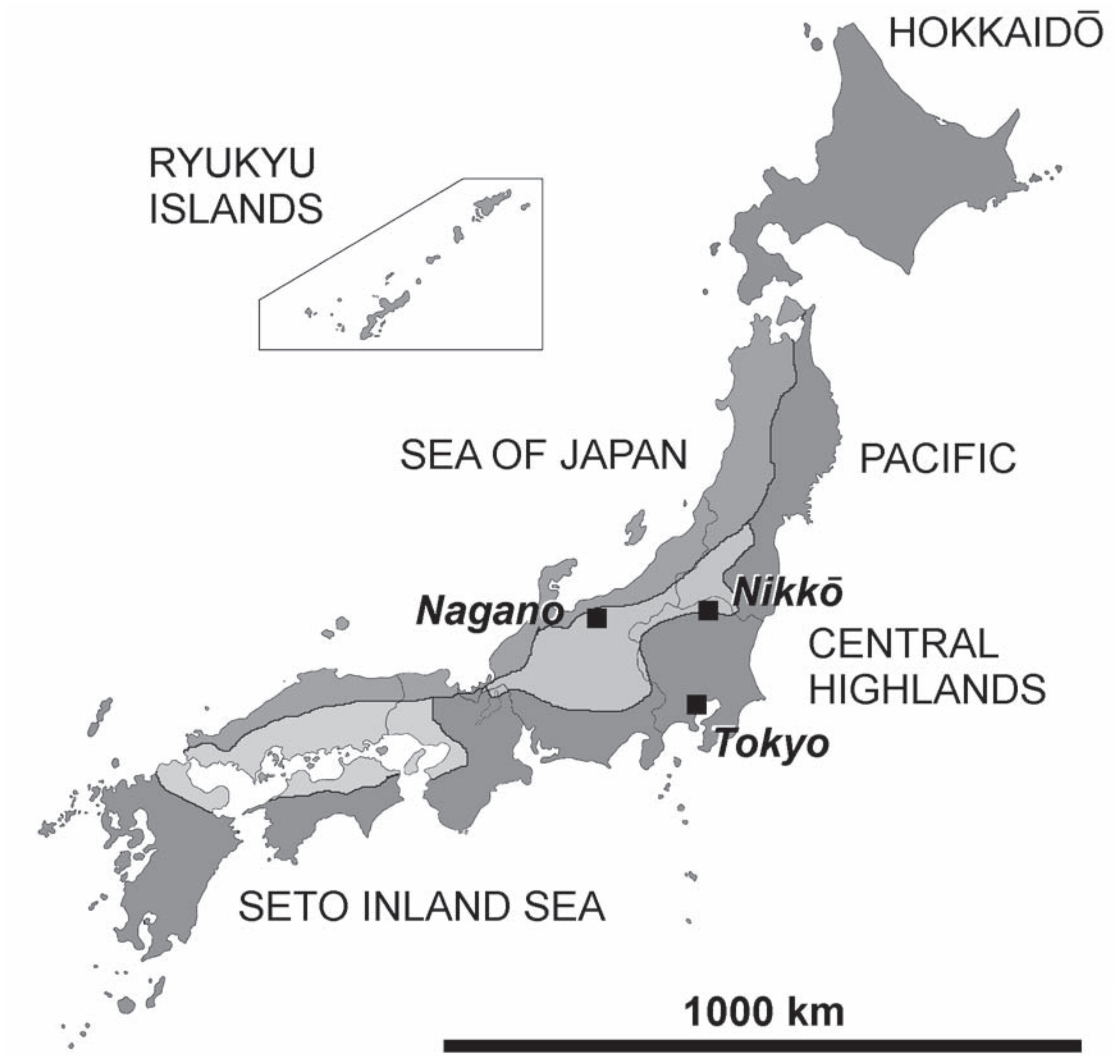

Figure 18.1. Map of Japan showing climate regions and key locations mentioned in the text.

of rainfall is delivered by typhoons that pass over Japan through the summer to autumn months, meaning that the Pacific side receives some precipitation even during the summer.

There are six principal climate classes associated with geographical features of the islands:

1. Hokkaido: a humid continental climate which has long, cold winters and cool summers
2. Sea of Japan: winter with heavy snow and occasionally extremely high summer temperatures
3. Pacific Ocean: significantly milder winters and more sun than on the west coast, while summers are hot and humid
4. Ryukyu Islands that include Okinawa: generally humid subtropical climates, but wide ranging
5. Central Highlands: climate associated with the high mountains of central Honshu, little affected by the monsoons, with stable low humidity and relatively low annual precipitation (about 1000 mm). There are large variations between summer and winter temperature and between night and day.
6. Seto Inland Sea: climate affected by mountains in Chugoku and Shikoku regions, which block the monsoon and bring mild and moderate conditions. Temperature is stable though the year and precipitation is around 1000–1600 mm, but droughts can occur when the rainy season is short and typhoons fail to cross the Inland Sea.

The observed rate of change in annual temperature in Japan is +1.15°C per 100 years, from 1898–2012, which is greater than the global value of +0.68°C per 100 years from 1891–2012 (JMA 2014a). Some details of historical trends in climate are illustrated in Figure 18.2. Much of the data were derived from the long record collected at Nagano (JMA nd), but a longer temperature record for Tokyo (Mikami 1996)

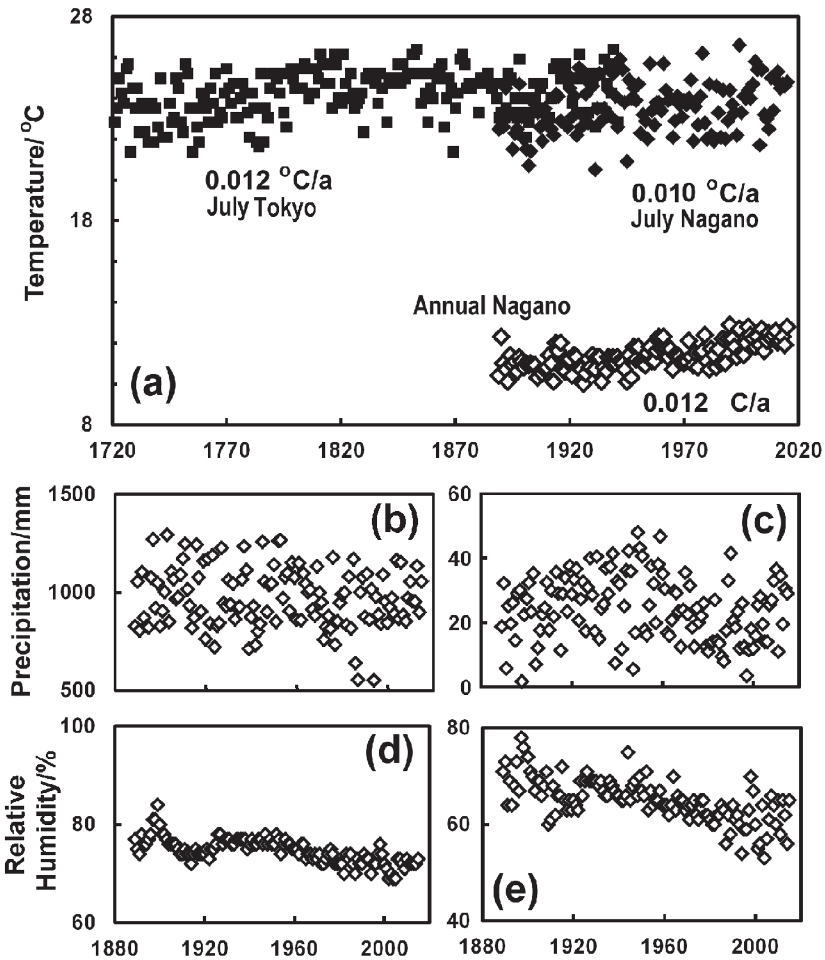

Figure 18.2. (a) Annual average temperature (open diamonds) and July temperatures (closed diamonds) at Nagano and Tokyo (closed squares), with slopes enumerated on the graph. (b) Annual precipitation at Nagano. (c) Rainfall during the driest month each year at Nagano. (d) Average annual relative humidity at Nagano. (e) Average April relative humidity at Nagano.

is also displayed. The city of Nagano is in a valley near the confluence of the Chikuma and Sai rivers, and is famous because of Zenkō-ji, a 7th century Buddhist temple. It is an environment that might also reflect the sort of changes likely at other temple sites, such as the temple complex at Nikkō, which is discussed in some detail in this chapter. The increase in temperature (Fig. 18.2a) both in the hotter months (*e.g.* July) and annually are significant at the 99% level (adopting a Kendall rank correlation). Figure 18.2b shows the annual precipitation at Nagano, revealing little change. Even the decreasing amounts of rainfall in the driest month of each year (Fig. 18.2c) are not significant. There is a general view that the future will likely be drier, but some studies have failed to find a monotonic trend in Japanese precipitation and have argued that the downward changes in century-long records lie within normal fluctuations (Xu *et al.* 2003). Relative humidity is in decline at Nagano, both in terms of the annual average (Fig. 18.2d) and that for the dry month of April (Fig. 18.2e), with both changes significant at the 99.9% level. Such declines in relative humidity are known elsewhere and are to be expected as temperature increases (*e.g.* Brimblecombe 2013).

These shifts in climate can cause higher temperatures, consequently changing the landscape and causing sea level rise (thermal expansion of seawater and melting of polar ice); changing animal, insect and plant ranges; increasing the risk of drought, fire, floods, stronger storms; and leading to economic losses. The evidence presented suggests that it is already possible to observe some aspects of climate change in Japan. In recent decades, some types of abnormal weather such as heat waves, devastating heavy rain, and drought have become more frequent, and global warming is observed on a century-scale in relation to the average temperature of Earth's climate system (JMA 2014b). Sea level rise is not discussed in this chapter, which focuses on inland sites, although it is likely to be a threat to sites such as the Itsukushima Shrine, on the island of Itsukushima.

Wooden heritage in Japan

Cultural heritage can be made of various materials: wood, stone, metal, textile, leather, clay, brick, concrete, plastic, *etc.* Japan's numerous wooden objects symbolise the 'culture of wood', supported by the ready availability of timber in Japan, where about 70% of the land is mountainous. High durability, which makes excellent structural material, has been found from species such as zelkova, cedar, chestnut, camphor, pine and cypress (Itoh 2005). The use of different species due to the nature of the timber has led to careful selection since the Jomon period (14,000–300 BC), as shown from excavations in various parts of Japan. Skilful craft techniques with timber materials form the basis for a rich heritage (Kohdzuma 2015).

In Japan, 90% of the national treasures and important cultural properties are wooden (Yamamoto 2008) and one of the oldest wooden buildings in the world, the Horyuji in Nara, dates from the late 7th century AD. It has been repaired many times since it was first constructed. In addition to daily and yearly maintenance, a major restoration is undertaken every 100–200 years. *Shikinen sengu* is a unique aspect of the Shinto tradition and expresses an ideal that sees shrines and buildings within sanctuaries meticulously disassembled and rebuilt; all sacred treasures and artefacts are refurbished, typically every twenty years, with exactly the same technology and traditions as in the past. Thus, methods and intricate craft skills are passed on from one generation to the next for long periods, preserving not only the buildings themselves, but also the construction techniques. The ideal of *shikinen sengu* is applied to nine shrines in Japan. The best-known example is the Ise Grand Shrine in Mie prefecture, where traditions began about 1300 years ago.

The most common wooden heritage, apart from buildings, comprises statues of the Buddha. Besides these there are wooden plaques with prayers, wishes or pictures (*ema*), furniture, and many kinds of instruments and articles of everyday use. Waterlogged wood from archaeological sites is a further aspect of wooden heritage.

The conservation environment and approach to wooden heritage differs among the stakeholders. Some do not use insecticide or fumigate religious objects, such as statues of the Buddha, so they have to rely on environmental controls. An important natural aspect of wood is its tendency to warp and swell under humid conditions and shrink and crack under drier conditions. These tendencies vary with the direction of the grain of the wood. In an outdoor environment, wood is constantly influenced by fluctuations in climate, temperature, humidity, ultraviolet rays *etc.* Moreover, catastrophic damage can be caused by extreme events such as typhoons and tornados. As wood is organic, biological deterioration and even changes in the physical, chemical and mechanical properties of wood can occur over time. The Shōsōin treasure house is a traditional log-cabin style store built in the 8th century AD. Here simple wooden boxes, books, artefacts and other treasures have been kept in a stable environment for many years. The Japanese cedar boxes and cypress building materials minimise fluctuation in relative humidity, and specifically larger wooden objects act as buffers and control moisture (Naruse 2002). This traditional storage appears to be effective and resembles modern preventative conservation practice.

Wood is a limited, but renewable, natural resource. The continual repair and maintenance of historic wooden heritage has been supported by initiatives such as the 'Forestation to Support the Culture of Wood' programme implemented by the Forestry Agency since 2003 and the 'Forest Hometown Cultural Assets' programme by the Japanese Government's Agency of Cultural Affairs since 2006. Such efforts will help to conserve heritage and traditional craft skills by securing material for future restoration.

Key threats to wooden heritage

Although the focus of this chapter is on large wooden structures, such as the shrines and temples of Nikkō, some smaller items, including musical instruments, furniture and sculptures can be especially sensitive to climate. Even though smaller items are stored inside buildings, some climate variables can penetrate indoors, particularly in historical buildings where climate controls are limited.

Wood is not especially vulnerable to typical urban air pollutants, although the deposition of nitrogen compounds can add nutrients, leading to it being more readily attacked by microorganisms. Key threats include wind driven rain, the frequency of wetting, and diurnal and seasonal cycles and long-term trends in relative humidity. Humidity can cause substantial changes to the water content of wood, leading to stresses (Jakieła *et al.* 2008) that form cracks. The importance of long-term changes in humidity is evident from the study of a large 15th century European wooden inlay bookcase cabinet (Camuffo *et al.* 2014). The changing environment within the rooms that the cabinet occupied has been estimated by proxy data from between 1500 to 2009. Large and sudden variations in humidity were noted to have occurred when the bookcase was moved or when heating fluctuated, rather than being caused by climate change, although it is noted that climate pressures may increase these variations.

Wood will remain wet for longer periods if rainy days become more common in the future, or if more frequent storms drive rain against wooden surfaces allowing droplets to penetrate deeper and saturate the wood. This itself can cause physical damage, but often the damage is

Figure 18.3. The main hall (Honden) of Takino-o-jinja, Futarasan Shrine in Nikkō illustrating the forest setting (Photo: M. Hayashi).

exacerbated by biological attacks. Most notably this arises through fungi (Lankester and Brimblecombe 2012), which can grow on a wide range of organic materials, including wood. Favourable climate conditions can also encourage the growth of insects; in Japan, wood boring beetles are especially dangerous. The temple complexes at Nikkō are set within a forested landscape (see Fig. 18.3) and are vulnerable to insects. In 2008, severe damage was evident in some wooden structural elements of the Sanbutsudō (in the large main hall – Hon-dō) of the Rinnō-ji Temple grounds at Nikkō. This appeared to be caused by the presence of a rare anobiid in Japan, *Priobium cylindricum*, which is a form of death-watch beetle (Komine *et al.* 2009). The damage led to surveys of two historic wooden buildings (Sanbutsudō and Taiyū-in Nitenmon) using adhesive traps in 2009 (Komine *et al.* 2010) and a more extensive survey throughout Nikkō in 2010, which revealed a large array of beetles (Hayashi *et al.* 2011). The exact reason for the infestation at Sanbutsudō remains unclear, and the role of climate in this is not well understood. While rising temperatures could potentially increase the abundance of insects (Brimblecombe and Lankester 2013), food and habitat may be limiting factors in the magnitude of increase (Brimblecombe and Brimblecombe 2015).

In response to the damage at Nikkō, a consortium of conservation institutes undertook Japan's largest-scale covered fumigation (11,450 cub m) between 17 July and 2 August 2013. This followed a long debate about potential risks to workers and visitors, but fumigation with sulfuryl fluoride gas appeared to be the only way to kill all of the *Priobium cylindricum* present (Harada *et al.* 2014). Thus far, the treatment appears to have been successful.

Buried wood in anoxic waters is an important archaeological resource. This environment preserves perishable organic materials that account for a significant part of our potential archaeological record. Waterlogged wood and subterranean elements of buildings, such as supports and posts, can be affected by changes in the water table that occur because of shifting precipitation patterns. In the UK, the Historic Buildings and Monuments Commission for England suggested that the loss of waterlogged wood is likely to increase over the next 100 years as summers become hotter and drier (Jones 2010). Additionally, climate scenarios suggest that soil moisture is likely to decline (Brimblecombe 2014). If building supports that have long been damp were to dry out, then structural stability could be affected. It is again not merely physical degradation that is important; the exposed wood is subject to biological attack, *e.g.* loss of cell wall material. Anaerobic bacteria in anoxic conditions cause deposition of iron sulphides in the wood cells and subsequent oxidation can lead to the disintegration of lignin (organic polymers that contribute the main structural support to plant tissue). Fungi require oxygen and benefit from the fact that the wood is likely to contain lots of water. This will cause the loss of cell walls, discolouration and then disintegration. Insects will bore into comparatively dry wood (8% moisture content) and cause rapid disintegration (Jones 2010).

Fire represents another particular risk to wooden heritage; forest fires are a potential threat to sites such as Nikkō, where many of the temples are closely associated with forests (see Fig. 18.3). Figure 18.4a shows the frequency of fires in Japan since the 1940s (FDMA 2015). The record is divided into earlier data and data after 1990 when more detail is available. The evidence suggests that a reasonable relationship exists between the number of fires and the area burned (inset to Fig. 18.4a). The number of fires peaked in the 1960–80s and probably represents changes in forestry practice, so we need to be cautious in using the data to look for climate change effects, hence the reason for dividing the data into two periods. The relationship between annual precipitation and the number of fires is shown in Fig. 18.4b and hints at a negative relationship between the amount of rain and fires, *i.e.* drought years would seem to encourage forest fires. Although the degree of scatter is high, clearly the number of fires is higher in the earlier period, and the Kendall τ rank correlation suggests a significant negative correlation for both periods (<1990, $\tau = -0.32$, $p = 0.003$, *i.e.* a very significant negative correlation; ≥ 1990, $\tau = -0.31$, $p = 0.03$, *i.e.* a significant negative correlation). By contrast, the relationships with temperature are weaker (<1990, $\tau = -0.10$, $p = 0.37$; ≥ 1990, $\tau = -0.10$, $p = 0.48$, *i.e.* no significant correlations) and negative, which would suggest, counter intuitively, that fires increased as it got colder. The notion that changed climate conditions are likely to lead to more fires is supported by other studies. In China, for example, spring and summer fires in the boreal forests are predicted to rise by 22–52% by the end of the 21st century (Yang *et al.* 2011).

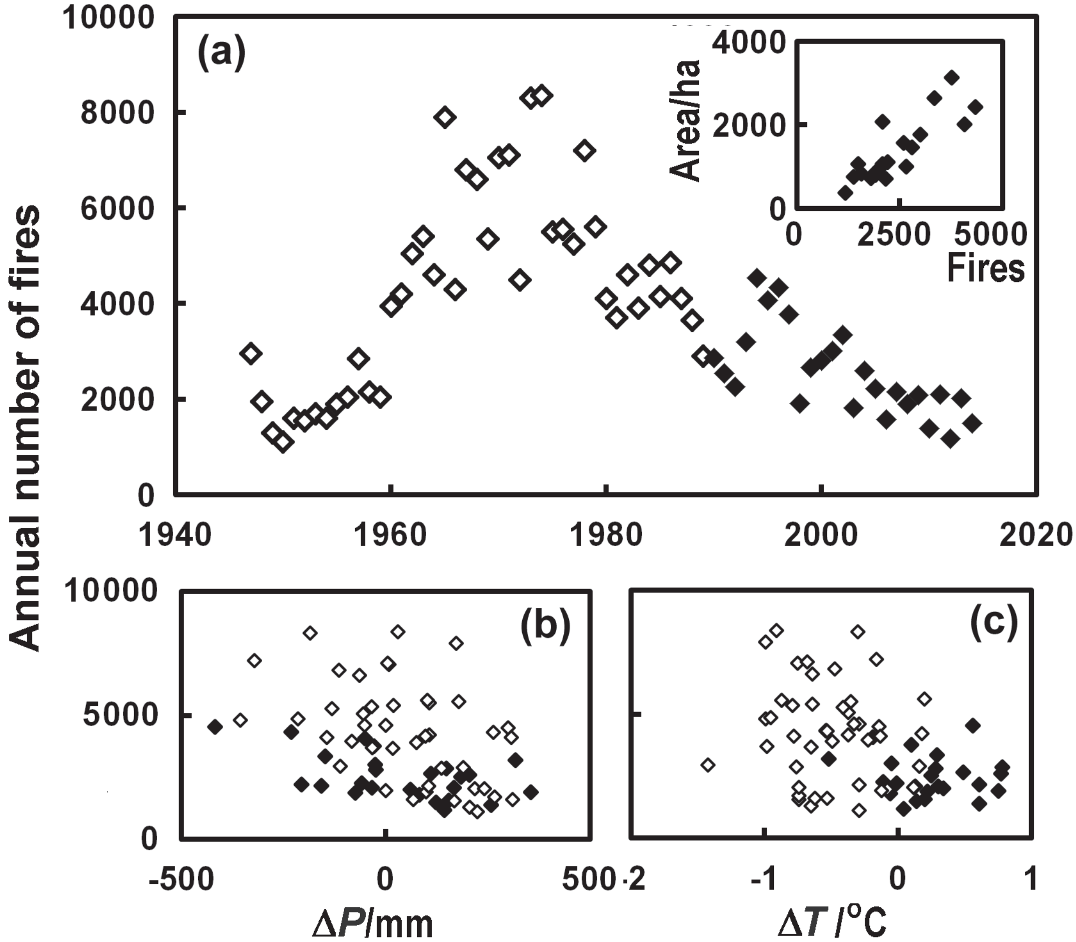

Figure 18.4. (a) Annual frequency of forest fires in Japan distinguishing the earlier set of data (white diamonds) and those from 1990 (black diamonds). The inset shows the relationship between the number of fires and the total area burnt from 1990 onwards. (b) The relationship between the deviation in annual precipitation from the 30-year mean (1981–2010) and the frequency of forest fires in Japan for both earlier and later periods. (c) The relationship between the deviation in annual mean temperature from the 30-year mean (1981–2010) and the frequency of forest fires in Japan for both earlier and later periods.

Projections for future climate have been made by the JMA (2014a) for various regions of Japan. Nikkō and Nagano lie at the western and eastern borders of the Pacific side of the eastern region of Japan, so we have selected this climatic region as representative of both sites. Future temperatures (2076–2095) are illustrated in Figure 18.5a, which shows changes in the annual number of days with extreme temperatures: the standard deviation is represented by the thick line and the mean represented by the horizontal cross bar; the present situation (1980–1999) is represented by a thin line and each has a mean change of zero, *i.e.* it is the same as at present. The number of days each year where the daily maximum temperatures are above 35°C increases by about ten days per year, while the number of days with a daily minimum temperature above 25°C increases by more than twenty days. By contrast, cold days, those with a daily minimum temperature below freezing point, will decrease substantially, and those with a daily maximum temperature below 0°C show little change. This suggests that there will be a greater number of hotter and potentially uncomfortable days for visitors in the future.

Figure 18.5b shows the changes in rainfall marked as thick lines, suggesting small future increases for all seasons other than autumn. However, we should note that only the increases in spring and winter are significant at the 90% level. The changes in extreme hourly and daily rainfall (Fig. 18.5c) are more significant, with substantial increases in the number of times each year heavy falls are likely to occur. The grey bars represent the present and the black bars represent the future. Hourly rainfall exceeding 30 mm will almost double over the course of the current century, and hourly amounts of rain, in excess of 50 mm, although still rare (less than once every two years), will be about three times as frequent as at present. Extreme daily rainfall (cases exceeding 100 mm and also cases which exceed 200 mm) will increase in the future, but not as notably as the hourly

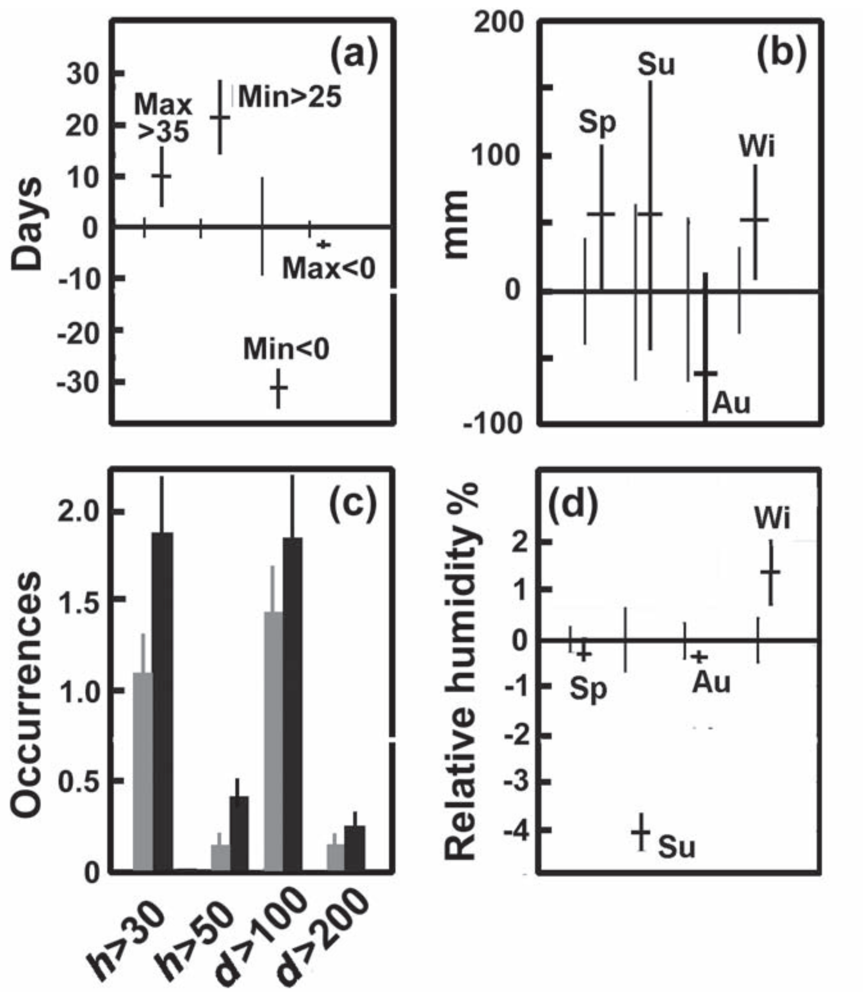

Figure 18.5. Differences in climate between the recent past (1980–1999) and the future (2076–2095) for the climate region which includes Nikkō and Nagano (JMA 2014a). (a) Changes in the annual number of days of extreme temperatures in the future (thick lines) compared with that of the recent past (fine lines). Max>35: daily maximum temperatures above 35°C; Min>25: daily minimum temperature above 25°C; Min<0: daily minimum temperature below 0°C; Max<0: daily maximum temperature below 0°C. The length of lines denotes the standard deviation. (b) Changes in seasonal precipitation for the region in the future (thick lines) compared with the recent past (fine lines) for spring (Sp), summer (Su) autumn (Au) and winter (Wi). The length of the lines denote the standard deviation. (c) Extreme rainfall for the region expressed at the number of occurrences at stations where hourly rainfall (h) exceeds 30 mm and 50 mm, and daily falls (d) exceed 100 mm and 200 mm. The grey bars are for the recent past and the black bars for the future. The length of the lines denotes the standard deviation. (d) Changes in seasonal relative humidity for the region in the future (thick lines) compared with the recent past (fine lines) for spring (So), summer (Su), autumn (Au), and winter (Wi). The length of the lines denotes the standard deviation.

falls. The potential for increased heavy rain could mean increased risk of surface flooding at sites, together with the possibility of water penetration into wooden structures, although the role of wind driven rain may be more significant than simply the amount of precipitation. It has also been forecast that the frequency of extreme falls of rain in very short periods (cloudbursts) will increase over the entire archipelago, and the number of dry days will also increase in most parts of Japan (JMA 2014a).

The seasonal relative humidity will also change in the future (Fig. 18.5d). Summers will be drier while winters will be damper, meaning that annual cycles will have a wider humidity span. This humidity change could impose new stresses on organic materials, including wood.

Other climate change threats to heritage sites

Historic sites and landscapes are also under threat from landslides and tsunamis. Heritage buildings have often been constructed atop or close to steep slopes, and so are vulnerable to landslides. These can be triggered by volcanoes, earthquakes, river erosion or intense rainfall. In 1792, volcanic activity at Mount Unzen triggered a landslide that swept through Shimabara and into the Ariake Sea, killing more than 15,000 people, many thousands of whom were killed by the landslide-induced tsunami. A repeat of this event would devastate the historic city of Shimabara and its 17th century castle (Sassa 2015). Increased rain intensity might also enhance the risk of landslides, as demonstrated by damage caused to the sacred sites and pilgrimage routes in the Kii Mountain Range (Sugio 2015).

Landscapes provide a context for heritage sites and can be much celebrated. In Japan, viewing the cherry blossom is an important traditional custom (*Hanami*), and celebrations of the arrival of spring are common. At Nikkō, the Yayoi Festival occurs between April 13th and 17th, heralding springtime. Floats decorated with cherry blossom are prepared and the heads of local towns visit other towns to exchange ritual greetings. These ancient customs are faithfully observed, as it is believed that any deviation can cause trouble; this festival is alternatively called *Gota Matsuri* or the 'Festival of Disputes' (the word *gota* meaning trouble). Such celebrations may be affected by climate change as the blooming dates of cherry blossoms in rural cities are occurring earlier (see Fig. 18.6a). Allen *et al.* (2013) suggest that over the coming century the cherry blossom may arrive some 30 days earlier than at present (see Fig. 18.6b), and at Nikkō, the floats now often use artificial blossoms.

Later in the year, viewing the autumnal colours of trees is also important, but the commencement of the autumnal tint to the Japanese maple has become progressively delayed, by more than 15 days over the last 50 years (Fig. 18.6c). Another important tradition is viewing the snow-covered landscape, and although not so popular at Nikkō (where most visits take place in summer), it is still important in Japanese art, as shown in Hokusai's famous view of Mount Fuji Tea House at Koishikawa the morning after a snowfall (*Koishikawa yuki no ashita*). Annual snowfall will decrease significantly in all regions of Japan over the next century. There will also be a northward movement of tropical grasslands, which may occupy as much as half of Japan (Sasaki *et al.* 2003).

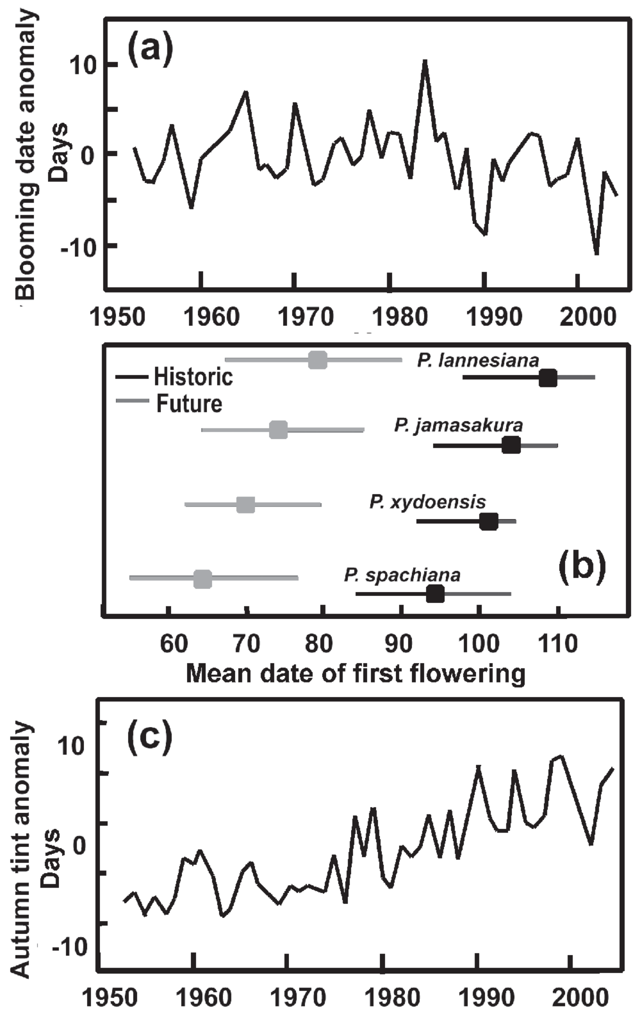

Figure 18.6. (a) Long-term trend in the anomaly of blooming dates of cherry blossoms in rural cities (JMA 2007). (b) The daily probability of first flowering of four species cherry blossoms and their 95% intervals (lines) for the historic (1981–2000) and future (2081–2100) periods (Allen et al. *2013). (c) Long-term trend in the date of the autumnal tint of the Japanese maple (JMA 2007).*

Public engagement with climate change and heritage

There is a significant public awareness of climate change in Japan. In a recent report, the Pew Global Attitudes Project (2006) stated that Japan had the highest degree of concern about climate change, with well over 90% of the population expressing awareness of the issue. This may be a product of Japan's 2005 Kyoto Protocol Target Achievement Plan (MoE 2005), one of the goals of which was to raise public awareness of the issue of climate change. Data collected in Japan are available from surveys repeated at intervals (CO 1977; 1999; 2001; 2005; 2007), although the questions asked have not remained constant. The evidence from the response rates plotted in Fig. 18.7 suggests that there is an increased awareness about some issues related to global climate change. Early studies (GlobeScan 2001 in Leiserowitz 2007) suggested that concern in Japan was mainly directed towards the effects of extreme weather on human health. The Program on International Policy Attitudes (PIPA 2009) says high-income countries (the US, Japan, and France) had somewhat fewer people who saw climate change as a very serious problem.

The school curriculum in Japan includes climate change, especially at the secondary level where it is found in textbooks as part of 'Education for Sustainable Development in Science' courses (Jung 2010). The Ministry of the Environment developed climate change education in 2005, including not only schools, but also promoting it within

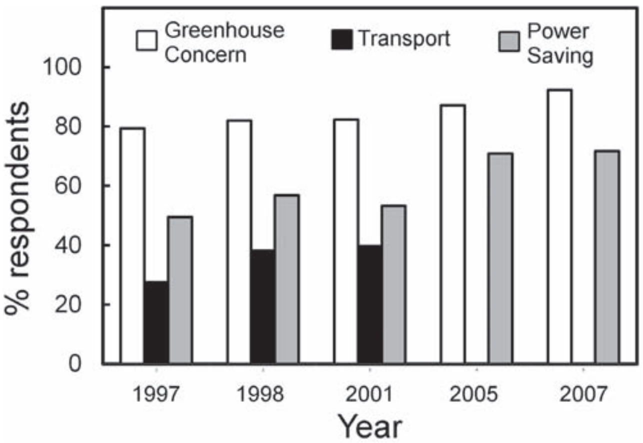

Figure 18.7. Changing percentage of respondents in Japan: (1) identifying concern (white bars) over global warming or adopting countermeasures for global warming at home; (2) in terms of using public transportation, bicycles or walking (black bars); and (3) decreasing their power consumption (grey bars). Source data from: CO 1997; 1999; 2001; 2005; 2007.

cultural and community activities and company seminars (MoE 2014). In terms of preserving heritage, the notion of *shikinen sengu* (discussed above) is widely understood and its representation at the Ise Grand Shrine is very important in Japan. Each year, the restoration work is covered by the media, including television, newspaper and magazines, so even those who do not live close to Ise are aware of the faithful reconstruction work.

Public awareness of the impact of climate change on heritage is much lower than awareness of climate change more generally. This is hardly surprising, as even amongst heritage professionals, interest has risen slowly and the issue has been largely ignored in Intergovernmental Panel on Climate Change documents to date. However, from the early 21st century, the UNESCO World Heritage Centre has produced reports on the issue, such as *Case Studies on Climate Change and World Heritage* (Colette 2007). In parallel, there have also been a number of research projects, notably in Europe, such as NOAHs ARK (Sabbioni *et al.* 2010) and Climate for Culture (*e.g.* Leissner *et al.* 2015). Some sociological studies have used climate research, such as Whittlesea and Amelung's (2010) analysis of tourism in South West England, which used climate data from UK Climate Projections (UKCP 2009). Planning documents, such as those from UNESCO, or more recent calls for research on the heritage impacts of climate, often neglect the expanding body of research on climate change and heritage and focus attention on strategy documents (*e.g.* Melnick *et al.* 2015). In Japan, the Agency for Cultural Affairs is responsible for matters related to heritage sites. Efforts to preserve heritage under threat can be very intense as seen after the Great East Japan Earthquake of 2011 (Agency for Cultural Affairs 2011). However, by and large the Agency has shown limited interest in the long-term impact of climate change compared to the more dramatic and immediate threats from earthquakes, tsunamis and typhoons. Japan has not embarked on the types of climate change strategies that are seen in some parts of Europe or North America. Historic Scotland (2012) has long had a very clear policy towards climate change and heritage and seen public communication as a key part of their endeavour. The US National Parks Service has also done an admirable job at introducing climate change impacts to visitors at sites (NPS 2010; 2012).

Public understanding of threats to heritage in Japan seems to focus on extreme events like earthquakes and tsunamis, such as those that occurred in 2011 (*e.g.* Sudo 2014). At that time, members of the public volunteered to assist with simple work such as documentation and reconstruction of library catalogues in affected areas (Kondo *et al.* 2013). Although forest fires represent a threat to wooden heritage, such fires are relatively rare, so public awareness of their importance is low compared to other countries such as Australia or the United States.

Educational groups are active in providing materials for school visits to sites such as Nikkō (MBE 2012). They raise children's interest in cultural heritage, but also encourage them to think about conservation issues. The documents at Nikkō focus on the history and meaning of the site, and additionally address events such as the Yayoi Festival. Despite the absence of details of the relevance of climate change, during a phone call they were enthusiastic about including this in upcoming revisions of the brochure.

Managing change at heritage sites

The management of sites with wooden heritage in Japan will have to incorporate responses to climate change. Climate shifts will alter the balance of various threats in the future. Heavy snowfall will be less frequent, but it is possible that heavy rain, and therefore local surface flooding, will pose a problem. Warmer conditions may mean that fungal attacks are more likely, and destructive insects could shift, posing a threat to Japanese heritage. In addition, drier conditions could enhance the risk of forest fires. Most threats that are likely to be experienced due to a changing climate are likely to have been experienced before, albeit at a lower frequency. This means that increased attention to maintenance, care of drainage and inspection of buildings can mitigate potential problems. For example, although insects may shift their range, the type of damage they induce is likely to have been experienced at other sites, perhaps further south. Climate change occurs slowly over decades; on the one hand this allows for strategic plans to evolve, on the other, the changes may occur so slowly that threats may be overlooked in the face of more immediate concerns.

It is also possible that along with a changing climate, visitor expectations may be altered. Different conditions are likely to affect the way that people appreciate historic properties (Brimblecombe 2016). Hotter weather may make sites less desirable to visit at certain times of year, or create a need for evening visitor hours during hotter summers. This may lead to opening times or visiting seasons being altered. Festivals, which often occur at a fixed time of year, may be especially troubled by a shifting climate. As noted above, it is likely that the cherry blossom will appear a month earlier in the future. If the dates of festivals are fixed, heritage managers may need to develop plans to meet visitor expectations in the future.

Although public understanding of climate change is widespread in Japan, as yet there is limited appreciation of the impact of climate on heritage. The Agency for Cultural Affairs has been very responsive to problems caused by the impact of earthquakes and tsunamis, but has made fewer efforts to respond to the more gradual effects of climate change. It has yet to develop the kinds of strategic documents addressing the threats to heritage that have been published in Europe and North America. There are excellent Japanese scientists working in both the area of climate change and heritage, but what is lacking is a strong sense of collaboration or a clear programme of joint research. The public appears interested in climate change and historic sites, so they are likely to be receptive to attempts to relate to both of these issues. Given the wealth of Japan's wooden heritage, greater publicity and planning would be beneficial in helping to preserve it in a changing world.

References

Agency for Cultural Affairs. 2011. Main countermeasures of Agency for Cultural Affairs for the Great East Japan Earthquake. Available at: http://www.bunka.go.jp/english/topics/countermeasures_for_geje/index.html [accessed 26 April 2017].

Allen, J. M., Terres, M. A., Katsuki, T., Iwamoto, K., Kobori, H., Higuchi, H., Primack, R. B., Wilson, A. M., Gelfand, A. and Silander, J. A. 2013. Modeling daily flowering probabilities: Expected impact of climate change on Japanese cherry phenology. *Global Change Biology* 20, 1251–63.

Brimblecombe, P. 2013. Temporal humidity variations in the heritage climate of South East England. *Heritage Science* 1, 3.

Brimblecombe, P. 2014. Refining climate change threats to heritage. *Journal of the Institute of Conservation* 37(2), 85–93.

Brimblecombe, P. 2016. Visitor responses and climate change. In R. Lefevre and C. Sabbioni (eds), *Cultural Heritage from Pollution to Climate Change*, 73–80. Bari, Edipuglia.

Brimblecombe, P. and Lankester, P. 2013. Long-term changes in climate and insect damage in historic houses. *Studies in Conservation* 58(1), 13–22.

Brimblecombe, P. and Brimblecombe, C. T. 2015. Trends in insect catch at historic properties. *Journal of Cultural Heritage* 16, 127–33.

Camuffo, D., Bertolin, C., Bonazzi, A., Campana, F. and Merlo, C. 2014. Past, present and future effects of climate change on a wooden inlay bookcase cabinet: A new methodology inspired by the novel European Standard EN 15757:2010. *Journal of Cultural Heritage* 15(1), 26–35.

CO (Cabinet Office). 1997. *Opinion Poll about Global Warming Issue, 22nd Oct 1997*. Tokyo, Cabinet Office, Government of Japan.

CO (Cabinet Office). 1999. *Opinion Poll about Earth Environment and Life Style, 25th Jan 1999*. Tokyo, Cabinet Office, Government of Japan.

CO (Cabinet Office). 2001. *Opinion Poll about Prevention of Global Warming and Life Style, 1st Oct 2001*. Tokyo, Cabinet Office, Government of Japan.

CO (Cabinet Office). 2005. *Opinion Poll about Countermeasures of Global Warming, 3rd Oct 2005*. Tokyo, Cabinet Office, Government of Japan.

CO (Cabinet Office). 2007. *Opinion Poll about Countermeasures of Global Warming, 8th Oct 2007*. Tokyo, Cabinet Office, Government of Japan.

Colette, A. 2007. *Case Studies on Climate Change and World Heritage*. 1st edition. Paris, UNESCO World Heritage Centre.

Fire and Disaster Management Agency (FDMA). 2015. *Fire White Paper*. Tokyo, Shobi, Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications.

Harada, M., Kigawa, R., Komine, Y. and Fujii, Y. 2014. Report on fumigation process conducted at Rinno-ji Temple. *Hozonkagaku* 53, 215–24.

Hayashi, M., Komine, Y., Kigawa, R., Harada, M., Kawanobe, W. and Ishizaki, T. 2011. Methods and results of counting beetles captured by adhesive traps at historic buildings in Nikko. *Hozonkagaku* 50, 123–32.

Historic Scotland. 2012. *A Climate Change Action Plan for Historic Scotland 2012–2017*. Edinburgh, Historic Scotland.

Itoh, T. 2005. Recent advances in studies of wooden cultural properties aspect of wooden identification and dendrochronology. *Mokuzai Gakkaishi* 51(1), 67–69.

Jakieła, S., Bratasz, Ł. and Kozłowsk, R. 2008. Numerical modelling of moisture movement and related stress field in lime wood subjected to changing climate conditions. *Wood Science and Technology* 42, 21–37.

JMA (Japan Meteorological Agency). 2007. *Long-term Trends of Phenological Events in Japan*. Tokyo, Japan Meteorological Agency. Available at: http://ds.data.jma.go.jp/tcc/tcc/news/PhenologicalEventsJapan.pdf [accessed 15 November 2016].

JMA (Japan Meteorological Agency). 2014a. *Global Warming Projection, Vol. 8*. Tokyo, Japan Meteorological Agency. Available at: http://ds.data.jma.go.jp/tcc/tcc/products/gwp/gwp8/index.html [accessed 15 November 2016].

JMA (Japan Meteorological Agency). 2014b. *Climate Change Monitoring Report*. Tokyo, Japan Meteorological Agency. Available at: http://www.data.jma.go.jp/cpdinfo/monitor/2014/pdf/ccmr2014_all.pdf [accessed 15 November 2016].

JMA (Japan Meteorological Agency). nd. *Tables of Monthly Climate Statistics*. Available at: http://www.data.jma.go.jp/obd/stats/data/en/smp/index.html [accessed 26 April 2017].

Jones, D. M. 2010. *Waterlogged Wood*. Swindon, English Heritage.

Jung, Y. J. 2010. Improving contents of school science education – Focusing on global warming education in Japan, Korea and the U.S.A. *Bulletin of the Graduate School of Education*, *the University of Tokyo* 50, 211–20.

Kohdzuma, Y. 2015. Prospects for conservation and restoration science for wooden cultural properties. *Mokuzai Gakkaishi* 61(3), 238–42.

Komine, Y., Kigawa, R., Harada, M., Fujii, Y., Fujiwara, Y. and Kawanobe, W. 2009. Damage by a rare kind of anobiid, Priobium cylindricum, found during restoration work of Sanbutsu-do, Rinnohji temple in Nikko (World Heritage). *Hozonkagaku* 48, 207–13.

Komine, Y., Harada, M., Nomura, M., Kigawa, R., Yamano, K., Fujii, Y., Fujiwara, Y. and Kawanobe, W. 2010. Survey of Wood-boring Anobiids at Rinnohji Temple in Nikko. *Hozonkagaku* 49, 173–81.

Kondo, Y., Uozu, T., Seino, Y., Ako, T., Goda, Y., Fujimoto, Y. and Yamaguchi, H. 2013. Voluntary activities and online education for digital heritage inventory development after the great east Japan earthquake. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science*s 40(5/W2), 391–96.

Lankester, P. and Brimblecombe, P. 2012. The impact of future climate on historic interiors. *Science of the Total Environment* 417–418, 248–54.

Leiserowitz, A. 2007. International public opinion, perception, and understanding of global climate change. Unpublished paper. Available at: http://environment.yale.edu/climate-communication/files/IntlPublicOpinion.pdf [accessed 15 November 2016].

Leissner, J., Kilian, R., Kotova, L., Jacob, D., Mikolajewicz, U., Broström, T., Ashley-Smith, J., Schellen, H. L., Martens, M., van Schijndel, J. and Antretter, F. 2015. Climate for culture: Assessing the impact of climate change on the future indoor climate in historic buildings using simulations. *Heritage Science* 3(1), 1–15.

MBE (Municipal Board of Education). 2012. *Wakuwaku Nikkō Shaji Tanken*. Nikkō, Munincipal Board of Education in Nikkō. Available at: http://www.nikko-syaji-tanken.jp/ [accessed 15 November 2016].

Melnick, R. Z., Burry-Trice, O. and Malinay, V. 2015. *Climate Change and Cultural Landscapes: Research, planning, and stewardship*. Eugene, OR, University of Oregon.

Mikami, T. 1996. Long term variations of summer temperatures in Tokyo since 1721. *Geographical Reports of Tokyo Metropolitan University* 31, 157–65.

MoE (Ministry of Environment). 2005. *Kyoto Protocol Target Achievement Plan*. Tokyo, Ministry of Environment, Government of Japan. Available at: https://www.env.go.jp/en/earth/cc/kptap.pdf [accessed 15 November 2016].

MoE (Ministry of Environment). 2014. *Environmental White Paper*. Tokyo, Ministry of Environment, Government of Japan.

Naruse, M. 2002. Temperature and relative humidity environment of the north section of Shoso-in repository. *Bunkazai hozon-syuhuku gakkaisi* 46, 66–75.

NPS (National Park Service). 2010. *Climate Change Response Strategy*. Washington, DC, National Park Service, US Department of the Interior.

NPS (National Park Service). 2012. *Climate Change Action Plan 2012–2014*. Washington, DC, National Park Service, US Department of the Interior.

Pew Global Attitudes Project. 2006. *No Global Warming Alarm in the U.S., China*. Washington, DC, The Pew Research Center for the People and the Press.

PIPA (Program on International Policy Attitudes). 2009. *Program on International Policy Attitudes (PIPA) at the University of Maryland. Public Attitudes Toward Climate Change: Findings from a Multi-Country Poll Report, December 3, 2009*. Available at: http://environment.yale.edu/climate-communication/files/IntlPublicOpinion.pdf [accessed 15 November 2016].

Sabbioni C., Brimblecombe, P. and Cassar, M. 2010. *The Atlas of Climate Change Impact on European Cultural Heritage: Scientific Analysis and Management Strategies*. London, Anthem Press.

Sasaki, H., Kohyama, K., Suyama, T. and Fukuyama, M. 2003. Effects of global climate change on the zones and productivity of forage grass cultivation, Japan. *Bulletin of the National Institute of Livestock and Grassland Science* 4, 39–44.

Sassa, K. 2015. Landslide risk assessment at cultural heritage sites. *Engineering Geology for Society and Territory* 2, 79–103.

Sudo, K. 2014. The role of museums in recovery from disaster: The great east Japan earthquake and tsunami. *Conservation Science in Cultural Heritage* 14(2), 151–54.

Sugio, K. 2015. Large-scale disasters on world heritage and cultural heritage in Japan: Significant impacts and sustainable management cases. *Landscape Research* 40(6), 748–58.

UKCP (UK Climate Projections). 2009. *UKCP09 Website*. Available at: http://ukclimateprojections.metoffice.gov.uk/21678 [accessed 26 April 2017].

Whittlesea, E. and Amelung, B. 2010. *Cost-a South West: What could Tomorrow's Weather and Climate Look Like for Tourism in the South West of England? UKCP09 Case Study – Tourism and Climate Change in SW England, South West Tourism*. Exeter, South West Tourism.

Yamamoto, H. 2008. *Research on Wood and Plant Materials Ensure for the Cultural Assets of Wooden Buildings*. Research report for Research Institute EEC (Environmental and Earthquake Engineering Research Center), 3–6.

Yang, G., Di, X., Guo, Q., Shu, Z., Zeng, T., Yu, H. and Wang, C. 2011. The impact of climate change on forest fire danger rating in China's boreal forest. *Journal of Forestry Research* 22(2), 249–57.

Xu, Z. X., Takeuchi, K. and Ishidaira, H. 2003. Monotonic trend and step changes in Japanese precipitation. *Journal of Hydrology* 279(1), 144–50.