



Understanding Pressures to Archaeological Heritage in the Face of Climate Change: An Integrated Approach to Coastal-Zone Assessments in Ireland

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Abstract Coastal heritage and archaeological sites are part of a complex system of socioenvironmental processes whose conditions are placed at risk from increasing climate-change pressures and impacts. Cultural-heritage managers are working to increase understanding of these pressures and create ways to assess, mitigate, and/or adapt to change. Coastal-zone assessments (CZA) are a recognized methodology in several national management plans to gather detailed data in order to provide an informed assessment of current resources and any

associated hazards and risks. A collaborative and innovative partnership is seeking to expand on current CZA models by integrating social, historical, and geomorphological criteria into archaeological site assessment, with aims toward the development of a resource-priority index for coastal-heritage managers in Ireland.

Resumen El patrimonio costero y los sitios arqueológicos forman parte de un complejo sistema de procesos socioambientales cuyas condiciones se encuentran en riesgo ante las crecientes presiones e impactos del cambio climático. Los administradores del patrimonio cultural están trabajando para aumentar la comprensión de estas presiones y crear formas de evaluar, mitigar y/o adaptarse al cambio. Las evaluaciones de zonas costeras (CZA, por sus siglas en inglés) son una metodología reconocida en varios planes nacionales de gestión para recopilar datos detallados a fin de proporcionar una evaluación informada de los recursos actuales y cualquier peligro y riesgo asociado. Una asociación colaborativa e innovadora busca ampliar los modelos de CZA actuales mediante la integración de criterios sociales, históricos y geomorfológicos en la evaluación de sitios arqueológicos, con el objetivo de desarrollar un índice de prioridad de recursos para los administradores del patrimonio costero en Irlanda.

Résumé Le patrimoine et les sites archéologiques côtiers font partie d'un système complexe de processus socioenvironnementaux dont les conditions sont exposées au risque des pressions et impacts croissants

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du changement climatique. Les administrateurs du patrimoine culturel œuvrent à accroître la compréhension de ces pressions et à créer des moyens d'évaluer, d'atténuer et/ou de s'adapter au changement. Les évaluations de zone côtière (CZA, coastal-zone assessments) constituent une méthodologie reconnue par plusieurs plans nationaux d'administration afin de collecter des données détaillées visant à fournir une analyse éclairée des ressources actuelles ainsi que tous les dangers et risques connexes. Un partenariat collaboratif et innovant s'attache à généraliser les modèles CZA actuels par l'intégration de critères sociaux, historiques et géomorphologiques au sein d'une évaluation de site archéologique. L'objectif est le développement d'un indice de priorité des ressources pour les administrateurs du patrimoine côtier en Irlande.

Keywords climate change · management · coastal · Ireland

Introduction

Coastal heritage and archaeological sites are part of a complex system of socioenvironmental processes whose conditions are placed at risk from increasing climate-change pressures and impacts. Given the sheer number of sites and varied, numerous pressures on the current and future coastlines, “there is desperate need to achieve a comparable level of general reconnaissance ... together with a synthesis of archaeological and paleoenvironmental data” (Turner et al 2001:7–8). This requires an identification of the extent and nature of the surviving coastal archaeology and assessment of the potential impacts of natural and man-made threats, particularly during the current and future periods of increasingly intense climate change. Through innovative methodologies, cultural-heritage managers are rapidly working to increase understanding of these pressures and create ways to assess, mitigate, and/or adapt to change (e.g., allowing breaches of a medieval sea wall in Cwm Ivy on Gower in Wales [Gerrard 2017:59–60]). Several national management plans have created opportunities to gather detailed data and provide an informed assessment of current archaeological resources through risk registers and assessments. In Ireland, a collaborative partnership—the Climate, Heritage, and Environments of Reefs, Islands, and Headlands

(CHERISH) Project—is seeking to expand on current coastal-zone assessment (CZA) models by integrating social, historical, and geomorphological criteria into archaeological site assessment. This integration aims toward the development of a resource priority index for coastal stakeholders, including coastal-heritage managers.

Irish Cultural-Heritage Resource and Climate Change

Ireland's climate record shows that long-term weather conditions are changing, with the last century characterized by an upward trend in temperature (Dwyer 2012; Daly 2019), and, as the century progresses, an increase in heatwave events (Nolan and Flanagan 2020). Climate predictions for Ireland for 2041–2060 expose the potential for warmer, wetter winters alongside warmer, drier summers with an increase in incidence and severity of extreme weather events (Nolan 2015; Kerr 2019; Nolan and Flanagan 2020). Coastal landscapes are most at risk from these climate-change transformations, such as rising sea levels and increased storm surge, temperature, and acidification. Given accelerated and continuing shifts of extreme processes, Ireland's government declared a climate emergency in 2019 and has since taken efforts in many arenas to address knowledge gaps and management initiatives (Daly 2019).

The earliest Holocene human settlement in Ireland has been dated to around 9750 cal B.P. with site distribution during this Mesolithic Period suggesting a substantial coastal presence (Woodman 2015; Warren 2017). Therefore, millennia of Ireland's cultural heritage and archaeological sites presenting diverse traces of human activity are at risk of damage and/or loss to the effects of accelerated climate change. With increasing incidents of severe storms, coastal flooding, and coastal erosion, there is growing concern for how to preserve cultural and historic assets. Damage from catastrophic weather events, such as flooding and severe storms, is likely to increase at the same time as slow-onset environmental-deterioration mechanisms, although effects of these changes on cultural heritage will vary according to sensitivity, exposure, and adaptive capacity (Daly 2018, 2019).

Despite agreement on the need to monitor change and its impacts, a variety of global approaches have

been undertaken, and a lack of national strategies and models has been noted as a problem in past approaches to heritage management (Daly 2018). However, as cultural-heritage management transitions away from a low-priority resource in terms of political and social support, Ireland's heritage managers have sought to inform policy for coastal cultural heritage and climate change, especially where it intersects with arenas of tourism and recreation (Heritage Council 2009). The ICOMOS Ireland (Daly et al. 2010) methodologies for monitoring Ireland's cultural heritage against climate-change impacts and risk have developed into a framework of site-based vulnerability assessments focused on ranking climate-change impacts for defined heritage values (Daly 2014, 2018:98). Assessments inform policymakers on account of potential “[long-term accumulative and indirect climate effects] when developing conservation and management plans” that include “monitoring of conditions and vulnerability, identifying threats and designing responses” (Daly 2018:98–99).

CHERISH Background

To pursue the call for an understanding of the impacts of climate change and provide a mechanism for documentation and monitoring, CHERISH was developed as a cross-disciplinary project “aimed at raising awareness and understanding of the past, present, and near-future impacts of climate change, storminess, and extreme weather events on the rich cultural heritage” of Ireland and Wales (CHERISH 2021). Starting in 2017, the six-year, European-funded Ireland-Wales project has brought together four partners—the Royal Commission on the Ancient and Historic Monuments of Wales; The Discovery Programme: Centre for Archaeology and Innovation Ireland; Aberystwyth University, Department of Geography and Earth Sciences; and Geological Survey Ireland—to work toward the aim of “increasing capacity and knowledge of climate-change adaptation for the Irish Sea and coastal communities” (CHERISH 2021).

To achieve this goal, CHERISH has set nine objectives/initiatives: (1) Provide good-practice integrated guidance on surveying and recording of climate-threatened heritage sites using innovative technologies and techniques; (2) fixed survey markers representing 3-D baseline points of heritage

assets, providing data for monitoring of change; (3) enhanced and updated historical environmental data to inform priority heritage lists; (4) enhanced paleoenvironmental data from selected sites within a chronological framework to reconstruct past environments and inform adaptation strategies for the future; (5) seamless onshore-offshore digital maps derived from a range of survey methods (multibeam bathymetry, LiDAR, and photogrammetry) to provide data for planning and management among terrestrial, intertidal, and marine environments; (6) engage citizen scientists through workshops, conferences, seminars, and outreach events to train them in survey and recording and raising awareness of heritage at risk and climate-change impacts; (7) excavation of heritage sites at risk through community excavation and citizen-science involvement in local recording; (8) shared Web portal as a key tool for information and data delivery for awareness and future adaptation strategies; and (9) GIS data and detailed landowner-management plans showing cultural-heritage assets at risk to climate-change impacts (CHERISH 2021). To approach and accomplish these initiatives, CHERISH has created and adapted a toolkit to map, measure, and examine coastal cultural-heritage sites at risk from climate threats, utilizing methods that merge disciplines through techniques such as terrestrial, aerial, and geophysical survey; paleoenvironmental and archival research; LiDAR and airborne laser scanning; and rapid surveys using maps, proforma, and photography to provide a visual record and baseline data.

Coastal-Zone Assessment Development in Ireland with CHERISH Toolkit

Coastal-zone assessments have been utilized since the 1990s in Scotland, England, and Wales, working with communities to gather data and provide long-term monitoring of coastal archaeology; examples are detailed later in the article. In Ireland, as part of the innovative CHERISH toolkit, CZA provides a rapid but detailed method for gathering historical, geological, and geomorphological data of a particular historical part of a coast at a particular point in time (CHERISH 2021). Using a methodology broadly similar to other international examples, the CHERISH CZA uses a dual methodology to identify and assess

archaeological potential and risk to coastal cultural heritage. The main goals and objectives of the dual methodology—desk-based assessment and field survey—are to increase knowledge of coastal archaeological sites and identify sites currently or potentially at risk to loss from erosion or climate-related impacts (Mullin et al. 2009).

The CZA methodology has been developed to collate and review all previously recorded heritage sites and finds, as well as any relevant research within the survey area. In addition, historical maps and aerial photographs are examined to identify unknown sites and archaeological potential. Study of coastal geomorphology and physical evolution allows assessment of potential site vulnerability through current and predicted processes of climate-driven change. Subsets of sites that are considered at risk and vulnerable to change may also be considered to benefit from field survey and evaluation of potential management endeavors. Field survey then allows participants to record the erosion status of the coast as well as locate, verify, and identify archaeological sites and features. The dual evaluation aids not only in assessing risk, but can “provide a sound basis for developing management policies, including identification of areas or sites meriting further survey or evaluation; positive management action; and/or statutory protection” through resource prioritization (Wessex Archaeology 2013).

Literature Review

Climate Change and Archaeology

Coastal cultural and environmental resources contain valuable and irreplaceable information, while being increasingly threatened by development and climate-driven degradation processes (Russell 2004; Phillips 2014; Jones 2017; Dawson et al. 2020). The increasing urgency of the threat from climate change “has prompted heritage agencies around the globe to develop strategies for preservation and monitoring of coastal heritage resources, with many recognizing the need to prioritize the use [and management] of resources” (Dawson et al. 2020:8281). There is great diversity in existing and developing programs and approaches to addressing climate-change impacts on archaeological resources. The international

case studies examined here highlight how climate change is impacting archaeological resources in the coastal and marine zones and how changes are being addressed.

International Studies

On national and regional scales, governmental and nongovernmental organizations quantify and model impacts within the coastal historical environment and develop technology and techniques to identify threats and monitor resources. For example, since 2006, *Archéologie, Littoral et Réchauffement Terrestre (ALeRT)* has worked in France through a network of archaeologists, volunteers, museums, and regional societies to provide a series of scientific multidisciplinary tools to help establish policies and procedures for identifying, observing, and quantifying risks and threats to coastal cultural heritage (Daire et al. 2012). The project’s aim is to provide archaeological outputs, such as maps and databases from field observations at various scales, in essence, to establish a baseline of vulnerability to natural and anthropogenic threats and resistance capacity. The organizing principle to compile data for this project is a standardized evaluation procedure based on objective observation (Daire et al. 2012:177).

Despite major challenges to prioritizing and monitoring at-risk sites in the United States (e.g., variable perception and understanding of climate change, limited or restricted access to sites and associated data, jurisdiction and ownership issues, and often inaction), there is increasing recognition of the need for partnerships for collecting data on climate-change threats, informing prioritization, and monitoring of sites. This has included a focus on citizen science and significance vs. risk-focused prioritization. For example, the Florida Public Archaeology Network—established to protect Florida’s archaeological sites through outreach and education—created a system to increase awareness of the climate emergency and aid government entities via education and citizen-science engagement. Heritage Monitoring Scouts have provided the public with a larger role in protecting Florida’s cultural heritage from climate change and sea-level rise (Dawson et al. 2020:8282). Additionally, the United States National Park Service (NPS) uses four pillars of climate-change response for understanding resource significance, condition, and vulnerability to

threats, and determining options for management and/or dealing with loss: science, adaptation, migration, and communication (Rockman 2015:38–39). To utilize the best science available, increase capacity, and strengthen partnerships, the NPS seeks to merge cultural-resource research and planning with major climate-change approaches, such as scenario planning, disaster risk response, sustainability and mitigation, communication about climate change, and a growing recognition of loss management (Rockman et al. 2016).

There are several national and transnational programs focused on coastal climate change and cultural-heritage management using CZA survey methodology to identify heritage assets at risk from climate impacts and provide recommendations for management and prioritization. Although this section will highlight notable contributions to the development and use of CZA from such programs as Scottish Coastal Archaeology and the Problem of Erosion (SCAPE) and Historic England (formally English Heritage), there is growing representation of this technique across the globe.

Management of coastal heritage has normally been driven by the definition and perception of “value,” but with growing awareness of the scale of threats to coastal heritage it has been recognized that many sites may not have observable or quantifiable values that would attract resources for protection and defense (Dawson 2015). This, coupled with the sheer number of threatened sites, variable threats, and limited resources, prompted a progression of management-plan development to determine high-risk areas and inform management actions. SCAPE was initiated to create a record of significant archaeological and historical sites threatened by coastal erosion. Initial SCAPE coastal-zone assessments focused on developing a standardized system of prioritizing sites using a transparent and repeatable methodology, with archaeological, historical, and physical information correlated in a single platform for examining and assessing vulnerability. The preliminary staged approach scored sites on archaeological importance and risk of climate-induced damage, first characterizing sites in terms of size, complexity, relationships, nature of context, period, archaeological potential, condition, and threats from erosion. Groups were assigned based on relative value and importance, and then evaluated for fragility and vulnerability. Once

sites considered threatened were prioritized, recommendations for further actions could be assigned (Dawson 2013). Analysis of this technique exposed that desk-based assessment (DBA) was particularly successful at “identifying geological and geomorphological features and at providing an assessment of vulnerability to erosion. The DBA was not as useful when it came to identifying archaeological sites” (Dawson 2015:93). Thus, a hybrid approach was recommended and further developed. ShoreUpdate surveys were created to review the priority status of sites identified through desk-based analyses of coastal-zone assessment surveys by utilizing site visits and field surveys (Dawson et al. 2020). SCAPE’s dual, standardized methodology has been the basis for other CZA development, such as in Ireland.

Since 1997 Historic England has also commissioned several rapid coastal-zone assessments (RCZAs) to examine the response and possible loss of foreshore environments to rising sea levels and coastal erosion (Paddenberg and Hession 2008; Daire et al. 2012). Historic England recognized that, at the time, the coastal historical environment had been under-investigated, and that the current National Monuments scheme did not provide an adequate outlet for responding to challenges posed by climate change, such as flooding and coastal erosion (Milner 2012:229). Thus, RCZAs were initiated to provide a sense of the degree and nature of threats to the historical and archaeological resources of the intertidal zone and coastal hinterland (Crowther et al. 2008). As an example, the Severn Estuary RCZA was created to enhance the coastal-zone archaeological record and inform shoreline-management plans employed for coastal management. The Phase 1 desk-based survey utilized known literature, local-authority Historic Environment Records, and other data to record all known archaeological sites in the study area, provide an overview of coastal change, and assess current threats and erosion patterns to create a list of sites that would require further field observation. Aerial photography was also analyzed to confirm features and identify sites (Chadwick and Catchpole 2010:48). Pilot fieldwork was used to assess methodologies and logistics, as well as identify previously known sites and new features. Although other RCZA projects had involved survey of the entire coastline, the Severn Estuary Project used a targeted approach to locating and characterizing coastal archaeological features

(Chadwick and Catchpole 2010:50). Historic England has continued to utilize desk-based and field surveys as part of a dual RCZA methodology.

Irish Studies

The effects of climate change (e.g., increased precipitation, shoreline erosion) on coastal cultural heritage in Ireland vary by site type and environmental exposure. Increasing sea level and associated wave heights are increasing vulnerability to coastal flooding and inundation. With the increase in storm intensity and associated winds, precipitation, and storm surge, examples of structural damage to and erosion and exposure of cultural heritage are occurring across the country. For example, catastrophic hard-rock cliff destruction and erosion are occurring at Dunbeg Fort in County Kerry, and Croom Castle, County Limerick, experienced tower house collapse during Storm Damian in 2014. Additionally, severe storms in 2015 led to exposure and disarticulation of *La Juliana*—one of three Spanish Armada shipwrecks (1588) at Streedagh Strand (Daly 2019). Climate-change processes have also been associated with the exposure of human remains, such as disturbance during Storm Ophelia at Forlorn Point in 2017, and numerous other instances of uncovered remains on sandy shorelines due to coastal erosion have been reported (Daly 2019:47).

A six-stage vulnerability framework using a coupled human-environment analysis was developed and utilized at Skellig Michael, a UNESCO World Heritage site under climate-change impact threat of erosion from increased rainfall, extreme storm-surge events, and extreme wave heights. The vulnerability framework defined heritage values and the sensitivity, exposure, and adaptive capacity of such values over time, creating a matrix of hazards for each value and indicators for these elements (Daly 2014). Major considerations at Skellig Michael are the impact of visitors and increased erosion on steep slopes and shallow soil, and the results of assessments exposed vulnerabilities associated with impacts on health and safety of both visitors and conservation staff. The matrix system also allows for continual review and support from monitoring and review input from stakeholders and experts with local and site-specific knowledge (Daly 2011). Additionally, the Heritage Council funded a vulnerability assessment of Ireland's coastal

archaeological heritage. This report looked at the reconstruction of the paleogeography of Ireland, providing a preliminary assessment of coastal vulnerability and the coastal and intertidal archaeological resource (Edwards and O'Sullivan 2007). Bolton's (2009) doctoral research thesis explored, evaluated, compared, and contrasted the vulnerability to physical decay and deterioration of archaeological and architectural stone monuments located along the Irish coast with those found in unpolluted inland environments.

In response to anticipated climate-change extremes and consequences of increased exposure and structural damage to archaeological resources and subsequent loss of heritage values, Ireland's archaeologists and heritage managers have focused on documenting and recording coastal cultural heritage and the development of risk registers to establish priorities and guide resource use. With a goal of improving understanding of the vulnerability of each specific heritage resource to climate-change impacts, objectives have been set to establish a baseline from which change can be measured, risk and vulnerability assessed, and monitoring undertaken (Daly 2019). Actions toward these objectives include producing a quantification of the number, nature, and location of heritage assets coordinated into a single information and analysis system and the assessment of condition, hazard, and risk, examining vulnerability and focusing on high-value and high-risk heritage sites. These data aid in prioritization through ranking resources and suggesting management regimes for recording, monitoring, and responding to both long-term and abrupt change, direct and indirect impacts (Daly 2019).

The CZA survey methodology has been adapted and molded to fit the unique socioenvironmental characteristics of Ireland's coastal and intertidal zones, as well as policy and logistical considerations. The CZA has become a key component of the CHERISH Project toolkit, combining desk-based identification of the archaeological resource and historical environment with field survey and reporting. This approach allows a CZA team to “familiarize themselves with the survey area, access areas inaccessible by foot, and highlight areas of interest” by examining maps, photographs, historical records, and LiDAR, among other data sources, while also allowing the team to assess erosion status and identify and record features—both known and unknown—once in the field (CHERISH 2021). Project reports outline the survey area,

methods, and results, along with recommendations for further action. In Ireland, recording of coastal archaeological surveys around monuments as part of the CHERISH project has occurred since 2017, but the October 2021 case study outlined below details the first CZA use in an Irish context.

Methodology Development

UAV Survey and Analysis

The development of structure from motion as a photogrammetric processing technique has created the ability to analyze overlapping images and produce increasingly sophisticated high-resolution (~2.5 cm) and accurate (better than 2 cm) products (e.g., digital surface models). This, combined with unmanned aerial vehicles (UAV), or drones, creates “a powerful and flexible mapping system” (Shaw 2020) that enables the remote monitoring of the coast. Data extrapolated from various flights are compared via GIS to establish a baseline against which future surveys can be carried out (Shaw 2020). Identifiable and quantifiable data can confirm any changes, providing evidence of erosion, accretion, or stability; repeat UAV mapping will reveal the extent of changes over time and in the future.

Desk-Based Assessment

Desk-based assessments are created to provide an overview of coastal change, archaeological potential, and degree and nature of any threats to the historical resource (Grant et al. 2019). Records were gathered from archives, museums, and libraries in Britain and Ireland that contained historical charts, maps, military surveys, aerial photographs, photographs, and sketches. Locations of archaeological finds, sites, excavations, and shipwrecks were gathered from visiting the National Monument Service and National Museum of Ireland, as well as viewing Websites displaying these data that they support. The Office of Public Works provided coastal LiDAR data as well as predicted flood and erosion models for 2030 and 2050.

A core goal of desk-based assessments has been to create a single, transferrable platform for archiving, integrating, and analyzing data. For CHERISH, this

has been a GIS database that houses a combination of historical and environmental landscape information, allowing the overlap of data sets and a visualization of known archaeological and historical resources in relation to results of predicted erosion, flooding, and other coastal change. The coupled characterization of a study area not only allows preparation for field survey, but also to begin the process of risk evaluation and resource prioritization (Dawson 2013, 2015; Jones et al. 2021).

“Proforma” Development

To ensure that multiple users can gather similar and comparable data during field surveys, a standardized template is needed. The CZA “proforma” was developed and formulated to the Irish context, using design concepts from previous studies (e.g., Scottish Coastal Archaeology and the Problem of Erosion, the Royal Commission on the Ancient and Historical Monuments of Wales). The CHERISH template combines assessment of the coastal, geological unit, archaeological sites, and observable threats to the historical and environmental landscape. Geologists provide information on geomorphology and paleoenvironment remains and produce an erosion classification of the landscape based on characteristics immediately observable during field survey. Archaeological site significance and cultural and amenity value are assessed alongside current condition, erosion, and threats to site at the time of survey. The three most significant specific threats are given a detailed record, providing a summary of the site condition and trend. Archaeological sites and features are further assessed in terms of survival (reflection of the site or feature’s original form), vulnerability, and general monument risk level (current condition + condition trend + vulnerability). Taking into consideration all these elements, surveyors provide recommendations for each site, such as monitoring, resurvey, excavation, or even no further action (Dawson 2013, 2015).

Walkover Survey Method

Field survey focused on visiting known sites and features—identified from historical records, maps, and photographs—and recording previously unknown

and unrecorded sites during walkover. A handheld GNSS (global navigation satellite system) receiver was used to locate sites and a survey proforma was completed. Known and newly identified archaeological sites and features are documented with unique identification numbers, written descriptions, sketches, estimated measurements, and scaled photographs of characteristics and condition. For previously recorded sites, the walkover survey provides data on previously unknown associated features and condition changes, such as deterioration, exposure, or erosion status. For sites that are newly identified, the walkover survey provides a baseline of character and condition that can be used to document any future change. Viewing sites in person also allows surveyors the opportunity to recommend further actions based on current and comprehensive assessment.

Fingal County Overview

Previous Archaeology and Current Programs

Fingal County, part of the north Dublin Region, is a diverse landscape with nearly 10,000 years of history and heritage reflected in the area's archaeological sites and monuments, designed landscapes and demesnes, geological-heritage sites, protected structures, conservation areas, and architectural heritage (Fingal County Council 2021b; Fingal Chamber 2022). As such, the Fingal heritage officer Christine Baker and community members contribute to and participate in numerous heritage and archaeological projects that facilitate engagement through excavation and survey (e.g., the Dublin Archaeology GIS Project, the Field Monument Advisor Scheme, and the Community Archaeology Program) (Fingal County Council 2018). For example, the promontory fort and martello tower at Drumanagh are prominent features in the Rush landscape. The Digging Drumanagh-Fingal Community Excavation Project was designed to address gaps in research of the area and investigate the original martello tower approach road. In 2018 trenches within the promontory fort contained evidence of 18th- and 19th-century pottery and pipes, as well as earlier activity, including flint, glass beads, bone pins and combs, and fragments of human remains. The 2019 field excavation of the approach road and construction uncovered metal surfaces, stone

flags, and gravel of the Iron Age, as well as Romano-British artifacts, such as a weaving comb and bone tools (Fingal County Council 2021a).

Climate-Change Efforts and Impacts in the Area

Fingal County Council and Christine Baker, along with widespread community involvement, are working to keep the historical and archaeological heritage, such as Drumanagh, relevant and protected in the face of increasing climate change. This includes actions and goals undertaken through the “Fingal Heritage Plan 2018–2023” and the “Fingal Climate Change Action Plan 2018–2023”; the development of these plans is contextualized by local and national policies, and, on a county level, current and evolving heritage directives reflect the importance of engaging the community through cultural and heritage services (Fingal County Council 2018:11). Programs such as Fingal HeritageXClimate 2021 allow the public and local communities the opportunity to monitor and record climate-change impacts on heritage resources through a standardized online reporting program. The “Fingal Cultural Heritage and Climate Change Risk Assessment” (Fingal County Council 2021b) was undertaken to identify heritage resources throughout the entire county to provide a baseline assessment of the risk to Fingal's 2,219 heritage assets. The assessment—the first of its kind within an Irish context—consolidates a number of records and databases (e.g., the National Inventory of Architectural Heritage [NIAH], Sites and Monuments Records [SMR], the Record of Monuments and Places, archaeological conservation areas, and geological heritage sites) and ascribes attribute values to assets based on location, typology, designation, and class. Alongside the historical assets, the assessment provides an overview of the natural hazards that dominate in the region: fluvial flooding, pluvial flooding, groundwater flooding, coastal erosion, and slope instability.

A Heritage Risk Register was created, assigning each asset a risk score (the likelihood of being impacted by each of the hazards) and an impact score (the potential impact of that hazard on the asset) (Fingal County Council 2021b). Each asset is assigned three scores: one risk and one impact for each of the hazards and an overall score. The assessment found that 282 assets (12.7%) are in the highest potential-risk category from at least one natural hazard. When

viewed by overall score, the register shows the assets most highly impacted are those from coastal erosion and/or slope instability (Fingal County Council 2021b). Climate-change impacts in Fingal are estimated to include a rise in annual mean temperature and a variability in precipitation between increased dry periods and increased rainfall. This increase in precipitation implies significant issues with flooding, especially around low-lying beaches and estuaries. The Fingal County heritage-risk assessment shows that 6% of the county's resources are highly exposed to coastal flooding, scattered along the full Fingal coastline. It is anticipated that this number will increase over time due to predicted climate-change impacts. The potential risk from coastal erosion occurs in 4% of the heritage assets, but it is predicted that those resources in the coastal belt may be completely eroded by 2050 (Fingal County Council 2021b).

Case Study: Fingal Coastal-Zone Assessment

Desk-Based Assessment Results

The desk-based assessment was created in fall 2021 to collate and review known available data regarding the physical and historical environment of the intertidal zone and immediate hinterland from, approximately, Loughshinny Harbor to the Rush edge of Rogerstown Estuary (Fig. 1). While the green polygon represents the general study area, the yellow line designates the walkover path taken during archaeological survey, and sites recorded during the survey are marked with red triangles.

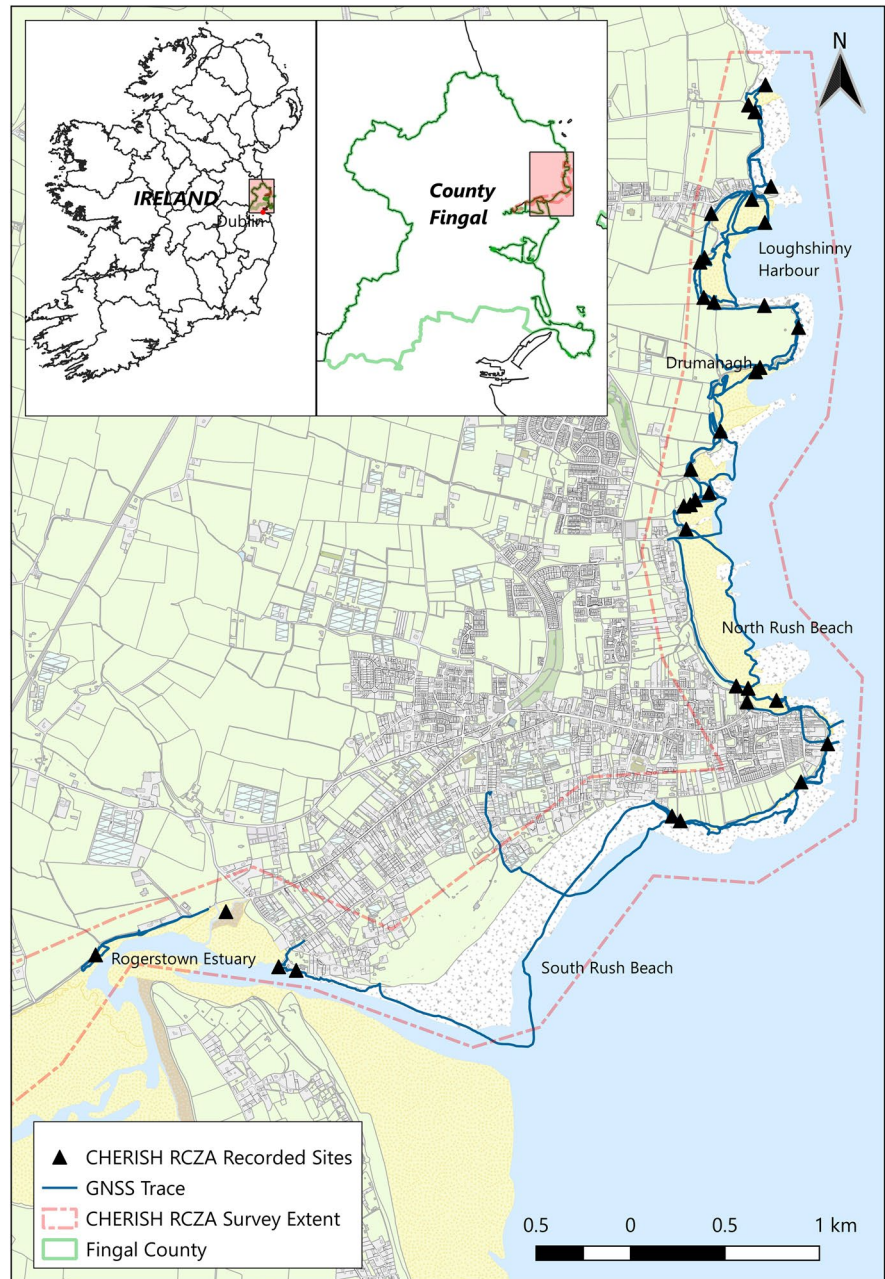
This stretch of coastline is the culmination of various geological periods and changing environments that have altered coastal geomorphology through stages of uplift, subsidence, and erosion. Variable sedimentation rates and types and seabed depths have led to varying rates of erosion and geomorphological diversity, creating a long and narrow coastline within a central lowland region. Continuous lower Carboniferous-period rock successions and folded compressions are prominently featured at Loughshinny (Parkes 2012). The study area varies between high cliffs and headlands and walkable beaches south of Loughshinny, at Rush. The beach

at Rush is approximately 2.4 km long and backed by sand dunes and the adjoining Rogerstown Estuary, which is separated from the sea by a sand and shingle bar and drains at low tide with intertidal flats of mud and sand (RPS 2013).

Examination of the historical landscape was enabled with assessment of previous archaeological and excavation reports, SMR, historical maps and charts (e.g., 1775 McKenzie coastline charts, a statement on ordnance from the 1830s concerning the martello towers from the National Archives in Kew, 1852 and 1855 Fingal coastline maps from Loughshinny to Malahide, and the 1648 Down survey), National Museum topographical finds, the NIAH, and aerial surveys, including military archives and those held at Cambridge (University of Cambridge 2022). Archival and previous archaeological research, along with SMRs, depict prominent excavations in the study area of Rush that have occurred during a variety of monitoring and survey projects, as well as local-resident discoveries (Table 1). In addition to the SMRs in Table 1, there are a further 17 shipwrecks recorded in the Underwater Archaeology Unit (part of the National Monument Service) for the study area, the oldest being a Norwegian vessel called *Nicholas* from 1774 that “sprang a leak *en route* from Drogheda, crew forced to run vessel ashore, vessel not expected to get off” (Brady 2008:177).

In 1932, plowing in Whitestown uncovered an inhumation burial with a bowl, protected by small stones. The capstone, vessel, and skull were all lifted by the finder, the vessel being broken and the skull damaged before being replaced (Mahr and Price 1932). Early Bronze Age grave goods were found in 1934 during a land reclamation adjacent; a cist burial containing an inhumation and bowl was found, the site reduced in size from when it was first indicated on first-edition OS 6in maps (O’Riordain and Price 1934). In 1989, in the same townland, a skull and long bone were discovered with a semicircular arranged grave and a small amount of cremated remains. Sites and features, such as a cereal-drying kiln, have been uncovered during topsoil stripping and monitoring in Rogerstown (Byrne 2010a), while a major high-voltage East–West Interconnector Project uncovered multiple features and artifacts, such as flint, medieval

Fig. 1 Study area with recorded sites and survey path. (Map by authors, 2022; base map from ESRI, 2021.)



and postmedieval pottery sherds, and clay pipes, in topsoil stripping north of Rogerstown Estuary and trench excavations along the roads to the village or Rush (Byrne 2010b, 2012). Charcoal spreads, burnt bone, late Iron and Bronze Age vessels, worked flint, and a shallow gully have also been exposed during engineering test pits along the Skerries Road in 2005 (Meenan 2005).

Drawings and maps created during historical geological surveys exposed not only physical features, such as the famous Loughshinny geological folds, but also associated an historical building and wall that were then used to locate features during field survey (Figs. 2, 3).

Aerial photographs and orthoimages from various archives and years provided evidence of prominent

Table 1 Previously documented sites within 300 m of shore in the SMR and NIAH

Archive	Registration No.	Class	Townland
SMR	DU008-006001-	Promontory fort—coastal	Drumanagh
SMR	DU008-006002-	Well	Drumanagh
SMR	DU008-006003-	Martello tower	Drumanagh
SMR	DU008-006004-	Enclosure	Drumanagh
SMR	DU008-006005-	Structure	Drumanagh
SMR	DU008-006006-	Enclosure	Drumanagh
SMR	DU008-006007-	Enclosure	Drumanagh
SMR	DU008-006008-	Ring-ditch	Drumanagh
SMR	DU008-006009-	Ring-ditch	Drumanagh
SMR	DU008-013001-	Megalithic tomb—passage tomb	Rush
SMR	DU008-013002-	Cist	Rush
SMR	DU008-013003-	Midden	Rush
SMR	DU008-015----	Martello tower	Rush
SMR	DU008-022----	Ritual site—holy well	Rush
SMR	DU008-051----	Enclosure	Loughshinny
SMR	DU008-077001-	Enclosure	Rogerstown
SMR	DU008-077002-	Road—road/trackway	Rogerstown
SMR	DU008-077002-	Road—road/trackway	Rogerstown
SMR	DU008-077003-	Field system	Rogerstown
SMR	DU008-078----	Ring-ditch	Rogerstown
SMR	DU008-079----	Field system	Rogerstown
SMR	DU008-080----	Enclosure	Rogerstown
SMR	DU008-081----	Enclosure	Rogerstown
SMR	DU008-090----	Promontory fort—coastal	Rush
SMR	DU008-094----	Enclosure	Drumanagh
SMR	DU008-108001-	Burial	Rogerstown
SMR	DU008-108002-	Enclosure	Rogerstown
SMR	DU008-108003-	Road—road/trackway	Rogerstown
SMR	DU008-109----	Fulacht fia	Rogerstown
SMR	DU008-110----	House—Neolithic	Rogerstown
NIAH	11318004	Drumanagh Martello Tower	Drumanagh
NIAH	11318005	Loughshinney Boathouse	Loughshinny
NIAH	11318006	Harbour View	Loughshinny
NIAH	11318007	Loughshinny Pier	Loughshinny
NIAH	11324012	Water pump	Rush
NIAH	11324013	Rush Harbour	Rush
NIAH	11324023	Rush Martello Tower	Rush
NIAH	11324032	Old Kilbush House	Rush
NIAH	11329017	Rogerstown House	Rogerstown
NIAH	11329017	Rogerstown House	Rogerstown
NIAH	11329017	Rogerstown House	Rogerstown
NIAH	11329017	Rogerstown House	Rogerstown

sites over time, such as the promontory fort at Drumanagh, but also exposed some features in the landscape that were not part of the previous survey

or documented reporting (i.e., enclosures). Some sites were found in the desk assessment, but their previous recorded positions were vague and were not located

Fig. 2 Survey drawing of Loughshinny Folds (Du Noyer 1857).



Fig. 3 Feature documented during field survey, October 2021. (Photo by Jennifer E. Jones, 2021.)

on survey, such as a shipwreck described as near the sewer in Rush (Brady 2008) and a navigation mark shown on 18th- and 19th-century maps of sand flats

at the mouth of Rogerstown Estuary. This may have been from site arrival at the not-optimum tidal stage, erosion or shifting sediments covering any remaining traces.

Assessment of the geological and physical environment, as well as historical shoreline change were facilitated by access to Ordnance Survey's geological maps, the Office of Public Works (OPW) erosion and flooding data, Ordnance Survey orthoimages, and Geological Survey Ireland coastal-vulnerability index data (Caloca et al. 2022). Coastal-vulnerability data combines coastal indicators, such as geological-boundary factors, coastal forcing, and coastal processes into a single measurement of vulnerability of an area to likely be affected by impacts of climate change, such as sea-level rise (Geological Survey Ireland 2021; Caloca et al. 2022). Data created for the Fingal area show that the study area exhibits variable shoreline rates and vulnerability classes ranging from very low to high (Fig. 4).

The area around Loughshinny Harbor in the north of the survey area exhibits moderate vulnerability, but as one moves south along the coastline this moderate vulnerability is interspersed with pockets of high and low vulnerability around the Drumanagh Promontory area and North Rush Beach. Vulnerability remains low to moderate around the Rush Martello Tower; however, at south Rush Beach, shoreline rates and vulnerability class become high or very high until

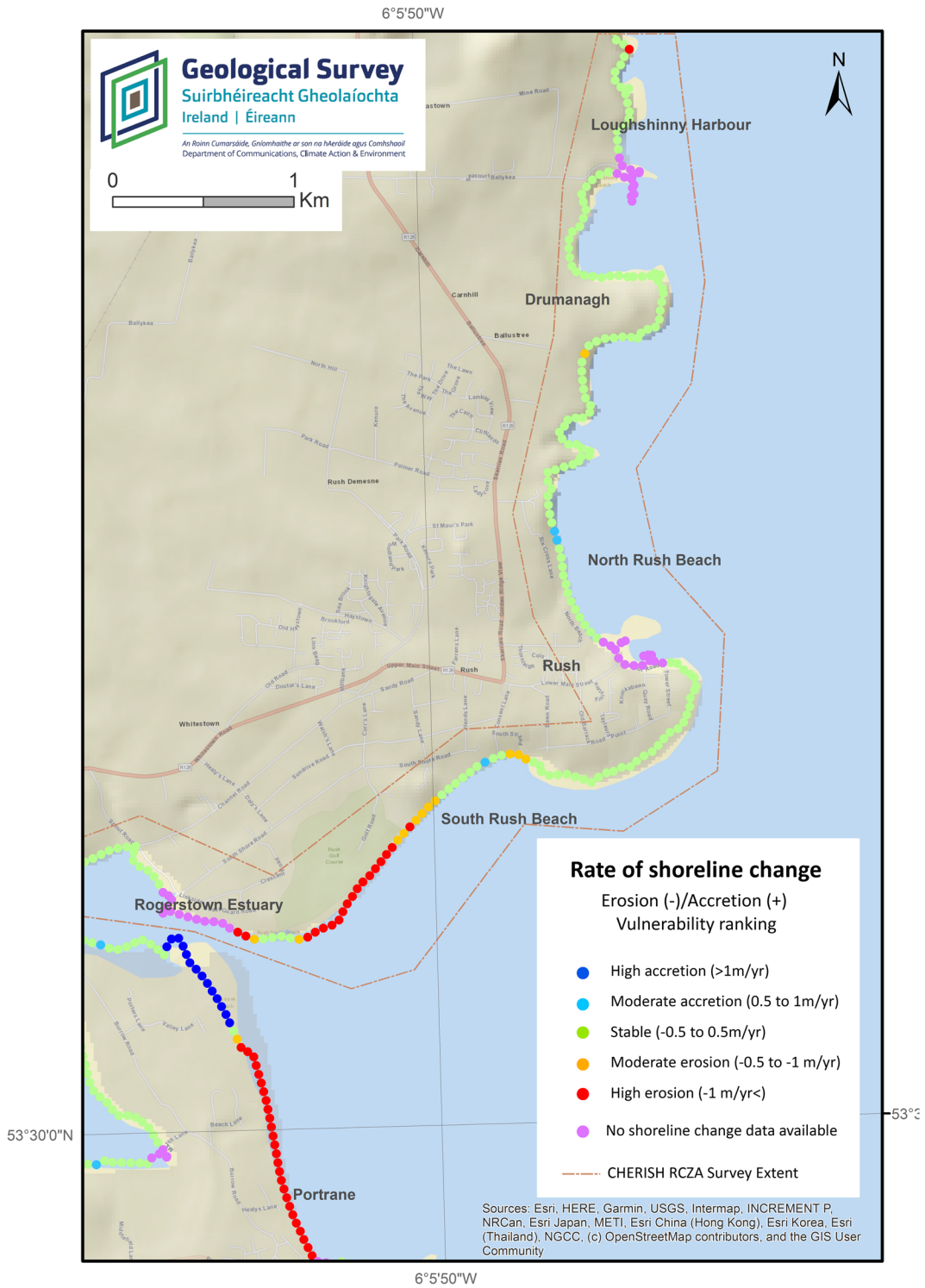


Fig. 4 Distribution of long-term shoreline change (m/yr) and vulnerability classes for the period 2000–2020 in the area of Portrane-Rush (North Dublin, Ireland). (Map courtesy of Geological Survey Ireland, 2022.)

entering the Rogerstown Estuary. This area is prone to high erosion rates and dune scarping (Fig. 4).

Field-Survey Results

The survey area was an 8 km stretch of coastline from north of Loughshinny Harbor to the Rogerstown Estuary (Fig. 1), consisting of an archaeological and geomorphological survey. The geomorphological survey was conducted in October 2021 by a two-person CHERISH Project team that surveyed the coastline, recording geomorphological and substrate type, and erosion and aggradation of erosion of soft sediments, rating from stable to major or aggrading. Once mapped, these data provide a visualization of current erosion potential in the study area as well as in relation to sites and features recorded during archaeological field survey (Fig. 5) (Table 1). As with erosion at specific sites and features, coastline erosion in the study area is variable, being stable to slight around Loughshinny Harbor and Rogerstown Estuary, but showing medium, widespread erosion around headlands and North Rush Beach. When one considers the rates of coastal erosion in relation to the recorded survey sites, one can see that many of the sites are located within general stable, slight-, or medium-erosive coastlines. Although there are two locations along the coastline that are in a state of major erosion—North Rush Beach and South Rush Beach—these survey locations do not correspond to any recorded sites. A possible 20th-century mooring occurs near the major erosive location in North Rush Beach, but the site itself is in fair condition with a medium level of risk and vulnerability.

Intertidal substrate varied from sandy beaches, easy to walk across at low tide, to rocky shores consisting of small cliff promontories, wave-cut platforms separated by small pebble to boulder beaches. If the rocky shores were possible to traverse, the route was very irregular due to the varying landforms making progress slower. A public cliff-top path extends from Loughshinny Harbor to the northern outskirts of Rush. This path went around larger promontories and bays. Occasional smaller paths allowed access down the cliffs to enclosed bays. The largest settlement was at Rush, and much of the land back from the shore there is urban, with farmland to the north and south. The survey finished on the northern side of the Rogerstown Estuary. The intertidal zone at the estuary

mouth is sandflats and -bars with mudflats within the estuary. The mudflats were not possible to walk across safely due to the soft substrate in which a surveyor could get stuck, but a road and track ran above along the high-water mark. Time constraints due to the tide, irregularity of substrate, wide sand flats, and access meant it was not possible to have total coverage at low tide (Table 2).

The archaeological walkover survey consisted of two surveyors and began near the cliff top path from Loughshinny Harbor at a higher stage of tide on the afternoon of 8 October 2021 (Fig. 1). The intertidal survey started the following morning during low spring tides of 0.2 m on 9 October rising to 0.9 m on 12 October. The surveyors had to start early to make the most of the hours around low tide. For areas of coast where there are sandbanks and no exit from the beach due to steep cliffs landward, the surveyors undertook intertidal survey before low tide. The area nearer the high-water mark and the cliff tops was mostly surveyed in late morning and early afternoon as the tide returned. Depending on beach access, this allowed a circular walk near the low-water mark and back nearer the high-water mark to each day's starting point.

The survey team recorded 34 sites and features over five days, 16 of which had previous documentation. Based on developed proforma, sites were documented according to their statutory protection, period, type, and importance, all which varied considerably along the study area. Current site condition was evaluated, along with erosion status, condition trend, and an assessment of cultural value, vulnerability, risk, and survival. Following this assessment, recommendations for future actions or management were also recorded (Fig. 5).

The most common site types in the study area were artificially cleared shorelines, slipways, moorings, and piers—sites to be expected in a coastal location. Eroding sites in the cliff included stone-lined graves, suggesting a previously unknown graveyard; possible Mesolithic flints found below a megalithic tomb; and shell middens, some of which are previously unrecorded features associated with previously recorded promontory forts. Intertidal sites included a copper mine, fords, posts from jetties, and landing places associated with cliff access paths. Given this variation in period and type, site significance also varied on local and regional levels (e.g., Loughshinny Pier, Harbor, and Boat-house), as well as on national levels (e.g., Drumanagh

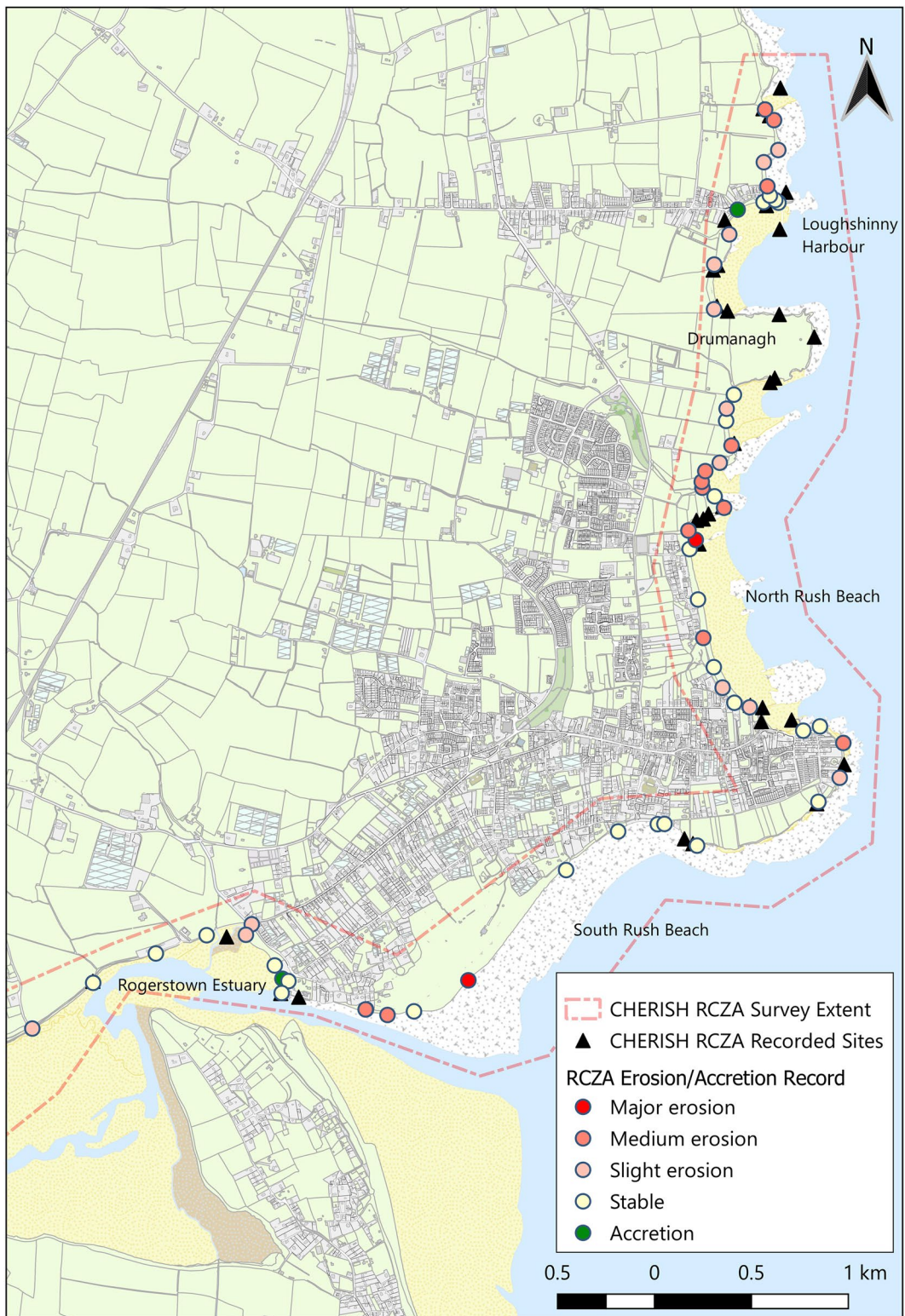


Fig. 5 Sites recorded and erosion status from field survey, October 2021. (Map by authors, 2021.)

Table 2 Sites recorded during field survey, October 2021

Site No.	Import.	Site Type	Period	Surv.	Curr. Cond.	Cond. Trend	Vulner.	General Risk Level	Cult. Value	Recomm.
001	Regional	Pier	1835, expanded by 1906	Intact	Good	Stable	Low	Low	High	Do nothing
002	Local	Boathouse & landing	Between 1835 and 1906	Intact	Good	Stable	Medium	Low to medium	High	Do nothing
003	Local	Shell midden	19th century	Not known	Poor	Not known	High	High	Medium	Do nothing
004.1	National	Subsidiary promontory fort	Iron Age/early medieval	Intact	Fair	Stable to worsened-superficial	Low to medium	Medium	High	GNSS survey
004.2	National	Ring enclosure	Iron Age/early medieval	Not known	Good	Insufficient information	Medium	Medium	High	Excavate
004.3	National	Spring & embankments	Iron Age	Partial	Fair	Medium	Medium	Medium	High	Monitor, UAV survey
004.4	National	Constructed path down cliff, midden	Napoleonic	Partial	Fair	Worsened-moderate	Medium	Medium	Medium	GNSS survey
004.5	National	Artificially cleared shore	Iron Age/early medieval	Partial	Fair	Medium	Medium	High	Medium	GNSS survey
005	Local	Copper mine	19th century	Near destroyed	Fair	Stable to worsened-superficial	Medium	Medium	Medium to high	Monitor
006	National	Shell midden; bank & ditch	Iron Age/early medieval	Not known	Fair to poor	Insufficient information	Medium to high	Medium	Unknown	Cliff access recording; excavation
007	Local	Constructed path down cliff & artificially cleared shore	18th century	Partial	Fair	Insufficient information	Medium	Medium	Medium	GNSS survey at low tide
008	Local	Landing place	18th century from smuggling associations?	Partial	Fair to poor	Insufficient information	Medium	Medium	Medium	Do nothing; monitor
009	Local	Ship timber	20th century	Wreckage	Very poor	Worsened-moderate	High	High	Low	Do nothing, but GNSS with other features in the bay

Table 2 (continued)

Site No.	Import.	Site Type	Period	Surv.	Curr. Cond.	Cond. Trend	Vulner.	General Risk Level	Cult. Value	Recomm.
010	Local	Artificially cleared shore	18th century	Near intact	Fair	Stable	Low	Low	Low	Do nothing
011	Local	Artificially cleared shore	18th/19th century	Near intact	Good	Stable	Low	Low	Medium	Do nothing, but GNSS with other features in the bay
012	National	Graveyard	Bronze Age/Iron Age	Partial	Poor	Worsened-severe	High	Immediate	High	GNSS, drone survey, cliff access, oral history, excavation
013	Local	Field boundary, house, or possible enclosure/promontory fort	Prehistoric? 18th century	Partial	Fair to poor	Worsened-moderate	Medium to high	Medium to high	High	Monitor; GNSS survey
014	National	Megalithic tomb/midden	Mesolithic/Neolithic	Partial to near destroyed	Poor	Worsened-superficial to worsened-moderate	Medium to high	Medium to high	High	Excavation; GNSS survey
015	National	Shell midden (possible)	Prehistoric	Partial	Fair	Insufficient information	Medium to high	Uncertain	Unknown	Monitor; drone survey; cliff access recording
016	Local	Breakwater	19th century	Intact	Good	Stable	Low	Low	High	Do nothing
017	Regional	Pier	18th century	Intact	Good	Stable	Low	Low	High	Do nothing
018	Local	House	18th century	Partial to near destroyed	Fair	Worsened-superficial to worsened-moderate	Medium	Medium	Medium	Monitor, vegetation clearance to assess with GNSS
019	Local	Mooring?	Unknown	Intact	Good	Stable	Low	Low	Low	Investigate with waders/dry suit
020	National	River ford/crossing/associated shell midden	Late medieval	Not known	Fair to poor	Insufficient information	Medium to high	Medium to high	High	Excavation; resurvey

Table 2 (continued)

Site No.	Import.	Site Type	Period	Surv.	Curr. Cond.	Cond. Trend	Vulner.	General Risk Level	Cult. Value	Recomm.
021	Local	Stone building foundation	20th century	Partial	Poor	Insufficient information	Medium	Uncertain	Unknown	Monitor, GNSS survey
022	Local	Holy well	Early medieval to present	Intact	Good	Stable	Low	Low	Medium	Check we have the correct well
023	National	Landing place	19th century	Partial	Poor	Worsened-moderate	High	High	Medium	GNSS survey
024	Regional	Jetty	Between 1835 and 1906	Partial	Good	Insufficient information	Medium	Low	Low	Do nothing
025	Regional	Pier	Before 1835	Intact	Good	Stable	Low	Low	High	Do nothing
026	Local	Boat/farm engine	20th century	Partial	Fair	Stable	Medium	Medium	Low	Do nothing
027	Local	Mooring?	20th century	Partial	Fair	Stable	Medium	Medium	Low	Do nothing
028	Local	Slipway	Between 1835 and 1906	Intact	Good	Stable	Low	Low	Medium	Do nothing
029	Local	Artificially cleared shore	19th century	Partial	Fair	Worsened-superficial to worsened-moderate	Medium	Low	Low	GNSS survey
030	Local	Slipway	Between 1835 and 1906	Intact	Good	Stable	Low	Low	Medium	Do nothing

Promontory Fort National Monument). Along with significance, amenity and cultural value were assigned to sites, ranging from none to high. Twelve sites were recognized as having high amenity/cultural value with remains easily visible and understood.

Site erosion rates also varied considerably along the coast. Although stable conditions were recorded at 10 of the 34 sites and features, many exhibited some form of erosion or threat, rated from slight to severe. Major erosion was recorded as occurring at a 19th-century shell midden, Iron Age/early medieval cleared shoreline and stone wall, Iron Age/early medieval shell midden, prehistoric shell midden, and a 20th-century stone house. Major to severe and/or severe erosion occurred at a Bronze Age/Iron Age stone-lined grave and Mesolithic/Neolithic tomb/midden, while high erosion was noted for a ship timber located on a storm beach.

Survival was recorded as intact or near intact at 12 of the 34 sites. An additional 12 sites were considered partially surviving, while 3 were considered near destroyed or only some features surviving, probably as buried remains. Along these lines, 12 of the 34 sites were recorded in a state of good condition, defined as form and structure of the asset survives well and damage (e.g., intrusive vegetation or erosion scars) is little. Fair condition—some damage or destruction apparent, but not affecting the asset as a whole—was noted on 12 sites, while 4 sites were recorded as fair to poor, 5 being in poor condition (active damage and/or decay that affects the form and integrity), and 1 site—the ship timber/wreckage—as very poor. Although there was insufficient evidence to evaluate condition trend at 8 of the sites—mainly given that there was no previous record—site stability was noted at 13 of the sites. Ten of the remaining sites recorded during this survey showed evidence of trends from stable to worsening conditions. The worsening conditions varied from superficial trends (i.e., damage is restricted to localized areas or minimal damage that may be improved by natural repair or change of management); moderate (i.e., damage that is active, requires more concerted management for recovery); and severe (i.e., major damage or collapse that will require urgent action and specialist management).

Given current conditions, vulnerability was assessed during field survey, with four of the sites considered to be of high vulnerability, where the threat exists or is likely to develop and the asset's

condition is likely to deteriorate over the long term. These sites included ship wreckage, the stone-lined graves, and a landing place. Additional sites were recorded with variable vulnerability ranging from high to low categories. Those sites with a low vulnerability ranking were considered to have no identifiable threat, or the threat was being adequately managed to prevent deterioration. Provided an assessment of current condition and condition trend, general monument risk level was recorded on a scale from uncertain to immediate. Due to high erosion and slumping on the cliff face exposing the Bronze Age/Iron Age stone-lined graves, the site was rated an immediate risk level, as the condition trend was expected to be severely worsened. Four of the recorded sites were documented as having high general risk level, showing poor/very poor condition and superficial or moderate worsening condition trends. The remaining sites exhibited varying levels of risk between medium and low. Recommendations for management or further action at sites covered a range of options, including monitoring, resurvey, and even excavation; however, given the overall risk, vulnerability, and value of the sites, GNSS marking monitoring was recommended in many cases, while "no further action" was warranted at several of the sites.

Discussion

Some issues have been recognized in the development and implementation of CZAs through previous studies and the current case study. Given localized deposition and often rapid change, there can be problems in classifying erosion, deposition, and/or stability of a coastal site. For example, only sites visible on the day of a survey are recorded; many sites can be obscured by sand deposits or may become uncovered during storm events and subsequently recovered as the coastline comes back to its normal processes (Dawson 2015; Jones 2017). As such, field surveys are highly dependent on day-of conditions. Additionally, certain types of terrain may limit the ability of surveyors to gather complete survey data in the field: high cliffs, steep slopes, and/or rocky shorelines can prevent access to sites for taking pictures, measurements, or notes. However, this may be balanced with the use of desk-based assessment and of advanced recording methods, such as drone photography.

Data gathering during the development and implementation of desk-based assessments and field survey may also create issues with interpretation. The alignment of various sources of spatial data and variable coordinate systems can create errors in spatial locations, and, either through lack of availability or low quality of data, regional or local data coverage may be lacking (Fingal County Council 2021b). Additionally, data normalization and a standardized vocabulary for characterizing assets (i.e., type, class, period, etc.) is also warranted for gathering data in the field; surveyors—archaeologists, geologists, citizen scientists—need to be aware of the definitions and contexts for defining archaeological and heritage resources in their specific study area. The development of a standardized system, such as the CZA, may help overcome issues with defining cultural values, significance, and risk both before and during field assessment.

Development of Ranking and Indexes

Ranking resources and sites for the purpose of prioritizing management has been gaining traction in archaeological-resource management, especially in the face of increased risk associated with global climate change (Phillips 2014; Graham et al. 2017; Heathcote et al. 2017; Heilen et al. 2018; Nash and Wholey 2018). The foundation for gathering data, identifying vulnerable at-risk resources, and developing community partnerships that sustain management initiatives are all present in the CZA methodology. These data, in turn, can be used toward the end goal of ranking sites in some form of priorities for management. For example, data gathered through CZA provide the variables and indicators used to assess conditions in archaeological/historical sites, the coastal environment, and the communities that value and utilize the resources. These indicators can reveal current conditions and values and trends in change. Either as direct measurements or proxies based upon relationships, indicators gathered through CZA can be grouped into meaningful and specifiable aspects of archaeological-site stability. These quantifiable variables and their attributes can be aggregated into an index that summarizes and ranks the indicators gathered from the CZA methodology, providing an overall score, rank, or grade for a coastal archaeology site's vulnerability and/or risk. This system provides managers with the basis for systematically aggregating the complex conditions based

on the specific issues encountered at their sites. This is also an integrated mechanism for standardizing documentation aimed at prioritizing at-risk sites and their management (Jones et al. 2021), a major concern for and theme of heritage-at-risk recording and monitoring worldwide.

Comparative Analysis

These assessments and registers of risks and threats to cultural heritage may be considered living documents from which further monitoring and data gathering can contribute to exposing shifts and changes from baseline assessments and clarifying definitions and contexts. As the issues of vulnerability, stability, risk, and value of coastal archaeological sites are complex and varied, there is need to test the applicability of a standardized system, such as the CZA methodology, at various sites. The intention of the current project is to conduct further CZA using the CHERISH-developed proforma and toolkit in study areas on the Irish west coast in Spring 2022. This will not only provide a baseline assessment of the area's heritage assets and associated climate-change threats, but also another set of data aimed at refining the standardized and transferable system.

Conclusions

Ireland has seen the detrimental impacts of climate change, and risks will only increase. With approximately 7,400 km of coastline, the irregular bay and headland configuration of Ireland's coastline creates variable exposure to climate-change threats, from increased waves and tidal action that attack cliff bases and move sediments, to heavier landfall and shoreline retreat. These actions may be localized but still catastrophic to the landscape and associated cultural heritage and may be seen as both immediate and catastrophic, as well as cumulative and long term.

The CHERISH Project seeks to target data gaps and raise awareness of threatened heritage in coastal locations (Baker et al. 2019). In this the objectives vary, and, in some cases, it may be preemptive “preservation by record in the face of inevitable loss; [or] cross-disciplinary techniques ... used to establish records of past environments, storminess, and extreme

weather events” (Baker et al. 2019:12). Cross-disciplinary practice continues to adapt to respond to climate-change impacts. As part of the climate toolkit for heritage sites, CZAs provide information on both short- and long-term conditions, highlighting the cultural and environmental characteristics of and climate-change impacts to coastal archaeological sites, both known and unknown. In addition to assessing the risk and vulnerability to coastal historical resources, the CZA can not only provide an archive of archaeological documentation, but also data that can be used to assess significance and rank sites in terms of prioritization for management action. CZAs may also be used to engage both policymakers and the public in a discussion of the immediate and cumulative consequences of climate change on heritage preservation, providing timely scientific data and management information for both present and future communities.

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Declarations

Conflicts of Interests/Competing Interests There are no financial interests or arrangements in the context of this manuscript that may be perceived as a real or apparent conflict of interest.

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