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Preservation by Record of Ireland's Shell Middens: Citizen Science Practice and Pedagogy

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Abstract PRISM (*Preservation by Record of Ireland's Shell Middens*) was a citizen science pilot in Ireland that mobilised volunteers to record vulnerable coastal shell middens through a digital reporting platform. The project enabled rapid documentation, targeted rescue sampling, and new radiocarbon determinations, while serving as a field-based teaching laboratory that tested place-based, co-productive approaches to at-risk heritage. By bringing deep-time archaeological archives into dialogue with contemporary climate hazards, PRISM, and similar projects, can advance environmental humanities practice and inform alternative climate adaptation strategies.

Keywords Citizen science. Coastal archaeology. Shell Middens. Place-based learning. Climate adaptation.

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1 Introduction

Human-induced environmental and planetary change has been the subject of extensive exploration in social sciences, humanities, and broader cultural frameworks.[1] In recent years, the environmental humanities (EH) have emerged as a vital field that challenges the separation of nature and culture and foregrounds questions of meaning, ethics, and justice in discussions of environmental change.[2] Scholars stress that climate change is not only a physical phenomenon but also a cultural one, shaped by competing narratives, images, media, and values (Higgins et al. 2020). Teaching the environmental humanities therefore requires attention to both scientific knowledge and the socio-cultural contexts through which it is understood and contested. The urgency of climate change, coupled with the loss of cultural heritage through erosion, sea-level rise, and other environmental hazards, calls for pedagogies that engage learners and the broader research community with complex socio-ecological systems and encourage collaborative responses (Holm et al. 2013; Izdebski et al. 2016).

Climate change has led to a myriad of impacts that resonate across all levels of our planetary systems. These impacts are varied and extensive, and present multiscalar challenges across physical, biological, and human systems. For instance, melting polar ice and glaciers, rising sea levels, and shifting weather patterns are tangible manifestations of a warming planet (IPCC 2022). Concurrently, these alterations trigger biological impacts, including shifts in species distribution, changes in phenology, and heightened risk of extinction.[3] Human societies, particularly those most vulnerable and least responsible for emissions, grapple with increased food and water insecurity, loss of livelihoods, threats to health, and displacement, further exacerbating existing socio-economic and political inequities (Adger et al. 2012; Markkanen, Anger-Kraavi 2019; Nyiwul 2021). The socio-cultural relationships that local communities maintain with their surrounding environments are also disrupted, leading to the erosion of cultural identities, knowledge systems, and ways of life (Eira et al. 2018; Green, Raygorodetsky 2010; Williams 2012). The intricate and multi-dimensional nature of these impacts calls for

1 See Briggle 2021; Bulkeley 2021; Hamilton et al. 2015; Leichenko, O'Brien 2020; Little et al. 2023; Merchant 2020.

2 See Castree 2021; Hansard, Moskowitz 2022; Holm et al. 2015; O'Gorman et al. 2019; Rose et al. 2012.

3 See Antão et al. 2022; Bestion et al. 2015;; Chatzimentor et al. 2023; Parmesan 2006; Urban 2015; Visser, Both 2005.

a profound shift in our understanding and responses to this crisis (Adger et al. 2012; Bauer, Bhan 2018; Holm, Winiwarter 2017).

In response to the planetary crises, EH curricula have proliferated across Europe over the past decade, yet they remain diverse and unevenly distributed. In the United Kingdom, for example, Bath Spa University created the first Master's programme in Environmental Humanities (MAEH) in 2016, drawing on strengths in ecocriticism, environmental philosophy, anthropology and heritage studies. Similar programmes at King's College London and the University of Leeds combine climate history, culture and society, postcolonial ecocriticism, and disaster studies (O'Gorman et al. 2019). In Ireland, the Trinity Centre for Environmental Humanities was established at Trinity College Dublin in 2017, offering an MPhil in Environmental History that promotes mixed (quantitative-qualitative) methods and interdisciplinary EH approaches. Indeed, Northern Europe hosts several such research hubs, including the Environmental Humanities Laboratory at KTH Royal Institute of Technology, or the Oslo School of Environmental Humanities, to name but a few (O'Gorman et al. 2019). It's important to note that while some programmes and centres may carry an explicit EH label, many nonetheless integrate EH approaches into various areas of environmental and historic studies. For instance, the Rachel Carson Center for Environment and Society (RCC) in Munich. What unites these initiatives is a commitment to interdisciplinarity and public engagement.

Site-specific and locally grounded perspectives are a vital, though often underutilised, resource for teaching EH in Europe. Archaeological practice, especially in its public and community-engaged forms, offers a particularly rich foundation for such place-based pedagogies. Field encounters with landscapes, monuments, and heritage sites situate learning within tangible socio-ecological contexts, encouraging participants to think critically about environmental change through material traces and lived experience. Whether through excavations or participatory heritage mapping, public archaeology exemplifies how education can connect abstract environmental questions to particular places and communities. While public participation in the research cycle has long been established in archaeology, its application within EH is a more recent development and part of the wider emergence of a citizen humanities.[4] Co-creative citizen science and transdisciplinary methodologies are likewise increasingly recognised as essential for addressing complex socio-ecological challenges and informing effective policy and management decisions (Agnew et al. 2022).

Building on these principles, we argue that place-based and participatory approaches can be tailored to diverse natural and

4 See Dobreva 2016; Gianquitto, LaFauci 2022; Hayes et al. 2025; Heinisch et al. 2021.

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cultural heritage settings across Europe to support research-based and co-creative pedagogy, while fostering socio-ecological awareness and collective capacity to address climate change and heritage loss.

2 Coastal Heritage and Co-Production: The PRISM Project

The PRISM (*Preservation by Record of Ireland's Shell Middens*) project was conceived as a pilot scheme under an Irish Research Council Government of Ireland grant, based out of University College Dublin (UCD), and supported by the UCD Earth Institute. It sought to test how citizen science could contribute to the recording of vulnerable coastal shell midden sites along Ireland's coast, preserving vital cultural and environmental data before it is permanently lost.

2.1 Coastal Shell Middens

Shell middens are archaeological deposits composed predominantly of mollusc shells, frequently intermingled with faunal remains or other artefactual materials. They form through repeated episodes of shellfish processing and consumption, accumulating as conspicuous mounds or stratified layers that can be several metres in thickness **[fig. 1]** (Waselkov 1987). Shell middens are a virtually global phenomenon recorded on all continents except Antarctica (Rick 2023; Robson et al. 2023). They date from at least the earliest stages of the Holocene, and continue to accumulate to the present day in certain regions.

Beyond their utility for reconstructing past dietary habits and subsistence systems, the shells themselves are increasingly utilised within multi- and interdisciplinary research projects as high-resolution palaeoenvironmental archives, reflecting fluctuations in past ambient environmental conditions and broader climatic shifts (Andrus 2011; Hausmann et al. 2017). Analyses of shell morphology and molluscan community composition can also provide vital historic baselines for ongoing conservation and restoration efforts (Faulkner et al. 2019; Roberts et al. 2025; Robson et al. 2024).

Figure 1 Eroding coastal shell midden sites in the north-west of Ireland. Photo by Rory Connolly, 2023

Ireland's National Monument Service (NMS) records 534 midden sites across the Republic of Ireland (NMS 2025) with the substantial majority of these being situated in coastal settings, making them highly susceptible to storm surges, erosion, and other destructive forces (Bonsall, Moore 2017). Ireland lacks a dedicated coastal archaeological response unit, and as a result, many coastal middens are damaged and lost each year without appropriate investigation, especially during extreme weather events. In line with global trends, climate projections show that Ireland will continue to warm, with the strongest warming and most heat-wave days in the south and east, while the north-west will see substantial increases in summer and autumn temperatures and a large reduction in frost and ice days. Precipitation projections are less certain, but the models indicate drier summers and wetter autumns and winters, along with a marked increase in heavy rainfall events, a pattern that implies heightened risks of flooding and erosion along the western and north-western coasts (Nolan 2024). Ireland's position on the North Atlantic storm track also exposes it to increasingly intense cyclonic activity. In recent years, extra-tropical systems such as storms Ophelia (2017) and Lorenzo (2019) brought hurricane-force winds leading to severe damage and abrupt episodes of coastal erosion (Met Éireann 2025). In August 2020 Storm Ellen, formed from the remnants of Tropical Storm Kyle, intensified rapidly and delivered gusts up to 143 km h^{-1}, with storm surge and spring tides causing coastal flooding and extensive tree blow-down across western counties. Most recently, in January 2025 Storm Éowyn set a new national wind record of

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183 km h^{-1}, highlighting how such intense systems amplify hazards to coastal infrastructure and cultural heritage (Met Éireann 2025). Unfortunately, even under the most optimistic future climate projections for Ireland, the loss of many shell midden sites is inevitable and unstoppable, particularly in areas of soft coastline (Daly 2019). Erosion also presents opportunities, however, as new previously unrecorded midden sites can become exposed (Bonsall, Moore 2017).

2.2 Co-Production and Decision-Making

PRISM's underlying rationale was that human responsiveness can, in some cases, be more effective than large-scale remote sensing technologies. Local communities possess intimate knowledge of their landscapes and can quickly detect changes as midden deposits are exposed or damaged following storm events. The project established four key objectives:

- **Objective 1** To pilot a scheme to build capacity for addressing climate change impacts in Irish coastal communities through citizen engagement.
- **Objective 2** To create a transdisciplinary framework for local communities to become active participants in the research cycle.
- **Objective 3** To promote the use of digital tools and participatory mapping and act as a proof-of-concept.
- **Objective 4** To strengthen cross-sectoral collaboration to mitigate loss of archaeological information at coastal shell middens under threat.

As a pilot scheme, PRISM focused its efforts in County Sligo, in the north-west of the island, where over 115 shell midden sites are recorded (NMS 2025). High-resolution projections indicate that the north-west, including Sligo, will face more variable precipitation regimes, heavier rainfall events, and heightened storm surge risk, exacerbating erosion and coastal heritage loss along already vulnerable coasts (Sligo County Council 2024). In response to these vulnerabilities, PRISM's workflow sought to emphasise reciprocal communication, distributed observation, and selective rescue sampling that foregrounded three epistemic concepts that are central to both responsible public archaeology and EH: (i) thick description across scales, where site-level observations about midden exposures are read against climatic and local infrastructural dynamics; (ii) ethical reflexivity, where the act of prioritising threatened sites triggered questions about value, loss, and care; and (iii) public narratability, where evidence is organised with audiences in mind from the outset, and not simply retrofitted after the fact.

With these ideas in mind, the project established an online reporting platform built on ArcGIS Online and ESRI geospatial cloud tools (Survey123 and Experience Builder). This digital infrastructure was intended not only to facilitate timely recording of at-risk sites but also to integrate citizen observations into a wider monitoring framework, in line with recent evaluations of geo-citizen-science approaches that emphasise the accessibility of Survey123 for spatial data collection and the flexibility of Experience Builder for creating interactive, cross-platform dashboards (objectives 1 and 3) **[fig. 2]** (Hennig et al. 2020; Uelmen et al. 2023).

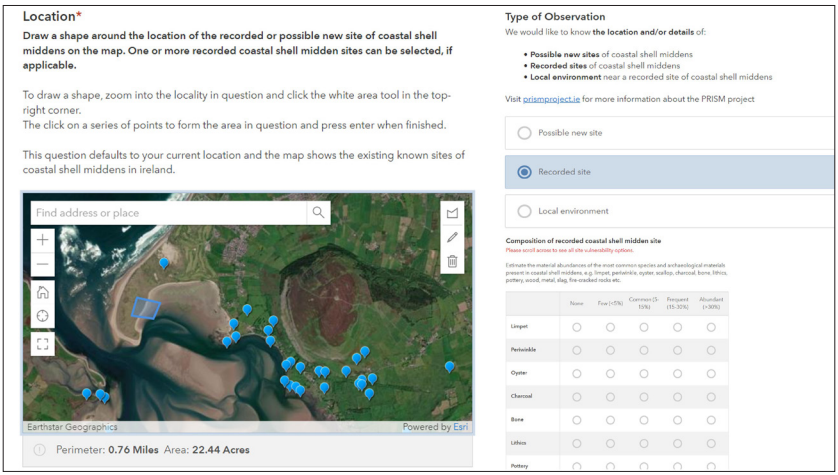

Figure 2 Selected screenshots from PRISM's Survey123 interface

Volunteer citizen scientists were recruited through direct engagement with local stakeholders, including coastal residents, local historical societies (Sligo Field Club), beach-clean initiatives (An Táisce Clean Coasts), and students enrolled in archaeology programmes. The project team organised public talks, guided field trips, and training sessions to equip volunteers with the skills needed to recognise midden deposits and to use the platform (objective 2) **[fig. 3]**.

Citizen scientists were encouraged to submit coordinates, geolocated photographs, and short observations on possible new sites or previously recorded sites. Importantly, they were invited to share relevant contextual information about the local environment, including possible changes to surrounding land use, or bioturbation caused by burrowing animals or vegetation growth. The project provided feedback on the status of reported sites, creating a two-way flow of information. The aim was to move beyond traditional top-down monologue interactions towards genuine dialogue, where

communication becomes reciprocal and collaborative (Rüfenacht et al. 2021).

Figure 3 Guided tour and information session on coastal shell middens in County Sligo. Photos by Rory Connolly, 2023

The platform incorporated a structured vulnerability assessment that enabled contributors to rank the severity of climatic and anthropogenic hazards affecting individual midden sites. Using a five-point scale ranging from 'no alteration' to 'major deterioration of fabric', participants evaluated risks such as coastal erosion, storm surges, sea-level rise, extreme temperatures, precipitation changes, and visitor footfall. These inputs were then visualised through interactive dashboards, allowing patterns of threat intensity and distribution to be compared across sites **[fig. 4]**.

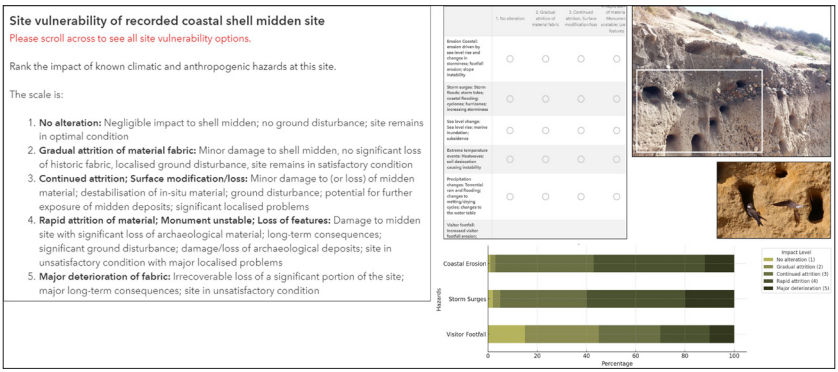

Figure 4 PRISM's structured site vulnerability assessment. Source: Rory Connolly

2.3 Data Validation and Sampling

Over twelve months PRISM collected numerous fully anonymised citizen observations through the platform, all of which were validated through ground-truthing by project archaeologists, including partners in the commercial archaeology sector (objective 4). The correspondence between volunteer assessments and professional evaluations demonstrated the reliability of citizen-scientist data, particularly when participants received clear guidelines and ongoing support. On the basis of the citizen-generated vulnerability assessments, sites deemed to be under imminent threat of substantial damage or complete loss were prioritised for rescue sampling to mitigate the loss of archaeological data. Six sites were selected from the townlands of Rosses Upper, Culleenamore (x2), Tanrego East, Tanrego West, and Streedagh **[fig. 5; tab. 1]**. Samples of marine shell were collected from exposed shell midden section faces and care was taken when sampling to target *in-situ* contexts with minimal evidence for disturbance.

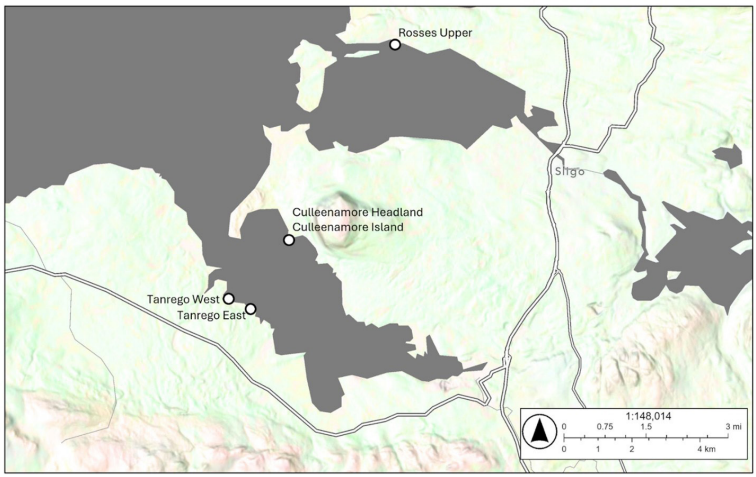

Figure 5 Map showing the midden sites sampled in Sligo Bay and Ballysadare Bay.
Source: Rory Connolly, using ArcGIS Pro basemap (ESRI 2024)

Table 1 Shell middens sampled by the PRISM project

Location	Rosses Upper, Co. Sligo	Culleenamore Island, Co. Sligo	Culleenamore Headland, Co. Sligo	Tanrego West, Co. Sligo	Tanrego East, Co. Sligo	Streedagh, Co. Sligo
SMR	SL008-214	SL013-117	SL013-091	SL013-117	SL019-057004	SL005-018
NMI Licence	22E0634	22E0643	22E0644	22E0641	22E0642	22E0645
ITM Coordinates	564079, 839676	560921, 833926	561058, 834007	559556, 832107	560123, 831659	563045, 850318
Lat. Long.	54.304574, -8.551916	54.252678, -8.599685	54.253416, -8.597593	54.236228, -8.620385	54.232247, -8.611628	54.400118, -8.569123
Period	Later Mesolithic	Middle Neolithic	Late Neolithic; Medieval	Late Neolithic; Medieval	Late Neolithic	Iron Age

Fourteen radiocarbon determinations were secured, spanning the Later Mesolithic through the Neolithic and into the fourteenth century. The prehistoric results are especially significant, as they considerably refine our understanding of how these coastal sites intersect with the broader prehistoric landscape, notably the major Neolithic ceremonial complex at Carrowmore (Bergh, Hensey 2013), recently added to the UNESCO World Heritage Tentative List as part of the *Passage Tomb Landscape of County Sligo* (UNESCO World Heritage Centre 2023). The archaeological implications of these radiocarbon determinations merit more detailed discussion than is possible here and will be developed in subsequent work.

3 Pedagogical Insights and Teaching EH

3.1 Bridging Research and Participation

PRISM forms part of a wider landscape of coastal citizen-heritage initiatives that seek to mobilise local expertise in the face of rapid environmental change. In England, for instance, the *Coastal and Intertidal Zone Archaeological Network* (CITiZAN) has developed long-term monitoring programmes in which trained volunteers systematically record eroding coastal archaeology and report new exposures (Parsonage et al. 2025; Milne et al. 2023). Similarly, previous pilot schemes like the MASC project (*Monitoring the Archaeology of Sligo's Coastline*) in Ireland have proved fruitful for recording at-risk archaeology in the intertidal zone (Bonsall, Moore 2017).

The citizen science approach adopted by PRISM led to the rescue sampling of six previously uninvestigated monuments, substantially enriching the archaeological record of the north-west. Several of these sites were subsequently damaged or destroyed by storms,

underscoring both their vulnerability and the urgency of intervention. Through rapid documentation and sampling, PRISM preserved chronological and cultural information that would otherwise have been lost, while citizen scientists helped determine which sites to prioritise, embedding co-production and community agency at the heart of the project. Such collaborative practices resonate with EH pedagogy, which increasingly emphasises participatory knowledge production and ethical engagement with local communities.[5] PRISM also reflects Riede's (2018) call for incorporating deep-time perspectives into EH by demonstrating how such perspectives can be made tangible through public engagement. By encountering the fragile material traces of prehistoric coastal lifeways, local stakeholders and residents became cognisant of the ephemeral and palimpsestic character of their surrounding coastal landscapes, recording features that often went unnoticed in everyday experience. These encounters invited participants to situate themselves within a continuum of human-environment interaction extending back thousands of years, fostering a renewed sense of belonging to coastal communities shaped by both environmental change and cultural memory.

3.2 Citizen Science as Method and Pedagogy

PRISM offers several lessons for EH teaching. It demonstrates how citizen science can serve as a form of experiential learning that invites participants to co-produce knowledge rather than simply consume it. Those who participated with PRISM developed practical skills in GIS, field recording, and community engagement, while gaining insight into the ethical challenges of allocating limited resources among threatened heritage sites. These experiences undoubtedly complement wider discussions of the Anthropocene and environmental justice by grounding abstract concepts in concrete decision-making.

Shell middens connect a variety of cultural and environmental processes across multiple scales of analysis. Reading them requires knowledge of coastal geomorphology, ecology, archaeology, and local histories. The coastal settings investigated by PRISM can be understood as part of what Westerdahl (1992; 2011) terms the 'maritime cultural landscape', an integrated land-sea assemblage of sites, practices, routes, and perceptions that arise from human engagement with the sea. For teaching purposes, introducing

5 See Gianquitto, LaFauci 2022; Heyne et al. 2024; Holm et al. 2013; Izdebski et al. 2016; O'Gorman et al. 2019.

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the maritime cultural landscape framework allows participants to situate the middens within a continuum of shoreline use and change, reinforcing PRISM's emphasis on relational, place-based understandings of climate impacts and heritage vulnerability. This integrative perspective contrasts with many climate impact frameworks that compartmentalise biophysical and social dimensions. Although such separation may serve practical ends, it can obscure and limit recognition of the relational character of climate change impacts (Adger et al. 2009). PRISM enabled participants to consider these interconnections and confront narratives of heritage loss and resilience, reflecting EH concerns with storytelling and affect (Hamilton et al. 2024; O'Gorman et al. 2019).

The project helped demonstrate the importance of place-based education, focusing on a specific region and involving local communities. Such locally grounded case studies enable learners to grasp how global environmental change is experienced within particular ecologies and cultural settings, making abstract processes tangible and meaningful (Gruenewald 2003; Smith 2007; Yemini et al. 2025). They also foreground the significance of local knowledge and practices in conservation and adaptation, highlighting how community expertise complements scientific approaches in responding to environmental challenges (Raymond et al. 2010). PRISM's co-production workflow was conceived as a transdisciplinary mode of collaborative learning that brought researchers, heritage professionals, and citizen scientists into a shared process of observation and decision-making. The inclusion of non-specialists from the outset, particularly their role in identifying and prioritising sites for sampling, blurred conventional boundaries between expert and lay knowledge, demonstrating how transdisciplinary practice can democratise research and extend its ethical and epistemic reach.

4 Concluding Remarks

As climate change accelerates and coastal heritage faces intensifying threats, projects like PRISM highlight how transdisciplinary collaboration can turn vulnerability into an opportunity for learning. By integrating archaeological methods, participatory mapping, and community knowledge, the project demonstrates how research can be rooted in ethical engagement and shared responsibility. Its co-production model shows that environmental understanding is generated by dialogue among multiple ways of knowing, from academic and professional to local and experiential.

Empirically, PRISM has contributed new chronological and cultural information for six previously unsampled shell middens in north-west Ireland, providing a vital record for monuments that in

several cases were subsequently damaged or destroyed. The project's structured vulnerability assessment and digital reporting platform provide a replicable workflow for identifying, prioritising, and sampling threatened sites in other coastal regions. Pedagogically, the scheme offered a concrete example of how EH teaching can be embedded in public archaeology and citizen science, giving participants hands-on experience with GIS, field recording, and the ethical dilemmas of triaging endangered heritage. These intertwined research and teaching outcomes suggest that citizen-led monitoring can be deployed as a form of critical, place-based education in its own right.

PRISM underscores that citizen science can both expand the evidential base for understanding past human-environment relations and cultivate the skills and sensibilities needed to navigate present and future climate risks. The project offers a working template for how EH teaching and research can cultivate situated, participatory, and reflexive practices that foster both heritage preservation and climate awareness, while opening pathways for similar collaborations in other vulnerable landscapes.

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