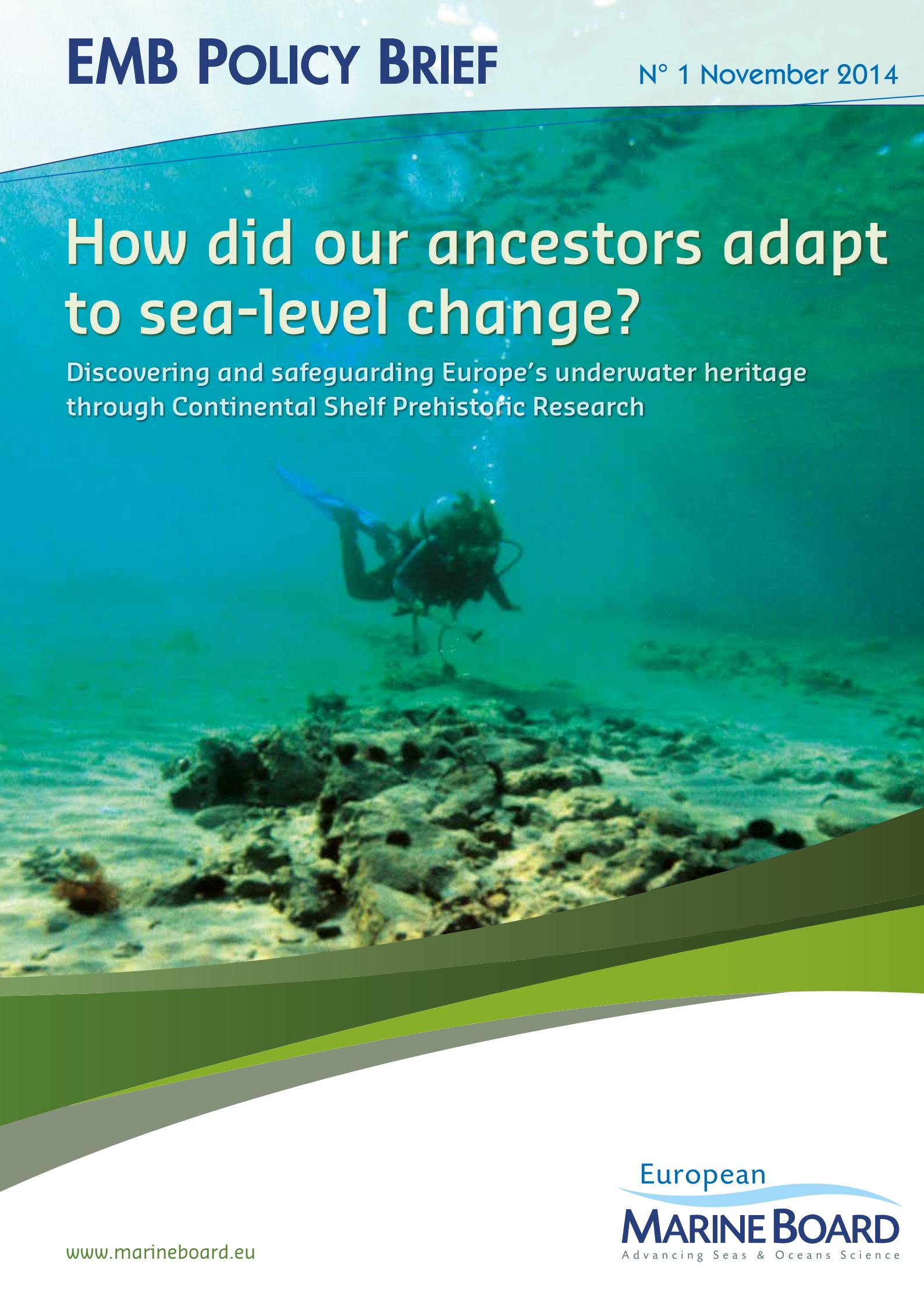


How did our ancestors adapt to sea-level change?

Discovering and safeguarding Europe's underwater heritage through Continental Shelf Prehistoric Research



The European Marine Board provides a pan-European platform for its member organizations to develop common priorities, to advance marine research, and to bridge the gap between science and policy in order to meet future marine science challenges and opportunities.

Established in 1995, the European Marine Board provides the essential components for transferring knowledge for leadership in marine research to promote the establishment of the European *marine* Research Area. Its members are major national marine or oceanographic institutes, research funding agencies, or national networks of universities with a strong marine research focus. In 2014, the European Marine Board represents 35 Member Organizations from 18 countries.

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This policy brief is based on Position Paper 21* of the European Marine Board, drafted by an interdisciplinary working group (WG SUBLAND, Sept. 2013-Sept. 2014) of 13 experts, nominated by the European Marine Board and the European Archaeological Council. The working group provided a comprehensive overview of recent progress in the study of Europe's submerged cultural heritage and set out key research questions and policy priorities necessary to support this research in the future.

* Flemming, N.C., Çağatay, M.N., Chiocci, F.L., Galanidou, N., Jöns, H., Lericolais, G., Missiaen, T., Moore, F., Rosenthal, A., Sakellariou, D., Skar, B., Stevenson, A., Weerts, H. (2014) Land Beneath the Waves: Submerged landscapes and sea level change. A joint geoscience-humanities strategy for European Continental Shelf Prehistoric Research. Chu, N.C. and McDonough, N. (Eds.) Position Paper 21 of the European Marine Board, Ostend, Belgium. 171 pp. ISBN: 978-94-920430-3-0.

Tracing our ancestors at the bottom of the sea

During the successive ice ages of the last 1 million years, the sea level dropped at times by up to 120m, adding the equivalent of an extra 40% to the land area of Europe. Vegetation, animals and people occupied this exposed terrain and left information on our ancestors' migration patterns, social structures, seafaring and exploitation of coastal resources. With the rising sea level, this substantial part of Europe's prehistory is now underwater and its preservation is being threatened by natural erosion and commercial maritime activities. A major increase in our efforts to explore these submerged prehistoric settlements is urgently needed to safeguard this heritage and support sustainable management of our coastal and offshore resources.

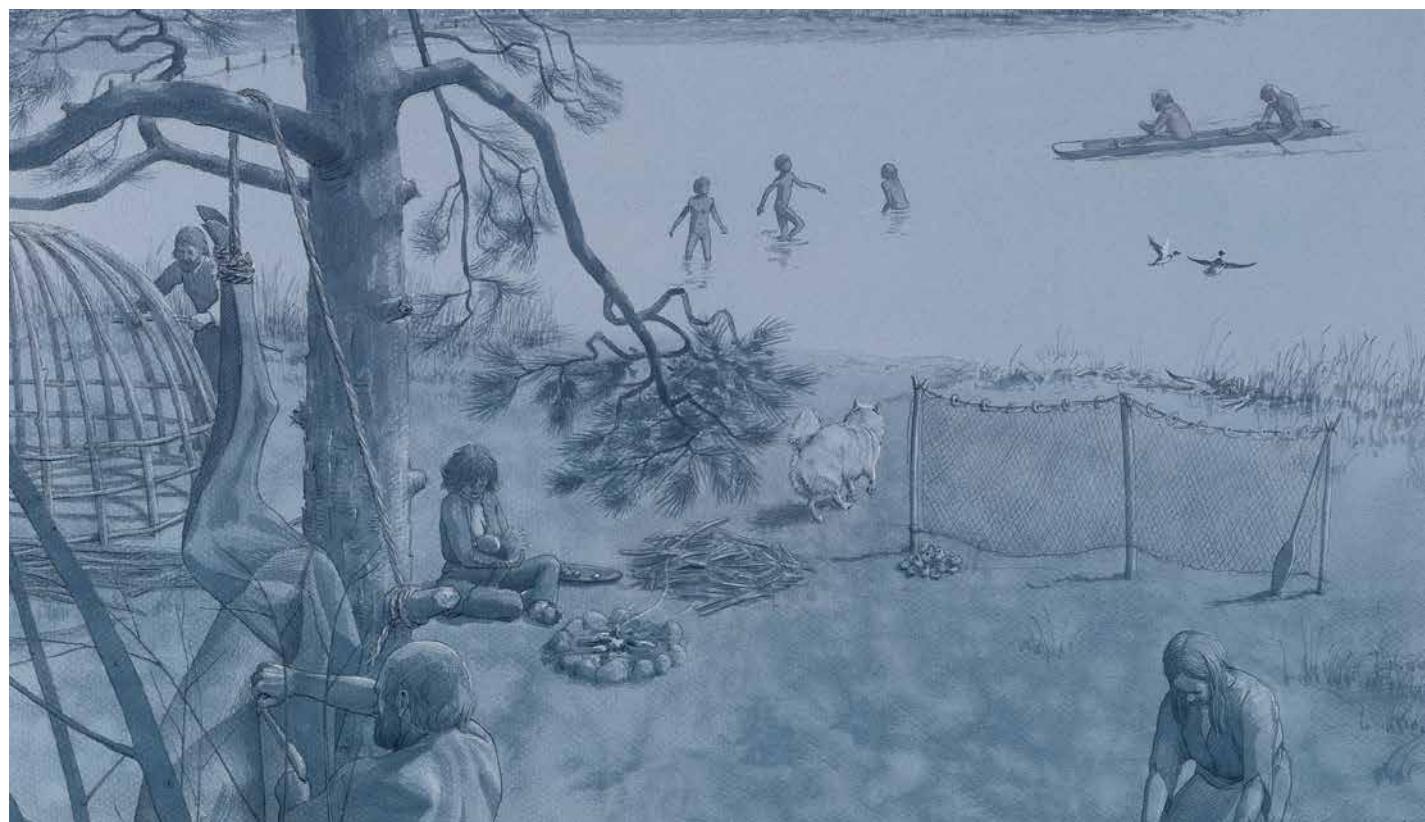
Prehumans inhabited the Black Sea coast 1.8 million years ago, the coast of northern Spain over 1 million years ago and the coast of Britain at least 0.8 million years ago. Rising sea levels have submerged some of the earliest routes from Africa into Europe, and the areas where people survived during multiple successive ice ages. To date, more than 2,500 submerged prehistoric artefact assemblages, ranging in age from 5,000 to 300,000 years, have been found in the coastal waters and open sea basins around Europe.

However, only a few have been properly mapped or assessed for preservation or excavation. In addition, climate change, industrial activities, lack of high resolution seabed maps, shortage of human capacity building and a misconception that prehistoric sites were destroyed by the post-glacial rise of the sea, are all affecting the protection of sea-submerged settlements.

Key enablers:

- Increased support for research and education to advance knowledge and build capacity in institutes and laboratories engaged in Continental Shelf Prehistoric Research;
- Access to technology and data from research and commercial sources for site discovery and analysis, and landscape reconstruction;
- A coordinated partnership with industry to report finds, to transfer technologies and to optimize project planning for offshore commercial activities;
- A multi-stakeholder mechanism for sustainable exploration, in compliance with treaties and legislation, to support best practice in Maritime Spatial Planning.

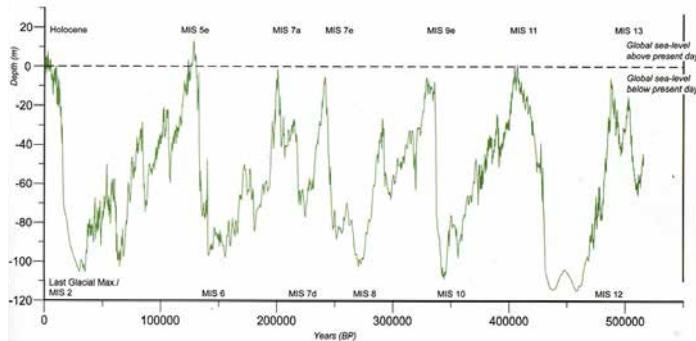
To safeguard this unique European heritage before it is lost forever, it is urgent to support targeted training for marine archaeologists, while promoting collaboration with oceanographers, engineers, climate change experts and numerical modellers. Many initial findings are made by industrial operators, whose role can be strengthened by improving collaboration with national cultural heritage agencies and research institutions, both to encourage the reporting of findings and to map, protect, and, where appropriate, excavate archaeological materials such as hut foundations, hearths, food remains, skeletons, shaped flint tools, hand axes and paddles for canoes embedded in the sediments on the sea floor. This research is essentially conducted at the scale of sea basins regardless of modern boundaries of national jurisdiction.



A typical Mesolithic coastal settlement at the Baltic Sea

Continental shelf: the missing piece of the human prehistory puzzle

Most of the European continental shelf was exposed by the lowering of global sea level many times during the last one million years (see the figure below). This vast exposed area was occupied by vegetation and animals, including humans and hominins. The extent to which people lived close to the ice and exploited the peri-glacial megafauna is still uncertain. We cannot understand the whole story by studying only the present dry land records and ignoring the now submerged seabed of the continental shelf. Did the fluctuating climate zones and migrating coastlines and river valleys influence where people lived? Did the fluctuating sea level create responses that are still felt or had impact in the historic world of writing and oral history?



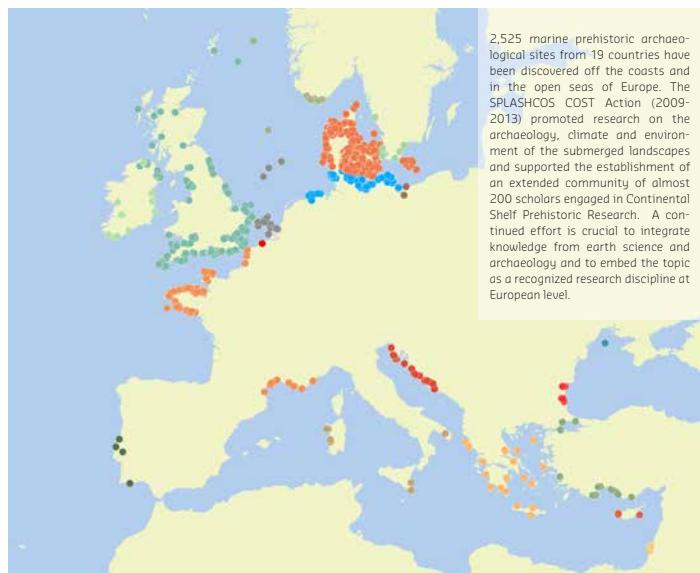
In the last 500,000 years, global sea level oscillated between 120-130m below and 5-10m above present sea level. Since the sea was lower than at present for most of the last million years, large areas of land were exposed and were occupied by terrestrial vegetation, animals and early humans. (Data from Rohling *et al.*, 2009, Nat. Geo. 2, 500-504)

A collaborative effort to integrate knowledge

Continental Shelf Prehistoric Research is a new scientific field formed from the progressive discovery and analysis of these submerged prehistoric remains, combining the expertise from disciplines of archaeology, oceanography and marine geosciences. This research will help us to understand how prehistoric people responded to changing sea levels and how we might need to adapt to future changes.

Continental Shelf Prehistoric Research requires a balanced and iterative relationship between the earth sciences and archaeology. The questions raised by trying to understand the human response to changes in climate and the bio-geographical environment force us to examine the data in a way that is not in line with the normal objectives of the earth sciences. For example, reinterpreting palaeoenvironmental data will provide much more detailed information than singular reference data on pollen, morphology or fossil remains. Improved modelling can help to examine the periglacial environment where hunting took place or to reconstruct coastlines for migration routes.

Previous initiatives (e.g. SPLASHCOS, see the map above) have helped to build a multidisciplinary research community in Europe. It is important to build on this progress and collaborate further with cultural heritage agencies, the private sector and public agencies with competency in maritime spatial planning.



Suggested research themes

Based on a survey of national heritage agencies conducted as part of the working group activities, the research objectives can be grouped into themes for future development:

1. Complexity of early coastal settlements;
2. Migration pathways between Africa, the Middle East and Europe at different stages of multi-glacial cycles;
3. Early stages of navigation and exploitation of islands in archipelagos;
4. Early stages of seafaring;
5. Response to changes in sea level;
6. The deeper history of coastal sedentism;
7. The spread of farming along the north Mediterranean coastal lands (now submerged);
8. The systematic integration of the continental shelf prehistoric data with the archaeology of the same periods on land, facilitating a complete European view of prehistory.

The identification of research themes will help to improve capacity building and strengthen regional and European collaboration to tackle large research ideas.



Palaeolithic hunters from 11,000 years ago sometimes elaborately carved their tools and weapons. Artefacts are now under threat of being destroyed from natural erosion and offshore exploitation. Without urgent action, this heritage will be lost.

Building capacity for Continental Shelf Prehistoric Research

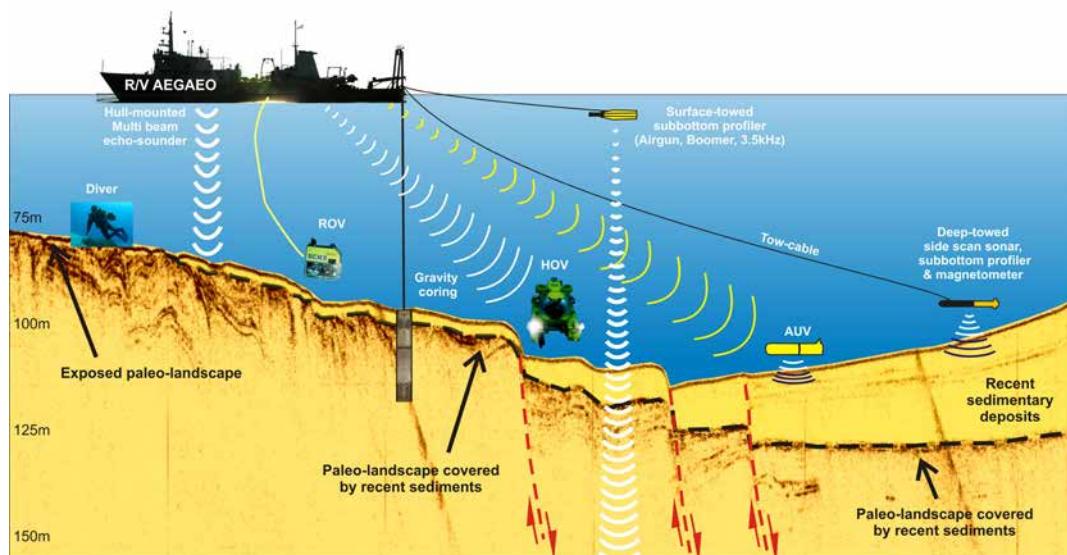
Knowledge and technology underpin Continental Shelf Prehistoric Research.

Knowledge of this domain has grown significantly over the last 30 years based on the activities of a small community of researchers from various disciplines of the geosciences and humanities. They have shown that **interdisciplinary and international cooperation will be key to the establishment of a sustainable scientific network** that is able to broaden and intensify research on the submerged part of European prehistory.

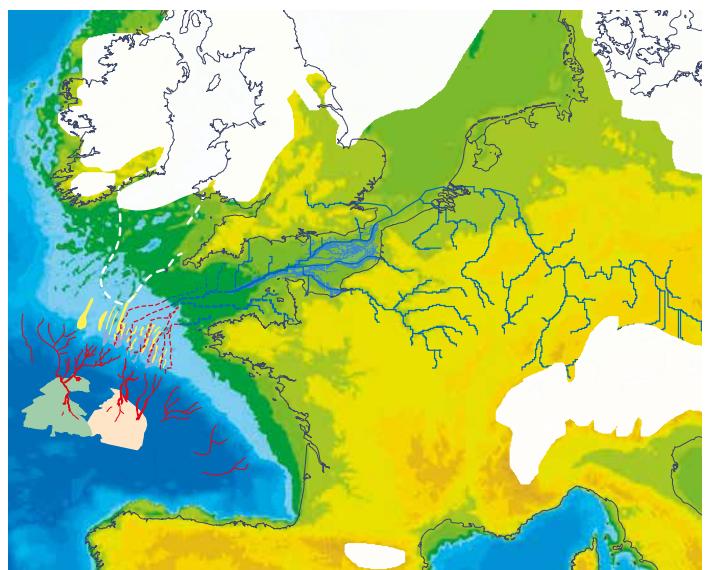
Creating a stable research and training base will be essential to sustain the discipline's future development. For example, the appointment of professorships and expansion of interdisciplinary courses, both in academia and engineering, will lay a solid foundation for the future.

Access to technology and data is essential both for research and heritage management. Most of the relevant offshore prospecting technology has been developed and managed by the marine science community and offshore industries. It is necessary that this infrastructure and technology expertise is shared. Likewise, long-term data archiving, data integration, computer modelling, and open access to offshore data with no commercial value is required to develop submerged landscape interpretation at European level. The community recommends that underwater archaeological data should be included in data initiatives such as EMODnet, part of the EU's Marine Knowledge initiative for more accessible and interoperable marine data. It is only through open access to data and technology that the required interdisciplinary integration of both the marine science community and offshore industries will be achieved.

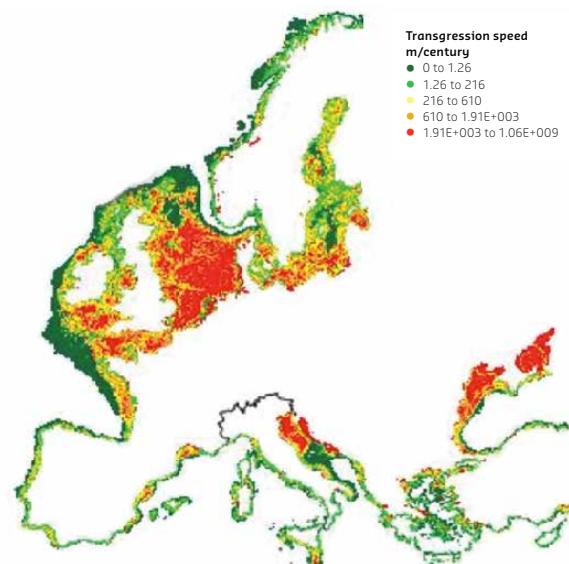
Marine transgression rates, modelled from the rate of post-glacial sea-level rise and sea floor gradient combined with the effects of local topographic relief and the physics of waves in shallow water, help to predict the potential preservation condition of prehistoric remains. The map shows computed horizontal transgression in metres per century on the European shelf.



Successful Continental Shelf Prehistoric Research relies on sharing technology, transparent guidelines and open access to data. It is also important to adapt existing technologies, such as remote sensing and underwater platforms, to various situations of scale, environment, resolution and application stage. The cost of ship time and advanced oceanographic technology can be optimized by collaboration between marine research agencies, industry and archaeological institutions.



Access to freshwater and food attracts humans. It is therefore valuable to identify and plot in detail the courses of river valley systems on the exposed continental shelf. Channel River drainage patterns, for example, have been intensively studied.



Credit: J.-F. Bourillet

Graphic and computation: F. Chiocci

Opportunity knocks

We are facing a situation where submerged archives of European prehistory are in danger of being lost. It is crucial to design a research and communication strategy and to turn these threats into opportunities. Governance through a multi-stakeholder model including environmental, industrial and academic sectors will improve the efficiency of site management.

For an effective research and communication strategy, we need to:

- Exchange best scientific practice through interdisciplinary research;
- Communicate scientific results to the public through outreach activities;
- Build a sustainable network with different actors, such as fishing, dredging, oil and gas, offshore industries, cultural heritage agencies, and recreational diving associations, to document discoveries, to enhance research, and to reduce the cost and complexity of enforcing conditions of licensing;
- Improve the resolution of seabed data and accessibility to them;
- Expand predictive modelling for areas where direct observation is difficult and as an effective tool to facilitate Maritime Spatial Planning;
- Train young technicians, engineers and researchers who understand the special technical requirements of this research.



Credit: P. Rodger



Credit: D. Mol



Credit: T. Missiaen



Credit: D.E.A. Schiltmans/ Port of Rotterdam and City of Rotterdam Archaeological Service

Industrial activities such as bottom trawling, aggregate dredging, harbour and channel constructions, cable and pipe laying, and windfarm construction all disturb the sediments of the sea floor on a large scale and have the potential to destroy prehistoric deposits. However, these activities are also opportunities to discover prehistoric remains on the seabed. Multi-stakeholder governance can facilitate finds being documented and studied. Examples include working with dredgers to recover stone tools (image 11) or incorporating archaeological investigation during port construction, as carried out via installation of an excavation pontoon in the Port of Rotterdam (image 1).

Marine space is shared by the entire community. Harmonized use of our coastal resources is the goal of maritime spatial planning. Recreational divers exploring a wreck by agreement near an offshore wind farm (image 12) and fishermen landing a mammoth skull (image 13) are examples of opportunities as a result of open communication and collaboration.

Suggested further reading

Flemming, N.C., Çağatay, M.N., Chiocci, F.L., Galanidou, N., Jöns, H., Lericolais, G., Missiaen, T., Moore, F., Rosentau, A., Sakellariou, D., Skar, B., Stevenson, A., Weerts, H. (2014) Land Beneath the Waves: Submerged landscapes and sea level change. A joint geoscience-humanities strategy for European Continental Shelf Prehistoric Research. Chu, N.C. and McDonough, N. (Eds.) Position Paper 21 of the European Marine Board, Ostend, Belgium. 171pp.

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Policy Implications

Heritage is a strategic resource for a sustainable Europe

The Council of the European Union has recognized that cultural heritage assets are unique and are a major driver of societal cohesion, identity and well-being (EC Council Decisions 2013/8743/EU, OJ L347). The Council recognized cultural heritage as a strategic resource for a sustainable Europe (EU Council Conclusions; 20 May 2014) and has invited the European Commission to further support projects aimed at fostering sustainable management of cultural heritage.

Since adoption of the Integrated Maritime Policy in 2007, the EU has been working to promote a coherent and integrated approach to manage marine activities and resources in European seas. To achieve its goal, the EU adopted a new Directive on Maritime Spatial Planning in July 2014. In the text of the Directive, cultural heritage is recognized as one of the key “users of maritime space.”

Aligning knowledge and skills to safeguard our heritage on the continental shelf

The training and education aspect of Continental Shelf Prehistoric Research is in line with the target of the Knowledge Alliance action of ERASMUS+¹ to boost innovation and stimulate the flow and exchange of knowledge between higher education and enterprise. This will encourage capacity building to tackle skills gaps for sustainable development.

The EU Blue Growth Strategy and European sea basin action plans have placed a clear policy priority on the need to expand our maritime economy, providing jobs and growth in our coastal regions. Continental Shelf Prehistoric Research is a discipline that involves users of coastal resources at every level. There is significant potential for a Sector Skills Alliance to support progress in this field. As a key goal of the Blue Growth Communication (EC COM(2012) 494final), Innovation in the Blue Economy (EC MEMO/14/337), Sector Skills Alliances¹ will promote European cooperation within a specific sector of the economy and also optimize investments in research. In addition, studies on Continental Shelf Prehistoric Research will contribute to integrating the environmental data required for implementation of the Marine Strategy Framework Directive, the environmental pillar of Integrated Maritime Policy.

Foreseen output to society

The media attraction of underwater cultural heritage shows the public interest in the history of human societies. Support for Continental Shelf Prehistoric Research directly reflects modern society's expectations in answering questions about early human migrations, the origins of seafaring, exploitation of marine resources, and responses to sea-level change.

Continental Shelf Prehistoric Research will contribute to the social awareness of our coastal resources. Discoveries displayed in local museum collections can capture people's imagination and boost coastal tourism. The sea-level changes and human interactions implied from this research will also contribute to our understanding of the potential future impacts arising from climate change. Endangered prehistoric sites will be preserved and cultural heritage management improved. Taking account of these additional benefits, it is clear that Continental Shelf Prehistoric Research has strong relevance in the fields of Social Sciences and Humanities (SSH).

As a solution-oriented research & innovation programme, Horizon 2020 is an ideal instrument to address this shared trans-boundary research challenge. Europe is amongst the world leaders in Continental Shelf Prehistoric Research; we must act now to capitalize on this leadership and to safeguard our unique cultural heritage.



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¹Knowledge Alliances and Sector Skill Alliances are two key actions of ERASMUS+, the new EU programme for education, training, youth and sport for 2014-2020. Knowledge Alliances aim at strengthening Europe's innovation capacity and at fostering innovation in higher education, business and the broader socio-economic environment. Sector Skills Alliances aim at tackling skill gaps, enhancing the responsiveness of initial and continuing vocational education and training systems to sector-specific labour market needs and demand for new skills with regard to one or more occupational profiles.

Acknowledgements

EMB would like to thank the experts of the WG SUBLAND for their work in analyzing the state of the art of this research field and in producing key recommendations for the next step. EMB is also grateful to various inputs through collaborators from European Archaeological Council, several National Cultural Heritage Agencies and other predecessor initiatives (Deukalion Planning Group and SPLASHCOS COST Action).

Keywords

sea level change, climate change, prehistory, continental shelf, geoscience, archaeology, cultural heritage, maritime spatial planning, offshore industry, underwater technology.

Citation

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EMB policy briefs provide a high-level summary of the key research needs and priorities on topics of strategic and emerging importance in seas and ocean science from a European perspective. Policy briefs are normally (but not always) summary versions of full EMB position papers, produced by EMB expert working groups.

Cover image: Pavlopetri, located at southeastern edge of Peloponnese in Greece, is the oldest submerged city (3-4m of water depth) dating from at least 5,500 years ago. Intact domestic buildings, larger public structures, courtyards, streets and graves can be identified over 8 hectares of remains.

Credit: Pavlopetri Project