CASE STUDY 3K - QUIBERON PENINSULA and MORBIHAN, FR. (Brittany)

Case Study Area: Quiberon peninsula and Morbihan, FR (Brittany)

Main geomorphological types: Rocky cliffs, sandy beaches, dunes, islands and estuaries.

Main Coastal Change Processes: Coastal erosion, cliff instability, beach change.

Primary resources used: Archaeology, palaeoenvironment, art, photography.

Summary: The study area contains diverse landscapes: clifflines, sandy dunes and beaches which are subject to erosion and instability, and numerous islands corresponding to former hills separated from the continent by Holocene sea level rise. Archaeological and palaeoenvironmental records have enabled us to see the rate and scale of this erosion over the last millenniums.

Recommendations: Coastal managers should use these resources when predicting future rates of erosion in this area, particularly where one of the main natural features - dunes and sandy bars, are so vulnerable to coastal erosion. An agreement between the various management policies is recommended, in order to define priorities within a global landscape strategy, and to combine policies on this territory, which due to its extent and diversity is highly complex (Cavalie, 2001).

Coastal managers face an ongoing battle to moderate impacts from the sea in the face of a changing climate and pressures from human use of the coastal zone. The challenges that lie ahead are forecast to increase while resources are being forced to go further.

This case study report is part of the Arch-Manche project, which quantifies the value of under-used coastal indicators that can be applied as tools to inform long term patterns of coastal change. In addition, it provides instruments to communicate past change effectively, model areas under threat and interpret progressive coastal trends.

Quiberon peninsula and Morbihan is one of four case study areas within the Brittany area of France. The area has been extended to include a large part of the Morbihan region in order to consider artistic resources including maps, charts and photographs, in a wider landscape context. This case study report introduces the study area and why it was chosen as part of the project, the results of the archaeological and palaeoenvironmental study are then presented along with the results of the art study. The analysis of these results and the potential for demonstrating the scale and rate of sea level change are then presented. Further details about the project methodology can be found in Section 2.

Within the Quiberon peninsula area, the archaeological and palaeoenvironmental resource and the available art resource have been researched, ranked and analysed. The extents of the detailed study areas are shown in Figure 3K1 below. The area considered for archaeology and palaeoenvironment has been selected to provide a representative range of types of evidence across a range of periods spanning from the Palaeolithic through to more modern coastal

heritage. The art, photograph and map case study area encompasses a broader stretch of the coastline to reflect the various coastal morphologies and features which have been depicted over time.

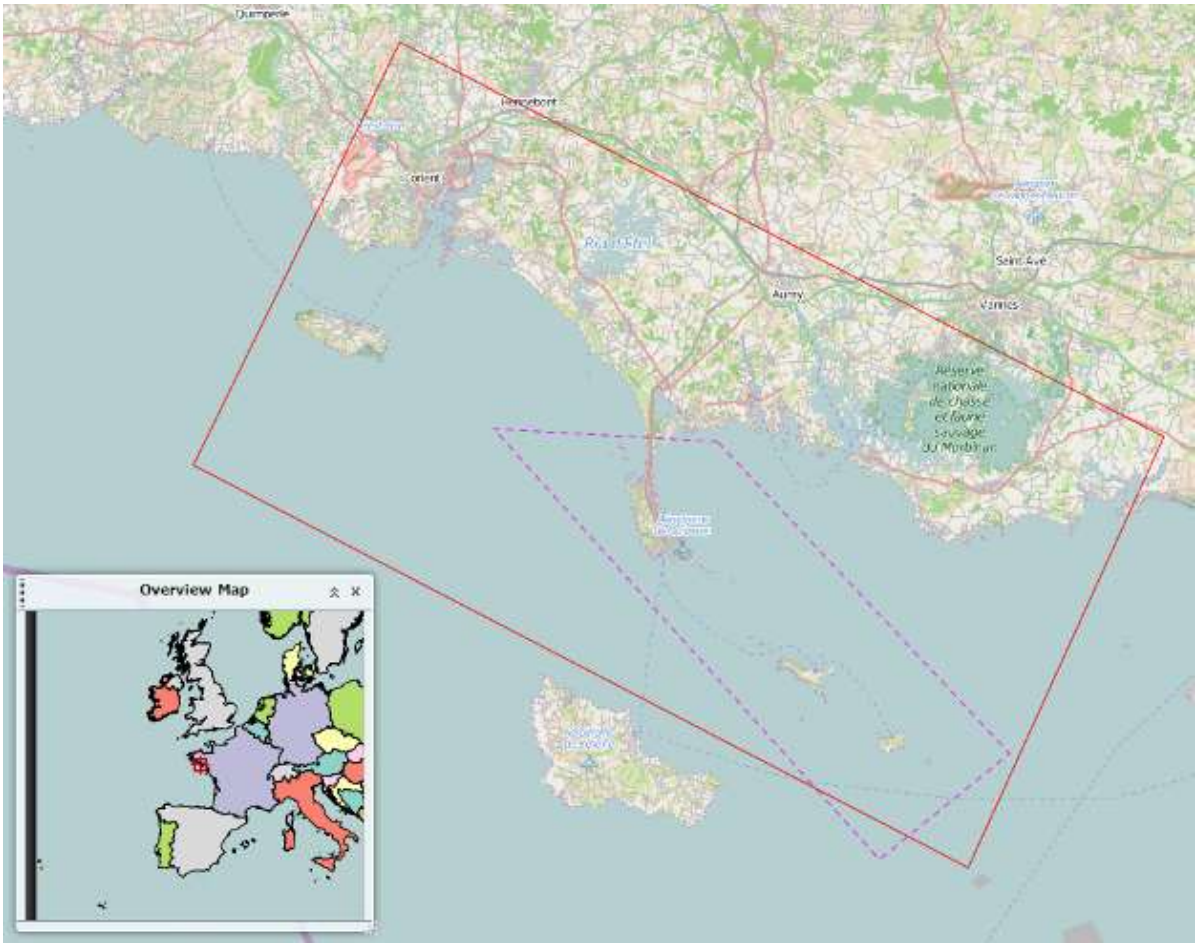

Figure 3K1. Map of the Quiberon peninsula and Morbihan study areas. The dotted line represents the extent of the archaeological and palaeoenvironmental research and the red line represents the extent of the art study area.

3K.1 Introduction to the Quiberon Peninsula Study Area

Located in the Morbihan department, the Quiberon peninsula is linked to the mainland at the southern coast of Brittany. This cape, orientated north-south, represents two very different coastal facades: one facing west is very exposed to wind and swell, with a wild landscape marked by a large number of archaeological sites of great importance. The eastern coast is much more protected and is now densely settled, while the southern part is the most touristic, containing the starting point of cruises and ferries to the islands (Belle-île-en-Mer, Houat and Hoedic).

This means that coastal engineers along the Quiberon peninsula have to manage with very different issues, some of them originated from natural risks and others being linked to seasonal human pressure (Figure 3K2). In recent centuries and decades the most common response to the protection of property and assets has been the construction of coastal sea walls and flood defences.

In this case study area, we will demonstrate the informative value of the archaeological and palaeoenvironmental studies, particularly the work carried out at the Beg-er-Vil Mesolithic site and the ancient fish weirs located in the southern part of the peninsula. Thanks to the huge amount of scientific documentation collected, the issues of coastal management will be thoroughly analysed as well as the efficiency and the sustainability of the current solutions.

3K.1.1 Geomorphology of the Area

This section outlines the key geological and geomorphological features and processes of the study area. These factors have a significant impact on the on-going changes to the coast and associated sites, deposits and features preserved relating to the archaeological and heritage resource, in addition to being depicted through a range of artistic resources.

Figure 3K2. Various features of the Quiberon peninsula coastal landscapes (top: Western "Côte sauvage", bottom: the protected Eastern coast) (after http://www.atlasdespaysages-morbihan.fr).

The rocky cape of the Quiberon peninsula advances 14km into the sea, and is in fact an ancient island connected to the continent by a sand bar. At its narrowest point, at L'Isthme de Penthièvre, the peninsula measures less than 100 meters across. To the west, facing the Atlantic Ocean, the 'Côte Sauvage' area contains a remarkable wild landscape of indented cliffs, while the eastern coast facing the bay, is protected from the predominant winds and is densely settled and visited by tourists.

Geological History

The Quiberon peninsula is a granite unit, belonging to a series of topographic high points, slightly parallel to the continental coast of Morbihan. This alignment is an inheritance of the hercynian structures, comprising the Groix island and the Glénan archipelago to the North and

the Houat and Hoedic islands to the South (Audren *et al*. 2003, Lardeux 1996, Menier 2004). The peninsula and the islands mentioned above contrast with the Belle-Île island, which is of micaschist substratum (Figure 3K3).

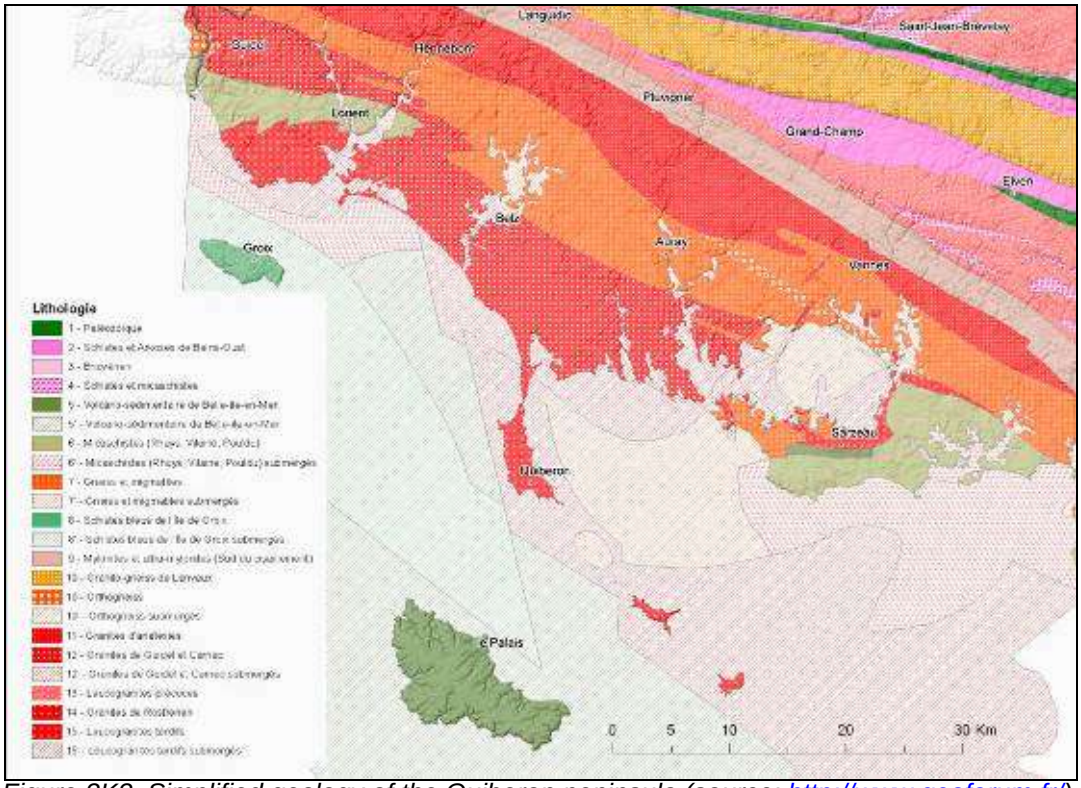

Figure 3K3. Simplified geology of the Quiberon peninsula (source: http://www.geoforum.fr/).

Geomorphologic Processes and Human Intervention

Located in the department of Morbihan, the coastline between the Gâvres peninsula south of Lorient and the Quiberon peninsula is representative of the largest wilderness coastline in Brittany. It covers nearly 2,500 ha, with almost 35 km of continuous natural shoreline. The wild coastline of the Quiberon peninsula is of international importance and includes the huge cordon dune stretching 25km to Lorient. The main feature of this large site lies in its unique geomorphologic unit: either end, two granite peninsulas are attached to the Continent by two large "tombolos" dunes which are interrupted by the mouth of the river Etel. This geomorphologic symmetry results at the landscape level in a contrast between rocky coasts and large dune arcs (Audren *et al.,* 2003).

The changing position of the shoreline due to sea level variations inferred that Quiberon was sometimes an island and sometimes a peninsula linked to the mainland by a sandy bar. Nowadays, with the current sea level rise (about 1,5 mm/year), the Gâvres – Étel –Penthièvre sandy bar is retreating. This phenomenon can be observed at Penthièvre, where the *tombolo* becomes very narrow and is currently limited to the cumulated width of the road and the railway.

This narrow stretch, called L'Isthme de Pentièvre, would have disappeared without human intervention and coastal management, consisting of the building of embankments and sea walls along the most exposed areas (Bournérias & Pomerol 1999). In some locations efforts have been made to stabilize the sand dunes.

Several reconstructions of the palaeolandscape evolution in the area have been proposed and synthesized by Le Pessec (2011) (Figure 3K4 & 5). As well as this, several hypotheses and chronologies exist concerning the periods of separation of the Quiberon Island from the mainland. These opinions are generally based on various observations of the northern sandy narrow and its evolution due to the marine streams and wind orientation (Le Pessec 2011) (Figure 3K5).

Concerning human intervention, the coast of Quiberon is relatively well served by a network of pathways and roads. The coastal road from the western coast gives access to the granite cliffs. As mentioned earlier Quiberon contains two very opposite landscapes, the first is the so called 'Wild Coast' ('Côte Sauvage'). Its aesthetic and cultural qualities have been recognized for over a century as it contains spectacular view points, especially during storms, and attracts crowds of tourists. The second feature, lesser known is composed of dune arcs, remarkable by their size and barren nature, quite a typical landscape in the country. Beyond these geographical and ecological aspects, the military past of the area creates a special atmosphere. Indeed, these landscapes also have a common military history, illustrated by the Chouannerie museum and Fort Penthièvre, and later by the large amount of WWII bunkers scattered throughout the coast.

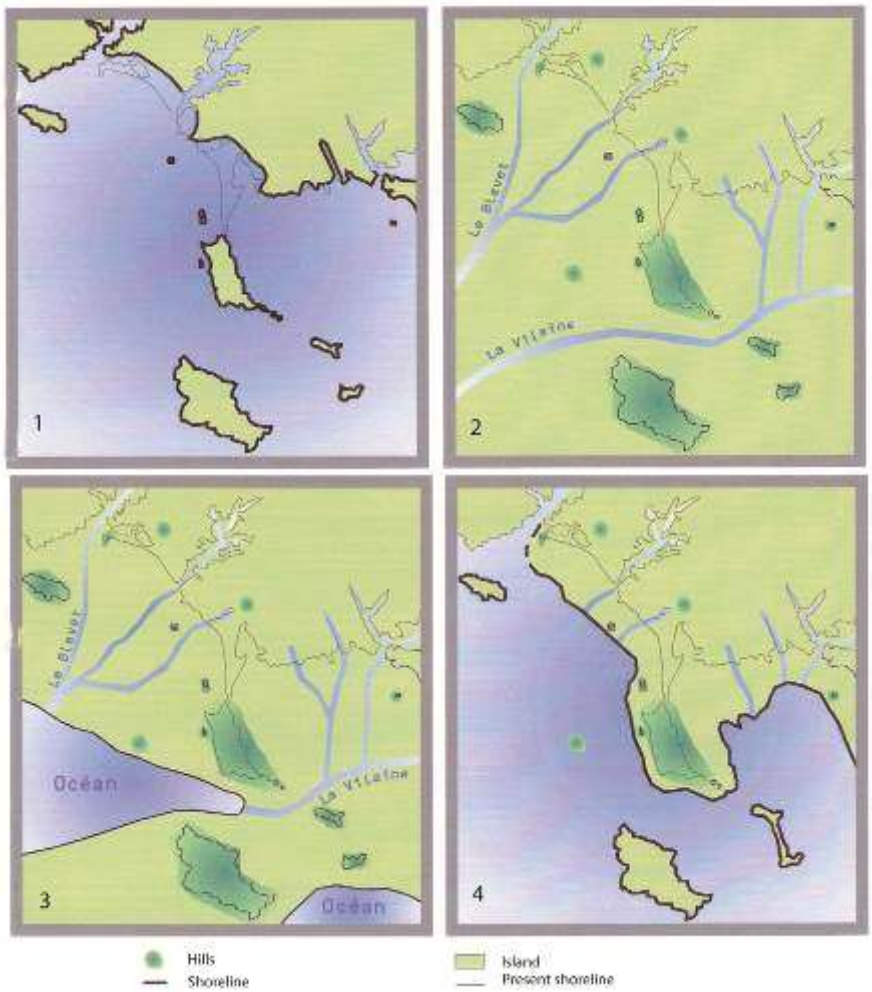

Figure 3K4. Palaeo reconstruction of the Morbihan and Quiberon peninsula environment (map by D. Allaire, after Le Pessec, 2011). (1) From 135.000 to 115.000, (2) From 115.000 to 18.000, (3) c. 9.000 BC, (4) c. 6.000 BC.

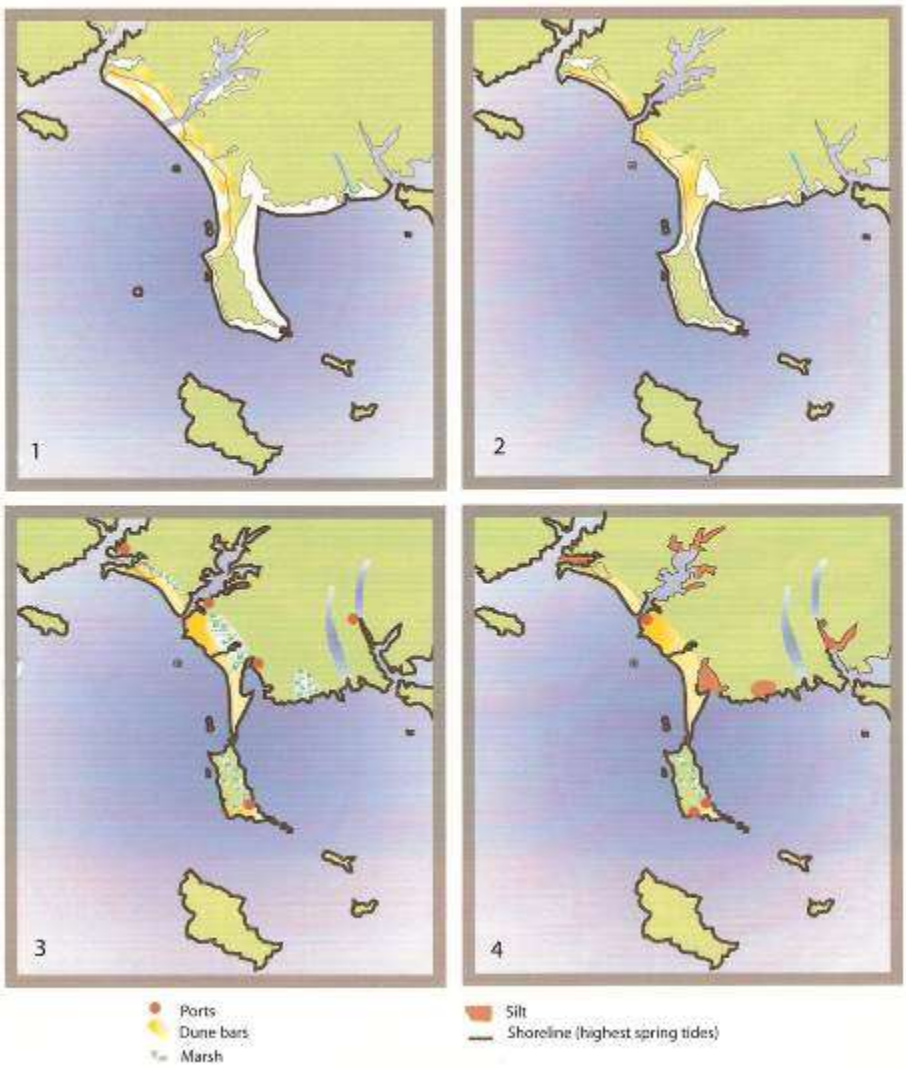

Figure 3K5. Palaeo reconstruction of the Morbihan and Quiberon peninsula environment (map by D. Allaire, after Le Pessec, 2011). (1) From 4.500 to 1.500 BC, (2) from 400 BC to 300 AD, (3) from 1.200 to 1.600 AD, (4) from 1850 AD to present.

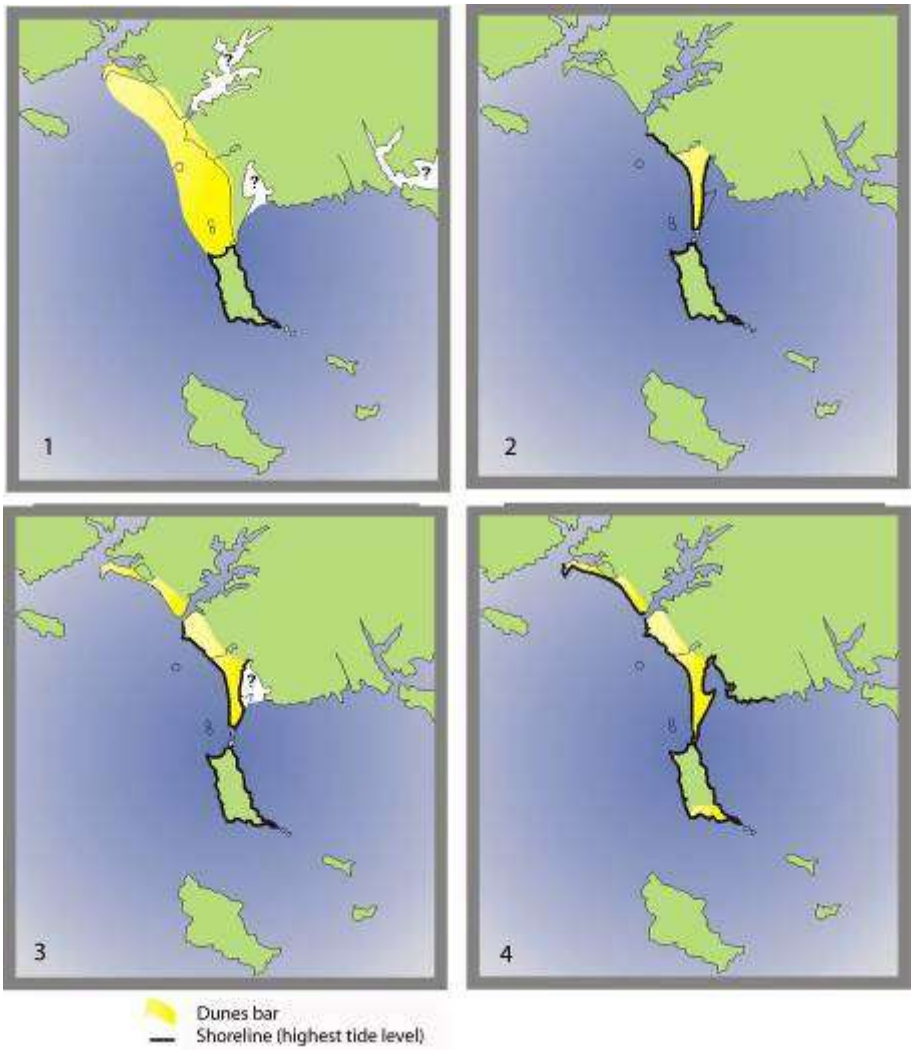

Figure 3K6. Hypothesis on the island vs continental evolution of the Quiberon peninsula/island (map by D. Allaire, after Le Pessec 2011). (1) 5th-4th millennium BC, (2) 3rd millennium BC, (3) Roman time (1st-4th century AD), (4) Modern times.

3K.1.2 Archaeological, Palaeoenvironmental and Coastal Heritage Resources Consulted for Project

The archaeological and palaeoenvironmental data has been obtained from the *AMARAI* Database, the *Atlas des Patrimoines* and the *Splashcos* Database. One important source has been the unpublished documents from M. Le Pessec (2011 and 2013), compiling all the available published documentation, completed by unpublished personal observation.

Several books were also used, either general on the prehistory and archaeology of Brittany (Giot *et al.,* 1995, 1998), thematic and focussed on one specific period (Monnier 1981), or diachronic but limited to one geographic area, such as the Morbihan department (Galliou, 2009) or the Gulfe of Morbihan (Lecornec, 2001).

Several archaeological projects have been carried out in this area over the last twenty years. The longest research project and excavation is on the Beg er Vil Mesolithic site which will be detailed further below (Marchand & Dupont, 2012, 2013). Another archaeological project was the study of fish traps from the Mesolithic to modern period along the Brittany coast coordinated

by Loïc Langouët and Marie-Yvane Daire, since 2006 (Daire & Langouët 2008, 2010). Over 750 fish traps were identified in Brittany, but the Quiberon ones were chosen for the Arch-Manche project because of the opportunity to carry out some underwater surveys on these prehistoric installations. The description of the works carried out in 2013 will be detailed below.

We also mention below, the results obtained by S. Cassen and his team on the partly submerged standing stone alignments, the study of which has provided additional evidence and new data on Holocene sea level rise. In addition, a database on submerged prehistoric sites has recently been constituted, as the French contribution to the international Splascos Atlas (in progress); it was a main resource for prehistoric sites in addition to archaeological inventories of the *Atlas des Patrimoines* (http://atlas.patrimoines.culture.fr/atlas/trunk/) and especially the AMARAI Database, which provided the most detailed and updated information about archaeological sites in Brittany, especially island and coastal ones.

3K.1.3 Summary of the archaeology and history of the Quiberon peninsula study area

Some sites of the Quiberon area belong to the most famous prehistoric sites in Europe, especially the Mesolthic cemeteries of the Téviec and Hoedic islands (Large 2002, Collective 2007). However, during the last decades, our knowledge concerning the prehistory and more widely on the archaeology of the Quiberon peninsula (Figure 3K7a&b) has been deeply improved, thanks to fieldwork programs on several sites including: Beg-er-Vil (excavated under the direction of Grégor Marchand & Catherine Dupont; Marchand & Dupont, 2012 & 2013), and Groh-Collé on the Kervihan cape (excavated by Jean-Noël Guyodo 2006-2008) (Guyodo, 2008). Interdisciplinary approaches have considered both terrestrial and underwater remains, leading to a real renewal of the data, particularly on the Kerbougnec and petit Rohu standing stone alignments (Cassen *et al.,* 2010).

The heritage of the Quiberon peninsula is clearly very rich and diverse, with sites and finds from the Palaeolithic through to the Middle Ages and modern times, this will be demonstrated below. The survival of these sites is primarily down to the sandy environment which has preserved not only the monuments but also the artefacts and organic remains (including wooden coffins, tools, skeletons etc). Even where the main part of the monuments has disappeared, a wide range of megalithic monuments are still visible in the peninsula and contribute to its tourist appeal. As well as this, the study of peat layers behind the Rohu beach allowed us to propose an environmental reconstruction of the peninsular landscape from 11000 BP to modern times (Gaudin, 2004).

Early Prehistory (Palaeolithic and Mesolithic)

Studies on the stratigraphy of Pleistocene deposits from the south coast of the Armorican Massif (Morbihan) are not as advanced as in the north of Brittany. Geological features are extremely different and the absence of loess, as the lesser slope deposits (lower cliffs), implies weakness of sediment. The fossil beach of Saint-Colomban connects deposits to the west, with an occupation platform at 6m. The geological study of the deposit in its general context, therefore suggests that human occupation dates back beyond the last interglacial, perhaps at the end of isotope stage 11 or 13, (Monnier, 1981). On the Quiberon peninsula, evidence for Palaeolithic occupation is minimal, one layer has been reported on Téviec Island (acheuléo-levalloisien facies).

The best-known Mesolithic sites from Brittany are the cemeteries on the islands of Hoëdic (10 graves) and Téviec (9 graves) in Morbihan (Ghesquière & Marchand 2010; Marchand, 2014). The collective graves are placed in shell middens without any particular order. Some graves show evidence of *post mortem* manipulations of the bones. There are also single burials and empty graves (cenotaphs). The graves are covered with stones, a hearth or antlers forming a sort of dome. Rich funeral gifts, flint tools, engraved bones, shell ornaments and ochre demonstrate the affluence of these hunter-gatherers, or rather fisher-gatherers. Certain shells are sex-specific.

In Teviec there are stone cist graves. The bones of an infant have been ornamented with striations. The radiocarbon date measured in 2005 for the Téviec site indicates an occupation c. 5300/5000 calibrated BC, i.e. 6514 +/- 45 years B.P. The corresponding settlements consist of shell middens. A radiocarbon date of 4625 (uncal.) for Hoëdic places it in the 6th Millennium BC, rather late in the Mesolithic sequence, and indeed there are some indications of contact with agricultural societies to the east. Their economy was based on marine resources. Recently, a number of accelerator dates have been published for Hoedic.

Dating back to the Mesolithic period, and 80 years after its discovery, the Téviec cemetery and its 23 skeletons are still objects of attention (recent analyses and exhibition in progress, Figure 3K8).

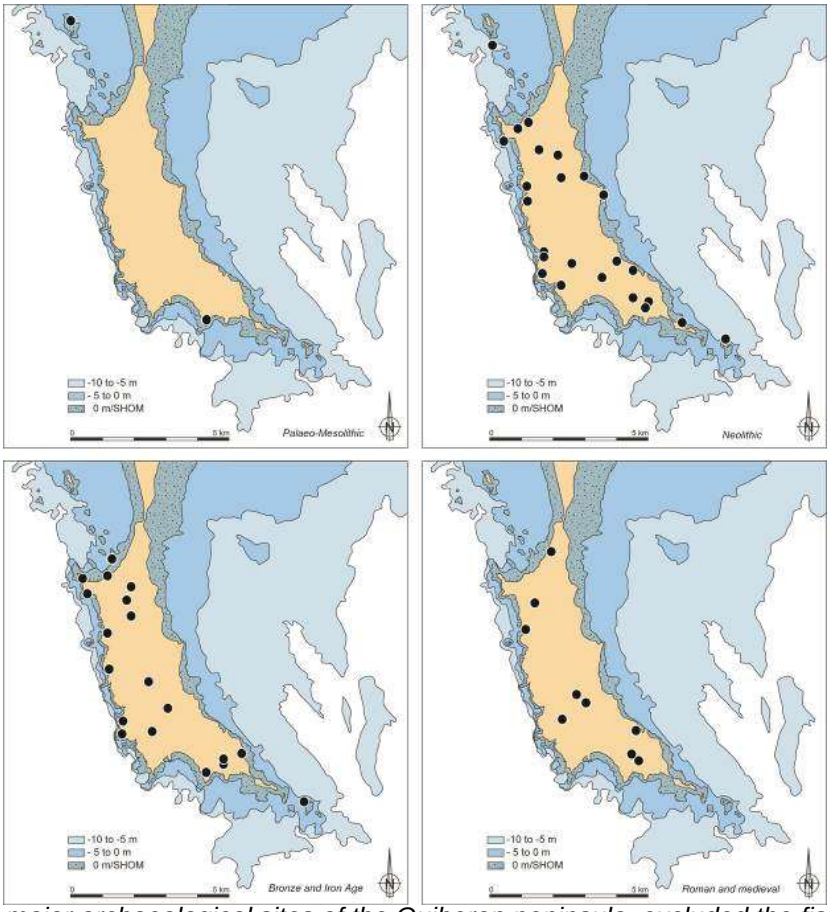

Figure 3K7a. The major archaeological sites of the Quiberon peninsula, excluded the fish weirs presented in a separate figure (map by L. Quesnel and M.Y. Daire).

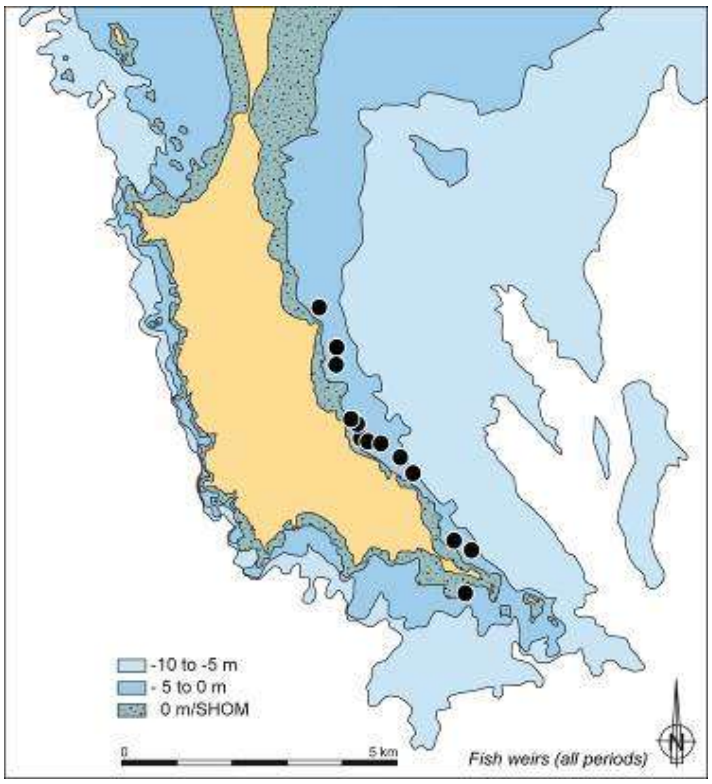

Figure 3K7b. The ancient fish weirs of the Quiberon peninsula (map by L. Quesnel and L. Langouet).

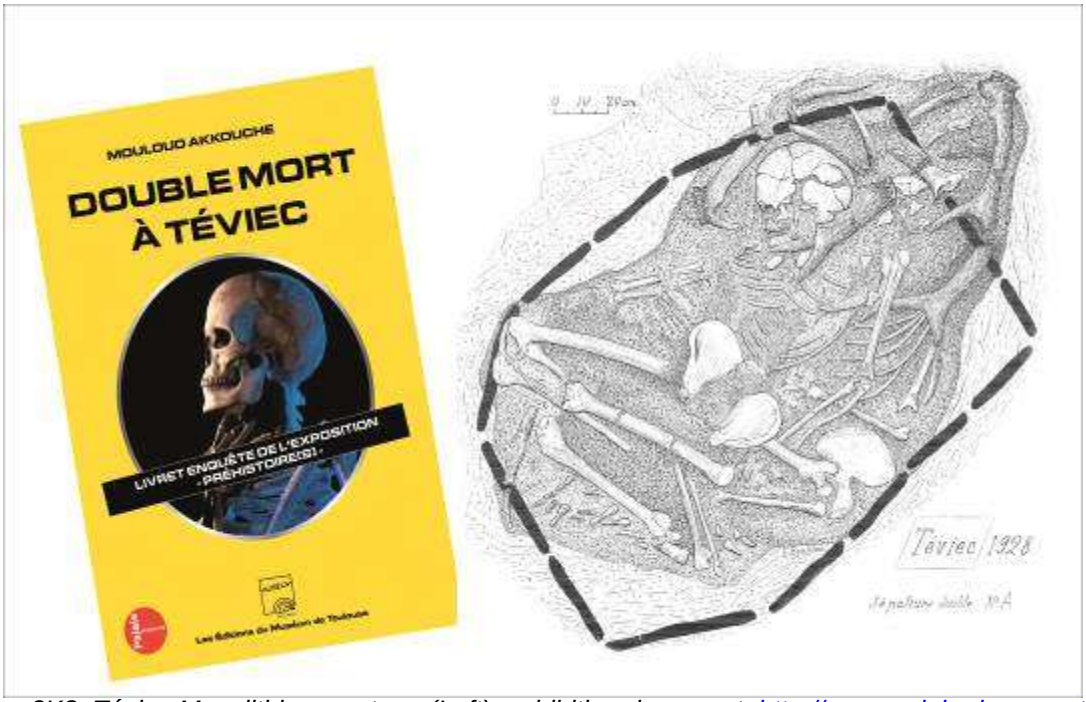

Figure 3K8. Téviec Mesolithic cemetery. (Left): exhibition document, http://www.palais-decouverte.fr/, (right): drawing of the A burial by F. Bouillon.

Section 3K.5 below will present in detail the Beg er Vil Mesolithic settlement, which is one of the main sites of our case study area; it consists of a prehistoric layer dating back to 6100 BC,

located above a hanging beach, and composed of a shell midden where prehistoric tools were preserved (Marchand & Dupont 2013).

Later Prehistory (Neolithic),
The cultures which occupied the area between 5500 and 1800 BC left a lot of megalithic monuments in the Quiberon peninsula. A lot of them disappeared during later periods, where they were reused for modern construction, destroyed by erosion or hidden under the sandy dunes. The main categories of megalithic monuments present on the peninsula are standing stones, sometimes grouped in alignments and funeral structures (passage graves).

In spite of the frequent destruction of standing stones, several 'menhirs' still exist in the peninsula (Figure 3K9); as in other regions of Brittany, their precise dating remains difficult as this tradition stems from the Neolithic up to the Bronze Age. The most famous monuments still visible are Manémeur, Er Palouenneù (road to the Vivier), Er Limouzen, Guerguerit cape, Beg er Vil, Goulvars (2 or 3 standing stones), Keridenvel and Er Ruguied.

Figure 3K9. Quiberon standing stones in Conguel (left) and Manémeur (doc. Le Pessec).

Megalithic burials are also numerous on the peninsula, mainly represented by passage graves, however, many have been destroyed by erosion or modern constructions: including Manémeur , Kerné, Roch Priol, Toul Braz islet, Roch an Aud, Percho, Beg-Portivy, Mané Beg-er-Noz. One of the most famous is the 'Conguel' passage grave, nowadays partly destroyed, it has long served as a reference for the ceramic typo-chronology. Famous for the skeletons and the ceramic set found during the excavation (by Z. Le Rouzic in 1925), this monument dates back to the late Neolithic, (2800/2500 BC) (L'Helgouac'h 1962). It was been "restored" in the early 20th century (Figure 3K10).

The Neolithic site of Groh Collé is another regional reference for the cultural assessment in Brittany. Located on a cape, it has been recently excavated by J. N. Guyodo (2006-2008). Its occupation dates back to the late Neolithic (4 000 to 2 000 BC) (Guyodo 2008).

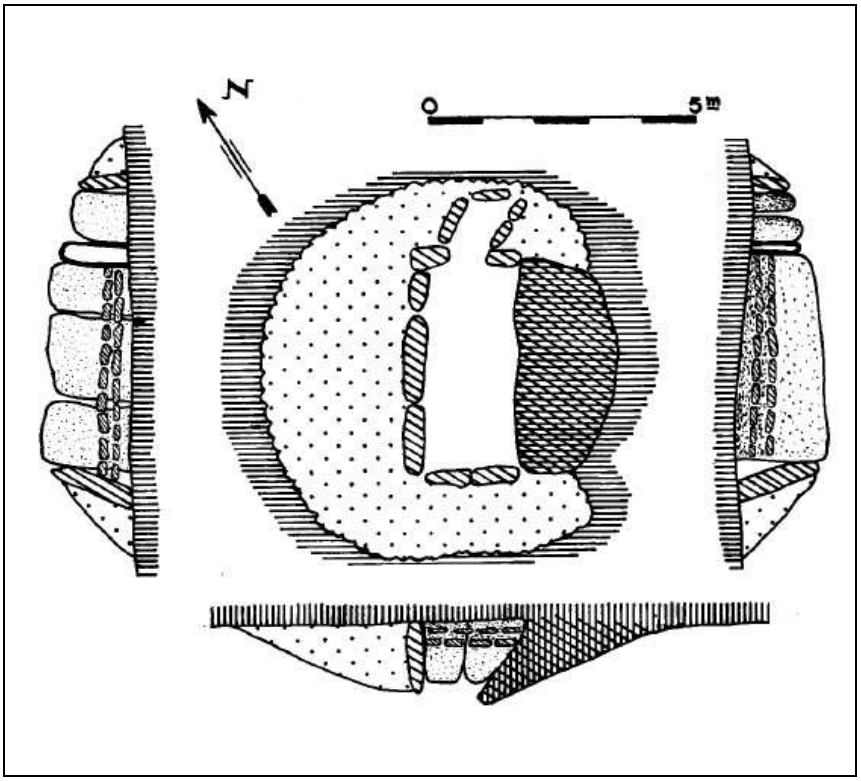

Figure 3K10. Plan of the Conguel passage grave (doc. Le Rouzic, 1930, after L'Helgouac'h, 1962).

Figure 3K11. The Neolithic Groh-Collé site during the excavation by J.N. Guyodo (source Le Pessec 2013).

The most important Megalithic site on the Quiberon peninsula is without a doubt the Kerbourgnec alignments situated in Saint-Pierre-Quiberon. Until the recent works by Cassen *et al.,* it was said to be made up of 25 sometimes oddly-shaped menhirs aligned in a sequence of five rows. Only a little further from this site, there is a "Cromlec'h" with a total of 27 menhirs placed in a circle - it is the third largest in the whole of Morbihan. Recent research has led to the discovery of the tidal and submerged part of the alignments. The menhir lines travel further down and out into the sea, remains of which can be seen at very low tide. They draw several very clear lines of rocks stretching out into the sea in parallel rows. The sediment has been washed away from around the rocks, and they now just sit on the rocky seabed, but it is possible to clearly see the lines. At least seven rows of rocks are visible but the end of the alignments remain permanently submerged, even during the lowest spring tides, providing evidence of the effects of sea level rise (Figure 3K12).

The site of the Moulin or Kerbougnec alignments has recently provided a revised vision of western France megalithism as well as for environmental studies combining terrestrial and underwater approaches (Cassen *et al.,* 2010).

On the Petit Rohu site, after the discovery of several stone axes in 2007, fieldwork carried out produced evidence for at least one submerged stone alignment located to the south-east of the axe head find spot and several dozen metres away (Cassen *et al*., 2008). The structure is readily distinguishable from a more recent stone structure, related to fishing, located 800m away. Peaty soils have been intermittently observed over several years, buried beneath marine sand; these are being progressively eroded away by the force of the sea, as their sand cover becomes thinner. These soils preserve marks, criss-crossing each other in places, which relate either to cultivation or to salt extraction; and there are also hoof-prints of ungulates (cattle and pigs). This palaeoenvironmental context allows us to argue that the axe heads had been deposited in a marshy environment that had developed behind a dune system, at the foot of a remarkable granite outcrop. Sea level rise since the mid-fifth millennium BC - the likely date at which the axe heads were deposited - means that the shore has advanced by some 500m since then.

Bronze Age and Iron Age

Evidence of Bronze Age human occupation is scarcely represented in the Quiberon peninsula, one of the best records being the Vivier settlement, excavated by J. Briard (Briard *et al.* 1990). Several burials in stone cists or under tumulus are also recorded. The palaeoenvironmental study, carried out in parallel with the most recent excavations, has shown that this region had been severely cleared by Neolithic people who built the numerous megalithic monuments during the former period.

The Iron Age is better documented by a large range of sites: fortified settlements (Beg an Aud), cemeteries and burials (Thinic islet), sometimes associated with villages (Kerhihuel/Kergallo, Kernavest, Port-Bara, Goulvars, Runaron, Kerné), and salt production workshops (Toul-Bras islet). As an illustration of the good preservation conditions of sandy dunes, during the excavations on the Thinic island (by F. Gaillard in 1883), 27 stone cists each of them containing one or several skeletons, stone tools, antlers etc. were found (Figure 3K13).

In the regional tradition, the Quiberon peninsula and, more widely, the 'Mor Braz' area is said to have been the setting of the naval battle between Caesar’s flotilla and the Vénète's flotilla in 56 BC.

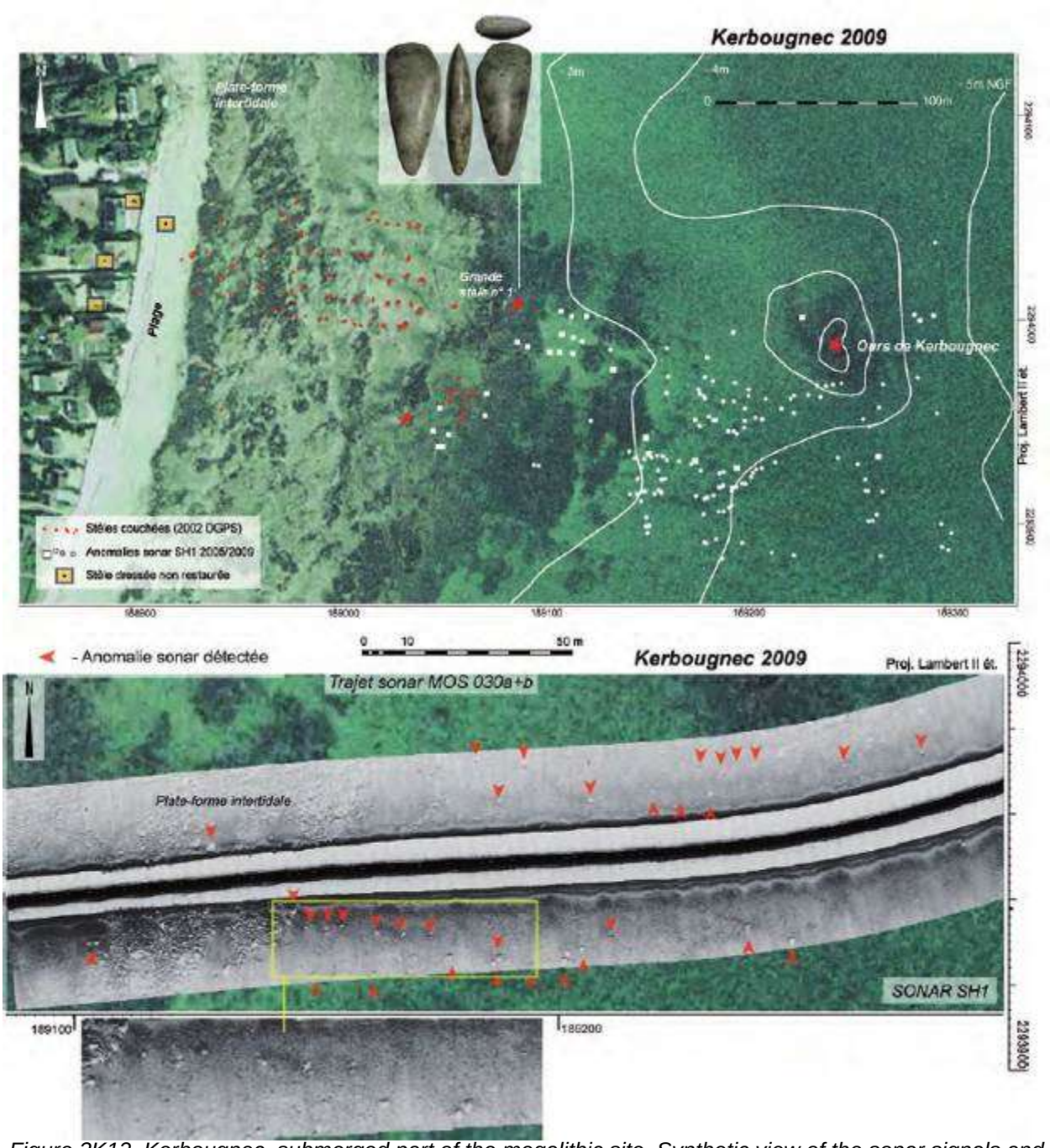

Figure 3K12. Kerbougnec, submerged part of the megalithic site. Synthetic view of the sonar signals and jadeite axe found on the site (after Cassen et al. 2010).

Figure 3K13. Thinic islet, Portivy-Quiberon (while low and high tide) (cl. Le Pessec).

Roman Period

Roman *villas* are not uncommon in the study area and remains are reported, notably in Keriaker (Figure 3K14), excavated in 1966 by G. Bernier, where a small building with two rooms was accompanied by a domestic kiln used for cooking. The walls were decorated with paintings and shells stuck on the coating. However, the Roman period is mainly represented in the Quiberon peninsula by the numerous finds of Roman coins and artefacts, in addition to isolated finds of objects. The Port Haliguen 1 treasure was composed of 450 coins and the second one contained 105 Roman coins (Goulpeau, 1985).

Medieval Period (500AD – 1485AD)

Several chapels and the Saint-Clément cemetery (excavated during the late 19th century) (Figure 3K15) appear in the Medieval period. Most of the churches of the peninsula had their foundation back in the Middle Ages. A document (chart) from the 11th century mentions the ancient name of the Quiberon peninsula which is "*Insula Keberoën*" (in 1037).

In the Bay of Quiberon, we have little documentation on navigation in the late Middle Ages. Nevertheless, this high sea level and low siltation Bay allowed from 1450, the use of many "ports" Port Haliguen as natural, perhaps also Port Orange.

Figure 3K14. The Kermarker site, the roman remains are currently buried under the dune (cl. Le Pessec).

Figure 3K15. The ancient cemetery in Saint-Clément, sarcophagus probably from the Carolingian period (751 à 987) (cl. Le Pessec).

Post-Medieval Period (1485AD – 1901AD)

To the north of the peninsula, the Plouharnel landing ports seem to have been used until around 1826, before siltation. In this area, the tide mill of Bego operated from 1774 until its destruction in 1850, due to the construction of the Auray/Quiberon road. Cabotage on the Atlantic coast grew strongly from that time, for various reasons, but the rise in sea level could also play a role in the development of ports at the river bottom such as Auray, Vannes, etc.

A significant element of the Post-Medieval period is the construction of coastal military defences, demonstrated here by the Fort Penthièvre (Figure 3K16). Built in 1746 in the framework of the military coastal defences, it was reused by the royalists after the French revolution of 1789. It was then reconstructed and reused several times (see below).

Modern

The majority of sites from the 20th Century comprise WWI and WWII defence systems. As mentioned above, the Fort Penthèvre (Figure 3K16) was reused, especially by the German army during WWII. Nowadays, the fort belongs to the Army and is still in use by the Marine Infantry Regiment of Vannes, for training.

Figure 3K16. The Fort Penthièvre, view from the north (cl. Le Pessec).

3K.1.4 Art History of the Area

This section presents the background to artistic representations within the area including key schools and individual artists. This provides the background to the broader consideration of individual artworks within the study area, the two main painters considered here being Maxime Maufra and Jules Noël (see below). The coastal region of the Quiberon peninsula, and more widely the coast of the continental shelf of Morbihan was quite well depicted, but probably lesser than the tourist zone of Cote d'Emeraude (see case study 3H) which was a major source of inspiration for artists from all over the world and is where the Pont-Aven School of painters was created in the 19th Century. We didn't deal here with the extremely rich set of paintings representing the Belle-Île-en-Mer island landscapes and rocky coasts (with the dominant character of Monet) as it is located outside of our case study area.

Several pioneers of photographic techniques captured numerous parts of this area; mainly due to the development of tourism and the creation of some seaside resorts, photographic postcards produce a lot of visual records of coastal tourist areas.

Figure 3K17. The Quiberon seafront and beach (early 20th century) (postcard, cl. Lannelongue).

Introduction

The study area focuses on the Quiberon peninsula, especially for the archaeological and palaeoenvironmental approaches; however, the area considered for artistic resources has been enlarged and covers a wider area of about 100 km wide, this is in order to gather a sufficient set of illustrations, and includes some very accurate case study sites.

As in the other case study areas, the approach for the coastal study sites will, therefore, aim to:

- demonstrate the role that historical works of art (oil paintings, watercolours and prints) and especially photographs can provide in terms of supporting understanding of long-term coastal change;
- assist understanding of the chronology of coastal change in southern Brittany, especially in the Quiberon area;

- provide examples of those artists' works which form reliable records of coastal conditions at the time they were painted.

Art Resource

Regarding the main sources used for paintings of the area, some illustrated books provided a wealth of paintings and watercolor drawings (Delouche, 2011). But the main source was the *Joconde* online database. The Culture ministry database *"Joconde"* is the gate of museums and public galleries collections in France. The catalog contains nearly 500,000 records including archeology, fine arts, ethnology, history, science and technology, it is enhanced by thematic options and virtual exhibitions. Joconde is the result of an ongoing partnership between the office of the digital broadcasting service collections of museums in France and the participating museums.

For the Gulf of Morbihan area, an interesting resource with a full list of all the artists (painters, photographs, postcard editors etc.) having depicted the area can be found on: http://dictionnairedugolfedumorbihan.over-blog.com/article-les-artistes-du-golfe-du-morbihan-73045992.html, some examples are also published in the paper version of the *Dictionnaire du Golfe du Morbihan* (De Beaulieu, 2011).

One of the most prominent figures for this area is Maxime Maufra (1861-1918) (Collective 1998, Ramade 1988) (Figure 3K18). He was introduced to painting with Charles Leduc and his brother Alfred Leduc in Nantes, reproducing landscapes of the Loire river banks. His father decided to make him a business man; this explains why he undertook a language course in England (Liverpool).There he discovered what painting really was, including the work of Turner. He visited Wales and Scotland, whose landscapes are his inspiration. He returned to France in 1884, where he tried to manage both his business and pictorial work.

Very quickly he established his own technique and approached landscape painting with a preference for maritime landscapes of Brittany. He moved around Quiberon, the Pointe du Raz, in the peninsula of Crozon and many other places. He settled in 1903 in a small farm at Kerhostin (Quiberon) which he then bought in 1910. He tried unsuccessfully to restore a small painting group in these places and he was appointed "Peintre de la Marine" (painter of the Navy) in 1916. Attached to the Breton regional culture, Maxime Maufra was one of the leaders of the "fine arts" in the Breton Regionalist Union section.

Landscapes, harbours and urban views of Britain have largely inspired the painter Jules Noël (1810-1881) (Figure 3K19). His style, comparable to the one of Eugène Isabey, varies between a wise and realistic effect of light, sometimes close to Impressionists. He spent is youth in Brest and started to teach drawing in Brittany, in Saint-Pol-de-Léon, Lorient and Nantes. From 1847 until his retirement in 1879, he taught at Paris and enjoyed holidaying in Normandy and especially in Britain (Rodrigue & Cariou 2005).

Figure 3K18. 'Plage de Portivy", by Maxime Maufra (1907) (private col. Source of the document: http://fr.wahooart.com/).

Figure 3K19. 'Port de Larmor', by Jules Noël (1868) (Private collection,source: http://enflanant.hautetfort.com/).

3K.1.5 Art Resources Consulted for the Project

In order to establish the resources available for this study it was necessary to review the existing artworks. The main source of artists has been the database of the Ministry of Culture of France, called "Joconde" (see above). For the Morbihan case study area, the art approach partly benefited from the academic work (Masters) led in the Rennes 2 University by Edwige Motte (Motte 2013). The theme of the dissertation was: "*Representation and Evolution of the Shoreline: What do regional paintings teach us about the Breton coastal environment*?". It was also necessary to review the topographical paintings, drawings and prints held by the principal national, region and local collections covering the case study area.

The photographic postcards consulted for the project belong either to private collections, or to public ones (Biet & Bouze 2007), particularly the Regional ancient postcard conservatory which is an important resource (http://www.cartolis.org/), and primarily the documentary collection

available in the Archéosciences Laboratory (University of Rennes) (ICARE, http://ntarcheo2.univ-rennes1.fr/icare/). Several books have recently demonstrated the importance of photographic pioneers in the region and provided a commentated documentation to our research.

Concerning the maps and charts used for the case study, one of the most informative resources for this area is the "*Carte des Ingénieurs géographes du Roy*" (18th century), which provides very accurate details especially along the coast. At a local scale, the "Cadastre Napoléonien" (19th century) is very detailed and provides a view of the extent of the private and public properties, buildings and fields, sometimes with additional textual information.

3K.2 Current Environmental Impacts/Threats and Coastal Management Approach

This section considers the current environmental impacts and threats along the coastline and reviews the current coastal management issues and approaches (Collective, 2009).

Figure 3K20. Excavations on the megalithic monument of Port-Blanc, Quiberon (Doc. Félix Gaillard, Société Polymathique du Morbihan).

3K.2.1 Review of Key Contributors to Coastal Change

It has been explained for the different case study areas that coastal erosion over the centuries is evidenced through the loss of a number of communities including places of interest regarding the natural and cultural coastal heritage (Figure 3K21). We underlined above that the two coasts of the Quiberon peninsula are very different regarding natural threats, the western one is most exposed to waves and wind erosion, especially during storms, while the eastern coast is more protected. Nevertheless, if we take into account the various kinds of geomorphological features (see above), the sandy dunes are one of the most vulnerable components of this landscape (Cavalie, 2001).

Concerning the dunes vulnerability, the document presented in Figure 3K22 is particularly interesting, since 1907 the vast majority of dunes were transformed, it is therefore difficult for us

today to realize the state of the landscape during the 18th and 19th centuries, and before the great works beginning around 1850. We can list some important changes: the construction of bunkers in 1939/45, the numerous sand quarries used for building during the 19th and 20th centuries (archives of the City Council), the numerous archaeological excavations carried out from 1850 to 1939 (sites buried under the dunes), and of course, the winds continuous work, especially where the vegetation is sparse. The situation of coastal areas of the Morbihan department regarding natural threats is summarized in Figure 3K23.

3K.2.2 Summary of Current Coastal Management Approach

Coastal risk management is a responsibility of coastal local authorities in partnership with national and regional ones. Aware of the great tourist potential of their coastal towns which were dominated by agriculture there was an increase in tourism development. The area has been largely developed with new roads and parking areas in order to improve access to the coastline alongside the construction of coastal defences including sea walls. Updated in February 2014, the presentation of the Integrated Coastal Zone Management (ICZM) approach in the Gâvres-Quiberon area underlines the changes to coastal management in this area http://www.labretagneetlamer.fr/?q=node/226.

The expected results are to develop new synergies to promote the understanding and management of the marine and coastal entity, Watershed Etel and the Gâvres –Quiberon dunes and initiate cooperation between the two union structures and their partners to jointly optimize the technical means and scope of the actions.

Figure 3K21. Natural threats on the Quiberon coasts, (top): damages on the Penthièvre dyke after a storm, (bottom): damaged Neolithic site of Kerné (cl. Le Pessec 2011).

Figure 3K22. The Quiberon dunes and beach, late 19th century (archives of the City Council).

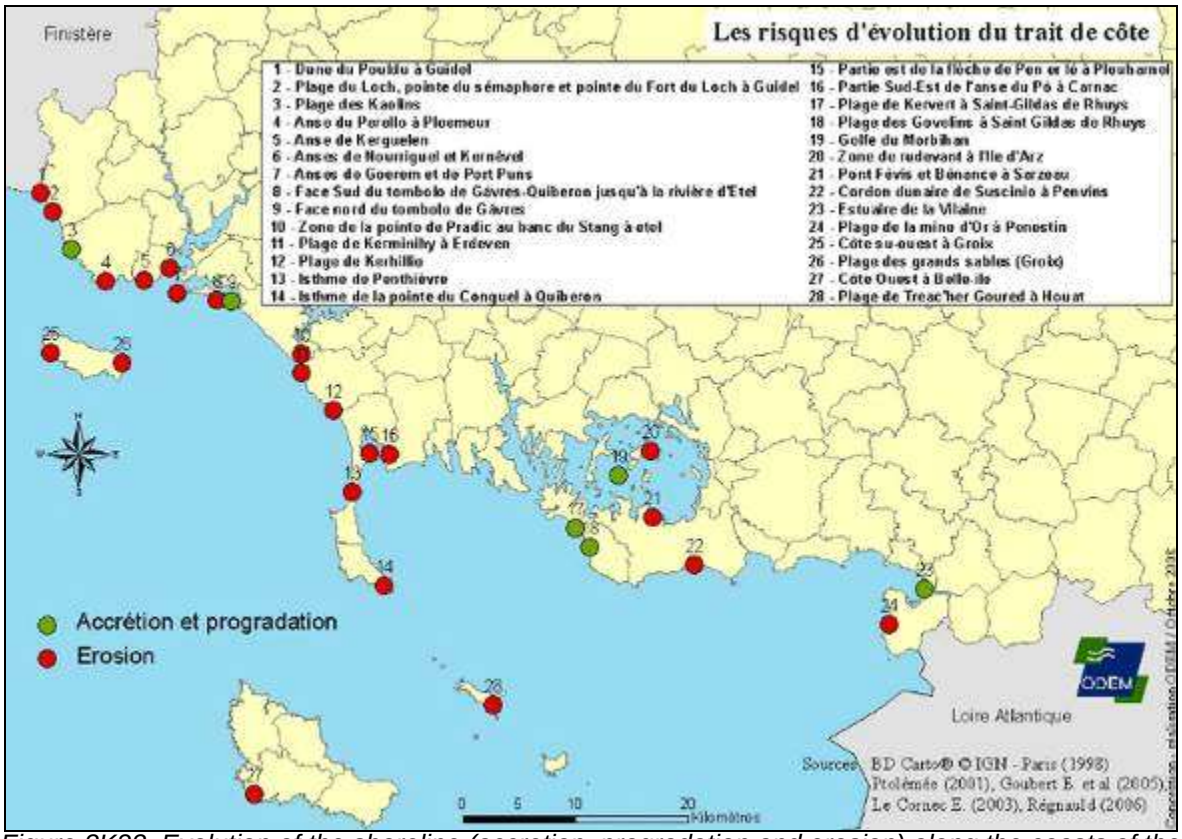

Figure 3K23. Evolution of the shoreline (accretion, progradation and erosion) along the coasts of the Morbihan department. Amongst the 28 sites, 22 are retreating due to erosion (source: http://www.bretagne-environnement.org/).

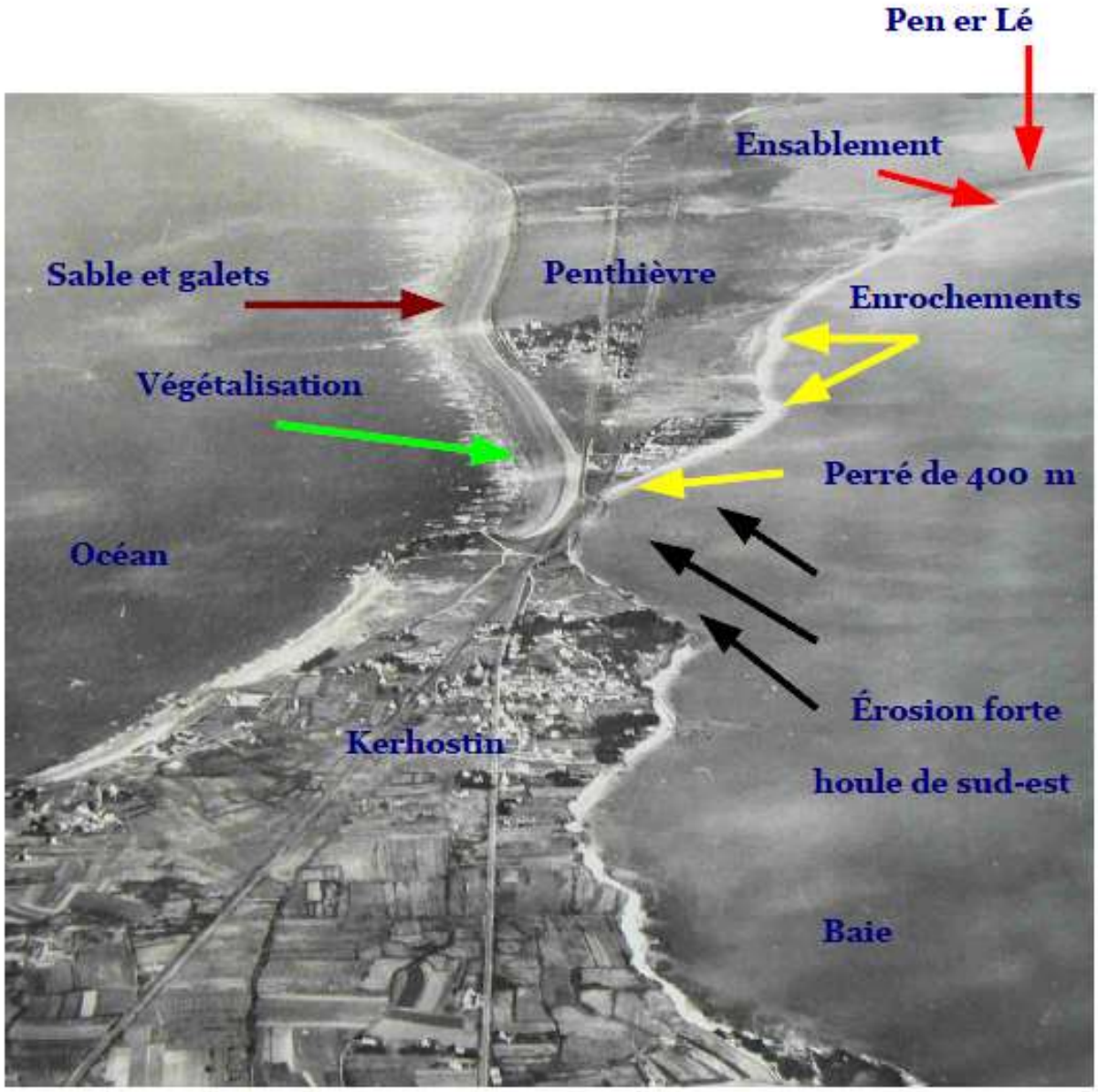

Figure 3K24 Evolution of the Penthièvre isthmus and coastal management (protections on 1 km length) (after Le Pessec 2011).

3K.3 Archaeological and Palaeoenvironmental Ranking

This section outlines the results of the archaeological and palaeoenvironmental ranking from the Quiberon and Morbihan study area, followed by a discussion of the results. The ranking methodology applied is detailed in Section 2.

The discipline of archaeology has a long history, much of the prehistoric element of the discipline developed from work in the Morbihan area (Collective 2007) where some of the most important European sites are located. This explains the richness of the available data, among which we had to choose some of the most representative illustrations of coastal change through the millenniums. Our interest turned then mainly to recent works and new approaches, and sometimes leaving out some emblematic monuments or major heritage records, which appear less informative for the issue of coastal evolution.

The environmental evolution of the Quiberon peninsula has been deeply studied and subject to field and desk based analyses carried out by P. Stéphan (in Marchand and Dupont 2013) especially in the framework of the Beg er Vil project. Complementary data has been obtained thanks to the underwater surveys by ADRAMAR (Le Ru 2013) in combination with the study of the submerged fish traps (Daire & Langouet 2010). These studies mainly concerned the southern part of the Quiberon peninsula, as the Penthièvre isthmus has long been the subject of a morphodynamic study, due to the importance of the dunes cover.

3K.3.1 Results of the Archaeological and Palaeoenvironmental Ranking

The table of highest ranking sites is dominated by prehistoric sites, more specifically Mesolithic settlements and Neolithic monuments (Table 3K1). It is clear that this area contains a concentration of Mesolithic sites showing an exceptional dataset and reference for Western Europe (Téviec and Hoedic cemeteries and Beg er Vil occupation).

The Quiberon peninsula is dominated by megalithic monuments (passage graves and standing stones), and at a lesser level, some Iron Age occupation sites of interest. The systematic surveys carried out by J.M. Large (Large, 2002) on the islands (Houat and especially Hoedic) have recently totally renewed our knowledge of the human occupation of the archipelago. There, major sites (standing stones alignments, settlements) provided resources for environmental analysis. The recent development of fish traps studies in Brittany (Daire & Langouët 2010) have taken benefit of new kinds of field investigations (underwater surveys), which were undertaken off the Quiberon peninsula. All these studies help us to reconstruct the environment of the Morbihan coast and its geomorphological changes from prehistoric times.

The presence of Neolithic monuments, burial graves and standing stones, is a constant in the Morbihan area, famous for major prehistoric stone monuments (Carnac, Locmariaquer etc.). One peculiar phenomenon, densely represented in this case study area is the one of standing stone alignments. Beyond the ones of Carnac, the standing stones of Hoedic (Large 2014) and the alignments of Kerbougnec and Petit Rohu, partly submerged, have recently drawn attention to a new vision of megalithism in Western Europe (Cassen *et al.* 2010).

Through the archaeological ranking analysis, we will consider the Mesolithic site of Beg er Vil and the fish traps of the south eastern coast of Quiberon as providing accurate data on sea level rise since the Mesolithic and, more generally, coastal change (see below).

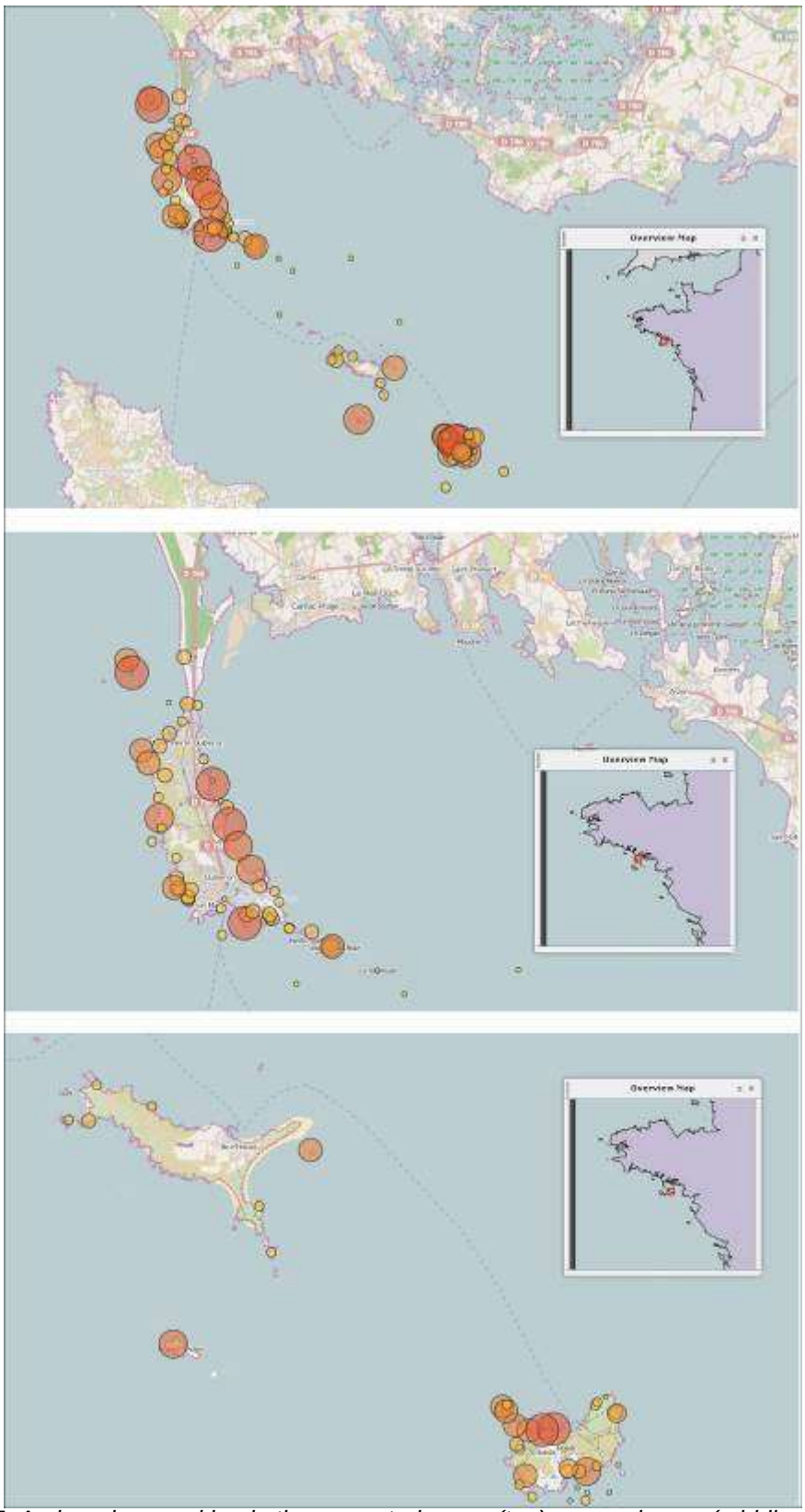

Figure 3K25 Archaeology ranking in the case study area (top): general map, (middle and bottom): detailed maps.

APE uid	Site Name	Site Type	Period	Score – Sea Level	Score – Environmental	Score – Temporal Continuity	Total Score	Coastal Context
1074	SAINT-PIERRE-QUIBERON - Ile Guernic	Other find spot	Neolithic	High	High	High	100	Coastal
1163	SAINT-PIERRE-QUIBERON - Kerbourgnec	Monument	Neolithic	High	High	High	100	Inter tidal
1166	SAINT-PIERRE-QUIBERON - Petit Rohu	Monument	Neolithic	High	High	High	100	Inter tidal
1213	QUIBERON - Beg er Vil	Other find spot	Mesolithic	High	High	High	100	Coastal
1297	HOEDIC - Douet alignement	Monument	Neolithic	High	High	High	100	Above HW
1298	HOEDIC - Groah Denn alignement	Monument	Neolithic	High	High	High	100	Above HW
1083	SAINT-PIERRE-QUIBERON - Groh-Collé	Other find spot	Neolithic	High	Medium	High	88	Coastal
1162	QUIBERON - Saint Julien fishtraps	Marine Installation	Bronze Age	Medium	High	High	88	Inter tidal
1161	QUIBERON - Port Haliguen fishtraps	Marine Installation	Bronze Age	Medium	High	High	88	Inter tidal
1285	ILE D'HOUAT - Ile aux chevaux	Other find spot	Iron Age	High	Medium	High	88	High Cliff
1491	HOEDIC - Sterflant	Other find spot	Iron Age	High	Medium	High	88	Dunes
1076	SAINT-PIERRE-QUIBERON - Ile Teviec habitat	Other find spot	Mesolithic	Medium	Medium	High	77	Above HW
1070	SAINT-PIERRE-QUIBERON - Beg-en-Aud	Monument	Iron Age	Medium	Medium	High	77	Above HW
1082	SAINT-PIERRE-QUIBERON - Porz Guen dolmen	Monument	Neolithic	High	Medium	Medium	77	High Cliff
1201	QUIBERON - Beg er Goalennec	Other find spot	Bronze Age	Medium	High	Medium	77	High Cliff
1204	QUIBERON - Ile Toul Bras	Other find spot	Iron Age	High	Medium	Medium	77	Above HW
1263	ILE D'HOUAT - Er Yoc'h	Other find spot	Neolithic	High	Medium	Medium	77	Coastal
1306	HOEDIC - En Inizen	Other find spot	Neolithic	High	Medium	Medium	77	Sandy foreshore
1296	HOEDIC - Koh Kastel alignement	Monument	Neolithic	High	Medium	Medium	77	Soft Cliff
1295	HOEDIC - Le Télégraphe dolmen	Monument	Neolithic	High	Medium	Medium	77	Soft Cliff
1293	HOEDIC - Port neuf necropolis	Other find spot	Mesolithic	High	Medium	Medium	77	Dunes
1289	HOEDIC - Port Louit dolmen	Monument	Neolithic	Medium	Medium	High	77	Above HW

Table 3K1. Top archaeology/palaeoenvironement ranking results.

Ranks for sea level change

	High	Medium	Low
Number of sites	18	53	27

Ranks for environmental change

	High	Medium	Low
Number of sites	9	29	60

Ranks for temporal continuity

	High	Medium	Low
Number of sites	13	35	50

Table 3K2. Analysis of the top archaeology/palaeoenvironment ranking results.

Figure 3K26. Map showing the distribution of the highest scores sites within the case study area

3K.3.2 Discussion of the Ranking Results

The table of highest ranking sites (Table 3K1) is dominated by Neolithic monuments, mainly standing stone alignments, then passage graves and settlements. Among these sites, those located either buried under dunes or currently located in the intertidal/marine area appear to be the most informative regarding coastal change. Alongside the megalithic monuments other top ranking sites include Mesolithic sites which contain environmental evidence.

The fish traps located off Saint-Julien bay and Port Haliguen harbour, in Quiberon, also provide new data thanks to a program of underwater survey. This data can provide information which will enable the modelling of past coastal change.

Some other sites which have ranked lower still have the potential to provide information on coastal change, such as Iron age settlements located next to the shore (Hoedic) or on the top of rocky cliffs (beg an Aud).

3K.4 Ranking Artistic Depictions

The ranking systems developed for artworks, historic photographs, maps and sea charts were applied to each of the selected depictions, the results are described in more detail below.

3K.4.1 Art Ranking

The research has identified two main exhibiting artists, Maxime Maufra (1861-1918) (Ramade, 1988) and Jules Noël (1810-1881). The development of the ranking system is described in Section 2. For this case study area, 10 pantings have been selected, which represent various kinds of lanscapes, most of them concerning the Quiberon peninsula area.

The majority of these artworks represent wild landscapes, especially before urbanisation and tourist buildings. The oil painting from Maufra depicts the Larmor port allowing us to consider the evolution of the structure, with a former small fishing port which turned into a sailing harbour in the middle of the 20th century. Maxime Maufra (1861-1918), landscape painter (Ecole de Pont-Aven) gives a synthetic view of the landscape, eliminating the details and sometimes exagerating some features, this must be considered when using the artworks to understand coastal change.

Jules Noël's style, comparable to the one of Eugène Isabey, varies between wise and realistic effects of light, sometimes close to Impressionists (Rodrigue & Cariou 2005).

Case Study Number	Location	Artist	Date	Score type	Score style	Score enviro	Total Score
101	La crique côté Quiberon	Maxime Maufra	1903	Oil	Picturesque	General view	37
102	La plage et le port de Portivy	Maxime Maufra	1907	Oil	Topographical	General view	59
103	Les dunes de Port Blanc à Quiberon	Maxime Maufra	1908	Oil	Picturesque	General view	37
104	L'Arche de Port Blanc, presqu'île de Quiberon	Maxime Maufra	1880-1920	Oil	Picturesque	General view	44
105	Pointe de Ker Bihan	Maxime Maufra	1885	Oil	Topographical	General view	59
112	Le port de Larmor	Jules Noël	1868	Oil	Picturesque	General view	40
134	Falaises de Quiberon	Jules Noël	1863	Oil	Topographical	General view	40
261	Pêcheurs ramassant leur senne près de l'isthme de Penthièvre	Elodie La Villette	1880	Oil	Picturesque	Detailed	48
262	La crique de Port Bara	Elodie La Villette	c1880	Oil	Picturesque	Detailed	48
263	Quiberon, cavernes de la côte sauvage	Christoph e Paul de Robien	1753-1756	Oil	Picturesque	General	51

Table 3K3. Top art ranking results for the Quiberon-Morbihan area.

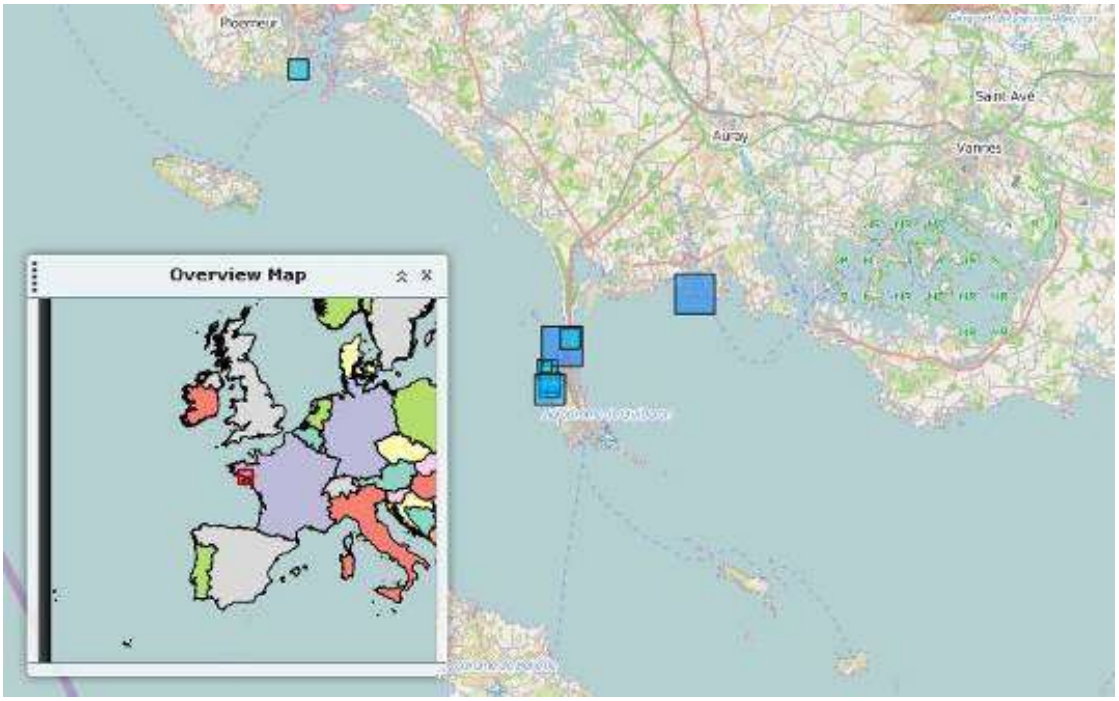

Figure 3K27. Location of art images within the Quiberon and Morbihan case study area.

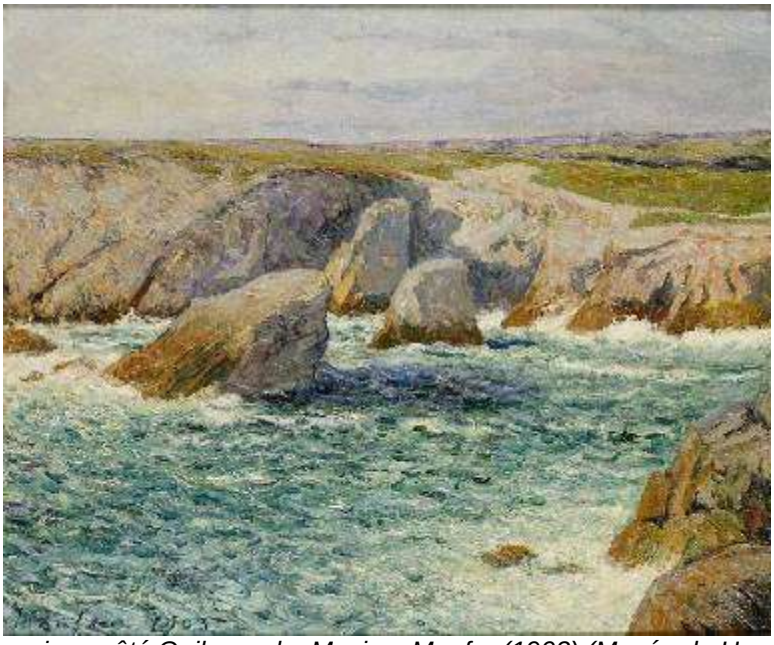

Figure 3K28. La crique côté Quiberon by Maxime Maufra (1903) (Musée du Havre, doc. source: http://www.quizz.biz/).

3K.4.2 Historic Photograph Ranking

Figure 3K29 Location of historic photos in the Quiberon and Morbihan case study area.

A total of 177 historic photos and postcards were assessed as part of the project for this case study area; images were primarily chosen from locations along the coastline where historic paintings and archaeological sites were also known. The photographs were collected and then ranked. Hundreds of historic images exist for this stretch of coastline, it should be noted that this study is not intended to be exhaustive, it simply aims to highlight the potential for historic photos to provide information on coastal change. A brief search of resources available online was

carried out, although further research online, in museums and galleries, as well as private collections has the potential to provide many more.

Table 3K4 below outlines the results of the ranking and presents the highest ranking images, note that photographs were ranked as either a heritage view or a non heritage view.The majority of photos assessed were of heritage views, containing features which can be identified today, the oldest photo assessed was taken in the late 19th century.

In addition, pictures showing parts of the landscape before the construction of modern infrastructures were included. Most of the photos with a score close to 100 correspond to monuments "multi pictured" (e.g. the Er Lannic standing stones circles, with 30 photos or the Pont sal site with 6 photos).

This tourist area along the coast of Morbihan is covered by a set of 177 photos and postcards; however, some zones of the case study area are not represented. Tourism was often a result of the megalithic monuments, particlularly Carnac and these monuments are therefore regularly depicted. After 1936 as mass tourism developed we begin to see photographs and poscards of more general coastal scenes.

Img_ uid	Title	Year	Score Heritage View	Score Non Heritage View	Physical Image State	Total Score
125	Dolmen dans le marais de Pont Sal (Plougoumelen)	1908	High		Good	77
248	Er Lannic (Arzon)	1900-1930	High		Good	77
329	Rocher isolé à Port Blanc (Saint-Pierre-Quiberon)	1911		Medium	Good	100
316	Er Lannic (Arzon)	1923-1926	Medium		Good	100
412	Menhir de Mané er Hroueg (Locmariaquer)	1907	Good		Fair	88
415	Coffres de Mané Beker Noz (Saint-Pierre-Quiberon)	1913	High		Good	100
443	Port Melin (Groix)	1900-1925	High		Good	77
464	Entrée de la Citadelle (Port-Louis)	1900-1925	High		Good	100
468	Fontaine Sainte Radegonde (Riantec)	1950-1970	Medium		Good	55
541	Fouilles à Port Neuf (Hoedic)	1934	Medium		Fair	66
543	Fouilles à Er Yoc'h (Houat)	1926	Medium		Fair	66

Table 3K4.Top photos ranking results for the Quiberon-Morbihan area.

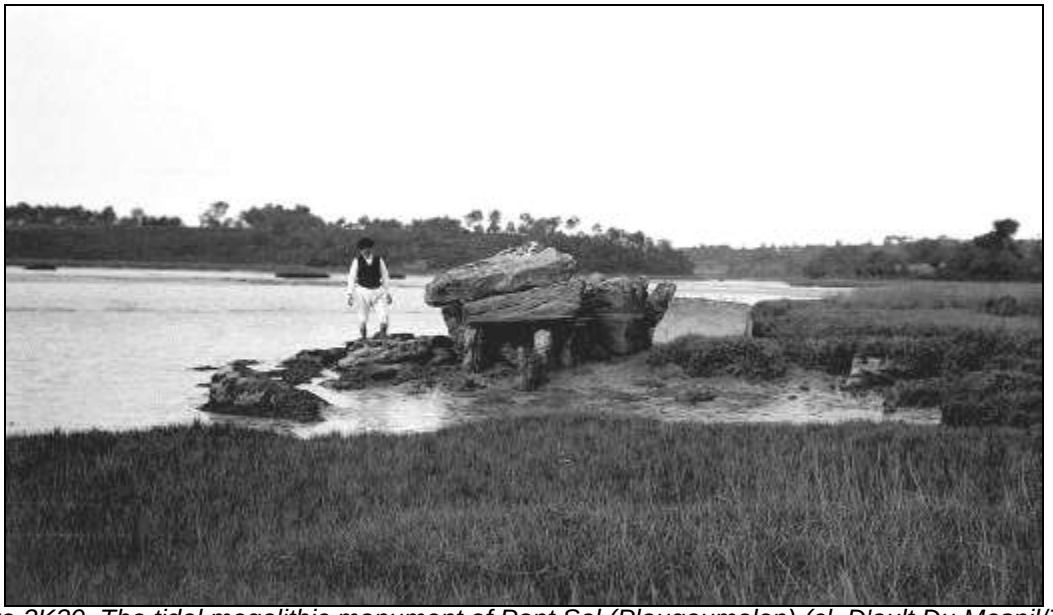

Figure 3K30. The tidal megalithic monument of Pont Sal (Plougoumelen) (cl. D'ault Du Mesnil/Z. Le Rouzic, (© Labo Archéosciences UMR 6566 CReAAH).

Many of the historic photographs assessed were taken by pioneers in scientific disciplines, many of which represent archaeological sites (including Megalithic monuments), and can tell us about coastal change and sea level rise (López-Romero & Daire, 2013). This is the case for the dolmen of Pont Sal (Plougoumelen), currently located in a swamp (river Bono) and regularly submerged (Figure 3K30). This is also the case from archaeological excavations carried out by M. and St.-J. Péquart in cooperation with Z. Le Rouzic on the Er Lannic island (Arzon), which allows you to see the restoration of the monument (documentary set of the Laboratory Archéosciences UMR 6566 CReAAH). Er Lannic is a symbolic and very early site illustrating sea level rise.

The Hoedic island (Mor Braz) remained relatively isolated (despite the presence of a permament population of several hundred people) untill 1930 as it was not a tourist location at this time. The pictures taken by the Péquart family, during their excavations of the Mesolithic cemetery in the 1930s are at the same time of archaeological interest and "ethnographic" (these photos have a "semi-private" status © Melvan and Institute of Paleontology).

These scientists sometimes took pictures of the landscape which can tell us about changes in the shoreline, particularly with infrastructure that will appear a few years later. The shoreline changes are noticeable in several places. Firstly the Etel bar (sandbar at the mouth of the estuary), which is visible at low tide but has a variable location (depending on winds and tides) and historic photos allow us to track this. Secondly, Port Melin on Groix Island, photographed before the construction of a dam in 1965, and finally the St. Radegund fountain, it was built in 1869 and was flooded at high tide, today, a new floor has led to the formation of a pond, where the tides no longer penetrate.

3K.4.3 Maps/Charts Ranking

Several historical maps exist of the coastline, with some dating back to the 17th century. It should be noted that this study is not intended to be exhaustive, it simply aims to highlight the potential for historic maps and charts to provide information on coastal change, through a selection of 15 documents. A brief search of resources available online was carried out, although further research online, in museums, libraries and galleries, as well as private collections has the potential to provide many more.

The focus of the maps/charts study was on the Quiberon peninsula and the Gulfe of Morbihan but some of the maps consulted depicted the whole of the Morbihan region (Figure 3K31). The maps were assessed and digitised to create map regressions of the coastline, this was later combined with all other data sources.

Figure 3K31. Location of the maps assessed in the Quiberon-Morbihan case study area.

Most of the older charts assessed relate to trade and military defences. They often provide detailed information on harbours, shelters, watering places, as well as anchorages, rocks and major landmarks for navigation (e.g. coastal shipping). Defensive points along the coast are highlighted on the maps during the wars (e.g. 17th and 18th centuries with Port-Louis and its citadel). While further offshore the charts often depict currents and tides. Finally, with the establishment of the Napoleonic cadastre (19th century), the plots are shown in more accurate maps.

We also have an archaeological map by A. Devoir (Figure 3K33). This is not accurate at the coast, but we see details of megalithic monuments. This allows us to consider the older studies highlighting the evolution of the coastline with the representation of the "channel of Morbihan."

Finally, some of these monuments have been destroyed (or missing), which tells us about their archaeological condition.

MAP_ uid	Title	Year	Score Chronometric Accuracy	Score Topographic Accuracy	Score Detail in non-coastal area	Score Geometric Accuracy
58	Orientations mégalithiques aux environs de Locmariaker	1890-1926	13.33	50	66.66	66.66
82	Ile Hédic	1746	13.33	16.66	33.33	33.33
83	Ile Hoedic	1886	6.66	16.66	33.33	50
84	Ile d'Houat	1886	6.66	16.66	33.33	50
85	Quiberon et ses îlots	1889	6.66	16.66	33.33	33.33
86	Belle-Ile, Houat et Hoedic	1857	6.66	16.66	33.33	50
87	Carte particulière des côtes de Bretagne : Depuis l'île de Groix jusqu'au Croisic, contenant Port-Louis, Belle-Isle et le Morbihan	1756	73.33	25	66.66	83.33
97	Carte du Morbihan et la presqu'île de Quiberon	1764	73.33	33.33	33.33	66.66
98	Carte hydrographique, topographique et archéologique du golfe du Morbihan et de son littoral	1869	66.66	66.66	66.66	100
99	Plan du Havre de Morbian	1680	20	38.88	33.33	66.66
110	Plan de l'isle d'Hedic	1693	73.33	33.33	33.33	66.66
111	Plan de l'isle d'Houat	1693	73.33	25	33.33	66.66
112	Plan du Port-Louis	1693	73.33	27.77	66.66	83.33
116	Carte Générale de l'Orient, le port Louis, l'isle de Grois et leurs Environs	1737	73.33	38.88	100	83.33
117	Carte des côtes de Bretagne, Quimperlé	1750	66.66	38.88	66.66	83.33

Table 3K5. Top ranking maps within the Quiberon-Morbihan case study area.

Figure 3K32. Section of the Cassini map (late 17th century) where the dunes are very well represented as well as the sand bar coming from the narrow part of the isthmus and the swamp which was filled in during the 18th and 19th centuries (source: Geoportail).

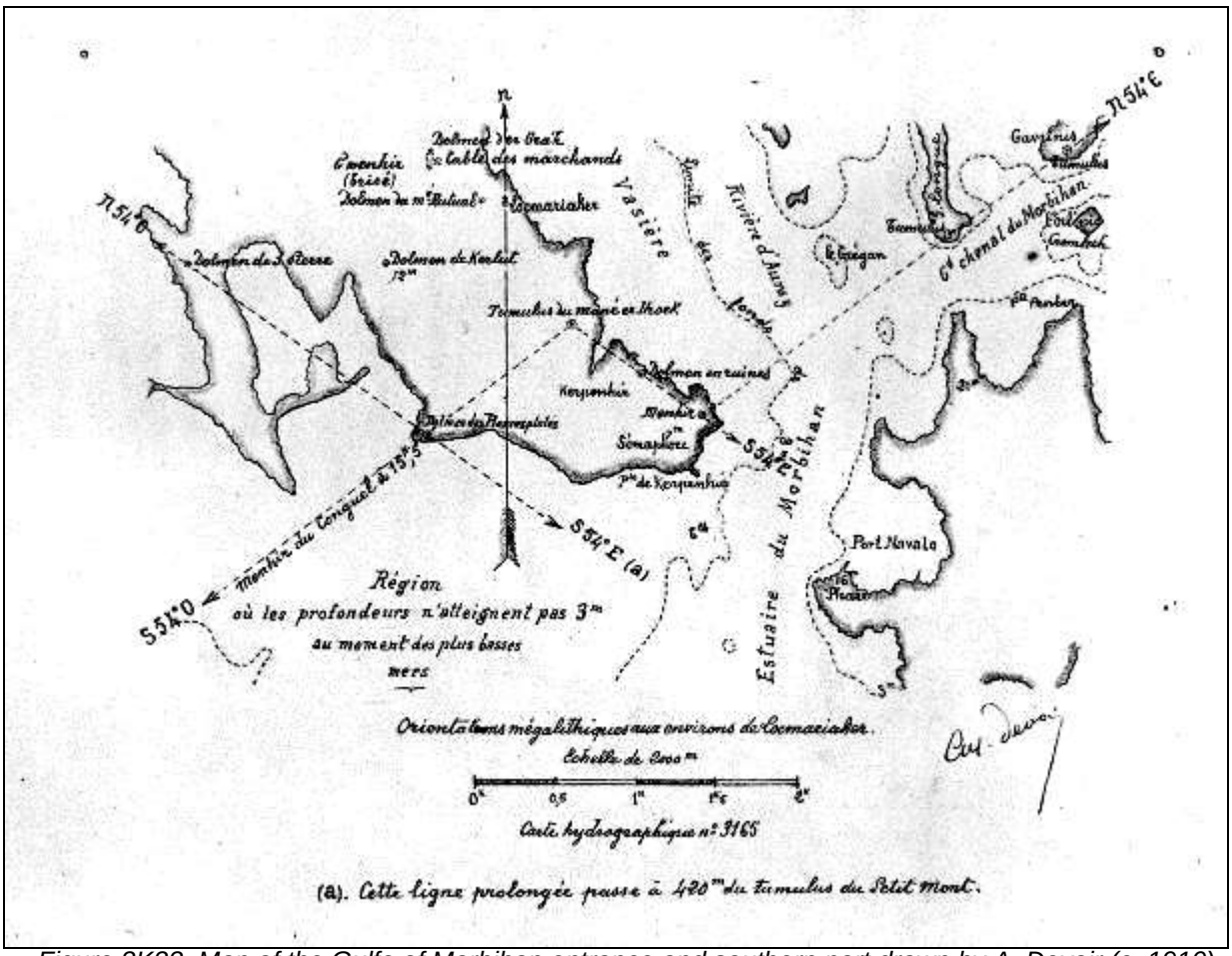

Figure 3K33. Map of the Gulfe of Morbihan entrance and southern part drawn by A. Devoir (c. 1910) (© Labo Archéosciences UMR 6566 CReAAH).

3K.5 Archaeological Fieldwork

Archaeological and palaeoenvironmental fieldwork was carried out on the Quiberon peninsula, this section outlines the field studies undertaken and the main results.

3K.5.1 Key Research Questions

The aim of the research was to determine the potential of archaeological and environmental data to inform on long term coastal change in the Quiberon area. The regional coastal changes were to be addressed on a long-term scale, with a very specific chronology for some periods, especially the Mesolithic and Neolithic.

3K.5.2 Approach to information gathering and fieldwork

The program dedicated to the Quiberon peninsula study area comprised detailed fieldwork (2011, 2012 and 2013) combined with desk based studies and analysis (radiocarbon dating combines with environmental). Various kinds of documentation have been used, as well aerial photos, ancient maps and charts and historic documentation, in order to retrace the environmental and human occupation history of this site. The fieldwork was comprised of several excavation campaigns on the Beg er Vil Mesolithic site (under the direction of Grégor Marchand and Catherine Dupont) and underwater surveys on the submerged structures and

fish weirs off the Saint-Julien bay and Port-Haliguen harbour (by ADRAMAR in cooperation with L. Langouët).

3K.5.3 Archaeology Field Data Gathering Results

The selected sites in the case study area have provided detailed information illustrating coastal evolution around the Quiberon peninsula, with a special focus on the southern part, and a very detailed study of the Beg er Vil Mesolithic site (Marchand & Dupont, 2012 and 2013).

Concerning the archaeological sources, as mentioned above, data has been obtained from both terrestrial and submerged sites. The main results of the fieldwork are presented below within two sub-sections, the first summarizing the results gathered on the Beg er Vil Mesolithic site, the second one showing the contribution of the underwater surveys on the submerged fish traps located off Saint-Julien bay and Port Haliguen harbour (Le Ru, 2013).

3K.5.3.1 Beg er Vil, Quiberon

Location

At the southern end of the peninsula of Quiberon in the commune of the same name, the tip of the Beg-er-Vil site is open to the south bay, which is home to Port Maria and the main pier to the Mor Bras islands. The prehistoric site is located at the bottom of a small cove on the western flank of the rocky point at a height of only 5m NGF.

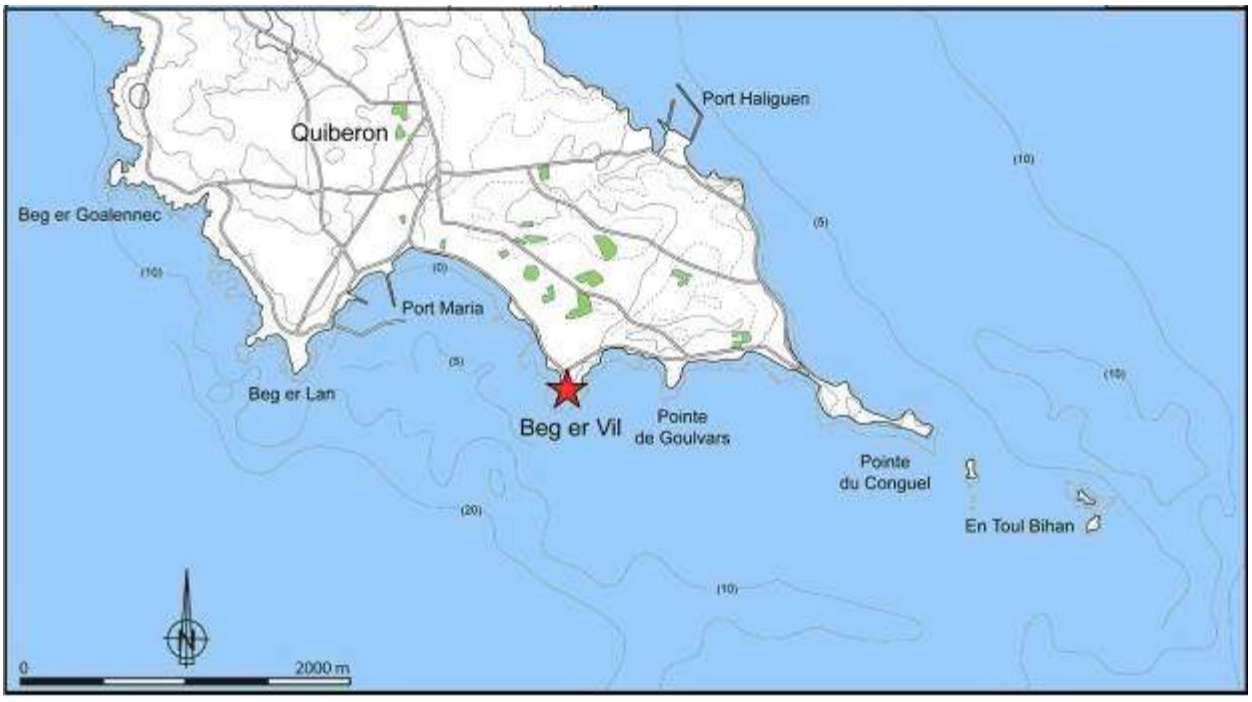

Figure 3K34. Location map of the Beg er Vil site (by L. Quesnel, after Manchand et al., 2013).

Why was the study site selected?

The Mesolithic site at Beg er Vil in Quiberon (Morbihan) is characterized by a remarkably well preserved shell midden, visible in the palaeo-cliff on the south coast of the peninsula. The site was occupied at the end of the 7th millennium BC and is very homogeneous and has not been affected by subsequent disturbance. The site contains unique evidence of the lifestyle of hunter-fisher-gatherers of Atlantic France, particularly during major climatic events of the Holocene. Rapid deterioration of the site caused by marine and anthropogenic erosion resulted in the establishment of a planned research program from 2012, held in collaboration with several research partners: CNRS, University of Rennes 1, Regional Service of Archaeology of Brittany, General Council of Morbihan, Arch-Manche Programme (Interreg IVA "2 Seas"), Mairie of Quiberon and Maison des Sciences de l'Homme in Brittany (MSHB).

Figure 3K35. View of the Beg er Vil site in 2013, from the south (after Manchand et al., 2013).

Marine resources have been exploited extensively, as evidenced by a layer of about 0.6m thick. This diversity reflects an opportunistic behavior of the Mesolithic population, who did not hesitate to exploit the diversity of the coastal environment. Beg er Vil is considered as a unique framework for study into the Mesolithic of the European Atlantic coast. Faunal remains from the site also provide very precise paleoenvironmental indicators.

This site is older than the well-known Téviec habitats and Hoedic-burial, but their inhabitants obviously shared the same techniques, traditions and the same symbolic thought.

Figure 3K36. Stratigraphy of the archaeological layer of the Beg er Vil site along the coast (after Manchand et al., 2013).

Geomorphological setting

Around the site, it is difficult to see the original layout, due to the dune cover and recent urban developments, but there seems to be a slight slope of the granite surface to the west and the ocean. In a network of geological fractures of south-west/north-east orientation that have been affected by marine erosion and the creation of the creek, a large flaw is significant, bordering the northwest Mesolithic habitat and may have once been a brook, now hidden by the dunes. This dune cover is thick (almost two meters at the site) and serves to support the current urban development. The site is located to the western part of a fossil beach dating to a previous interglacial stage (Figure 3K37).

What was the position of the Mesolithic settlement at the end of the 7th millennium BC in relation to the coastline of the time? Many geomorphologic studies are needed to answer this question; marine erosion, sand inputs and human developments have combined their effects to alter our perceptions. However, it is possible to offer a first glimpse from the bathymetric contours chart (SHOM - No. 7141S - Baie de Quiberon). For the record, the level 0 of Hydrographic and Oceanographic Service of the Navy (SHOM) corresponds to lower levels of spring tides, 5 m below the current level of the highest tides, in the light of the local value of tidal range. It is clear that this parameter is the most important for human occupancy. With a lower sea level of 12-15 m below the current level (Stephan, in Marchand, 2013), we must then consider the bathymetric curves -7m to 14m.

At this sea level it is possible there was an old cove between the basse Treac'h An and the existing rocks of Four. It is probable that the extensive Mesolithic habitat was at about 500 meters from the shore, maybe more if soft rocks or dunes grew in front of the coast. The slurred facing west or southwest slope should be significant. Even if the image can be surprising as the current coasts seem low, the Mesolithic habitat was placed in a dominant position in a radius of 2 km, or about 20 minutes walking. The west coast of the peninsula would have been beaten by swell and the more peaceful east coast were more easily exploitable. For the record, the Mesolithic site at the Téviec necropolis is located 10 km as the crow flies to the N/NW. The Hoedic necropolis, also famous, is 22 km to the southeast, but you must take a boat to reach this island camp today.

From 8200-8100 cal BP, all coastal floors therefore stood at a position between -14 m and 12.5 m compared to the current one. To achieve a first recovery of the intertidal zone, it is therefore necessary to reduce current levels of tide by 10 m. Thus, the low-water level of spring tides (LLW), currently set by SHOM at the 0.75 m level (SHOM, 2013), should be at the current depth between -13.25 m and -11 75 m. The highest water-level of spring tides was, meanwhile, at a depth that can be estimated between -7.15 m and -8.75 m.

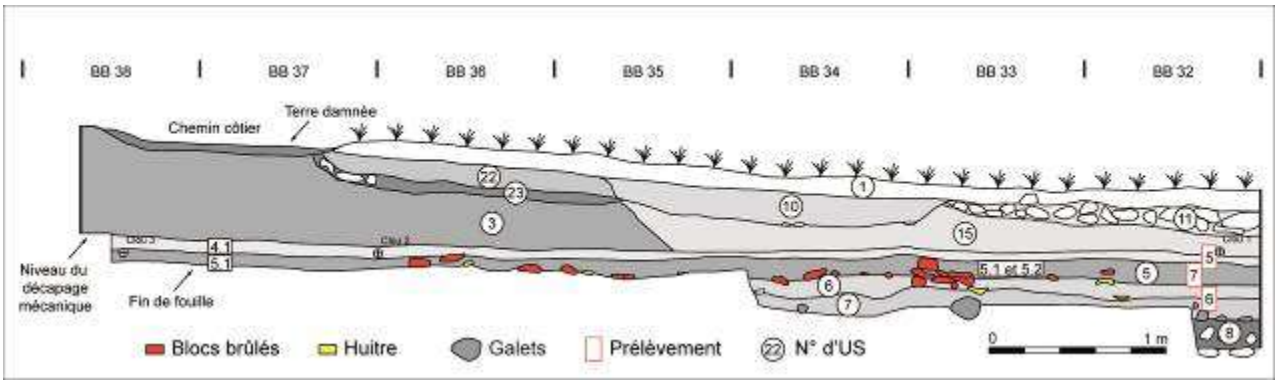

Figure 3K37. Stratigraphy of the archaeological layer of the Beg er Vil site (after Manchand et al., 2013).

Key coastal risk management issues for the frontage

A study of aerial photographs available (from 1932 to present) clearly shows the dynamic erosion of this part of the point of Beg er Vil (Figures 3K38 & 39). On its north side, the site would have declined by 6.4 m ± 0.86 m; but much less on the rockier south. A digital land survey has established the position of the site in its immediate environment. A total of 6000 measurement points corresponding to geographical and altitudinal dimensions (X, Y, Z) were obtained over an area of about 1.4 ha. A first reconstruction of paleo-coastal landscapes is then proposed, taking into account the most recent work that put the sea level between -15.5 and -11 m below the present (ie a tide of white water depth contour - 7.15 and -14.02 m).

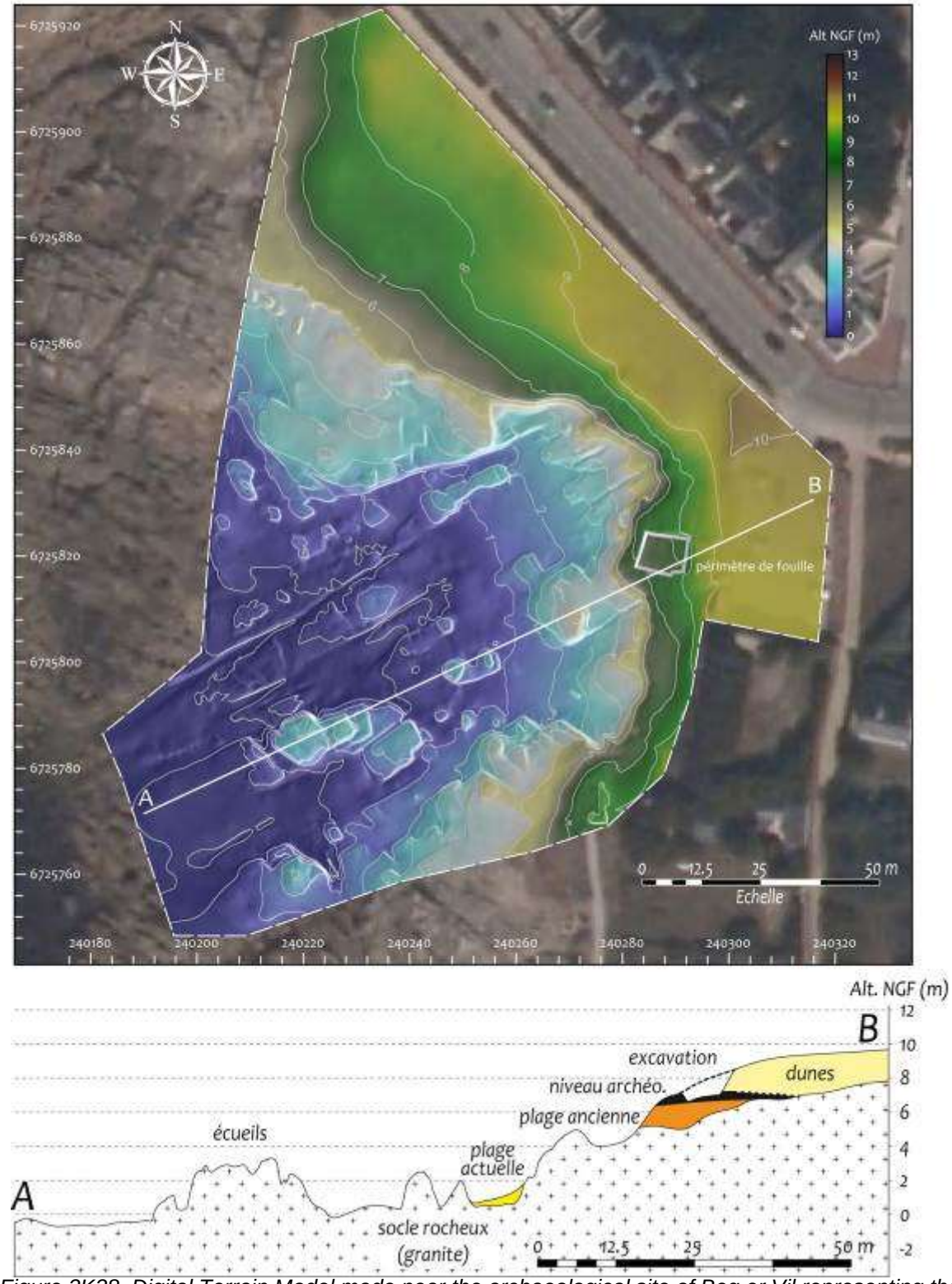

Figure 3K38. Digital Terrain Model made near the archaeological site of Beg er Vil representing the topographic modeling of the foreshore. Here, the terrain is superimposed on the coastal orthophoto taken September 28, 2011 at 10:40 (UTM) (Source: © Ortho Littorale V2 - MEDDE). A topographic profile was extracted from the DTM between points A and B (doc. P. Stéphan, after Manchand et al., 2013).

Figure 3K39. The Beg er Vil site in march 2011. Since 2007, the cliff coatal retreat is estimated to 1 m (cl. G. Marchand, after Manchand et al., 2013).

How the site can inform coastal risk management

Measures of the changes in the coastline were made from the DSAS (Digital Shoreline Analysis System) module in ArcGIS along 55 transects perpendicular to the shoreline and equidistant from 5 m.

By 1932, some private houses are present north of the site (Figure 3K38). One can observe further phases of construction as seen in 1964 and continuing to the present state (Figure 3K39 to 3K42). In the south, several buildings were constructed on the tip of Beg er Vil. In 1932, the houses north of the site are served by an unpaved road. In 1964, one can observe the paving and widening of the road. The construction of the roads is clearly visible (lots of materials on roadsides and land crossing to the east of the site). Since the general shape of the road has not evolved (adding a lane parallel to the pedestrian road), between 1964 and 2008, a car park adjacent to the site of Beg er Vil and probably covering parts of it was constructed (Figure 3K41).

From a general point of view, the coastline around the site of Beg er Vil has changed little apart from some very localized areas. Erosion seems more active in the bottom of the bay where the decline of the coastline locally reached 6.4 m ± 0.86 m. Thus, the values are very high between transects 25 and 40 and between 40 and 45 transects (Figures 3K47 & 48). However, the most advanced points were only slightly subject to erosion (Figures 3K44 to 46). These dynamics are likely explained by the micro topography of the foreshore.

The archaeological site of Beg er Vil is installed on a rocky massif. It was therefore relatively protected from marine erosion during the past eight decades. However, it has recently been affected on the northern edge (with erosion reaching this place 6.4 m ± 0.86 m) and to a lesser extent on its southern flank (Fig 3K47).

Beg er Vil Mesolithic site - Ranking score achieved: 100

Figure 3K40. Evolution of the coastline in the background with the image of Géolittoral 2011 (source Ministry of Ecology, Sustainable Development and Energy) The site of Beg er Vil is indicated by a red star (after Manchand et al., 2013).

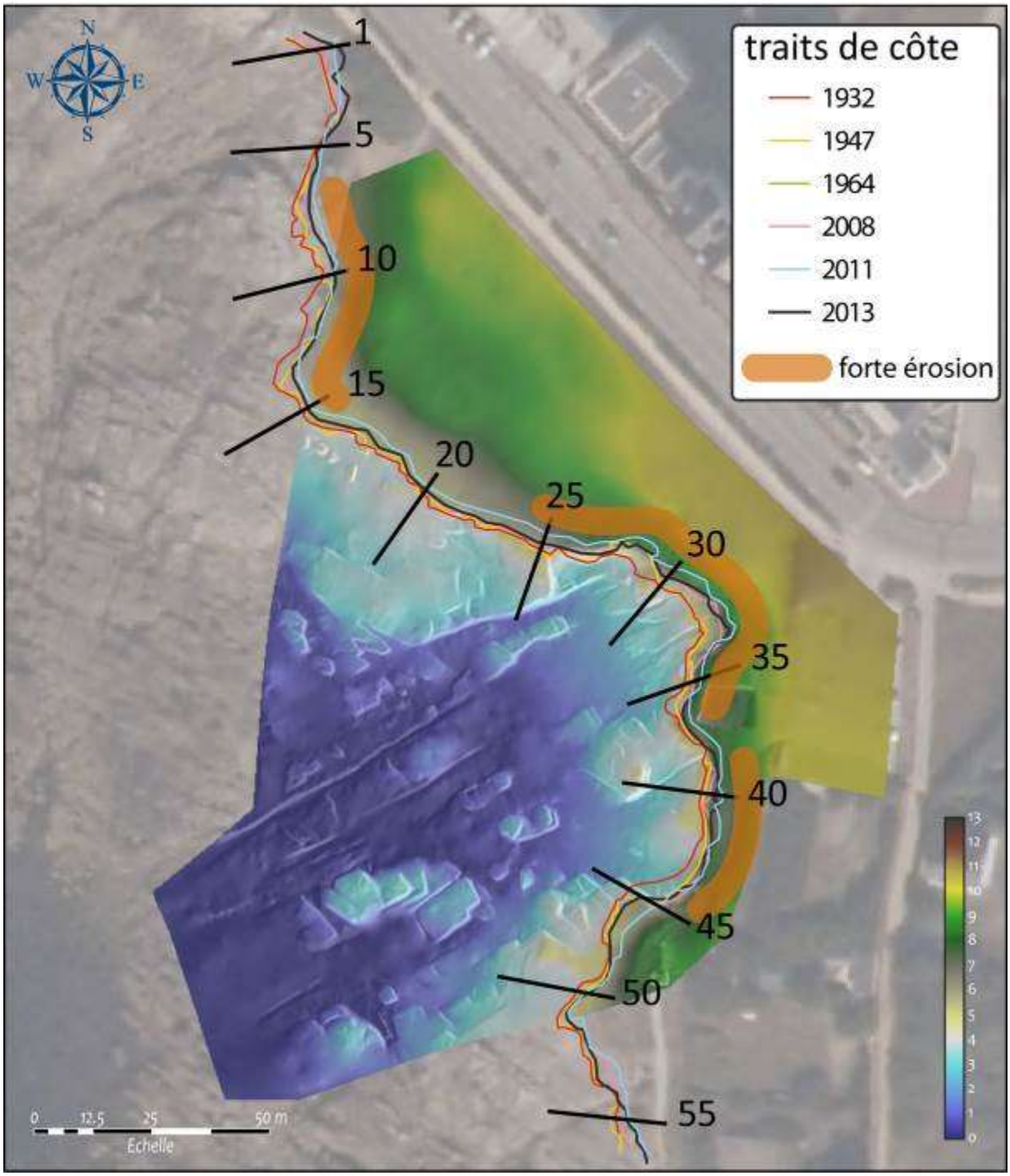

Figure 3K41. Kinematics of coastline around the site of Beg-er-Vil (doc. P. Stéphan, after Manchand et al., 2013).

Figure 3K42. Panoramic view of the Beg er Vil site from thevwestern bay (cl. Marchand, after Manchand et al., 2013).

Figure 3K43. The Beg er Vil site dunring the 2013 excavations, panoramic view from the North (cl. Marchand, after Marchand et al., 2013).

3K.5.3.2. Fish weirs of the Quiberon Peninsula

Location

All the fish weirs discovered along the coasts of the Quiberon peninsula are located on the eastern and south-eastern façade (Figure 3K44). The two fish traps of Port- Haliguen are situated to the north of the harbour of the same name and opposite the hamlet of Kermorvan. The four alignments at Saint-Julien lie opposite the hamlet of the same name and are of various types. Note, the tidal range in Quiberon Bay is about 4 m.

Why was the study site selected?

The purpose of the operation was to resolve two distinct issues. The first of these related to methodology because we wanted to see if underwater geophysical surveys are a pertinent method for studying fish- weirs that no longer dry out at low tide and add to the information already available, notably information collected during aerial surveys, archives and ancient texts.

The second was scientific because the fish weirs of Port-Haliguen and Saint-Julien are 4 of the 83 known fish traps that are permanently submerged and therefore their study requires the use of underwater archaeology techniques (Langouët and Daire, 2009). The intention was to supply the facts that would allow us to document these structures, to study their architecture and organization, and to determine their archaeological levels for the purpose of dating them. Giving that their location in a current submerged area, i.e. no longer reachable by dry foot, is by itself an indication of sea level rise since the time of their construction.

By virtue of their position, the zones of Port-Haliguen and Saint- Julien are subject to considerable environmental pressure and Port-Haliguen is also a site of intense anthropic activity. It is therefore probable that only the sturdiest of structures have survived.

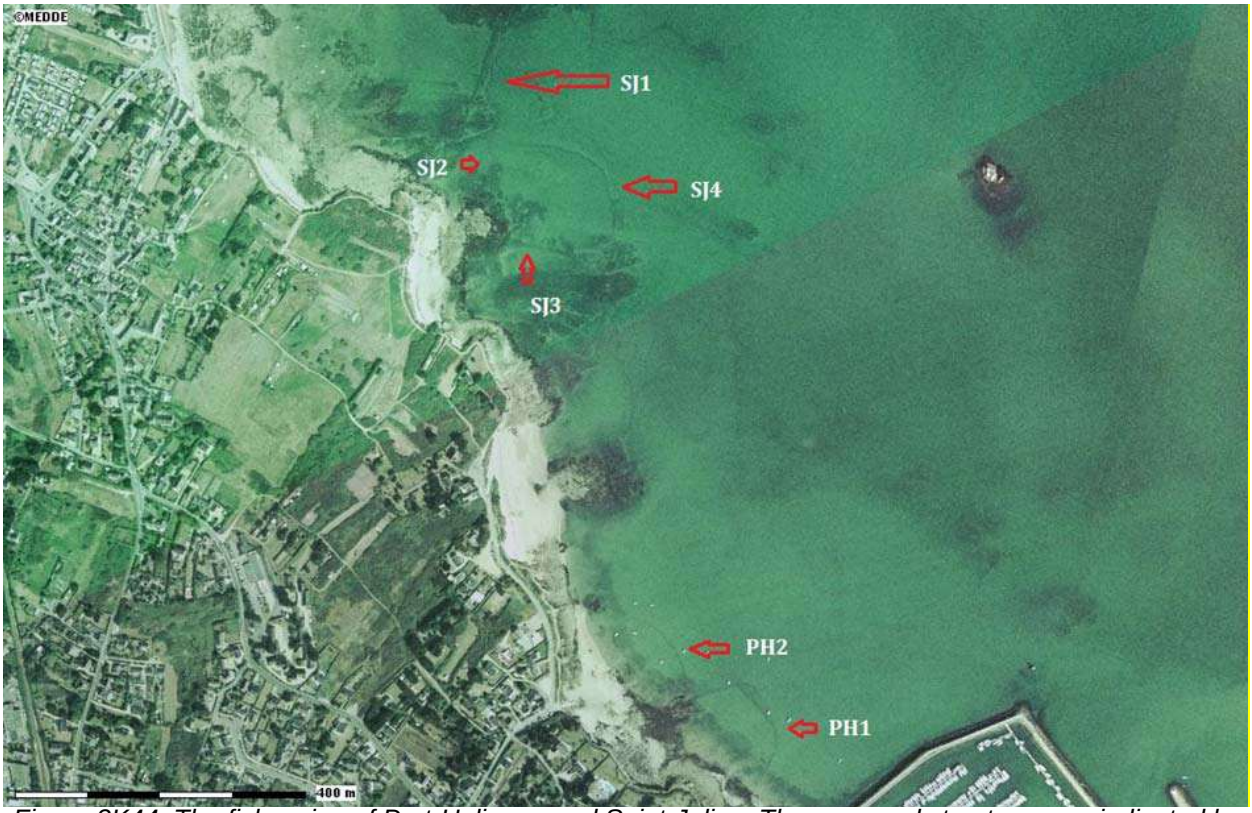

Figure 3K44. The fish weirs of Port-Haliguen and Saint-Julien. The surveyed structures are indicated by the red arrows and their names are written in white. View provided by Ortho Littorale 2000.

Methodology

Operations were timed to coincide with suitable tide levels. For the first part of the survey, the highest tides ensured we had sufficient water depth for our operations and allowed us to sail as closely as possible to the rip- rap and the coast without endangering the survey equipment and the boat. For the second part, the lowest tides were chosen for diving operations.

The location of the fish traps, which are obviously close to the coast, required us to take an unusual approach. In addition, the area in front of the Port-Haliguen fish traps is a roadstead. Maneuvering in the zone was, as a result, laborious. In terms of methodological approach, geophysical survey could be complemented with direct observation through diver survey, however, poor weather conditions meant that only limited dive operations were carried out.

Operations carried out by ADRAMAR (Le Ru, 2013) on these fish traps are able to provide new information on geomorphologic context and risks of the underwater and coastal area of the Bay of Quiberon. In this aim, several nautical and scientific mediums were involved during the 2013 campaign. Here is the main data and results of the 2013 field campaign.

Hermine-Bretagne is Adramar's support ship. Eighteen meters long, she is a research vessel specializing in underwater archaeology. Her shallow draught (1 m) allowed us to sail extremely close to the rocks during the survey. The vessel's role in the operation was to deploy and maneuver the geophysical devices (side- scan sonar, sub-bottom profiler). She was also used as a platform for the survey dives.

The objective of the survey was to:
- acquire a wide sonar mosaic of the zone;
- corroborate by GPS the precise location of the fish traps;
- generate geophysical data;
- determine the existence or absence of features near the fish weirs that are not visible from the air.

In the area of Saint-Julien surveys focused on two alignments, Saint-Julien 1 and Saint-Julien 4 because of the inability to sail above the alignments Saint-Julien 2 and 3. The erratic sailing routes resulting from the environmental conditions and the shallowness of the waters, which limits the useful range of the profiles but was offset by the satisfactory coverage, greatly affected the surveys. Nevertheless these problems did not prevent the identification of the alignments.

The side- scan sonar lived up to expectations in the sense that it allowed us to delimit the study zone by accurately locating and highlighting the characteristics of the fish traps. For example the duality of Port-Haliguen 1 is clearly visible. Acquisition through the side- scan sonar also allows for the remains to be studied in terms of height, length and breadth2. Thus, once the surveys were complete, the six rocky alignments at Port-Haliguen and Saint-Julien were identified and mapped.

Fish trap PH1 extends from 3°06.47’ W – 47°29.39’ N to 3°6.39’ W – 47°29.34’ N3. The doubling of the feature occurs at 3°06.42’ W – 47°29.41’ N and is about 15 meters long. We intended to observe this dual feature in greater detail but poor diving conditions prevented us from doing so. This alignment is between 1.5 and 4 meters wide with a length of 208.2 meters for the main alignment and 65.2 meters for secondary alignment.

Port-Haliguen 2 extends from 3°06.48’ – 47°29.42’ N to 3°06.55’ W – 47°29.55’ N and and measure between 1.2 and 2.6 meters wide and 135.3 meters long. The coordinates of Saint-Julien 1 are: 3°06.76’ – 47°29.88’ N to 3°06.76’ W –47°29.82’ N. The alignment has a width between 1.6 and 2.8 meters and a length of 105.4 meters.

Saint-Julien 2 is larger: between 1.4 and 4.1 meters and a length of 59 meters. Its coordinates are 3°06.74’ – 47°29.80’ N to 3°06.73’ W – 47°29.77’ N. Saint-Julien 3 has the same width as SJ2 and a length of 53.1 meters. Its coordinates are 3°06.71’ – 47°29.73’ N to 3°06.64’ W – 47°29.72’ N.

Saint-Julien 4 from 3°06.59’ – 47°29.74’ N to 3°06.66’ W – 47°29.80’ N with a width from 1.8 to 3.2 meters and a length of 144.4 meters. However for Saint-Julien 4, after taking into account the data acquired through sonar and the faintness of the trace, we extrapolated the final coordinate to be 3°06.72’ – 47°29.79’ N.

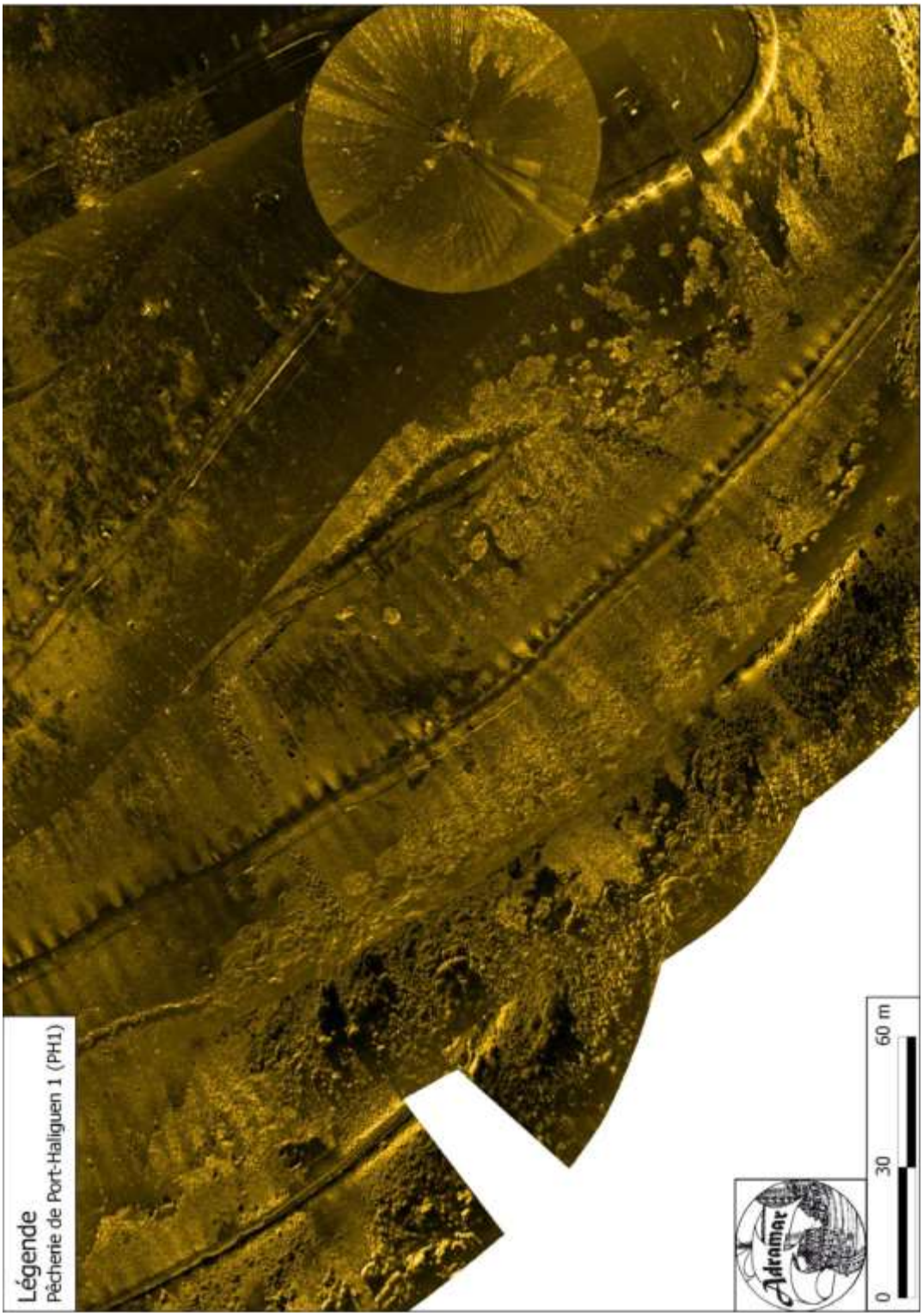

Figure 3K45. Sonar image of the fish trap Port-Haliguen 1 © ADRAMAR (after Le Ru 2013).

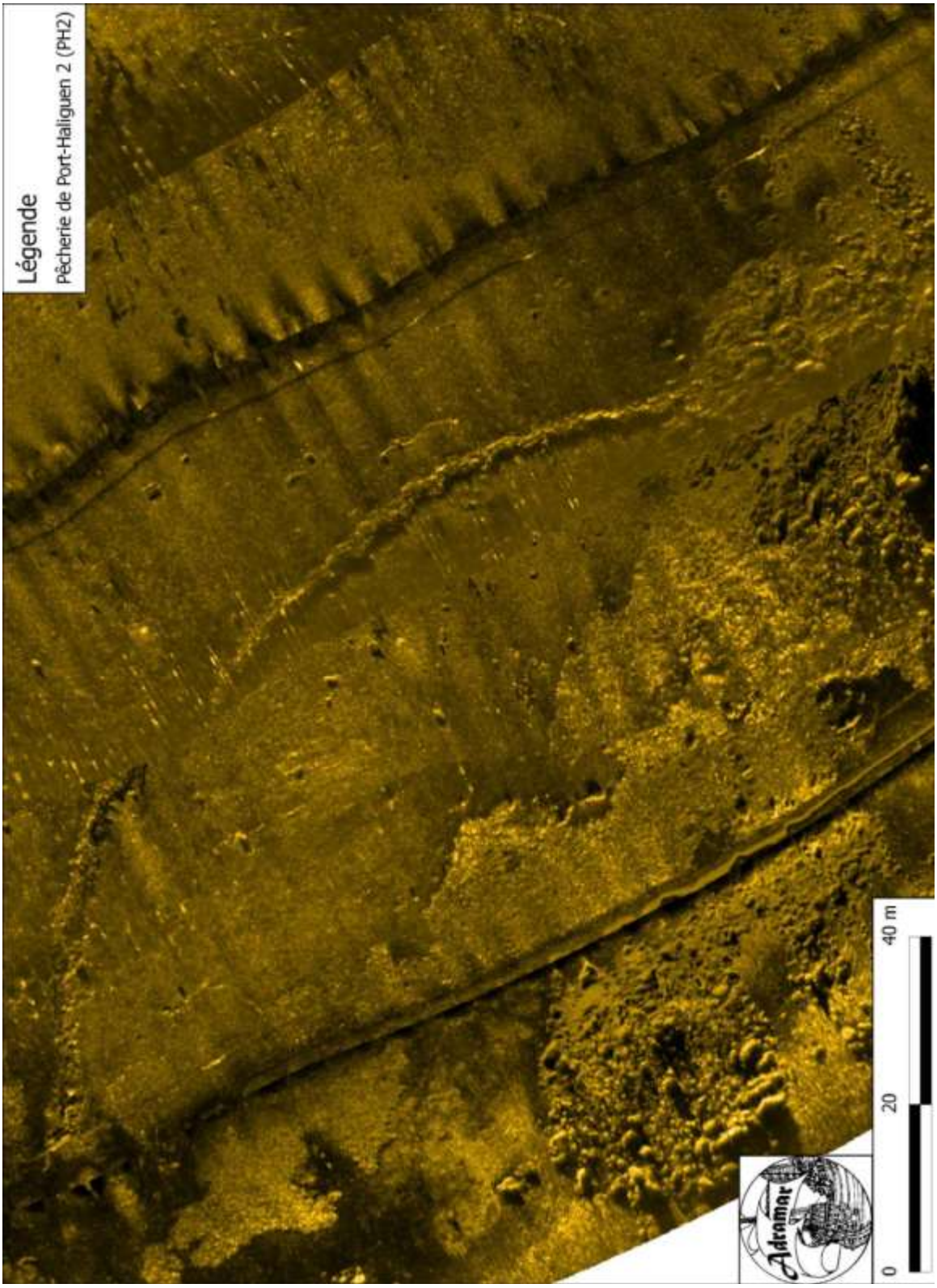

Figure 3K46. Sonar image of the fish trap Port-Haliguen 2 © ADRAMAR (after Le Ru 2013).

The failure to observe the remains directly prevents us from gaining accurate information about the architecture alignments but does not prevent us to learn the depth at the lowest dam point, which is critical to the understanding of the development period and implementation of the structure. Sonar surveys allow us to target and to bring information about areas more precisely because we know the date, time, water depth between tow fish sonar and its target, the height of the target and the depth of immersion of the tow fish. This allows us to determine the height of water above the point then apply a correction in relation to the value of the atmospheric pressure taken where necessary.

Thus, for Port-Haliguen 2 April 2, 2013 between 10:28 and 10:35 a.m. we can average a height of 4.7 meters of water. In Saint-Julien, same date, on the alignment of SJ1 between 9:46 and 9:48 a.m., can be determined by averaging all three targets, a water height of 4,6 meters. In Saint-Julien 2, at 11:35 a.m., the water depth is about 4.4 meters. Saint-Julien 3, there is an average of 4.5 meters between 11:35 and 11:40 a.m. However, Saint-Julien 4, on the same date at 9:46 a.m., the water depth is 4.1 meters.

We have to note also the considerable anthropic activity shown by the observation of lockers, berths and other debris on the sonar. There are 60 unidentified remains, excellent markers of the intensity of human activity on the study area and the potential risks it poses to the archaeological remains in the area.

Because of the uncertainty of the route taken during the sub-bottom profiler surveys, the sailing conditions mentioned above rendered the interpretation of the data and the identification of the features complex.

Contacts were classified as follows:
- Reliable contacts: these contacts that correspond to abnormalities in the structure of the rock alignment or nearby and are of particular interest.
- Unreliable contacts: these contacts are anomalies in the data but the data does not allow us to be certain of their nature (acoustic artifact, buried element etc.)

Rock alignments are sometimes visible in the data sediment penetrator. The detection of these rock alignments is evident when these alignments are located in sandy areas, as soon as you approach the rocky areas the differentiation between naturally occurring rock and alignments of fish traps is very complex or even impossible.

Four contacts have nevertheless been identified over the area of Port-Haliguen. These contacts do not appear to be an extension of the observed side- scan sonar structures. On the area of Port-Haliguen 1 there are 2 contacts. One is classified as reliable, the other as unreliable. Reliable contact (CF-2) is located ten meters from the rocky alignment Port-Haliguen 1. The latter indicates an abrupt change in the nature of the sediment at that location and was not observed anywhere else on the study area.

The unreliable contact (CPF-7) is located directly in the structure of the fish trap between 0.4 and 0.5 meters of trenching. This contact could correspond to a structural element in the fish trap with its intensity but could also correspond to an acoustic artifact as observed in the rest of the profile; this is why it classified as unreliable.

It also counts two contacts for Port-Haliguen 2. One classified as reliable, the other as unreliable (Figure 3K48). The unreliable contact (CPF-6) may correspond to a slight increase of the underlying sedimentary layer but is much more intense than the surrounding reflectors. It is also

situated close to the alignment. The reliable contact (CF-1) is composed of two distinct but related segments. They both correspond to contacts that appear to delineate the fish trap in height and contacts of higher intensity. They can therefore be either buried fish trap structures or the boundary between the sedimentary layer and the underlying rock mass.

For the area of Saint-Julien, five contacts have been identified. They are all located on the alignment Saint-Julien 4. On SJ1, the quality of the data allowed us only to detect rock alignments on some profiles. It should be noted that these contacts do not appear to be an extension of the observed side- scan sonar structures. On the five detected contacts on the alignment SJ4, three are reliable contacts and two are unreliable contacts.

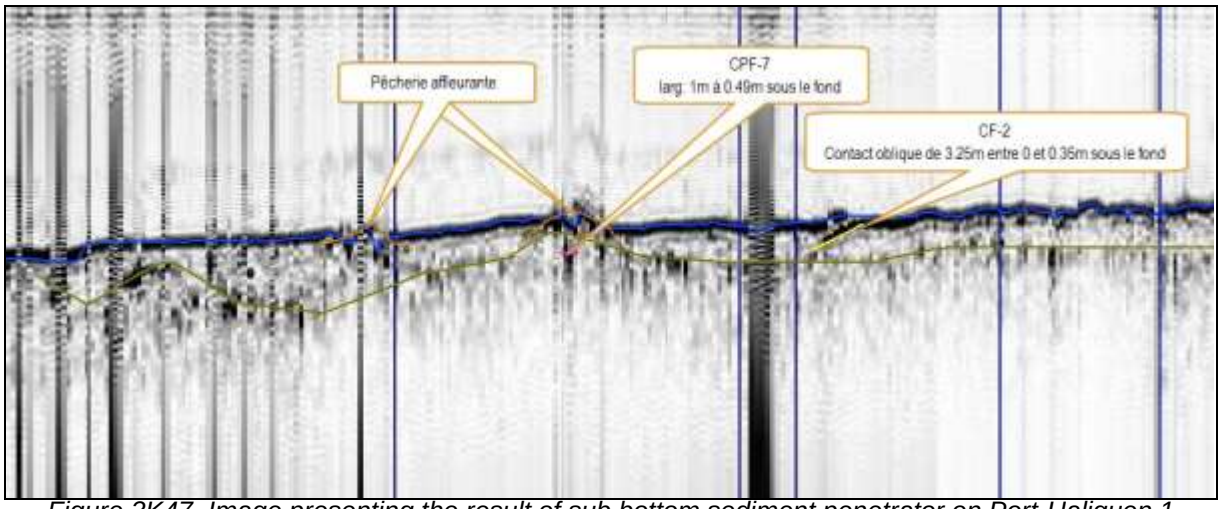

Figure 3K47. Image presenting the result of sub bottom sediment penetrator on Port-Haliguen 1 © ADRAMAR (after Le Ru 2013).

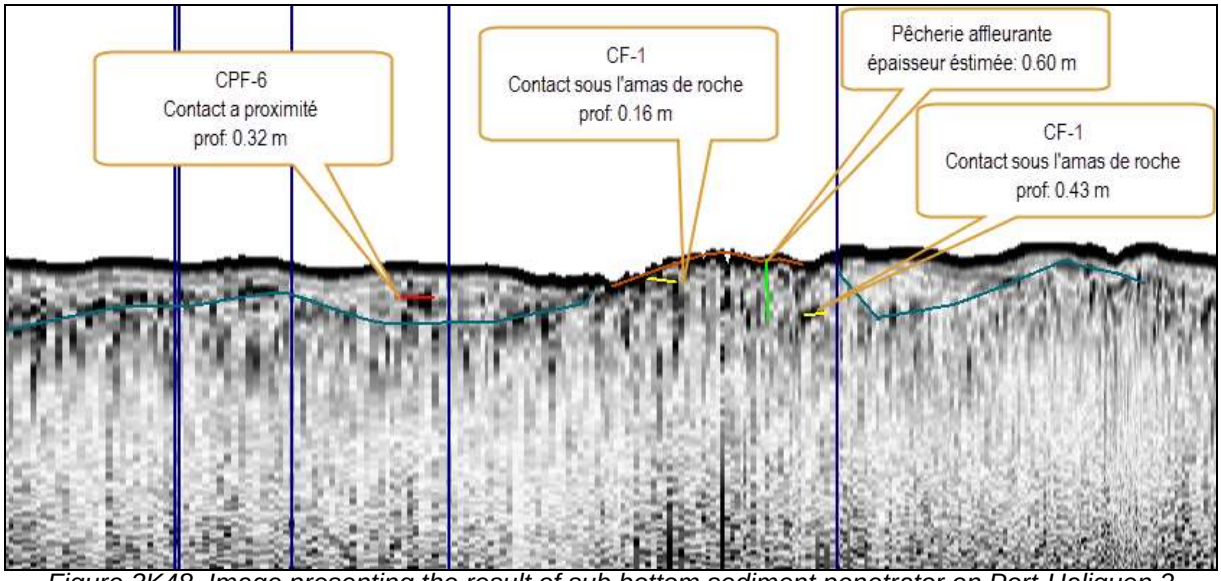

Figure 3K48. Image presenting the result of sub bottom sediment penetrator on Port-Haliguen 2 © ADRAMAR (after Le Ru 2013).

The contact CF-1 (Figure 3K49) is a frank limit at 0.56 m under the heap of rock forming the alignment. This limit could be either the limit of the mass of rock forming the fish trap or a fish trap component structure.

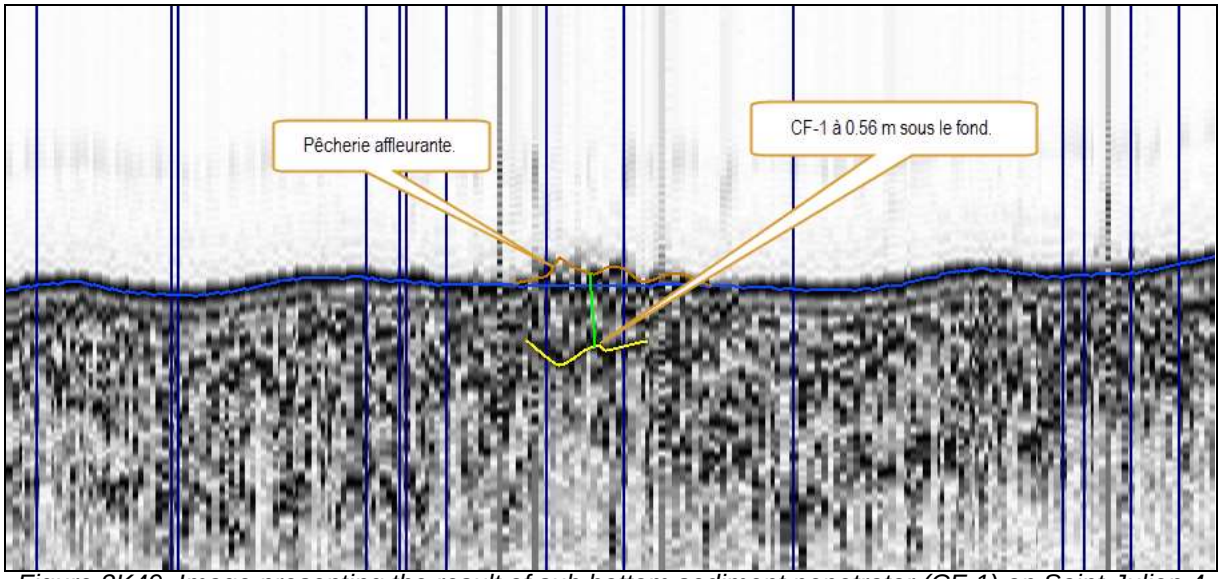

Figure 3K49. Image presenting the result of sub bottom sediment penetrator (CF-1) on Saint-Julien 4 © ADRAMAR (after Le Ru 2013).

Contact CF-4 (Figure 3K50) is composed of two linked contacts. Both contacts correspond to very sharp boundaries in the sedimentary layer and are very straight which does not seem to be of natural origin. These two contacts being located near the alignment, it is possible to correspond to a previous structure that is now buried. Their width is between 2 and 5 meters which correspond to the widths observed on the other surface alignments.

Contact CF-5 highlights a frank boundary with suspicious form. It is possible that this corresponds to a sedimentary layer but, inclination and intensity make a remarkable anomaly that could correspond to a structure or buried object. This contact is approximately 4 meters in length.

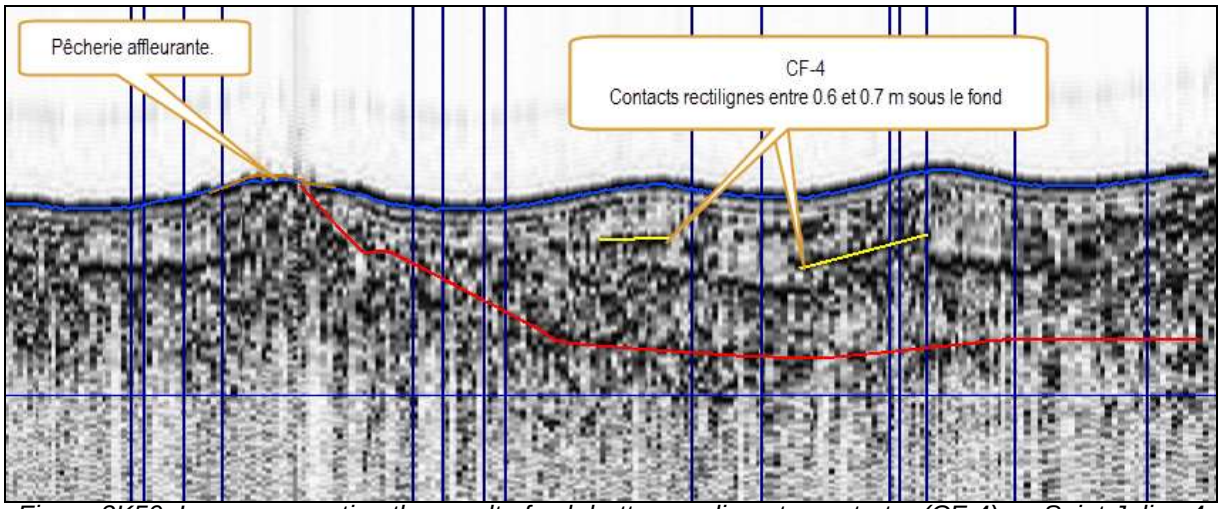

Figure 3K50. Image presenting the result of sub bottom sediment penetrator (CF-4) on Saint-Julien 4 © ADRAMAR (after Le Ru 2013).

Contacts CPF-8 and CPF-9 (Figure 3K51) correspond to two small contacts in the sedimentary layer surface. They are too small to match rows of rocks as observed previously but may be the subject of signing at least 2 metres and very different nature of their environment.

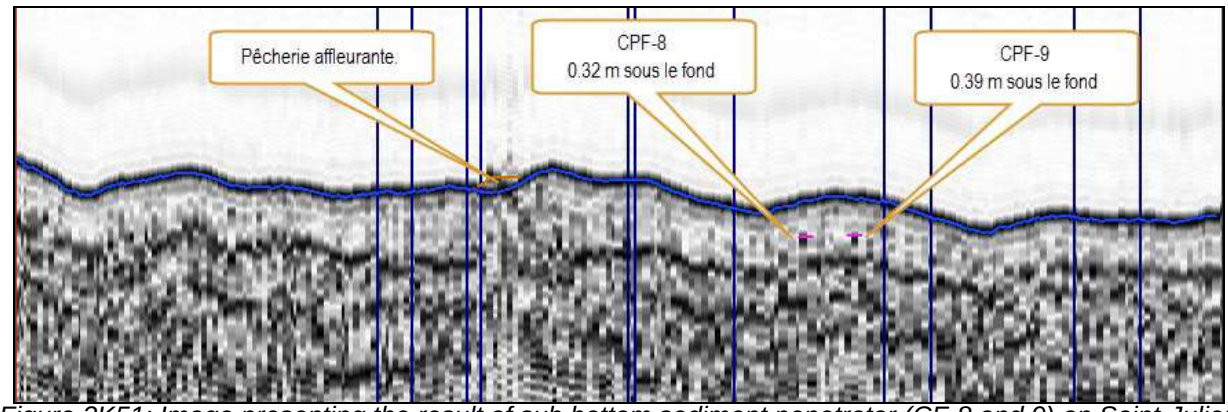

Figure 3K51: Image presenting the result of sub bottom sediment penetrator (CF-8 and 9) on Saint-Julien 4 © ADRAMAR (after Le Ru 2013).

Data from the sediment penetrator provides valuable information that should be explored further. Note that if on PH2 contact CF-1 corresponds to the base of the fish trap (Figure 3K48), as well as the CF-1 contact for SJ4, and the thickness of PH2 is estimated at 0.60 metres then information for a more precise dating of structures is available. Indeed, by adding these burial depths to depth measured at the base of fish traps and recorded during dives or measure the level of water which is available through sonar surveys, then we can more accurately determine the height of water above the point.

The six alignments were to be the subject of survey dives. To do this, several dive points were determined for each alignment; the purpose being to collect, at various places, the height of the feature and information relating to the stone structure. Unfortunately poor weather conditions prevented us from carrying out the dives which would have involved visual observation and measurements. Several buoys were installed but only two of them were used as starting points for dives and, because of the poor weather, underwater visibility was extremely limited.

The first dive was made on 3 April 2013 and lasted 3 min. because visibility was nil. On 6 April another dive was made despite a considerable quantity of suspended matter. An hour long dive in water at 6°C was made on part of the Port-Haliguen 1 fish trap, starting from the peak and heading towards the doubling. The dive began at 11 a.m. and, taking place during the rising tide, it was the depth closest to the end of the dive which was recorded. Thus at 12.15 p.m. at the base of the fish trap the depth was 3.6 metres. This dive was the only opportunity for us to take photographs.

After that, dives were made on 15 and 16 April but visibility was very poor, at best 20 cm, and this prevented us from making any useful observations. On 15 April the dive at 9.25 a.m. indicated a depth of 4.8 metres on the same section as that of the April 6 dive. The first part of the second section of Port-Haliguen 4 underwent visual survey during two dives on 16 April. The aim was to collect additional information on the dual part of the fish trap. Water depth at 9.39 a.m. was 4 m and 4.9 m at 9.40 p.m.

The dives that took place were therefore limited to the fish trap Port-Haliguen 1 and concentrated on two areas, both situated on the first section of the alignment: ALPH1_P01 and ALPH1_P028. The poor weather conditions prevented us from gaining an overview of the

features and the very limited visibility prevented us from carrying out a satisfactory study of their architecture. However it was possible to observe a relatively well preserved structure. To the diver, the fish trap is legible and can be followed underwater. It is especially the case for the first part of the first section of the Port-Haliguen fish trap. Indeed the dives made on the last part of this section established that the feature was less dense and the blocks were somewhat scattered. Nevertheless the feature remained legible, visibility permitting.

In some places we noticed a difference in size and shape between the blocks on the edge of the feature and the infilling. Some of the outer bonding blocks were 80 to 120 cm long, were embedded in the substratum width wise and were inclined approximately 20°. The filling comprised blocks of either 20 or 50 cm long. The alignment was up to 5 m wide. The substratum seems to be very thin because our staking came up against a layer of rock, especially in the first part of the section. Was it the underlying rock or ballasting buried in the sediment? Staking on the last part of the section showed that the sediment layer was thicker.

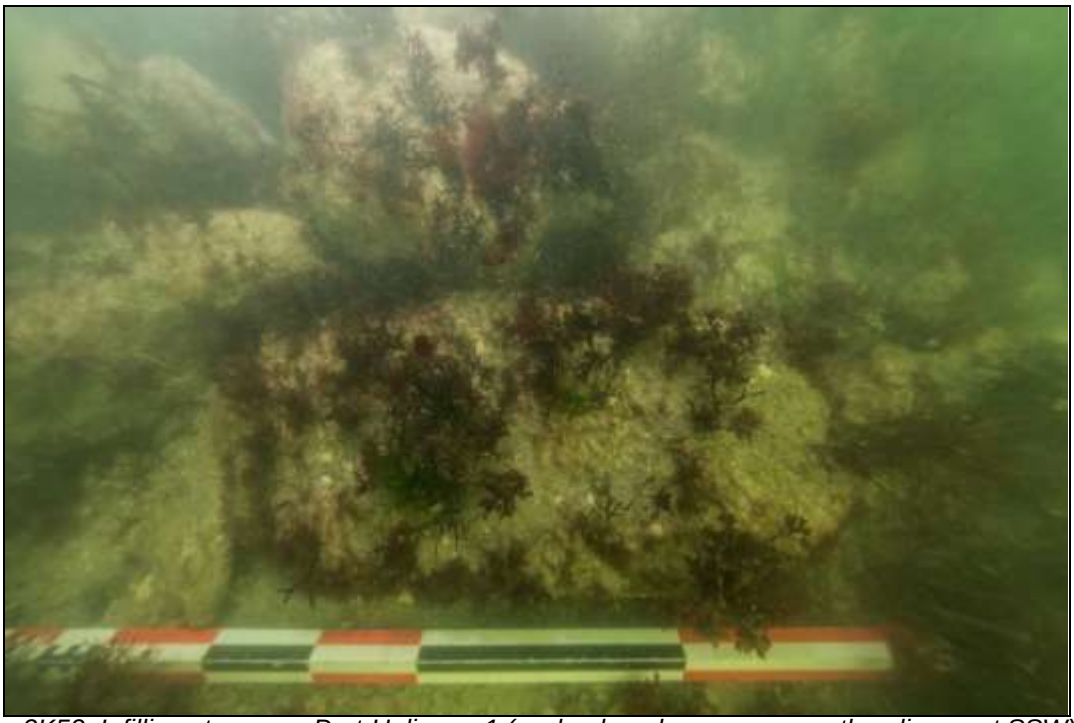

Figure 3K52. Infilling stones on Port-Haliguen 1 (scale placed crossways on the alignment SSW) © T. Seguin /ADRAMAR (after le Ru 2013).

Quiberon fish weirs - Ranking score achieved: 88

3K.6 Art Field and Research Studies

As mentioned above, this area has been depicted through various media including; paintings, photos, maps and charts. For each kind of data source, field studies helped us in the analysis of the informative value of the pictures as illustrations of coastal change in the Quiberon peninsula case study area. The main results are presented below.

The art approach partly took profit from the academic work led by E. Motte (Motte, 2013) in the Rennes 2 university. This work was completed by consultation of several art books and online resources (e.g. Joconde database). Ancient postcards used for the project were available either in private collections or though online resources; the main part of the ancient photos illustrating this coastal area belongs to the Archéosciences laboratory collection (university of Rennes, ICARE project; López-Romero and Daire, 2013).

3K.6.1 Key Research Questions

The aim of the research was to understand what kind of information the selected datasets can provide and how informative they are regarding past coastal change.

3K.6.2 Approach to information gathering and fieldwork

Concerning art, the academic work of E. Motte partly consisted of a comparison of the paintings or artistic representation with the real current landscape, based on a geomorphologic approach, with detailed measurements and depictions (Motte 2013).

Sites represented on ancient photos were also subject to a field approach, comparing the current situation with the one pictured in the late 19th century and the early 20th century images; in this approach, when possible, several photos of various dates taken from different angles have generally been compared; we will present below a synthetic result.

Historical maps in this area have been compared with present and with historical satellite images in order to assess the conditions of the coastline and changes that may have taken place over time. The IGN Database provides a huge collection of aerial views of Brittany from 1947, which have been compared with the aerial views of Brittany provided by GeoBretagne.

3K.6.3 Art Field Data Gathering Results

The selected sites in the Quiberon peninsula and southern Morbihan case study area were chosen to reflect various geomorphological features and to understand the coastline changes and human impacts.

For the various artworks the fieldwork element has been largely visual in terms of identifying the location of the paintings and making judgments, on site, of the role that art can fulfill as a qualitative or quantitative tool to support coastal risk management.

The main focus for the maps and charts has been the examination of one particular map and to make an assessment of what it tells us about changes over time from field observation. However, for some of the study sites it has been found that the area is depicted in several maps. This helps us to establish a chronology of coastal change through the eighteenth and twentieth centuries. The results for each case study location are described below.

K1. Pêcheurs ramassant leur senne près de l'isthme de Penthièvre, by Elodie La Vilette, 1880 (Figure 3K53).

Location
The painting represents a section of the Penthièvre isthmus, which is located in the Northern part of the Quiberon peninsula (Figure 3K53).

Why was the study site selected?
The painting has been selected because it is one of the rare artworks showing a settled area, as more often painters of the Quiberon peninsula have shown the wild rocky coast (see below).

Geomorphological setting
The isthmus is composed of sandy dunes which is the main visible feature (see above).

Key coastal risk management issues for the location
The issues for the coastal risk management combine here the pressure of erosion on the soft rocks and dunes and the urbanization and construction linked to human activities.

How the artwork can inform coastal risk management
The painting shows a quay and port constructions, linked to fishing and seaweed gathering activities and depict the anthropic pressure on this landscape. The comparison with the current view indicates that vegetation is growing in this area (Figure 3K53); this may be a positive things as plants can contribute to the stabilization of dunes.

Where can the original artwork be viewed?
Département des Arts graphiques du Louvre

Pêcheurs… près de Penthièvre - Ranking score achieved: 48

K2. Quiberon, cavernes de la côte sauvage, by Christophe Paul de Robien, 1753-56 (Figure 3K54).

Location
The painting represents the rocky wild coast of the Quiberon peninsula, located on the western façade facing the ocean.

Why was the study site selected?
This picture has been selected as it one of the most ancient paintings depicting this area.

Geomorphological setting
The main geomorphological setting is the natural grottos, cut into the granite cliffs, and visible on the painting.

Key coastal risk management issues for the location
The main coastal risk management in this area is linked to the natural coastal erosion, even if it is less active on the rocky cliffs than on the sandy dunes.

How the artwork can inform coastal risk management
As it was drawn by E. Motte in her analysis of the painting (Motte 2013), the artist has exaggerated the size and visual importance of the grottos, compared to the current reality

(Figure 3K54) However, the existence of the grottos is itself an indicator of the erosive tendency of the cliff body, along this wild coast which is very exposed.

Where can the original artwork be viewed?
Département des Arts graphiques du Louvre

Quiberon, caverns de la côte sauvage - Ranking score achieved: 51

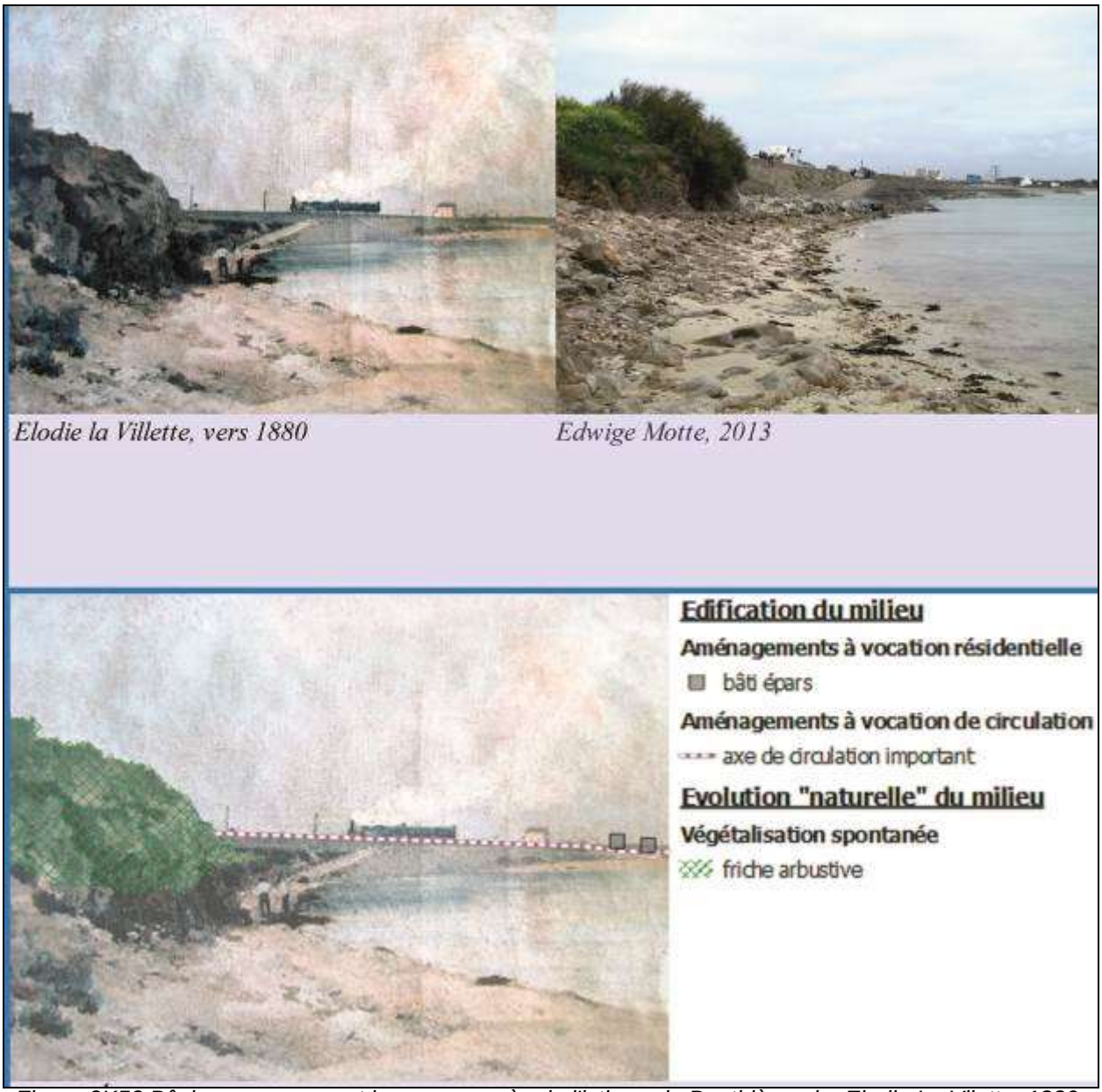

Figure 3K53 Pêcheurs ramassant leur senne près de l'isthme de Penthièvre, by Elodie La Vilette, 1880, analysis of the painting by E. Motte (after Motte 2013).

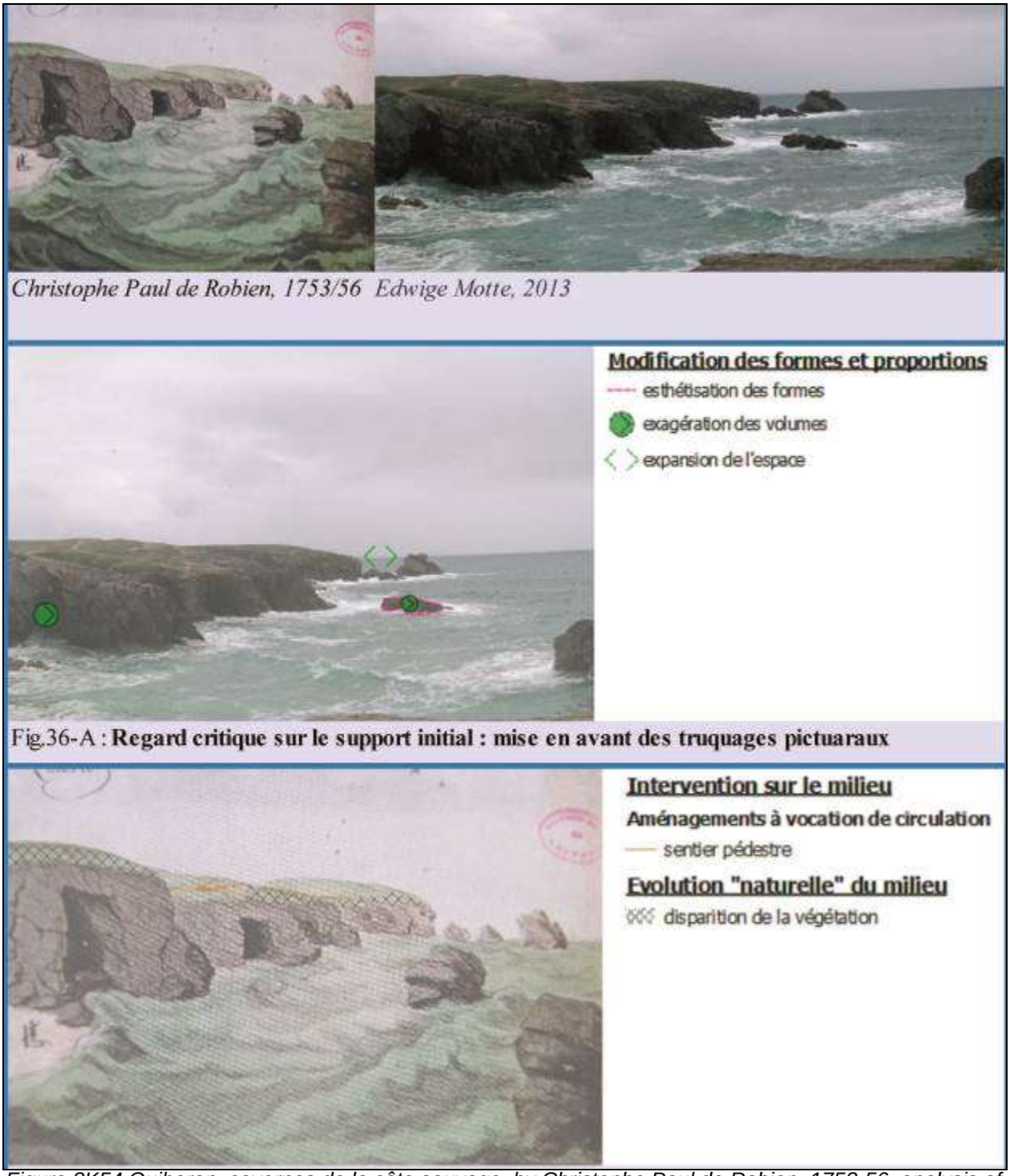

Figure 3K54 Quiberon, cavernes de la côte sauvage, by Christophe Paul de Robien, 1753-56, analysis of the painting by E. Motte (after Motte 2013).

K3. La crique de Port-Bara, by Elodie La Vilette, c. 1880 (Figure 3K55).

Location
Port Bara is one of the scarce beaches located on the western coast of the Quiberon peninsula.

Why was the study site selected?
The painting has been selected as it provides a detailed view of the rocky cliff, with a tendency to certain realism (Figure 3K55).

Geomorphological setting
The painting represents a sandy beach the Port-Bara which is located at the foot of a rocky (granite) cliff.

Key coastal risk management issues for the location
The main coastal risk management in this area is linked to natural coastal erosion, even if it is less active on the rocky cliffs than on the sandy dunes.

How the artwork can inform coastal risk management
Only slight cliff erosion but no major change can be visible along this part of the rocky coast of the peninsula, which is more resistant to erosion than the sandy dunes. The changing aspects of the beach are due to the annual movements of sand, the quantity of which generally diminishes during winter and comes back in spring.

Where can the original artwork be viewed?
Département des Arts graphiques du Louvre.

La crique de Port-Bara - Ranking Score achieved: 48

Figure 3K55. La crique de Port-Bara, by Elodie La Vilette, c. 1880, analysis of the painting by E. Motte (after Motte 2013).

K4. L'arche de Port Blanc, presqu'île de Quiberon, by Maxime Maufra, c. 1880 (Figure 3K56).

Location
Port Blanc is located on the western coast of the Quiberon peninsula.

Why was the study site selected?
The site has been selected as it shows one of the typical erosive features of the western rocky cliff of the wild coast of Quiberon peninsula, i.e. the famous "arch" of Port-Blanc.

Geomorphological setting
The geomorphologic setting is the granite rocky cliff of Quiberon, along its western coast.

Key coastal risk management issues for the location
The main risk in this area is erosion of the granite cliffs.

How the artwork can inform coastal risk management
The artwork represents a rocky arch, formed in the granite cliffs by the waves and the swell. The current view (photo on Figure 3K56) shows a wooden barrier, the presence of which corresponds to a risk management measure, designed to protect visitors as well as the natural site.

Where can the original artwork be viewed?
Private collection.

L'arche de Port-Blanc - Ranking Score achieved: 44

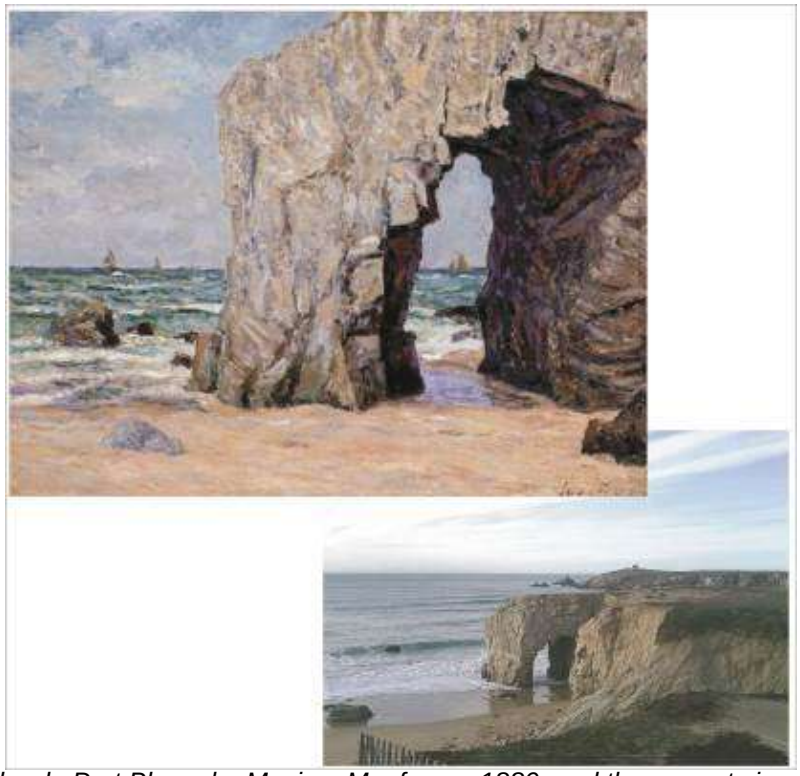

Figure 3K56. L'arche de Port Blanc, by Maxime Maufra, c. 1880, and the current view of the site (source: Wikipedia).

3K.7 Analysis

The Quiberon peninsula study has combined the use of archaeological and palaeoenvironmental data, paintings, historic photographs, maps and charts in order to demonstrate how these tools can be used to improve our understanding of coastal change in the long and short term.

3K.7.1 Archaeology and Heritage Features

Many studies are still needed before we can have all the information necessary for the reconstruction of past landscapes and environments of the Quiberon Peninsula. Topographic surveys conducted at the archaeological site of Beg -er- Vil cover only a very small area and are particularly difficult to obtain due to a very chaotic morphology. Also, Lidar data promised on the French coast in the Litto3D program are eagerly awaited as they will read, both fine and large tracts of coastal landforms. This topographic data should be extended seawards by bathymetric surveys at high resolution using multi beam. This information will then satisfy the needs of specific morphological data in sub- tidal areas. As such, we can already welcome the measurement campaign carried out by Adramar which will clarify the nature of the seabed in the area.

In the Quiberon Bay, in depths ranging between -5 and -15 m below low water spring tides, the sedimentary cover contains valuable information on coastal environments and their evolution since 10,000 years ago. Coring conducted by Marion Dufresne confirms: 5000 years of environmental history are preserved (from 9700 to 4300 cal BP), in about 9 m of marine sediments. Pollen and foraminifera contained in this core are under study and should help to refine the paleogeography. To extend this approach, new cores would be necessary, at lower depths. Indeed, coverage of between 0 and -5 m deep sediment was never truly investigated, due to the difficulty of whether coring shallow depths. However, we assume that it contains organic deposits that would more accurately reconstruct ancient shorelines.

Geomorphological setting

Sub-seabed immediately south of the peninsula of Quiberon presents the two main morphological sets that characterize the Breton Précontinent.

1. The rocky spine 'prélittorale' in the Peninsula and its offshore extensions in the direction of Houat and Hoedic islands (Teignousse and Béniguet paths). Shoals are limited to the south by an escarpment fault oriented N120 morphological barrier. This barrier is cut in four places by tidal passes orientation at N30 passages Teignouse (51 m) of Béniguet (20 m) , Sisters (15 m) and between Hoedic and Basse Guérin (30 m). The transition from Teignouse forms the deepest notch and corresponds to a fossil valley. It is marked by particularly strong submarine slopes (between 5 and 10%), reflecting a deep incision of an ancient river organization in the bedrock. Menier (2004) showed that during phases of low sea level of the Pleistocene, the Vilaine and its tributaries then flowed through this narrow valley (whose width does not exceed 1 km) and would extend to the sea more to the west.

2. The pre-coastal depressions are located on either side of the Quiberon Peninsula and are marked by gentle slopes, between 0 and 0.25%. On the west side of the peninsula, the finds are mainly rocky since the wave action limit the sedimentation and reveal the base on a large area (plateau Birvideaux). On the east side, however, low hydrodynamics inside the bay of Quiberon resulting in muddy, rocky flats belted near the coast.

The outline of the palaeoenvironmental history of the region is now well known thanks to recent work by marine geologists in the Mor Bras (Proust *et al.* , 2001; Menier, 2004 ; Sorrel *et al.* , 2010). During the phase of low sea level of the last glacial maximum (about 20,000 - 18,000 BP) , the whole " Précontinent Breton " was part of a continental system , traversed by a network of valleys incised into the bedrock. As we said earlier, the Vilaine flowed offshore to the west of the peninsula of Quiberon in the current pass through the Teignouse. It received the waters of many tributaries that now drain the Gulf of Morbihan and the small estuaries of Crac'h St Philibert, Auray. In the main valleys and interfluves, coastal rivers deposited sand and silt before the sea began its ascent.

At the beginning of the Holocene, the fluvial system gradually gave way to a river-estuary system. The sea flooded the valleys and at the interface between the river and the sea, where fluvial currents lose their jurisdiction and where the sea penetrates daily, muddy material rich in marine shells was deposited in thicknesses of 5 to 10 m. This estuarine phase is likely staggered between 10 000 and 7000 cal. BP, gradually winning the upstream portion of the valleys as the sea level rose. It is in this time range that is the occupation phase of the Mesolithic site of Beg er Vil, at a time when the rate of sea level rise is still high (about 0.8 cm / year to globally) and where, throughout the Mor Bras, valley bottoms rapidly transformed.

Thereafter, the rates of sea level rise slowed (around 6500 cal BP) and without the shoreline gradually stabilized. Marine silt continued to accumulate in the shallows, while in the upper part of the foreshore area Neolithic bog existed which is today located just below the LLW, as evidenced by peat deposits discovered at the bottom of the foreshore of the small Rohu (Gaudin, 2004; Cassen *et al.*, 2010), to Kerpenhir (Visset *et al.*, 1996) to Kerbougnec (Marsille, 1930).

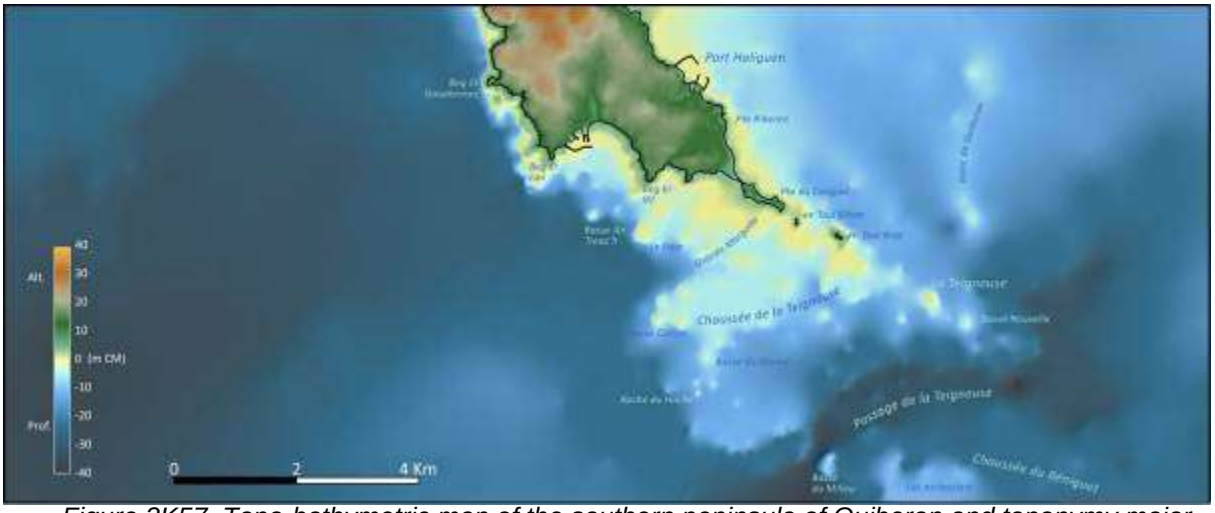

Figure 3K57. Topo-bathymetric map of the southern peninsula of Quiberon and toponymy major seamounts (doc. P. Stéphan, after Manchand et al., 2013).

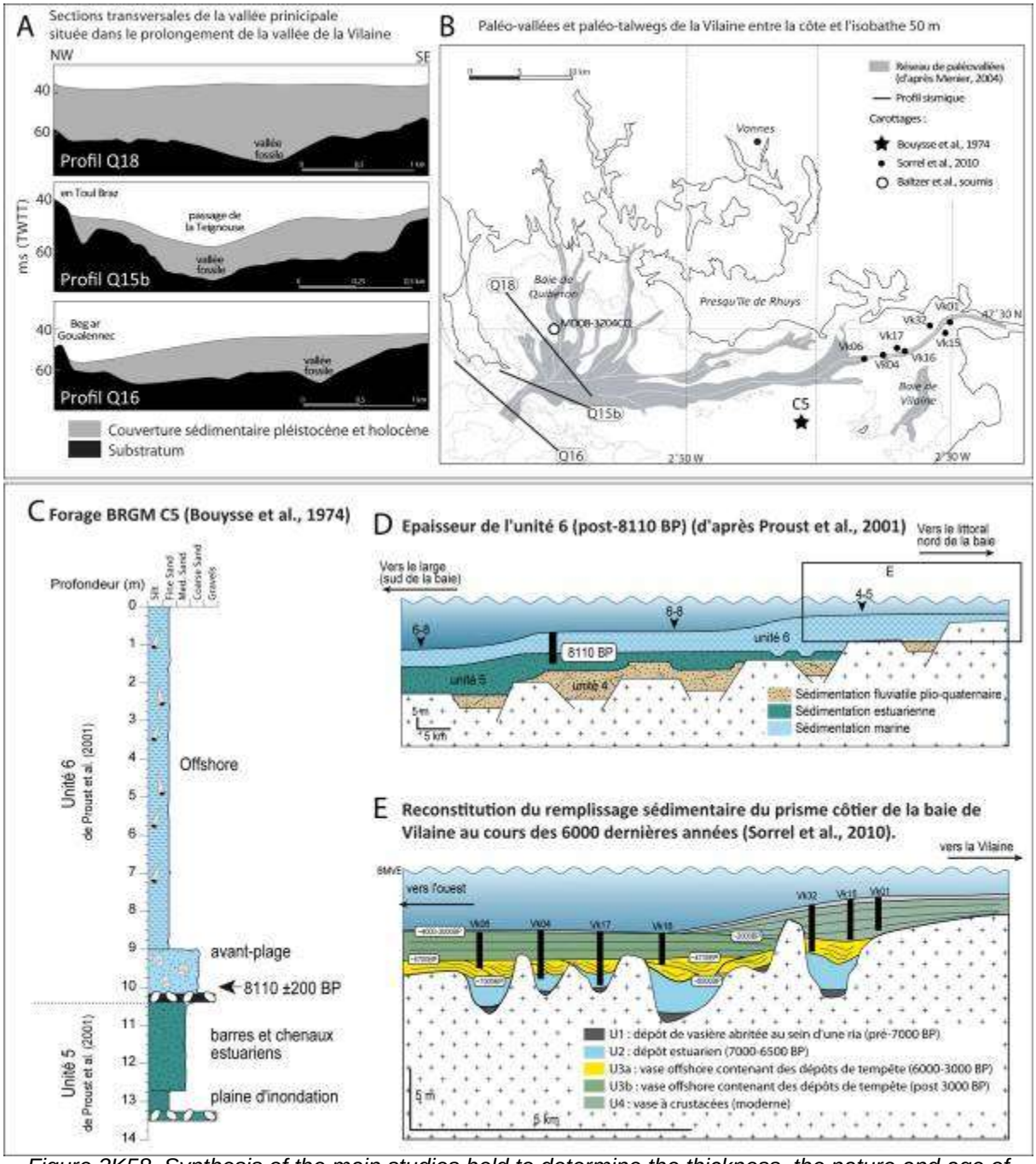

Figure 3K58. Synthesis of the main studies held to determine the thickness, the nature and age of submarine sediments between the Quiberon Peninsula and the Bay of Vilaine (A and B: modified Menier, 2004. C: modified Bouysse et al, 1974; modified. D: Proust et al, 2001. E: amended Sorrel et al, 2010) (doc. P. Stéphan, after Manchand et al., 2013).

3K.7.2 Artistic Depictions

Following the research and location of a quite small number of artistic images of the coastline along the Quiberon study area we have underlined their relative importance in terms of their value in informing on long and short term coastal change. The art case study area only provided some focuses on specific areas, especially the wild coast on the western façade of Quiberon peninsula.

Although not a comprehensive study, several historic photographs and maps were also assessed. In addition, some modern postcards dating from the tourism development during the early 20th century (Figure 3K60) have promoted the natural landscapes of Morbihan and especially the Quiberon peninsula.

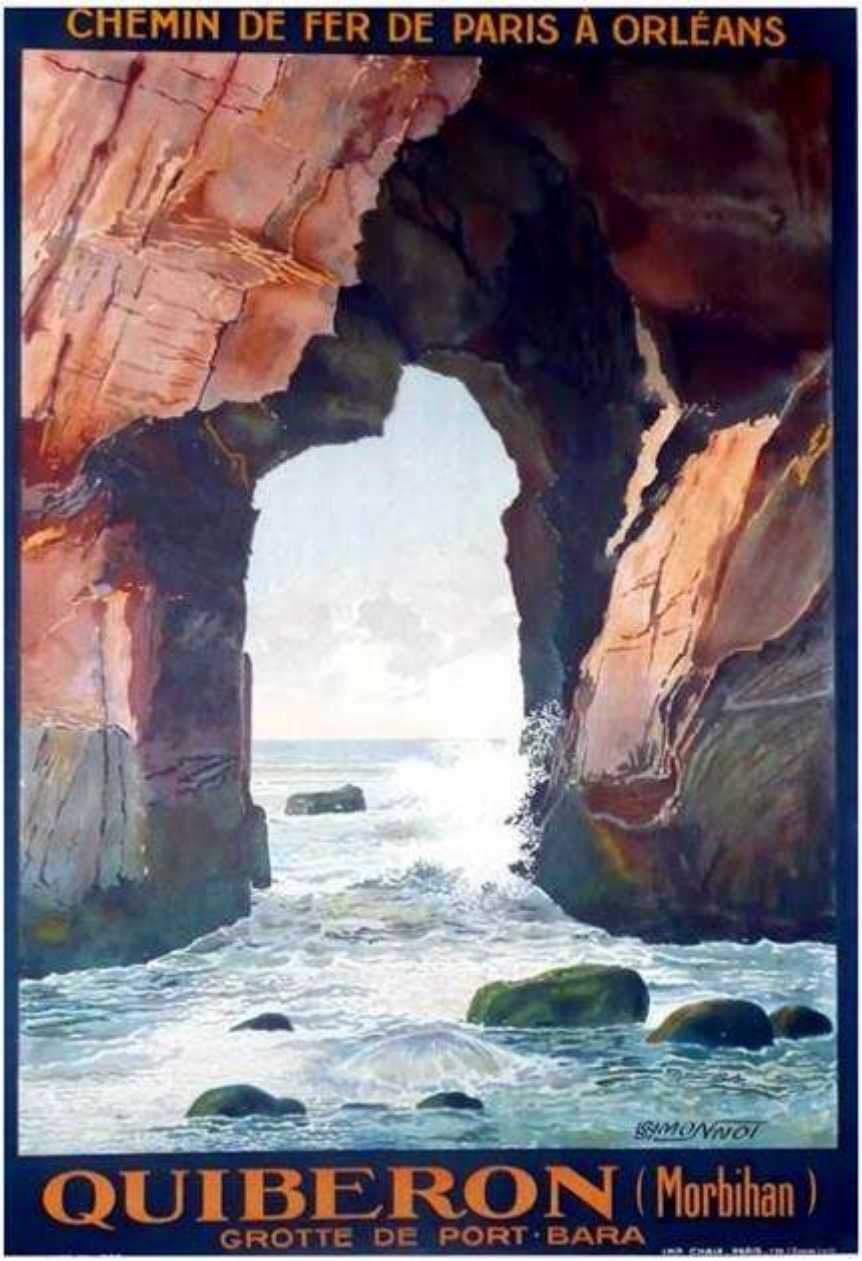

Figure 3K59. Quiberon, grotto of Port-Bara" by L. Symonnot - 1929 (source vintage-posters-gallery.com).

3K.7.3 Combined Resources

The Er Lannic megalithic monument, Gulf of Morbihan.

Located on the Atlantic Armorican facade, the gulf of Morbihan means “small sea” in Breton. It is a small inland sea, closed by the peninsula of Rhuys, which covers 12.000 hectares. Among the hundreds of islands and islets which the gulf counts, about thirty are inhabited.

The gulf is a highly touristic area, well known for its megalithic monuments: standing stones, passage graves, monumental burials and cairns make up the richness of the prehistoric heritage. Several of these monuments, e.g. the 60 m wide cairn of the Gavrinis Island became gradually isolated from the mainland because of sea level rise. Another example is the twin standing stone circles on the Er Lannic islet, which now appear partially submerged.

The 2 main islands, “’île d’Arz” and the “’île aux Moines”, are charming by the diversity of their landscapes and natural environments. The gulf of Morbihan is home to thousands of hectares of rocks, beaches, herbaria, salt-springs and also more than 100,000 birds: stilts, egret, goosander, gulls, seagulls, etc. These unusual landscapes move according to the rhythm of the tides. The gulf is also a place for fishing (fish and shells); it features a famous oyster center with an orientation towards the production of oyster spats. The images (Figure 3K60) show various aspects of the landscape, as well as its evolution during the past millennium, especially the importance of sea level rise for this flat where former palaeovalleys were progressively invaded by sea water and isolated the hills that then became islands and islets.

On the islet of Er Lannic, 500m (0.3mi) south of Gavrinis, there are two stone circles, both made of some 60 stones (Figure 3K61). They are now half submerged by the waters of the Gulf of Morbihan, but in prehistoric times they stood on the mainland. Only the northern circle can be seen, the southern one being entirely submerged. Er Lannic is now a Bird Reserve and cannot be visited, so the northern stone circle is visible only from the air or by boat. This circle, half submerged, is 65m (213ft) in diameter and its stones are 2 to 5.4m (6.5 to 17.7ft) high.

The site was excavated in the 1920s by Zacharie Le Rouzic, who calculated that Er Lannic had been erected about 5000 years ago. He found around each stone a cist containing charcoal, animal bones, worked flints, pottery, and a lot of polished axes. Two stones are carved with axes and a yoke, and one of the uprights' packing stones has nine cupmarks (according to Le Rouzic, arranged to form the outline of the constellation Ursa Major). The southern submerged stone circle is horseshoe-shaped open to the east, 61m (200ft) in diameter.

Two outlying stones, now fallen and below the water, lie east and west 50m (164ft) and 90m (295ft) from the circle, on a line tangent to the visible ring's northern corner, marked by the highest stone of the circle (5.4m - 17.7ft). At the southern tip of the submerged horseshoe there was a great pillar called *the blacksmith's stone* by fishermen (Gouezin & Le Gall 1992). These lines to cardinal points had probably some astronomical connections, presumably to the moonsets (sources: http://www.stonepages.com/france/erlannic.html and Labo Archéosciences UMR 6566 CReAAH).

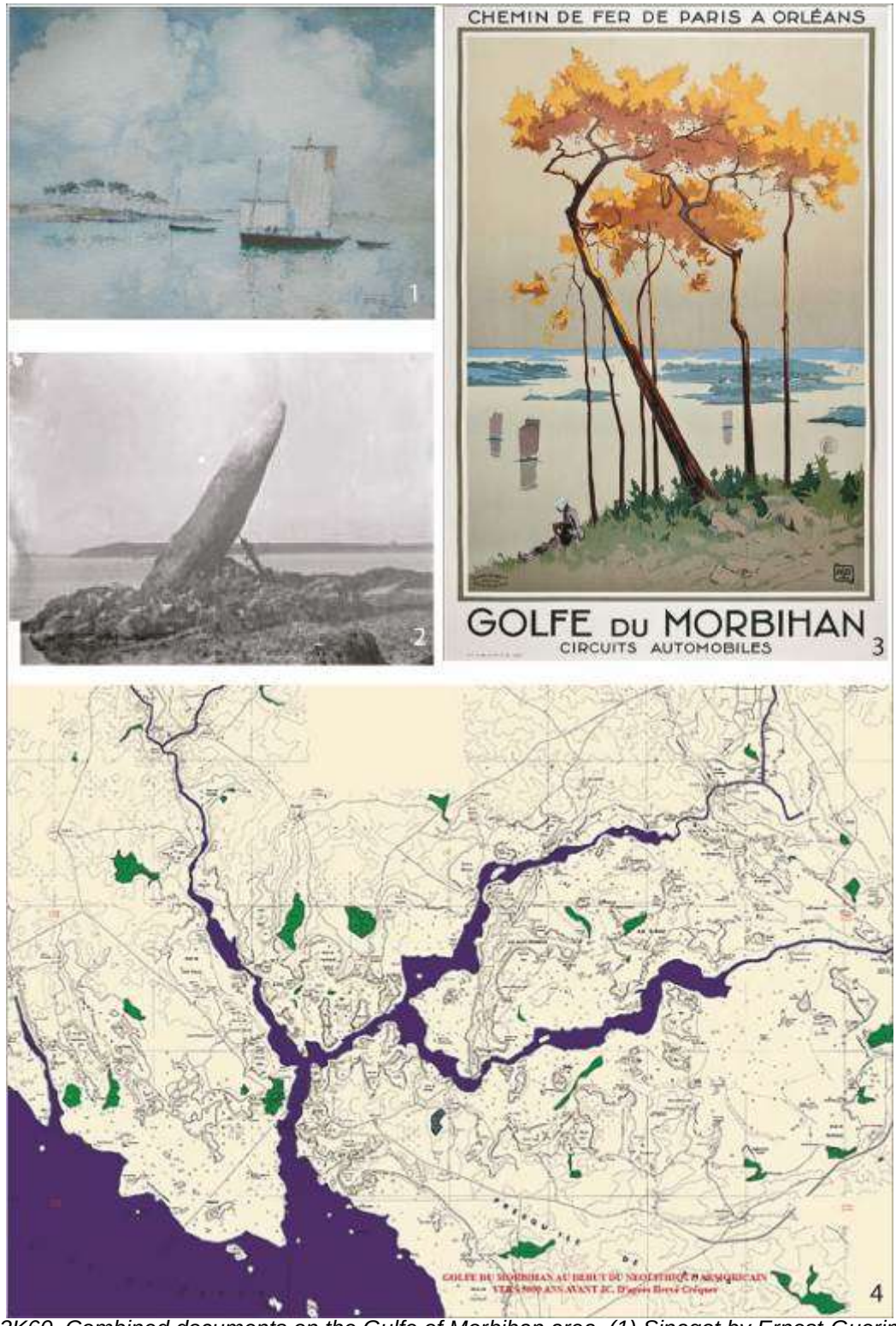

Figure 3K60. Combined documents on the Gulfe of Morbihan area. (1) Sinagot by Ernest-Guerin (1887-1952), (2) The Er Lannic megalithic site during the restoration by Z. Le Rouzic (c. 1920), (3) Golfe du Morbihan, porter 1927 (source http://www.vintage-posters-gallery.com/fr/affiches-de-la-bretagne-htm), (4) Schematic map produced by shifting the bathymetry of 10 meters and incorporating qualitative sedimentation phenomena and deepening (source: http://www.ileauxmoines.fr/articles.php?id=25).

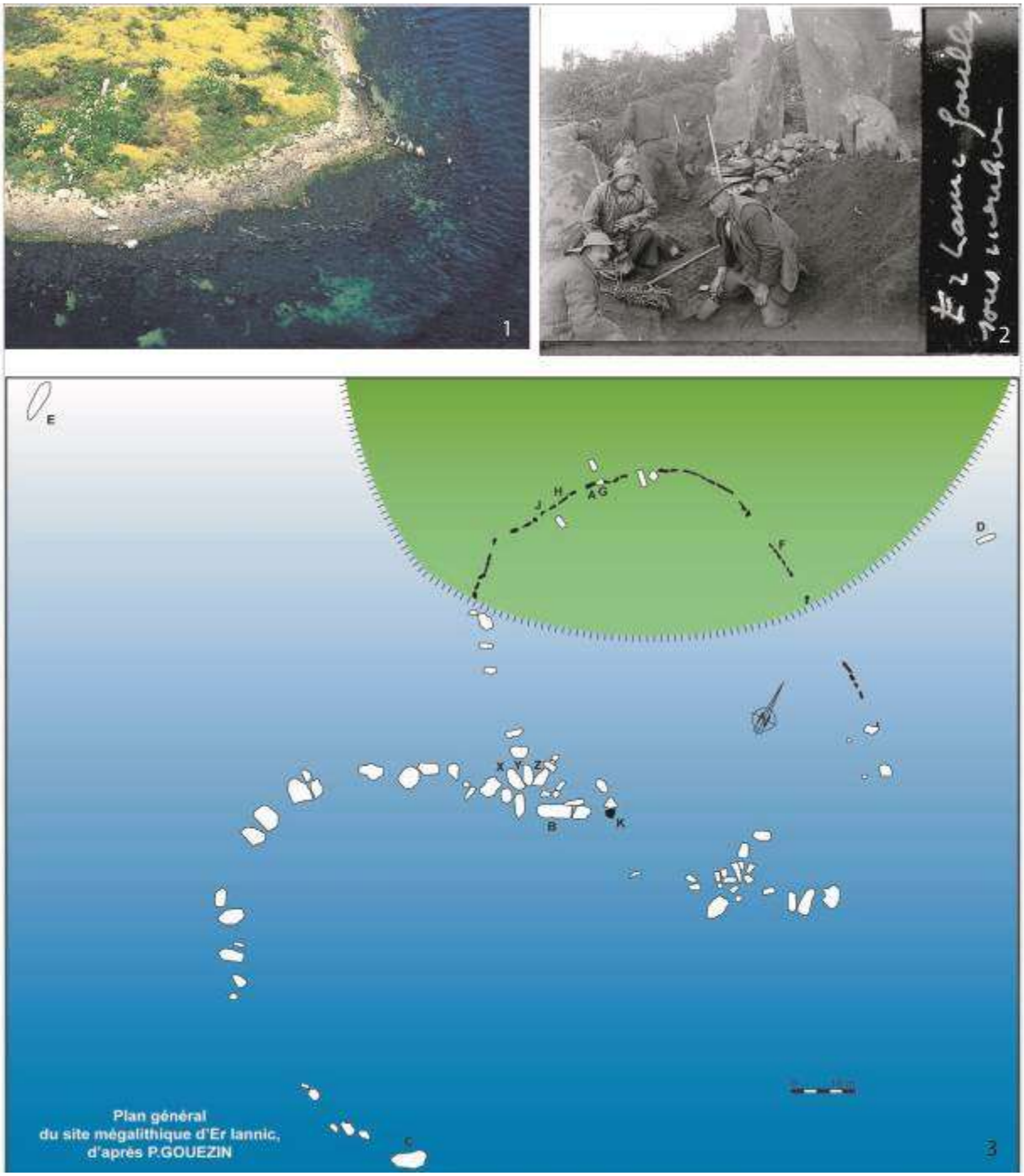

Figure 3K61. Combined documents on the Er Lannic megalithic site. (1): A view from the air of the half submerged stone circle on the islet of Er Lannic, in the Gulf of Morbihan (Cl. Reynaud, source futura-sciences.com), (2) Zacharie Le Rouzic, Marthe and Saint-Just Péquart, during the restoration of the Er Lannic monument (c. 1920). © Labo Archéosciences UMR 6566 CReAAH.), (3) Map of the Er Lannic stone circles (doc. P. Gouézin, after Gouézin & Le Gall 1992).

3K.8 Conclusions and Recommendations

One of the main natural features in this case study area is represented by dunes and sandy bars, which are vulnerable to coastal change. If we assess the risks on the dunes environment, it appears that the period from 1965-1985 corresponds to a "let happen" phase, parallel with the mass tourism development with various consequences: multiplication of wild paths on the dunes surface, shuffling along and erosion that striped down important surfaces etc. The vegetation disappearance and its consequences on fauna led the authorities to react. In 1985, various settlements were set up in order to limit the touristic flow and to forbid the access of vehicles on the dunes. Access paths to the beaches were created as well as structured car parks (Cavalie, 2001).

In conclusion, we can notice that the various coastal management decisions or actions are not always coordinated and those irreversible destruction processes are going on, damaging the natural environment and the landscapes. Each partner or manager makes their own decisions, all having the same target but without agreement. This situation leads to divide up the territory. In addition, the existing protection settlements are not numerous enough and sometimes inefficient facing the growing tourist development. These gaps are especially sensitive in the protection of natural environments (free circulation and walking, lack of control etc.) and in the tourist equipment (insufficient car parks, lack of sanitary and sport equipments etc.).

Specialists recommend setting up an agreement between the various management policies, in order to define priorities within a global landscape strategy, and to federate the policies on this territory the complexity of which being due to its extent and diversity (Cavalie, 2001).

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