Paths Across the Sea: Meteo-Marine Conditions for Coastal Navigation Around the Balearic Islands During the Middle and Late Bronze Ages

Published Version:
Manuel Calvo-Trias, A.G. (2023). Paths Across the Sea: Meteo-Marine Conditions for Coastal Navigation Around the Balearic Islands During the Middle and Late Bronze Ages. INTERNATIONAL JOURNAL OF NAUTICAL ARCHAEOLOGY, 52(1), 158-178 [10.1080/10572414.2022.2155384].

Availability:
This version is available at: https://hdl.handle.net/11585/913122 since: 2023-06-20

Published:
DOI: http://doi.org/10.1080/10572414.2022.2155384

(Article begins on next page)

Paths across the Sea: Meteo-marine Conditions for Coastal Navigation around the Balearic Islands during the Middle and Late Bronze Ages

Alejandra Galmés-Alba (ArqueoUIB Research Group, Department of History and Theory of Art, University of the Balearic Islands, Palma, Balearic Islands, Spain; b Institute of Heritage Sciences (INCIPIT), Spanish National Research Council (CSIC), Santiago de Compostela, Galicia, Spain)

Manuel Calvo-Trias (ArqueoUIB Research Group, Department of History and Theory of Art, University of the Balearic Islands, Palma, Balearic Islands, Spain)

Stefano Medas (Alma Mater Studiorum University of Bologna, Department of Cultural Heritage, Ravenna, Italy)

Gabriel Servera-Vives (ArqueoUIB Research Group, Department of History and Theory of Art, University of the Balearic Islands, Palma, Balearic Islands, Spain)

ABSTRACT

Throughout history the Balearic Islands have had different degrees of social connectivity between the islands themselves and between them and the mainland. While the influence of historical dynamics is well documented, less so is the impact of winds, currents, and meteo-marine conditions. This paper analyses the meteo-marine conditions for coastal navigation to better understand how these configured the main maritime routes across the islands. We focus on the seafaring communities of the Balearic Islands in the Bronze Age when a series of sites along the coastline suggest the creation of a network of coastal infrastructure to support maritime mobility.

Keywords: Coastal navigation, meteo-marine conditions, visibility, Balearic Islands, Bronze Age, Mediterranean.

‘Just as deserts are far from uniform, so the sea too is variegated’ (Broodbank, 2013, p. 72)

‘*Bona mar i bons vents*’ Common saying among Catalan fishermen translating to ‘fair winds and fair seas.’

Introduction

Braudel (1972, p. 140) thought about the Mediterranean as “not a single sea but a succession of small seas that communicate by means of wider or narrower entrances,” and the connections that they enable require different paths and routes be taken. Thus, meteo-marine conditions were a key factor for prehistoric seafaring, as was nautical technology and the need to maintain vision of the coastline. Specifically, prevailing winds and the direction of surface currents, as well as conditions regarding visibility of the coastline, are the factors that conditioned interconnections across the Mediterranean.

The Mediterranean is shaped by a complex meteo-marine system, and thus, it is not an open space that can be travelled in any direction (Guerrero Ayuso, 2006a). Winds and currents form a series of routes that facilitate certain connections and make others more difficult. During prehistoric times, due to the nautical technology available, mobility dynamics were strongly shaped by these maritime and meteorological conditions. However, they cannot be seen in a deterministic way, as naval technologies along with seafaring knowledge and experience played a significant role in the connectivity dynamics of each community. Therefore, maritime connectivity must be understood as a combination of factors in which both the habitus and the agency of seafaring communities had significant roles in the perception of meteo-marine conditions. It is the combination of environment, experience, and human interaction that shaped paths across the sea (Erlandson and Fitzpatrick, 2006; Fitzpatrick, 2013; Montenegro, Callaghan and Fitzpatrick, 2016).

The study of the sea was first theorized as a maritime cultural landscape by focusing on the maritime related material culture, as well as the use of maritime resources, thus connecting the archaeological remains under water and on land that showed the connection with the sea (Westerdahl, 1992, 2008, 2013; Tuddenham, 2010). In parallel, the focus on the seascape allowed for understanding the mechanisms by which different communities actively engaged with the sea, and how the sea is conceptualised by the cosmologies that frame its perception and the interaction with it (Cooney, 2003; McNiven, 2003, 2008; Van de Noort, 2003). The idea of 'islandscape' (Broodbank, 2000) brought somehow together these two spaces, to understand islands as shaped by both land and sea, and how the coastline is a perceptive and changing limit (Helms, 1988; Ford, 2011). In an 'islandscape', both landscape and seascape are socially active spaces, experimented upon and perceived by the people who move through them (Broodbank, 2000). In an archipelago, this fluidity, connectivity, and capacity of agency are especially interesting, as they highlight the activities that happen between islands, thus forming an 'aquapelago' (Stratford et al., 2011; Dawson, 2012; Hayward, 2012). All these levels interact creating a 'maritime small world', with different spheres of connection at a coastal, islandic, archipelagic, and regional scale (Tartaron, 2013).

This paper focuses on the seafaring communities of the Balearic Islands in the Bronze Age, a period during which a series of sites along the coastline suggest that such communities created a network of coastal infrastructure to support maritime mobility. The Middle and Late Bronze Ages (1400/1300-900/850 BC) saw connections expand between the insular communities of the archipelago, as well as between the islands and the mainland (Guerrero Ayuso, 2006a; Guerrero et al., 2007; Albero Santacreu et al., 2011; Calvo et al., 2011; Calvo Trias and Galmés-Alba, 2018; Perelló Mateo and Llull Estarellas, 2019; Sureda, 2020; Valenzuela-Suau et al., 2021). This connectivity can be traced across the archaeological record, too, as there are formal and technological similarities that can be seen in architecture, pottery production, and bronze metallurgy among the islands. Moreover, the presence of foreign objects and raw materials, such as African ivory, stone used for macrolithic tools, copper, and tin, shows the integration of the islands in the wider Mediterranean context of connectivity (Guerrero et al., 2007; Albero Santacreu et al., 2011; Javaloyas et al., 2015; Gornés Hachero, 2016; Sureda, 2016, 2019, 2020; Calvo Trias and Galmés-Alba, 2018; Llull Estarellas et al., 2019; Perelló Mateo and Llull Estarellas, 2019). Common practices across the archipelago, as well as the identification of materials, objects, and ideas that moved between islands, has led to the proposal that there was a shared habitus between the insular communities of the Balearic Islands (Albero Santacreu et al., 2011) or even a "small maritime world" (Tartaron, 2013) across them (Calvo Trias and Galmés-Alba, 2018).

Typological and technological convergences and the similar praxis of the islands' communities during the Middle and Late Bronze Ages can only be explained by a high level of connectivity between them. Such connectivity required maritime mobility based on coastal navigation, which can be tracked archaeologically via the multitude of repeating coastal sites across the islands. Archaeological surveys to identify these sites are currently being conducted, and so the number of them may increase, although a considerable number have already been identified (see Table 1 and Figure 1). These sites could have been landmarks that were used during coastal navigation to serve as points of reference and orientation along routes. They are located in three different spaces: on top of islets near the coast, in small bays of coves, and on top of coastal promontories near bays or beaches that could have potentially been used as places of anchorage, although no archaeological remains have yet been documented there (see Table 1 and Figure 1). Moreover, another group of sites that could have functioned as landing and anchoring places has been documented. These coastal sites, the archaeological remains found there, and their relationship to coastal navigation have been extensively analysed (Guerrero Ayuso, 2006b; Guerrero et al., 2007; Orfila Pons, Baratta and Mayer, 2010; Albero Santacreu et al., 2011; Calvo Trias and Galmés-Alba, 2018).

Nautical iconography has been documented on the islands; however, their chronology is still under debate (Guerrero Ayuso, 2006a, 2006b; Guerrero et al., 2007; Albero Santacreu et al., 2011). Thus, the nautical propulsion techniques used during the Middle and Late Bronze Ages are rowing, paddling and the use of square sails, or potentially a mixed square sail-oars system too, as documented in the Aegean and Eastern Mediterranean (Marangou, 1990; Georgiou, 1996). The square sail favours sailing downwind up to abeam, but makes it difficult to manoeuvre with headwinds (Guerrero Ayuso, 2006b; Whitewright, 2009, 2011).

Following the steps taken by authors such as Guerrero (Guerrero Ayuso, 2004, 2006a; Guerrero et al., 2007), the present paper aims to analyse further the factors that influenced the configuration of the main maritime routes used by sailors in the Balearic Sea during the Middle and Late Bronze Ages. Our main goal is to recognise both meteo-marine conditions and the agencies of the islands' communities to shape mobility and connectivity dynamics across the islands. To do this, we will combine modern biogeographical data, paleoclimate data, analyses of archaeological materials, and geographic information models to get a sense of the factors that shaped prehistoric coastal navigation around the Balearic Islands.

Meteo-marine Conditions for Navigating the Balearic Sea

The Balearic archipelago is located in the western Mediterranean and is one of the five main island groups in this sea, the others being Lampedusa, Pantelleria, and Malta; Sicily and its archipelagos; the Aegadian and Aeolian Islands; and the Sardo-Corsican ensemble. The Balearic archipelago is formed by the islands of Mallorca, Menorca, Eivissa, Formentera, and Cabrera, as well as more than 250 islets. It has a northeast-to-southwest orientation, as it is formed geologically by the underwater continuation of the Baetic System, which connects with the south-eastern Iberian Peninsula.

Environmental, meteorological, and maritime conditions are key to the study of navigation, both in pre- and proto-history, as well as in historic times (Morton, 2001; Medas, 2020). In the context of an archipelago, they take on even greater importance, and thus, there is a greater need to assess their role in and impact on navigation around the Balearic Islands during the Middle and Late Bronze Ages. We will not take into consideration here other variables that were previously used in island biogeography studies, such as the surface area of an island or the distance from an island to the mainland (MacArthur and Wilson, 1967), as these measures take into account an island's connectivity from a geographical point of view and have already been extensively studied in the context of the earliest occupation of the Balearic Islands (Cherry, 1981; Chapman, 1990; Costa, 2000; Guerrero et al., 2007; Cherry and Leppard, 2018).

Overview of Paleoclimate Conditions in the Western Mediterranean Region

Many paleoclimatic and paleoenvironmental studies have noted increasingly drier conditions in the western Mediterranean region since the mid- to late-Holocene transition (Frígola et al., 2007; Jalut et al., 2009; Magny et al., 2013; Burjachs et al., 2017; Servera-Vives et al., 2018). Despite the existence of regional differences in the timing between terrestrial and marine records, a general drying trend started between ca. 3550-3050 cal BC (ca. 5500-5000 cal yr BP). This is shown by several indicators, such as increasing fire activity, the expansion of Mediterranean thermophilus taxa (Carrión et al., 2010; Burjachs et al., 2017; Servera-Vives et al., 2018) and sedimentary/geochemical proxies in lagoon, lake, and marine deposits (Frígola et al., 2007; Jiménez-Espejo et al., 2014). The intensification of drier conditions has been related to the southern displacement of the intertropical convergence zone (ITCZ) and respective changes in atmospheric/oceanic dynamics, such as the North Atlantic Oscillation (NAO), likely driven by a decrease in northern hemisphere summer insolation (Ausín et al., 2015; Cisneros Bermejo, 2019).

The NAO mechanism is one of the most influential atmospheric phenomena affecting climate in the Mediterranean region due to the well-established teleconnection between the western Mediterranean and northern latitudes (Moreno et al., 2005). Recent paleoclimate reconstructions of the western Mediterranean have associated increased winter precipitation and warmer conditions with negative NAOs, while drier and colder conditions have been associated with positive NAOs (Trouet et al., 2009; Olsen, Anderson and Knudsen, 2012; Ausín et al., 2015). Negative NAO-like conditions have also been related to increased northerly and westerly winds over the Gulf of Lion (Roberts et al., 2012; Fletcher, Debret and Sanchez Goñi, 2013), which is one of the most important deep-water formation sites in the Mediterranean. Therefore, changes in the formation of western-Mediterranean deep water (WMDW) would have important impacts on regional ocean circulation. Wind intensity is another vector determining the WMDW formation and thermohaline circulation during the Holocene (Ausín et al., 2015).

Another proxy to be considered in the reconstruction of past aridity, wind intensity, air mass circulation, and wind direction is Saharan aeolian dust found in lake and marine deposits. Positive NAO phases have been associated with increased Saharan dust in the Mediterranean Sea, as southerly Saharan winds are stronger during arid periods (Martín-Puertas et al., 2010; Nieto-Moreno et al., 2011; Zielhofer et al., 2017) and coincide with dry phases in the western Mediterranean. The overall aridification process during the transition from the mid- to late-Holocene (Mayewski et al., 2004) has also been associated with a long-term southward movement of the ITZC. This would have altered the Hadley circulation and strengthened the winds transporting Saharan aeolian dust during these arid periods (Weldeab et al., 2003; Nieto-Moreno et al., 2011).

In addition, sediment composition data from the Balearic Sea indicate a reduction in river run-off (decrease in Si/Al ratios) from the mid-Holocene to the present, suggesting drier conditions in northern Menorca (Frígola et al., 2007). This paleoclimate reconstruction identified nine Menorcan cold events in the Balearic Sea, which the authors understand as evidence of increased deep-water overturning in the Gulf of Lion connected to the intensification of north-westerly winds. As per new NAO reconstructions, it is possible that an increase in WMDW formation in the Gulf of Lion was driven by negative NAO-like atmospheric conditions (Ausín et al., 2015). As mentioned above, the NAO is associated with the direction, latitude, and the strength of westerly winds (Trigo et al., 2004). The Middle and Late Bronze Ages in the Balearic Islands coincided with a cold event (Minorca abrupt event M3), dating from 1450 to 1150 cal BC (3400-3100 cal BP), possibly implying enhanced northerly winds (*tramontane* and *mistral*) during the winter season (Frígola et al., 2007). Similarly, the study of aeolian sand sheets in Menorca also suggest the importance of *tramontane* winds during the Holocene (Martín Prieto et al., 2017; Pons Buades et al., 2017).

Current Climate Dynamics and their Influence on Meteo-marine Conditions

The Mediterranean acts as a hinge between the arid and dry Sahara region and the temperate and more humid Central European region, and between the arid conditions of the Near East and the Atlantic Sea to the west. It is an enclosed sea with only one natural water inlet (the Strait of Gibraltar), which creates a highly complex and particular hydrological dynamic throughout. Moreover, it is surrounded by mountain ranges, which has a bearing on atmospheric conditions. Because of all of this, the Mediterranean is affected by contrasting thermal air masses that create rapid atmospheric changes that can sometimes be quite intense. In fact, changes in atmospheric pressure can lead to the sudden appearance of storms and winds. More specifically, strong winds commonly stem from the change in atmospheric pressure leeward from the main mountain ranges of the western Mediterranean, such as the *mistral* and *tramontane* winds (Moreno, 2005).

Thus, we require an understanding the climate conditions around the Mediterranean and its subregions to assess the influence of meteo-marine conditions on coastal navigation. Mediterranean meteorology is highly variable, depending on the season. In the spring, there is a remittance of cold air from the Atlantic as the Azores high moves up in latitude, which in turn brings its area of influence over the Mediterranean. This results in a decrease of northern winds. In parallel and in combination with this phenomenon, the warm front from the Sahara and southern winds, which are hotter, dryer, and hold suspended dust, become stronger. This changes at the end of the summer when storms and DANAs (isolated depressions at high levels) become more frequent as cold air at high altitudes enter the region and collide with the warm, humid air above the sea, creating strong storms.

Sea Surface Currents

Sea surface currents in the Mediterranean are shaped by the configuration of the Mediterranean basin, circulation currents, climate conditions, evaporation levels, and the constant influx of colder water from the Atlantic. Also, the topography of the coastline and the islands produce specific regional dynamics, as well as fluxes between warmer surface waters and colder deep waters (Millot, 1999; Millot and Taupier-Letage, 2005). Altogether they form a complex dynamic of sea surface currents that interconnect into regions and subregions.

In and around the Balearic Sea, between three and four hydrodynamic regions have been identified, and they vary in number from winter to summer (Rossi et al., 2014), although three of them are relatively stable regardless of the season (Figure 2). One connects the channel between Eivissa and Mallorca with the Alboran Sea. This area is shaped by the water influx from the Atlantic Sea, which generates a clockwise current that goes from the coast of Morocco to the eastern coast of the Iberian Peninsula and back to the Moroccan coastline. Along the coastline of Algeria is a second identifiable region known as the Algerian current. It is shaped by a current that runs eastward and parallel to this coast (Millot, 1999; Millot and Taupier-Letage, 2005). Within this region, especially in its western area, anticyclonic mesoscale gyres can sometimes be found. Between the Balearic Islands and the Sardo-Corsican ensemble, a third hydrodynamic region can be identified and defined by the border of the Algerian current and the dynamics off the southern coast of France. The number, dimensions, and shape of the gyres in the area is highly complex and varies from summer to winter.

During the winter months, another region can be traced between the Gulf of Lion and the Alboran Sea, and it connects the coast from Valencia to southern Catalonia with the Balearic Islands. The Gulf of Lion itself has very complex dynamics. From it, sea currents run parallel to the coastline of the Iberian Peninsula in a clockwise direction, with gyres along the coast. Occasionally, due to the topography of the area, anticyclonic gyres can appear (Millot, 1999; Millot and Taupier-Letage, 2005).

In turn, these regions have very fluid boundaries between them, with streams, meanders, water fronts, and gyres (Rossi et al., 2014). Altogether, they generate complex internal dynamics as well as points of connection between the different regions. For example, the northern current runs from the Gulf of Lion along the Iberian coastline and branches off into three different currents just north of Eivissa. The first one continues to the south, between Eivissa and the mainland, creating anticyclonic gyres. The second one, also goes south but through the channel between Eivissa and Mallorca. The third one goes from the north of Eivissa to the western coast of Mallorca, and from there to the north of the island and to Menorca. This third current is known as the Balearic Current (Pinot, López-Jurado and Riera, 2002; Balbín et al., 2014) (see Figure 2).

Besides the dynamics in the Gulf of Lion, other currents, and gyres form in the region due to the effects of the Alboran Sea and the Algerian current. They in turn create surface currents that run north from the eastern Iberian Peninsula. Between Cartagena and the Cap de la Nau, a bifurcation of these currents occurs, making them run northeast from the southern coast of Eivissa towards Menorca, along the south of Mallorca. Occasionally, they produce anticyclonic gyres (Pinot, López-Jurado and Riera, 2002; Balbín et al., 2014). All in all, this general dynamic is affected by gyres of variable intensity and duration that form as an effect of the northern current between the south of Eivissa and the west of Mallorca, as well as between Eivissa and the mainland (see Figure 2).

System of Winds

The low intensity of surface currents may have had little effect on prehistoric coastal navigation, especially when sailing with currents, as has been seen in the Eastern Mediterranean (Bar-Yosef Mayer et al., 2015). However, the type, intensity, and direction of winds and breezes did have a major impact on the formation of routes around the Balearic archipelago (see Figure 2).

Today, the system of winds around the Balearic Islands depends on the active circulation of the Gulf of Lion, especially during the winter and in the northern part of the archipelago, which sees predominantly northern winds (from the north-east, north, and north-west: *gregale*, *tramontane*, and *mistral*). During the summer, northern storms (from wind force 7 on the Beaufort scale) occur infrequently, although after autumn and winter, the northern winds can evolve into raging storms that sweep the coasts of Mallorca and Menorca. In the southern part of the archipelago, that is, in Eivissa and Formentera, the winds mostly depend on the active circulation between the Balearics and the northern coast of Africa, with prevailing winds coming from the east and north-east during the summer, and from the west and south-west during the winter (Medas, 2005).

This general system varies locally, in that the winds over the western and eastern coasts of Mallorca are different. The western coast is swept by winds that run between the island and the mainland, or between Mallorca in Menorca, the latter alternating between southern and western winds, while to the east the prevailing winds come from the north from the Gulf of Lion. In Mallorca, sea breezes are relevant due to the size of the island. Between April and October, the heat produces a thermal gradient that creates the *embat*, a breeze running from the sea inland, and which is especially strong during the summer months (Ramis Noguera, 1998; Alomar Garau, Grimalt Gelabert and Laita Ruiz De Asúa, 2004). Along the southwestern coast and in the northwestern bays, the sea breeze and the prevailing winds during the peak hours of sunlight come from the south-west and the north-east, respectively. However, at night and during the first hours of the day, due to the land breeze, the direction of the *embat* is reversed, although it is weaker. In the southwest part of the islands the prevailing winds come from the north-west, although they are less strong due to the orographic barrier that is the Serra de Tramontana mountain range.

The sea breeze, the direction of which depends on coastal currents, has a speed between 6 and 7 knots (or a strength between 2 and 5 on the Beaufort scale) and can blow until 2pm. In Menorca, this phenomenon has little impact, with prevailing winds from the north, especially the *mistral* and *tramontane*, which blow for three-quarters of the year, and which are notably strong. During the summer, southeasterly and southwesterly winds are frequent across both islands. These are usually accompanied by fair weather. Calm conditions are frequent at night and during early morning hours. The breezes in Mallorca favour navigation along the coast, as well as the one between Menorca and Mallorca and between Eivissa and Mallorca. This is because during episodes of high heat, breezes can extend 10-15 miles from the coastline.

Under normal meteorological conditions, that is, in the absence of extreme phenomena, the strength of the winds that blow across the Balearic Islands is usually modest, ranging between 1 and 10 knots (or 0-3 on the Beaufort scale), and they are indeed favourable to coastal navigation, even with the nautical technology possessed by Middle and Late Bronze Age communities.

Visibility during Coastal Navigation

Visibility was one of the most important factors in prehistoric coastal navigation. Seeing the coastline at all times provided landmarks that allowed for early sailors to orient themselves and recognise routes (Broodbank, 2000; Dawson, 2005, 2014). This enabled the development of highly connected regions (Horden and Purcell, 2000; Broodbank, 2013; Cunliffe, 2017). Across the Mediterranean there are only a few areas that serve as visual deserts in which there are no coastlines in sight that can serve as landmarks for navigation (Schüle, 1970) (see Figure 2).

Thus, an assessment of the role of visibility during coastal navigation around the Balearic archipelago needs to consider both the visual connection between the Balearic Islands and the mainland, and between the islands of the archipelago itself (see Figure 3). Patton (1996) proposed a classification of islands in relation to their visual connection with the mainland. In it, type A islands can be seen from the mainland most of the time, i.e., under conditions of normal visibility. Type B islands would allow a connection between them and the mainland as long as one geographic skyline is visible. And finally, type C islands require deep sea navigation, as their connection with the mainland is not possible using only visual references to a skyline.

Within the Balearic Islands, a different classification can be applied to each of the archipelago's islands (see Figure 3). Eivissa can be considered a type A island (Patton, 1996), as it can be frequently seen from the Montgó Massif (Denia, Alicante). Mallorca can be considered a type B island (Patton, 1996), as under conditions of optimum visibility—that is, with clear atmospheric conditions and at sunrise—the skyline of the Serra de Tramuntana can be seen from the Catalan Coastal Range and the Ports de Tortosa-Beseit. However, most of the time, with conditions of average visibility, it is not possible to have a direct visual connection between the Catalan coast and Mallorca, but during navigation from the Catalan coast, the silhouette of Mallorca, especially its main peaks (Puig Major, 1445 m.a.s.l. and Massanella, 1364 m.a.s.l.), quickly come into view. Lastly, Menorca cannot be seen from the mainland. However, it can be understood as part of an island bridge (MacArthur and Wilson, 1967), as during navigation from the mainland to Menorca, one never loses sight of at least one coastline. Then, Eivissa and Mallorca work as bridges between themselves. This is because Menorca's main elevations give a visibility range of about 42 nautical miles, while Mallorca, with a more prominent topography, has a range of between 70-80 nautical miles (130-148 km). Therefore, navigation from the mainland can be always done with at least one coastline in sight, as from 28-30 nautical miles from the Catalan coast, the Serra de Tramuntana skyline can already be seen (Guerrero Ayuso, 2006a) (see Figures 3, 4 and 5). So, although there is no direct coast-to-coast visibility, navigators would always have at least one coastline in sight across this whole area. Direct visibility of the north African coastline, the south of France, and the coastlines of Corsica and Sardinia is not possible, as these connections are hindered by visual desserts. Thus, they require deep-sea navigation and orientation techniques similar to those used in the context of oceans.

Within the Balearic archipelago, the islands are visually connected (see Figures 3, 4 and 5). Mallorca's Serra de Llevant can be easily seen from Menorca, and from the area of Capdepera (Mallorca), Menorca can be seen under clear atmospheric conditions (see Figure 4). From Eivissa, the southern part of the Serra de Tramuntana in Mallorca, especially Puig des Galatzó (1027 m.a.s.l.) can be seen, while from Mallorca, especially from Santa Ponça, Cap Andritxol, and the south of the Serra de Tramuntana mountain range (Puig des Galatzó and Mola de S'Esclop, 926 m.a.s.l.), Eivissa can be seen, especially at sunset (see Figure 5). Also, the position of the islands can also be noticed thanks to the clouds that gather above the mountains, especially in the Serra de Tramuntana (Mallorca), and moving west to east.

It is known that in Antiquity navigation was mostly done during the most favourable season, which in Roman Imperial times was from the beginning of spring to late autumn (Janni, 1996, pp. 107–122; Medas, 2022). There is some textual evidence that hints at a winter navigation season (Tammuz, 2005; Marzano, 2011; Beresford, 2013), but it is difficult to know if this was a common practice across the whole Mediterranean (Guerrero et al., 2007; Medas, 2008, pp. 63–64). There is obviously no data on prehistoric times. The first written records about this topic date to the 8th century BC. Hesiod's *Works and Days* (618-694) mentions that safe navigation can be completed in the 50 days after the summer solstice and recommends a navigator stop the practice before the new wine and the autumn rain (both suggesting early autumn). Hesiod's recommendation reads like a warning and an overt caution for an activity that is always dangerous. However, it seems that the navigation season was longer, running from at least the end of spring to the end of summer, approximately between June and September.

Moreover, we must consider short-distance coastal navigation, with distances that could be attained over a single day and night. This could have been done at any time of the year, as navigators would have had experience with and knowledge of local meteo-maritime conditions, which would have allowed them to understand the weather forecast (Medas and Brizzi, 2008). The geographical characteristics and climate of the Balearic archipelago would have possibly allowed for short-distance coastal navigation outside of the favourable season, at least leeward along the coast and between the major islands.

The Conditions of Anchorages during the Middle and Late Bronze Ages

Once the main factors that regulated coastal navigation during the Middle and Late Bronze Ages in the Balearic Islands have been analysed, the characteristics and conditions of anchorage areas nearby coastal sites must be considered. A good anchorage offers protection from prevailing winds and currents, especially in extreme conditions, such as those experienced during storms, which are frequent in the Mediterranean. A safe place for anchoring and landing must be protected from prevailing winds, surrounded by elevated lands, and dip into the coastline. They usually present a sinuous layout that breaks waves. They need to be easily accessible, and protected from rocks and shallows, i.e., have smooth seafloors beneath, without large rocks or stones, preferably muddy bottoms covered in sand. They must end in a shallow beach where small vessels can be brought aground, and freshwater needs to be available nearby. All these characteristics define an optimum anchorage point, both in Antiquity, as documented in the *Stadiasmus Maris Magni* (Medas, 2008; Arnaud, 2021), and in medieval and modern times. As an example, *De Navigatione* (1464), written by the Dalmatian humanist Benedetto Cortugli, has a whole chapter (number 48, from his first book titled *Della qualità dello portu*) dedicated to the characteristics of a good anchorage (Salopek, 2005; Falchetta, 2009)[1].

As previously stated, several Middle and Late Bronze Age anchorages have been identified across the Balearic Islands, mostly in connection with the downwind southern route that connects the islands (see Table 1 and Figure 1). They can be divided into three different typologies: settlements on top of coastal islets, settlements in small bays or coves, and anchorage places nearby coastal sites, that is, beaches or coves where no archaeological remains have been documented but which have a direct geographical

[1] Also, an advanced theoretical analysis on the wind and wave impact in anchoring in ancient harbours is Cerezo Andreo et al., 2020.

connection with coastal promontories where Middle and Late Bronze Age sites have been found (Guerrero et al., 2007; Calvo et al., 2011; Calvo Trias and Galmés-Alba, 2018; Galmés-Alba and Calvo Trias, 2022). All of them are generally protected from extreme meteo-maritime conditions, especially northern storms, which are the most intense. For this reason, they are used as refuges by small fishing boats today, a common practice that has also been documented in the portolan charts of the 18th and 19th centuries ('*Derrotero de las costas de España en el Mediterráneo y su correspondiente de África.*', 1832; '*Derrotero general del Mediterráneo*', 1860). Changes in coastal geomorphology may have occurred since the Bronze Age, but the evidence provided by *portolans* (and by *portolan* charts even more) should only be understood in a general was, as a trend line, and especially referred to the wider anchorage and landing place, like large bays and promontories. Sedimentation in the bottom of the bays may have reduced the bathymetry, and therefore, the space available for anchoring, which suggests that the stretches of coastline used for this purpose in modern times were more accessible in previous centuries. Moreover, no significant changes on the relative sea level have been detected during the past 4000 years (Tuccimei et al., 2012; Giaime et al., 2017; Vacchi et al., 2018), and consequently the Late Bronze Age shoreline broadly corresponds to that of the present day.

These are the conditions at anchorages along the southern coast of Menorca (Cala Blanca, Macarella, Llucalari, Calescoves, and Cap de Forma), small bays that have been formed by inland water sources eroding the coastline. They have sandy beaches that allow for small vessels to be pulled on the beach. Most of these anchorages, like Calescoves, as well as settlements in small coves, such as Cala Blanca, are noted on the *portolan* charts as places of refuge for small fishing boats; they are not deep enough for high tonnage ships. However, other anchorages, such as Llucalari, are considered useless on the *portolan* charts due to having shallow stone sea bottoms or their lack of sandy beaches that could be used for beaching. Even so, they are protected from extreme meteo-maritime conditions, though their narrow, elongated shapes and shallow depths do not ensure safety in rough waters, as wind and waves can be channelled into them. For this reason, and as it happens nowadays, boats need to be on beaching or anchored some distance from the beach, away from the shoal.

The anchorages that would be affected by northern storms, such as Cala Morell or Pop Mosquer in Menorca and S'Illot in Mallorca, have a different layout. They are places that could only be used seasonally with favourable weather conditions. Their locations are significant to the route that would bring navigators to the islands from the Iberian coast with the prevailing northern winds. The site located at Illa de Ses Mones, in the Addaia Port (Menorca) can be understood to be part of the same route. The islet is located 1 km inside the natural harbour, which is deep and protected at its mouth by shallows and reefs. The harbour is protected from northwesterly winds but exposed to northerly, and to a lesser extent, northeasterly winds, which can channel waves into the harbour. The *portolan* charts explain that it is difficult to enter the harbour due to the shallows and reefs, and so many vessels would anchor at its mouth, guarded by the harbour's two islets, while it is specifically indicated that Illa de Ses Mones is for small vessels ('Derrotero general del Mediterráneo', 1860, pp. 326–327). The conditions at Illot des Porros, located just 100 m from the coastline in the centre of the Bay of Alcúdia (Mallorca) are also particular. This location could be related to the route that connects the southwestern coast of Menorca (in particular, Cala Blanca) with the northern coast of Mallorca.

The anchorages located on the southwestern coast of Mallorca are all well protected from prevailing winds and breezes. An example is Portocolom, with a wide bay and a mouth opening to the south. There, southerly and southeasterly breezes determine the shoal, especially in the northern part of the bay. However, the wider western part of the bay guarantees a safe anchorage and calm waters. Topographically different is the possible anchorage at Portocristo, near the coastal promontory of Sa Ferradura. It is a meandering bay, shaped like an "S" with a mouth opening to the south-east. This double curvature ensures calm waters in the inner part of the bay, and it is protected from the prevailing winds. However, this inner part can only be reached by small and medium vessels ('Derrotero general del Mediterráneo', 1860, pp. 300–301).

The sites located along the southwestern coast of Mallorca (Puig de Sa Morisca and the islets of Na Galera and Na Moltona) are located along the route that, with the aid of southwesterly winds, would have connected Formentera and Eivissa with Mallorca and Menorca. From Formentera and Eivissa, the southwesterly winds would help facilitate a connection to Mallorca, and from there, the route could go along the southern coast of Mallorca, aided by breezes, as well as by southerly and southeasterly winds. Along this route, there is a series of known and protected anchorages, such as Portocolom and Portocristo.

Finally, the anchorages nearby coastal sites that have been identified in Eivissa and Formentera are mostly small bays that are exposed to prevailing winds, such as Cap des Llibrell (Eivissa). Among them, it is worth noting that Cala Jondal, the anchorage connected to the coastal promontory of Punta des Jondal, is protected from northerly winds, although it is exposed to the southerly ones. It can only function as an anchorage in favourable weather conditions, when vessels can get into the bay, or small vessels can be beached on the sandy beach.

Conclusion: Navigation and Routes across the Balearic Sea

Our analysis of meteo-maritime conditions in the context of coastal navigation has led to the emergence of two positions (Broodbank, 2013, p. 75). First, there is a group that considers meteo-maritime conditions, especially visibility and prevailing winds, to be key to understanding the routes (examples include Guerrero Ayuso, 2004, 2006a; Moreno, 2005), in that, areas with favourable meteo-maritime conditions would have promoted maritime connectivity while areas lacking these conditions, like the eastern part of the North African coast, with leeward winds and a homogenous coastline without many landmarks and lots of sandbanks, would not have promoted such connectivity. Second, there is a group that emphasises the flexibility of routes based on human communities, their way of seeing and experiencing the world. This is a much more dynamic, contingent, and fluid point of view on the use and maintenance of maritime routes over time (Broodbank, 2000, pp. 92–96; Horden and Purcell, 2000, pp. 123–143).

However, as Broodbank (2013, p. 75) states, it is not a case of one versus the other; rather, we need to understand connectivity dynamics as an assemblage of both. Therefore, meteo-maritime conditions and the agency of local communities are both key structuring factors (Bourdieu, 1994), and their coming together would have traced the paths across the sea. These paths are the result of knowledge and experience passed down by communities regarding winds, currents, anchorages, and contacts with other communities. Together, they make up an entanglement of interactions that would have led to the creation of routes, places of passage, destinations, and connections, under specific historical and social conditions.

In nautical terms, a route is not the most direct path between two points, but rather the safest and most predictable way (Moreno, 2005, p. 784). Thus, a route is really a corpus of knowledge that connects an understanding of meteo-maritime dynamics and the effects that they have on the vessel, to landmarks along the coastline, rocks, reefs, and shallows, freshwater sources, coastal communities, and previous interactions with them, as well as the technical possibilities of the vessel to navigate the route. The knowledge of routes, places, and communities could have been strategic knowledge, as an expression of power (Foucault, 1992). For this reason, it is not surprising that over time, this type of knowledge has been highly controlled and access to it has been limited to few (Abulafia, 2011).

Visibility, surface currents, and prevailing winds especially, are the key factors that favour some connections yet limit others. For example, a direct connection between Corsica and Sardinia and the Balearic Island poses the problem of having to face difficult deep-sea conditions (see Figure 2). So, the safest route is to the north, to the mouth of the Rhône River and following the coastline west with the coastal current and eastern winds through the Gulf of Lion and to Cap de Creus. From there, superficial currents and gyres, as well as northerly and northeasterly winds favour a connection to Mallorca and Menorca. A preliminary route would connect the Cap de Creus to the channel between Mallorca and Menorca, while a second route might connect the delta of the Ebro River to the channel between Mallorca and Eivissa. Other gyres favour the route from Cap de la Nau to Eivissa, downwind from the southern coast of Mallorca and Menorca. However, the northerly winds that favour the route from the mainland to the islands make it difficult to return. Historical sources have therefore explained how the route to the Iberian Peninsula would have passed through Eivissa and from there continued on to Cap de la Nao, going up the Gulf of Valencia with sea breezes (see Figure 6).

Between the Balearic Islands, winds and currents favour safe downwind navigation, which is reflected in the number of coastal sites scattered along the shoreline (see Figure 6). The route, guided by the prevailing winds, would have run from Eivissa to Mallorca, with the mountains of Galatzó and S'Escolp in the Serra de Tramuntana being used as landmarks. From there, the route would have continued downwind along the southern coast of Mallorca and to Menorca. This southern route was later used by Punic-Ebusitan agents, who used the islets of Illot d'en Sales, Na Galera, and Na Guardis in Mallorca, and the bay of Calescoves in Menorca as seasonal stops along this route (Guerrero Ayuso, 1997). Moreover, a second route would have connected the northern coast of Mallorca and Menorca through the channel between the two islands (see Figure 6).

Coastal navigation would have been aided by landmarks and sight of the coastline. To this end, orientation strategies would have been connected to acquired knowledge and the identification of known places along routes. Their identification would provide other information such as the duration of voyages, dangers such as reefs and shallows, sources of freshwater, and possible interactions with other communities, all of which together represent a corpus that makes these coastal landmarks meaningful places that conveyed knowledge to navigators along the route.

In this sense, coastal sites, when related to meteo-marine conditions, can be understood as a network that provided aide and support for coastal navigation. Their location is along the main maritime routes connecting the islands (see Figures 2 and 6), while the assessment of visibility shows how the islands were connected through coastal navigation (see Figures 3, 4, and 5). Throughout this paper we have examined the meteo-marine conditions around the Balearic Islands, to tie together coastal sites, islands, the archipelago, and the connection with the mainland. Understanding these conditions and how do they relate with coastal sites, allow us to understand their role as a network of coastal infrastructure that connects the islands, through the main maritime routes.

All of this meteo-marine knowledge allows us to understand navigation routes during the Middle and Late Bronze Ages that can also be documented through archaeological materials found across the Balearic Islands. The main indicator of mobility, beyond typological similarities of archaeometric pottery analyses, are isotope analyses of copper-based objects (Salvà Simonet, Perelló Mateo and Llull Estarellas, 2018; Sureda, 2019, 2020; Llull Estarellas, Perelló Mateo and Calvo Trias, 2021, 2022), which provide evidence of connections between Menorca, the main source of copper, and Mallorca and Eivissa (see Figure 6). This connectivity would have used the coastal sites documented along the southern coasts of Menorca, Mallorca, and Eivissa, and possibly to a lesser extent, the northern route. Moreover, the isotope analyses suggest a high degree of connectivity with the area of the Gulf of Lion (i.e., the southern French coast and the Catalonian coast). Finally, there are some data that hint to connections with Sardinia and mainland Europe (see Figure 6).

In parallel, an analysis of typological similarities in pottery, architecture, and metal objects suggests a connection between Mallorca and Menorca, and to a lesser extent, between these islands and Eivissa and Formentera (Albero Santacreu et al., 2011; Calvo

Trias and Galmés-Alba, 2018). This high degree of connectivity can be also traced through the large number of coastal sites in Mallorca and Menorca compared to Eivissa and Formentera.

The routes of connectivity and mobility that can be traced through material culture, follow the meteo-maritime routes that were analysed in this study. It is the combination of both that created a shared space across the Balearic Islands during the Bronze Age, and it also allows us to consider islands beyond their geographical limits, that is, we can understand them as spaces of both land and sea, which together would generate new historically relevant "islandscapes" (Broodbank, 2000) or even "aquapelagos" (Dawson, 2012; Hayward, 2012). It is for this reason that our analysis of the interaction of meteo-marine conditions and communities of praxis provides a broader perspective and deeper understanding of the connectivity and mobility between these islands.

Acknowledgements

This study was supported by the following R&D project: *Movilidad y conectividad de las comunidades prehistóricas en el Mediterráneo occidental durante la prehistoria reciente: El caso de las Islas Baleares* (PID2019-108692 GB-I00), which is financed by the Spanish government's Ministry of Science, Innovation and Universities MCIN/ AEI /10.13039/501100011033. This work has been partially sponsored by the Comunitat Autonoma de les Illes Balears through the Direcció General de Política Universitaria i Recerca with funds from the Tourist Stay Tax Law ITS 2017-006 (PRD2018/19). All of these are projects have been undertaken by the Prehistory Group at the University of the Balearic Islands under the direction of tenured professor and lead researcher Dr. Manuel Calvo Trias. Gabriel Servera-Vives also received funding from Juan de la Cierva-Incorporación [IJCI-2016-30581] financed by the Spanish Ministry of Economy, Industry and Competitiveness. Alejandra Galmés-Alba is funded by the NextGeneration EU funds (Plan de Recuperación, Transformación y Resilencia) with a Margarita Salas postdoc position (Ministry of Universities) at the University of the Balearic Islands. We also thank Paola Moffa-Sánchez for her comments on the original version of this paper.

References

Abulafia, D. (2011) *The Great Sea. A human history of the Mediterranean*. Penguin Books.

Albero Santacreu, D., García – Rosselló, J., Javaloyas Molina, D., Calvo Trias, M. (2011) 'Cultura material, habitus, espacio y movilidad en el archipiélago balear durante el Bronce Final (c. 1400-1100 BC)', *Bolletí de la Societat Arqueològica Lul·liana (BSAL)*, 67, pp. 15–37.

Alomar Garau, G., Grimalt Gelabert, M. and Laita Ruiz De Asúa, M. (2004) 'La percepción geográfica del régimen de brisas en Mallorca. De la experiencia directa a los datos instrumentales.', in García Codron, J. C., Liaño, D., De Arróyabe, P., Garmendia Pedraja, C., Rasilla Álvarez, D. (eds) *El clima entre el Mar y la Montaña. IV Congreso de la Asociación Española de Climatología*. Serie A. Zaragoza: Universidad de Cantabria, pp. 551–559.

Anglada, M., Ferrer, A., Ramis, D., Salas, M., Van Strydonck, M., León, M.J., Plantalamor, Ll. (2017a) 'Dating Prehistoric Fortified Coastal Sites in the Balearic Islands', *Radiocarbon*, 59(Special Issue 5), pp. 1251–1262.

Anglada, M., Ferrer, A. and Ramis, D. (2017b) 'Actividad humana en el litoral de Menorca durante la Prehistoria.', in Gómez Pujol, L. and Pons Buades, G. X. (eds) *Geomorfologia Litoral de Menorca. Dinámica, evolución y prácticas de gestión*. Monografies. Societat d'Història Natural de les Balears, pp. 213–233.

Arnaud, P. (2021) *Stadiasmus Maris Magni, Edition critique et commentaire*. New Jacoby. Leyde: Brill.

Ausín, B., Flores, J. A., Sierro, F. J., Cacho, I., Herández-Almeida, I., Martrat, B., Grimalt, J. (2015) 'Atmospheric patterns driving Holocene productivity in the Alboran Sea (Western Mediterranean): a multiproxy approach', *The Holocene*, 25(4), pp. 583–595.

Balbín, R., López-Jurado, J. L., Flexas, M. M., Reglero, P., Vélez-Velchí, P., González-Pola, C., Rodríguez, J. M., García, A., Alemany, F. (2014) 'Interannual variability of the early summer circulation around the Balearic Islands: Driving factors and potential effects on the marine ecosystem.', *Journal of Marine Systems*, 138, pp. 70–81.

Bar-Yosef Mayer, D. E., Kahanov, Y., Roskin, J., Gildor, H. (2015) 'Neolithic Voyages to Cyprus: Wind Patterns, Routes, and Mechanisms', *The Journal of Island and Coastal Archaeology*, 10(3), pp. 412–435.

Beresford, J. (2013) *The Ancient Sailing Season*. Leiden-Boston: Brill.

Bourdieu, P. (1994) *Raisons pratiques. Sur la théorie de l'action*. Paris: Seuil.

Braudel, F. (1972) *The Mediterranean and the mediterranean world in the age of Philip II*. Volume I. New York: Harper Press.

Broodbank, C. (2000) *An Island Archaeology of the Early Cyclades*. Cambridge: Cambridge University Press.

Broodbank, C. (2013) *The Making of the Middle Sea. A History of the Mediterranean from the Beginning to the Emergence of the Classical World*. Londres: Thames & Hudson.

Burjachs, F., Pérez-Obiol, R., Picornell Gelabert, Ll., Revelles, J., Servera-Vives, G., Expósito, I., Yll, E. (2017) 'Overview of environmental changes and human colonization in the Balearic Islands (Western Mediterranean) and their impacts on vegetation composition during the Holocene', *Journal of Archaeological Science: Reports*, 12, pp. 845–859.

Calvo, M., Javaloyas, D., Albero, D., García-Rosselló, J., Guerrero, V. (2011) 'The ways people move: mobility and seascapes in the Balearic Islands during the late Bronze Age (c. 1400-850/800 BC).', *World Archaeology*, 43(3), pp. 345–363.

Calvo Trias, M. and Galmés-Alba, A. (2018) 'De islas e isleños. Movilidad, conectividad y generación de identidades en las islas Baleares durante el Bronce Medio y Final. Nuevas líneas de reflexión.', in *La Préhistoire et la Protohistoire des îles de Méditerranée Occidentale. Matières premières, circulation, expérimentation et traditions techniques. Atti del Workshop*. Sassari: Quaderni del LaPArS. Università di Sassari, pp. 139–162.

Carrión, J. S., Fernández, S., González-Sampériz, P., Gil-Romera, G., Badal, E., Carrión-Marco, Y., López-Merino, L., López-Sáez, J. A., Fierro, E., Burjachs, F. (2010) 'Expected trends and surprises in the Lateglacial and Holocene vegetation history of the

Iberian Peninsula and Balearic Islands', *Review of Palaeobotany and Palynology*, 162(3), pp. 458–475.

Cerezo Andreo, F., López-Castejón, F., Ramallo-Asensio, S., Gilabert-Cervera, J. (2020) 'Wave Hindcasting and Anchoring Activities in Ancient Harbours: The Impact of Coastal Dynamics on Ancient Carthago Nova (Cartagena, Spain)', *Journal of Maritime Archaeology*, 15, pp. 209–237.

Chapman, R. (1990) *Emerging Complexity. The Later Prehistory of South-East Spain, Iberia and the West Mediterranean*. Cambridge: Cambridge University Press.

Cherry, J. F. (1981) 'Pattern and Process in the Earliest Colonization of the Mediterranean Islands', *Proceedings of the Prehistoric Society*, 47, pp. 41–68.

Cherry, J. F. and Leppard, T. P. (2018) 'The Balearic Paradox: Why Were the Islands Colonized So Late?', Pyrenae, 49(1), pp. 49–70.

Cisneros Bermejo, M. (2019) *Reconstrucció climàtica dels darrers 2.700 anys a la Mediterrània occidental: sediments marins i estalagmites*. Universitat de Barcelona.

Cooney, G. (2003) 'Introduction: seeing land from the sea.', *World Archaeology*, 35(3), pp. 323–328.

Costa, B. (2000) 'Plantejaments per l'anàlisi del procés d'establiment humà en petits medis insulars. El cas de l'arxipèlag balear.', in Guerrero, V. and Gornés, S. (eds) *Colonització humana en ambients insulars. Adaptació en el medi i adaptació cultural.* Palma: Universitat de les Illes Balears, pp. 11–72.

Cunliffe, B. (2017) *On the Ocean: The Mediterranean and the Atlantic from prehistory to AD 1500*. Oxford: Oxford University Press.

Dawson, H. (2005) *Island colonisation and abandonment in Mediterranean prehistory*. London: University College London.

Dawson, H. (2012) 'Archaeology, aquapelagos and island studies.', *Shima: The International Journal of Research into Island Cultures*, 6(1), pp. 17–21.

Dawson, H. (2014) *Mediterranean Voyages. The archaeology of island colonization and abandonment*. Walnut Creek, California: Left Coast Press.

Depalmas, A. (2014) 'New data from fortified coastal settlement of Cap de Forma, Mahon, Menorca (Balearic Islands)', *Radiocarbon*, 56(2), pp. 425–437.

'*Derrotero de las costas de España en el Mediterráneo y su correspondiente de África. Escrito en los años de 1783 y 1784, por el brigadier de la Real Armada Don Vicente Tofiño de San Miguel*' (1832). Madrid: Segunda edición.

'*Derrotero general del Mediterráneo*' (1860). Madrid: Tomo I.

Erlandson, J. M. and Fitzpatrick, S. M. (2006) 'Oceans, Islands, and Coasts: Current Perspectives on the Role of the Sea in Human Prehistory', *The Journal of Island and Coastal Archaeology*, 1(1), pp. 5–32.

Falchetta, P. (2009) 'Il trattato De Navigatione di Benedetto Cotrugli (1464-1465). Editzione commentata del Ms. Schoenberg 473 con il testo del Ms. di Yale', *Studi Veneziani*, LVII, pp. 15–334.

Fitzpatrick, S. M. (2013) 'Seafaring Capabilities in the Pre-Columbian Caribbean', *Journal of Maritime Archaeology*, 8, pp. 101–138.

Fletcher, W. J., Debret, M. and Sanchez Goñi, M. F. (2013) 'Mid-Holocene emergence of a low-frequency millennial oscillation in western Mediterranean climate: Implications for past dynamics of the North Atlantic atmospheric westerlies', *The Holocene*, 23(2), pp. 153–166.

Ford, B. (2011) 'The Shoreline as a Bridge, Not a Boundary: Cognitive Maritime Landscapes of Lake Ontario.', in Ford, B. (ed.) *The Archaeology of Maritime Landscapes*. Springer, pp. 63–80.

Foucault, M. (1992) *Microfísica del poder*. Madrid: Ed. La Piqueta.

Frígola, J., Moreno, A., Cacho, I., Canals, M., Sierro, F. J., Flores, J. A., Grimalt, J. O., Godell, D. A., Curtis, J. H. (2007) 'Holocene climate variability in the western Mediterranean region from a deepwater sediment record', *Paleocenography and Paleoclimatology*, 22(2), pp. 1–16.

Galmés-Alba, A. and Calvo Trias, M. (2022) ‘Connecting architectures across the landscape. A visibility and network analysis in the island of Mallorca during the Late Bronze Age and Early Iron Age.’, *Cambridge Archaeological Journal*, 32(3), 467-487. doi:10.1017/S0959774321000627

Georgiou, H. S. (1996) ‘The rigging of Bronze Age ships’, in Tzalas, H. (ed.) *TROPIS IV. 4th International Symposium on Ship Construction in Antiquity*, Athens, 1991, Proceedings. Athens, pp. 213–227.

Giaime, M., Morhange, C., Cau Ontiveros, M. A., Fornós, J., Vacchi, M., Marriner, N. (2017) ‘In search of Pollentia’s southern harbour: Geoarchaeological evidence from the Bay of Alcúdia (Mallorca, Spain)’, Palaeogeography, Palaeoclimatology, Palaeoecology, 466, pp. 184–201. doi: 10.1016/j.palaeo.2016.11.023.

Gornés Hachero, J. S. (2016) *Sociedad y cambio en Menorca: sistematización de los contextos arqueológicos de las navetas funerarias entre el 1400 y el 850 cal ANE*. PhD Thesis, Universitat Autònoma de Barcelona.

Guerrero Ayuso, V. M. (1997) *La colonización púnica de Mallorca. La documentación arqueológica y el contexto histórico*. Palma: El Tall.

Guerrero Ayuso, V. M. (2004) ‘Las Islas Baleares en los derroteros del Mediterráneo Central y Occidental.’, in Peña, V., Wagner, C. W., and Mederos, A. (eds) *La navegación fenicia. Tecnología naval y derroteros. Encuentro entre marinos, arqueólogos e historiadores*. Centro de Estudios Fenicios y Púnicos, Universidad Complutense de Madrid, pp. 85–133.

Guerrero Ayuso, V. M. (2006a) ‘Nautas baleáricos durante la Prehistoria (parte I). Condiciones meteomarinas y navegación de cabotaje.’, *Pyrenae*, 37(1), pp. 87–129.

Guerrero Ayuso, V. M. (2006b) ‘Nautas baleáricos durante la Prehistoria (parte II). De la iconografía naval a las fuentes históricas.’, *Pyrenae*, 37(2), pp. 7–45.

Guerrero, V., Calvo, M., García, J., Gornés, S. (2007) *Prehistoria de las Islas Baleares. Registro arqueológico y evolución social antes de la Edad del Hierro*. B.A.R. International Series 1690.

Hayward, P. (2012) ‘Aquapelagos and Aquapelagic Assemblages. Towards an integrated study of island societies and marine environments.’, *Shima: The International Journal of Research into Island Cultures*, 6(1), pp. 1–11.

Helms, M. W. (1988) *Ulysses’ Sail. An Ethnographic Odyssey of Power, Knowledge, and Geographical Distance*. Princeton, New Jersey: Princeton University Press.

Hernández - Gasch, J. and Sanmartí, J. (2019) ‘Contextualització de datacions radiocarbòniques, estratigrafia i fases cronològiques al jaciment de les Edats del Bronze i del Ferro de S’Illa des Porros (Santa Margalida, Mallorca).’, *Materialidades. Perspectivas en cultura material*, 6.

Horden, P. and Purcell, N. (2000) *The Corrupting Sea. A study of Mediterranean History*. Blackwell Publishing.

Jalut, G., Dedoubat, J. J., Fontugne, M., Otto, T. (2009) ‘Holocene circum-Mediterranean vegetation changes: Climate forcing and human impact’, *Quaternary International*, 200(1–2), pp. 4–18.

Janni, P. (1996) *Il mare degli antichi*. Bari: Dedalo.

Javaloyas, D., García-Rosselló, J., Albero, D., Calvo, M. (2015) ‘Swords without warriors: a new reading of Bronze Age Artefacts in the Balearic Middle and Late Bronze Age (c. 1600/1550-850 cal BC)’, in Suchowska-Ducke, P., Scott Reite, S., and Vandkilde, H. (eds) *Forging Identities. The Mobility of Culture in Bronze Age Europe*. Oxford: BAR International Series, 2772, pp. 63–71.

Jiménez-Espejo, F. J., García-Alix, A., Jiménez-Moreno, G., Rodrigo-Gámiz, M., Anderson, R. S., Rodríguez-Tovar, F. J., Martínez-Ruiz, F., Giralt, S., Delgado Huertas, A., Pardo-Igúzquiza, E. (2014) ‘Saharan aeolian input and effective humidity variations over western Europe during the Holocene from a high altitude record’, *Chemical Geology*, 374–375, pp. 1–12.

Llull Estarellas, B., Perelló Mateo, L., Guerrero Ayuso, V., Fullola Pericot, J. M., Petit i Mendizàbal, M. A., Calvo Trias, M. (2019) ‘Caracterización isotópica y elemental de los metales de Cova des Pas (Ferreries, Menorca). Una necrópolis en transición del Bronce Final al Hierro.’, *Trabajos de Prehistoria*, 76(1), pp. 102–119.

Llull Estarellas, B., Perelló Mateo, L. and Calvo Trias, M. (2021) ‘A geochemical characterization of copper ore deposits in the Balearic Islands: an isotope database for archaeometallurgical studies in Western Mediterranean Prehistory’, *Archaeological and Anthropological Sciences*, 13, p. 118. doi: 10.1007/s12520-021-01370-9.

Llull Estarellas, B., Perelló Mateo, L. and Calvo Trias, M. (2022) ‘Maritime connections in the Western Mediterranean and access to copper resources in the Balearic Islands during the Late Bronze Age. Isotopic characterization of the bronze deposit at Es Mitjà Gran, Mallorca.’, *Archaeometry*, Preprint. doi: 10.1111/arcm.12755.

MacArthur, R. H. and Wilson, E. O. (1967) *The theory of island biogeography*. Princeton and Oxford: Princeton University Press.

Magny, M., Combourieu-Nebout, N., De Beaulieu, J. L., Bout-Roumazeilles, V., Colombaroli, D., Desprat, S., Francke, A., Joannin, S., Ortu, E., Peyron, O., Revel, M., Sadori, L., Siani, G., Sicre, M. A., Samartin, S., Simonneau, A., Tinner, W., Vannière, B., Wagner, B., Zanchetta, G., Anselmetti, F., Brugiapaglia, E., Chapron, E., Debret, M., Desmet, M., Didier, J., Essallami, L., Galop, D., Gilli, A., Haas, J. N., Kallel, N., Millet, L., Stock, A., Turon, J. L., Wirth, S. (2013) ‘North-south palaeohydrological contrasts in the central mediterranean during the holocene: Tentative synthesis and working hypotheses’, *Climate of the Past*, 9(5), pp. 2043–2071. doi: 10.5194/cp-9-2043-2013.

Marangou, C. (1990) ‘Rowers paddling sailing ships in the Bronze Age Aegean’, in Tzalas, H. (ed.) *TROPIS II. 2nd International Symposium on Ship Construction in Antiquity*, Delphi 1987, Proceedings. Athens, pp. 259–270.

Martín-Puertas, C., Jiménez-Espejo, F., Martínez-Ruiz, F., Nieto-Moreno, V., Rodrigo, M., Mata, M. P., Valero-Garcés, B. L. (2010) ‘Late Holocene climate variability in the southwestern Mediterranean region: an integrated marine and terrestrial geochemical approach’, *Climate of the Past*, 6, pp. 807–816.

Martín Prieto, J. A., Pons Buades, G. X., Roig i Munar, F. X., Fraga i Arguimbau, P., Rodríguez Perea, A., Galabert Ferrer, B., Mir Gual, M. (2017) ‘Mantos eólicos en la costa septentrional de Menorca: naturaleza y distribución.’, in Gómez Pujol, L. and Pons Buades, G. X. (eds) *Geomorfología Litoral de Menorca. Dinámica, evolución y prácticas de gestión*. Monografies. Societat d’Història Natural de les Balears, pp. 137–155.

Marzano, A. (2011) ‘Snails, wine and winter navigation’, in Harris, W. K. and Lara, K. (eds) Maritime Technology in the Ancient Economy: ship-design and navigation. Journal of. Portsmouth: *Journal of Roman Archaeology, Supplementary Series*, 84, pp. 179–187.

Mayewski, P. A., Rohling, E., Stager, J. C., Karlén, W., Maasch, K. A., Meeker, D. L., Meyerson, E. A., Gasse, F., van Kreveld, S., Holmgren, K., Lee-Thorp, J., Rosqvist, G., Rack, F., Staubwasser, M., Schneider, R. R., Steig, E. J. (2004) ‘Holocene climate variability’, *Quaternary Research*, 62(3), pp. 243–255.

McNiven, I. J. (2003) ‘Saltwater People: spiritscapes, maritime rituals and the archaeology of Australian indigenous seascapes.’, *World Archaeology*, 35(3), pp. 329–349.

McNiven, I. J. (2008) ‘Sentient Sea: Seascapes as Spiritscapes’, in David, B. and Thomas, J. (eds) *Handbook of Landscape Archaeology*. New York: Routledge, pp. 149–157.

Medas, S. (2005) ‘La navigazione di Posidonio dall’Iberia all’Italia e le rotte d’altura nel Mediterraneo occidentale in età romana.’, *Mayurqa*, 30, pp. 577–610.

Medas, S. (2008) ‘Lo Stadiasmo o Periplo del Mare Grande e la navigazione antica. Commento nautico al piú antico testo portolanico attualmente noto’, *Gerión*, 26(Extra 12), pp. 5–225.

Medas, S. (2020) ‘I viaggi di colonizzazione e gli sviluppi della nautica in epoca arcaica’, in López Castro, J. L. (ed.) *Entre Utica y Gadir. Navegación y colonización fenicia en el Mediterráneo occidental a comienzos del I milenio AC*. Granada: Editorial Comares, pp. 13–30.

Medas, S. (2022) *Nautica antica. Itinerari nel mondo della navigazione tra storia, archeologia ed etnografia.* Roma: <<L’Erma>> di Bretschneider.

Medas, S. and Brizzi, R. (2008) ‘Meteorologia pratica e navigazione. Elementi a confronto tra antichità e tradizione.’, in Lugi, F. and Stoppiello, A. A. (eds) *Atti del 3o Convegno Nazionale di Etnoarcheologia, Mondaino, 17-19 marzo 2004*. Oxford: BAR International Series 1841, pp. 197–204.

Mestres i Torres, J. S. and De Nicolás i Mascaró, J. C. (1997) 'Contribución de la datación por radiocarbono al establecimiento de la cronología absoluta de la prehistoria de Menorca', *Caesaraugusta*, 73, pp. 327–341.

Micó, R. (2005) *Cronología absoluta y periodización de la Prehistoria Reciente de las Islas Baleares*. British Archaeological Reports (BAR), 1373. Oxford: Archaeopress.

Millot, C. (1999) 'Circulation in the Western Mediterranean Sea.', *Journal of Marine Systems*, 20(1–4), pp. 423–442.

Millot, C. and Taupier-Letage, I. (2005) 'Circulation in the Mediterranean Sea', in Saliot, A. (ed.) *Handbook of Environmental Chemistry*. vol 5K. Berlin - Heidelberg: Springer.

Montenegro, Á., Callaghan, R. T. and Fitzpatrick, S. M. (2016) 'Using seafaring simulations and shortest-hop trajectories to model the prehistoric colonization of Remote Oceania', *PNAS*, 113(45), pp. 12685–12690.

Moreno, A., Cacho, I., Canals, M., Grimalt, J., Sánchez-Goñi, M. F., Shackleton, N., Sierro, F. J. (2005) 'Links between marine and atmospheric processes oscillating on a millennial time-scale. A multi-proxy study of the last 50,000 yr from the Alboran Sea (Western Mediterranean Sea)', *Quaternary Science Reviews*, 24(14–15), pp. 1623–1636.

Moreno, S. (2005) 'Rutas de navegación en el Mediterráneo occidental: condicionantes atmosféricos y aspectos técnicos de la navegación en la antigüedad.', *Mayurqa*, 30, pp. 781–799.

Morton, J. (2001) *The Role of the Physical Environment in Ancient Greek Seafaring*. Leiden-Boston: Brill.

Nieto-Moreno, V., Martínez-Ruiz, F., Giralt, S., Jiménez-Espejo, F., Gallego-Torres, D., Rodrigo-Gámiz, M., García-Orellana, J., Ortega-Huertas, M., de Lange, G. J. (2011) 'Tracking climate variability in the western Mediterranean during the Late Holocene: a multiproxy approach', *Climate of the Past*, 7, pp. 1395–1414.

Van de Noort, R. (2003) 'An ancient seascape: the social context of seafaring in the early Bronze Age.', *World Archaeology*, 35(3), pp. 404–415.

Olsen, J., Anderson, N. J. and Knudsen, M. F. (2012) 'Variability of the North Atlantic Oscillation over the past 5,200 years', *Nature Geoscience*, 5, pp. 808–812.

Orfila Pons, M., Baratta, G. and Mayer, M. (2010) 'Los santuarios de Calescoves (Alaior, Menorca): Coberzo Blanc y Cova dels Jurats o de l'Esglesia. Informe preliminar.', *Cuadernos de Prehistoria y Arqueología de la Universidad de Granada*, 20, pp. 395–433.

Patton, M. (1996) *Islands in Time. Island Sociogeography and Mediterranean Prehistory*. London - New York: Routledge.

Perelló Mateo, L. and Llull Estarellas, B. (2019) 'Circulación y consumo de plomo en las islas Baleares durante la Edad del Hierro. Nuevos datos isotópicos de galenas y metales arqueológicos.', *Zephyrus*, 84, pp. 89–113.

Pinot, J. M., López-Jurado, J. L. and Riera, M. (2002) 'The CANALES experiment (1996-1998). Interannual, seasonal, and mesoscale variability of the circulation in the Balearic Channels', *Progress in Oceanography*, 55(3–4), pp. 335–370.

Plantalamor, L. (1991) 'Los asentamientos costeros de la isla de Menorca', in *Atti del II Congreso Internazionale di Studi Fenici e Punici, vol. III*. Roma: Consiglio Nazionale delle Ricerche, pp. 1151–1160.

Plantalamor, L. and Van Strydonck, M. (1997) *La cronologia de la prehistòria de Menorca*. Treballs del Museu de Menorca. Maó: Museu de Menorca.

Pons Buades, G. X., Anglada, M., Ferrer, A., Ramis, D., Salas, M. (2017) 'Depósitos eólicos arenosos en el yacimiento arqueológico de es Coll de Cala Morell (Ciutadella de Menorca, Islas Baleares)', *Geotemas (Madrid), 17(IX Jornadas de Geomorfología Litoral (Menorca, 2017*)), pp. 31–34.

Ramis Noguera, C. (1998) 'L'embat a l'illa de Mallorca', *Territoris*, 1, pp. 253–274.

Ramón, J. (1985) *Els monuments antics de les Illes Pitiüses*. Eivissa: Consell Insular d'Eivissa i Formentera.

Roberts, N., Moreno, A., Valero-Garcés, B. L., Corella, J. P., Jones, M., Allcock, S., Woodbridge, J., Morellón, M., Luterbacher, J., Xoplaki, E., Türkeş, M. (2012)

‘Palaeolimnological evidence for an east–west climate see-saw in the Mediterranean since AD 900’, *Global and Planetary Change*, 84–85, pp. 23–34.

Rossi, V., Ser-Giacomi, E., Lopez, C., Hernandez-Garcia, E. (2014) ‘Hydrodynamic provinces and oceanic connectivity from a transport network help designing marine reserves’, *Geophysical Research Letters*, 41, pp. 2883–2891.

Salopek, D. (ed.) (2005) *Benedictus de Cotrullis / Benedikt Kotruljević, De Navigatione O Plovidbi (1464)*. Zagreb: Ex Libris.

Salvà Simonet, B. (2007) ‘El mar y la prehistoria balear. Una nueva perspectiva: el material arqueológico de Sa Bassa nova de Portocolom.’, in Riera, M. (ed.) *Arqueología e Historia de Portocolom*. Palma: Documenta Balear.

Salvà Simonet, B., Perelló Mateo, L. and Llull Estarellas, B. (2018) ‘Metalurgia prehistórica en las Islas Baleares. Cambios y continuidades.’, in Melis, M. G. (ed.) *La Préhistoire et la Protohistoire des îles de Méditerranée Occidentale. Matières premières, circulation, expérimentation et traditions techniques. Atti del Workshop*. Sassari: Quaderni del LaPArS. Università di Sassari, pp. 69–98.

Sánchez López, E., Gutiérrez Rodríguez, M. and Orfila Pons, M. (2013) ‘Los asentamientos costeros de Menorca: el caso de Es Castellet (Calescoves, Alaior)’, in Riera, M. and Cardell, J. (eds) *V Jornades d’Arqueologia de les Illes Balears*. Palma: Edicions Documenta Balear, pp. 59–67.

Schüle, G. (1970) ‘Navegación primitiva y visibilidad de la tierra en el Mediterráneo’, in Beltrán, A. (ed.) *XI Congreso Nacional de Arqueología (Mérida, 1968).* Zaragoza: Secretaría General de los Congresos Arqueológicos Nacionales, pp. 449–450.

Servera-Vives, G., Riera, S., Picornell-Gelabert, L., Moffa-Sánchez, P., Llergo, Y., Garcia, A., Mus-Amezquita, M., García Álvarez, S., Calvo Trias, M. (2018) ‘The onset of islandscapes in the Balearic Islands: A study-case of Addaia (northern Minorca, Spain).’, Palaeogeography, Palaeoclimatology, Palaeoecology, 498, pp. 9–23.

Stratford, E. et al. (2011) ‘Envisioning the Archipelago.’, *Island Studies Journal*, 6(2), pp. 113–130.

Van Strydonck, M. et al. (2002) Royal Institute for Cultural Heriage Radiocarbon Dates XVIII. Brussels.

Sureda, P. (2016) Les comunitats prehistòriques pitiüses i la seva interacció social: aportacions des de l'arqueometal·lúrgia i els espais domèstics. PhD. Thesis, Universitat Pompeu Fabra.

Sureda, P. (2019) 'The first metallurgy in the Pityusic Islands (Balearic archipelago, Mediterranean Sea).', *Journal of Archaeological and Antrhopological Sciences*, 11(6), pp. 2727–2741.

Sureda, P. (2020) 'Metallic encounters in the Balearic Islands: An approach to Western Mediterranean trade dynamics in the "global" Late Bronze Age', *Quaternary International*, 550, pp. 130–146.

Tammuz, O. (2005) 'Mare clausum? Sailing Seasons in the Mediterranean in Early Antiquity', *Mediterranean Historical Review*, 20(2), pp. 145–162.

Tartaron, T. (2013) *Maritime networks in the Mycenaean world*. Cambridge: Cambridge University Press.

Trias, M., Ramis, D., Riera, M., Llovera, P., Salom, J. Riera, M. M. (2009) 'Noves aportacions al coneixement de la Cabrera prehistòrica (Illes Balears)', *Endins: publicació d'espeleologia*, 33, pp. 125–138.

Trigo, R. M., Pozo-Vázquez, D., Osborn, T. J., Castro-Díez, Y., Gámiz-Fortis, S., Esteban-Parra, M. J. (2004) 'North Atlantic oscillation influence on precipitation, river flow and water resources in the Iberian Peninsula', *International Journal of Climatology*, 24(8), pp. 925–944.

Trouet, V., Esper, J., Graham, N. E., Baker, A., Scourse, J. D., Frank, D. C. (2009) 'Persistent Positive North Atlantic Oscillation Mode Dominated the Medieval Climate Anomaly', *Science*, 324(5923), pp. 78–80.

Tuccimei, P., Onac, B. P., Dorale, J. A., Ginés, J., Fornós, J. J., Ginés, A., Spada, G., Ruggieri, G., Mucedda, M. (2012) 'Decoding last interglacial sea-level variations in the western Mediterranean using speleothem encrustations from coastal caves in Mallorca and Sardinia: A field data -- model comparison', *Quaternary International*, 262, pp. 56–64. doi: 10.1016/j.quaint.2011.10.032.

Tuddenham, D. B. (2010) 'Maritime Cultural Landscapes, Maritimity and Quasi Objects', *Journal of Maritime Archaeology*, 5, pp. 5–16.

Vacchi, M., Ghilardi, M., Melis, R. T., Spada, G., Giaime, M., Marriner, N., Lorscheid, T., Morhange, C., Burjachs, F., Rovere, A. (2018) 'New relative sea-level insights into the isostatic history of the Western Mediterranean', *Quaternary Science Reviews*, 201, pp. 396–408. doi: 10.1016/j.quascirev.2018.10.025.

Valenzuela-Suau, L. (2020) *L'Edat del Bronze a Mallorca. Una aproximació a través de l'anàlisi arqueozoològica*. PhD thesis, Universitat de les Illes Balears.

Valenzuela-Suau, L., Valenzuela-Lamas, S., Ramis, D., Bosch, D. (2021) 'Caprine Mobility on the Balearic Islands During the Middle and Late Bronze Age (ca. 1600–850 BC): First Results Based on Strontium Isotopes (87Sr/86Sr)', *Environmental Archaeology*, Published.

Valenzuela, A. and Alcover, J. A. (2017) 'La naveta des Caló de Betlem: una nova estructura d'habitació de l'Edat del Bronze de Mallorca', in Anglada, M., Riera, M., and Martínez, A. (eds) *VII Jornades d'Arqueologia de les Illes Balears*. Maó: Consell Insular de Menorca, pp. 15–19.

Weldeab, S., Siebel, W., Wehausen, R., Emeis, K., Schmiedl, G., Hemleben, C. (2003) 'Late Pleistocene sedimentation in the Western Mediterranean Sea: implications for productivity changes and climatic conditions in the catchment areas', *Palaeogeography*, Palaeoclimatology, Palaeoecology, 190, pp. 121–137.

Westerdahl, C. (1992) 'The maritime cultural landscape', *The International Journal of Nautical Archaeology*, 21(1), pp. 5–14.

Westerdahl, C. (2008) 'Fish and Ships. Towards a Theory of Maritime Culture.', *Deutches Schiffahrtsarchiv Wissenschaftliches Jahrbuch des Deutchen Schiffahrtsmuseums*, 30, pp. 191–236.

Westerdahl, C. (2013) ‘The Maritime Cultural Landscape’, in Ford, B., Hamilton, D. L., and Catsambis, A. (eds) *The Oxford Handbook of Maritime Archaeology*. Oxford: Oxford University Press.

Whitewright, J. (2009) ‘The Mediterranean Lateen Sail in Late Antiquity’, *The International Journal of Nautical Archaeology*, 38(1), pp. 97–104.

Whitewright, J. (2011) ‘The Potential Performance of Ancient Mediterranean Sailing Rigs’, *The International Journal of Nautical Archaeology*, 40(1), pp. 2–17.

Zielhofer, C., von Suchodoletz, H., Fletcher, W. J., Schneider, B., Dietze, E., Schlegel, M., Schepanski, K., Weninger, B., Mischke, S., Mikdad, A. (2017) ‘Millennial-scale fluctuations in Saharan dust supply across the decline of the African Humid Period’, *Quaternary Science Reviews*, 171, pp. 119–135.

Figures and tables captions

Figure 1: Bronze-Age coastal sites across the Balearic Islands.

Figure 2: Currents and hydrodynamic regions in the Balearic Sea.

Figure 3: A map showing maximum visibility horizons calculated for a range of elevations accounting for the earth's curvature. Orographic height has been clustered in horizons by grouping the areas with similar height and location. Visibility horizons show the upper limit of visibility, which will only be achieved in optimum visibility conditions. The map shows how navigation between the archipelago and between the islands and the continent can be achieved with at least one landmass being always in sight.

Figure 4a: Cumulative visibility from theoretical points located in the first visibility horizon from Mallorca heading to Menorca. It shows how both islands' horizons can be seen during simultaneously navigation.

Figure 4b: Cumulative visibility from theoretical points located in the first visibility horizon from Menorca heading to Mallorca. It shows how both islands' horizons can be seen simultaneously during navigation.

Figure 5a: Cumulative visibility from theoretical points located in the first visibility horizon from Mallorca heading to Ibiza. It shows how both islands' horizons can be seen simultaneously during navigation.

Figure 5b: Cumulative visibility from theoretical points located in the first visibility horizon from Ibiza heading to Mallorca. It shows how both islands' horizons can be seen simultaneously during navigation.

Figure 6: Main navigation routes around the Balearic Islands and areas of provenance of copper (Cu) and lead (Pb) (Sureda, 2020; Llull Estarellas, Perelló Mateo and Calvo Trias, 2022)

Table 1: Chronological information of the Middle and Late Bronze Age coastal sites.

Table 1

Site	C14 code reference	C14 BP age	Cal BC. OxCal v4.4 (Bronk Ramsey, C. 2009)	Type of sample	Context and reference
MENORCA					
Coastal promontories					
Cap de Forma	UtC-10076	2930 ± 35	1226-1014 BC (95.4%)	Animal bone	No stratigraphic reference (Depalmas, 2014, p. 433)
	KIA-21224	2915 ± 30	1209-1016 BC (95.4%)	Animal bone	No stratigraphic reference (Depalmas, 2014, p. 433)
	KIA-48791	2895 ± 35	1209-979 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
	KIA-48790	2890 ± 35	1207-976 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
	KIA-48789	2885 ± 35	1196-960 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
	UtC 10077	2815 ± 45	1110-845 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
	UtC 10075	2755 ± 30	978-827 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
	UTC-4742	2470 ± 30	786-431 BC (95.4%)	Animal bone	SU 118, area with traces of burning (Depalmas, 2014, p. 433)
Castellet de Pop Mosquer	UBAR-426	3020 ± 20	1383-1208 BC (95.4%)	Animal bone	Animal bones found out of context due to looting (Mestres i Torres and De Nicolás i Mascaró, 1997; Micó, 2005, p. 523)
Coll de Cala Morell	KIA-48796	3265 ± 35	1617-1491 BC (83.1%) 1484-1449 BC (12.3%)	Sheep metatarsus	Naviform 11, SU 20. First level of occupation (Anglada et al., 2017)
	RICH-20066	3112 ± 23	1440-1368 BC (56.4%) 1356-1296 BC (39.1%)	Indeterminate domestic animal bone	Naviform 11, SU 28. Base of the combustion structure (Anglada et al., 2017)
	KIA-48164	3065 ± 25	1412-1261 BC (95.4%)	*Caprinae* humerus	Naviform 11, SU8. Second level of occupation (Anglada et al., 2017)
	KIA-48811	3000 ± 35	1386-1339 BC (11.5%) 1315-1121 BC (83.9%)	*Caprinae* scapula	Naviform 11, SU8. Superior level of the combustion structure (Anglada et al., 2017)
	KIA-48812	2995 ± 35	1385-1340 BC (9.5%) 1315-1116 BC (85.9%)	*Caprinae* phalange	Naviform 11, SU12. Intermediate level of the combustion structure (Anglada et al., 2017)
	RICH-22788	2918 ± 34	1219-1011 BC (95.4%)	Bovine vertebrae	Naviform 11, SU67. Level where the apse of the naviform sits. The dating result is not considered valid and is interpreted as an intrusion (Anglada et al., 2017, p. 10)

Site	C14 code reference	C14 BP age	Cal BC. OxCal v4.4 (Bronk Ramsey, C. 2009)	Type of sample	Context and reference
	RICH-21672	3048 ± 33	1407-1219 BC (95.4%)	*Caprinae* metatarsus	Naviform 12, SU38. Occupation floor (Anglada et al. 2017)
Es Castellet de Cales Coves				Architectural typology	(Plantalamor, 1991; Guerrero Ayuso, 2006a; Sánchez López, Gutiérrez Rodríguez and Orfila Pons, 2013)
Macarella	No chronological data available				
Llucalari	No chronological data available				
Maón	No chronological data available				
Anchorage places					
S'Illa de Ses Mones (Islet)				Architectural typology	Index Card nº 066155. Built heritage, Consell Insular de Menorca
Cala Blanca	IRPA-1123	3320 ± 40	1731-1721 BC (1.7%), 1689-1505 BC (93.8%)	Bone remains	Level underneath the naviform (Plantalamor and Van Strydonck, 1997)
	D-AMS 029810	3430 ± 32	1876-1843 BC (12.7%), 1822-1797 BC (5.4%), 1779-1625 BC (77.4%)	Sheep jaw	Interior level, underneath the naviform (Q. B2) (Valenzuela-Suau, 2020)
	D-AMS 029813	3374 ± 39	1751-1534 BC (95.4%)	Caprine jaw	Level underneath the naviform (Valenzuela-Suau, 2020)
	D-AMS 029811	3122 ± 30	1493-1480 BC (2%), 1452-1367 BC (60.4%), 1360-1293 BC (33.1%)	Sheep jaw	Naviform level (Q. B2) (Valenzuela-Suau, 2020)
	D-AMS 029812	3150 ± 27	1499-1387 BC (89.3%), 1338-1320 BC (6.2%)	Caprine jaw	Naviform level (Q. B2) (Valenzuela-Suau, 2020)
	IRPA-1124	3100 ± 40	1489-1484 BC (0.5%), 1449-1260 BC (94.9%)	Bone remains	Naviform level (Plantalamor and Van Strydonck, 1997)
MALLORCA					
Coastal promontories					
Cala S'Almunia				Pottery typology	Pottery barrels (Typology I), Final Bronze Age (Guerrero et al., 2007, p. 258)
Puig de Sa Morisca	KIA-17998	2985 ± 25	1284-1122 BC (95.4%)	Animal bone	SU57, floor underneath Tower I (Guerrero et al., 2007)
	KIA-17979	2885 ± 25	1190-979 BC (95.3%)	Animal bone	SU70, floor underneath Tower I (Guerrero et al., 2007)
	KIA-33825	2834 ± 30	1086-910 BC (95.5%)	Animal bone	SU30, floor underneath Tower I (Guerrero et al., 2007)
	KIA-17980	2835 ± 35	1110-909 BC (95.4%)	Animal bone	SU51, floor underneath Tower I (Guerrero et al., 2007)
Sa Ferradura	RICH-21675	2908 ± 33	1216-1007 BC (95.4%)	Bovine molar	SF1, Sector 1, SU50, combustion structure (Anglada et al., 2017a; Anglada, Ferrer and Ramis, 2017)

Site	C14 code reference	C14 BP age	Cal BC. OxCal v4.4 (Bronk Ramsey, C. 2009)	Type of sample	Context and reference
	KIA-48826	2835 ± 35	1111-906 BC (95.4%)	Bovine rib	SF2, Sector 1, SU5, combustion structure (Anglada *et al*., 2017b)
	KIA-48827	2830 ± 35	1111-903 BC (95.4%)	Caprinae jaw	SF3, Sector 1, SU7 (Anglada *et al*., 2017b)
	KIA-48828	2795 ± 35	1045-1032 BC (2%) 1019-834 BC (93.5%)	Caprinae scapula	SF4, Sector 1, SU22, combustion structure (Anglada et al., 2017a; Anglada *et al*., 2017b)
	RICH-22784	2841 ± 29	1110-917 BC (95.4%)	Goat metatarsus	SF5, Sector 2, SU68. Occupation level (Anglada et al., 2017a)
Anchorage places					
Na Moltona (Islet)				Pottery typology	Typology I, Middle – Late Bronze Age (Guerrero et al., 2007)
Na Galera (Islet)				Pottery typology	Typology I, Middle – Late Bronze Age (Guerrero et al., 2007)
S'Illot de Porros (Islet)	KIA-11868	3100 ±35	1441- 1266 BC (94.5%)	Bone remains	SU27 (Calvo *et alii*. 2011 Table 1, Hernández 2021, Strydonck *et alii*., 2001: 40-41) (Van Strydonck et al., 2002; Calvo et al., 2011; Hernández - Gasch and Sanmartí, 2019)
	KIA-11243	2975±25	1367-1360 BC (0.4%) 1285-1112 BC (95%)	Bone remains	SU110 (Van Strydonck et al., 2002; Calvo et al., 2011; Hernández - Gasch and Sanmartí, 2019)
	KIA-11244	2765±30	993-830 BC (95.4%)	Bone remains	SU112 (Van Strydonck et al., 2002; Calvo et al., 2011; Hernández - Gasch and Sanmartí, 2019)
	KIA-11246	3040±30	1401-1216 BC (95.4%)	Bone remains	SU118 (Van Strydonck et al., 2002; Calvo et al., 2011; Hernández - Gasch and Sanmartí, 2019)
Porto Colom				Pottery typology	Typology I and VI, Middle-Late Bronze Age (Guerrero et al., 2007; Salvà Simonet, 2007)
Cala en Tugores				Pottery typology	Typology I and VI, Middle-Late Bronze Age (Guerrero et al., 2007; Salvà Simonet, 2007)
Naveta des Caló	RICH-22212	3031±31BP	1401-1200 BC (95.1%), 1138-135 BC (0.3%)		SU4 (Valenzuela and Alcover, 2017)
CABRERA					
Coastal promontories					
Punta de Sa Corrent				Pottery typology	(Trias et al., 2009)
Cova des Burri				Pottery typology	(Trias et al., 2009)
Anchorage places					
Cova des Francesos				Pottery typology	(Trias et al., 2009)

Site	C14 code reference	C14 BP age	Cal BC. OxCal v4.4 (Bronk Ramsey, C. 2009)	Type of sample	Context and reference
IBIZA					
Coastal promontories					
Punta des Jondal				Pottery typology	Pottery fragments compatible with Final Bronze Age chronologies in Ibiza (Ramón, 1985, p. 65)
Cap des Llibrell	No chronological data available				