CHAPTER 6

In the Wake of Ulysses: Contextualization and Typology of Ancient Island Harbors in the Mediterranean: From Natural Hazards to Anthropogenic Imprints

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1 Introduction

For several decades, archaeological studies undertaken on Mediterranean islands have showed that these have been, since prehistoric times, attractive areas for humans. The islands played an important role in the improvement of navigation technics (Ferentinos et al. 2012; Vigne et al. 2014). If Late Pleistocene occupation seems to be a phenomenon restricted to members of the "Big Five" (Sardinia and Corsica [united at times of glacial maxima as "Corsardinia"], Sicily, Crete, and Cyprus; Cherry and Leppard 2018), Epipaleolithic presence has been attested on the majority of Mediterranean islands. This fixes an earlier settlement date of 9000 BCE for most of them (Guilaine 2012; Papoulia 2016). Populations in search of new territories were attracted to islands. They settled and flourished on islands such as Cyprus (Bar-Yosef Mayer et al. 2015) or Malta, maintaining contacts with their own home settlement on the mainland (Simmons 2012). This phenomenon is particularly perceptible in Cyprus. Vigne et al. (2014) demonstrated an increase of large ruminants transported by boats from the Levant and the coast of Turkey between the twelfth and tenth centuries BCE. Crete is also one of the first islands where the presence of "agricultural villages" is attested. It is one of the oldest pieces of evidence for successful "maritime transfer" of a full agricultural economy (Broodbank and Strasser 1991). This phenomenon would not only be related to major enhancement of naval engineering technics, but could also be associated with a better control of sailing by Upper Paleolithic and Neolithic peoples thanks to knowledge transfer from generation to generation (Vigne et al. 2014). If the islands are being regarded as key steps in the colonization process of the Mediterranean (Howitt-Marshall and Runnels 2016), the importance of the island in human-environment relations of island harbors has never been clarified or classified.

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It seems therefore appropriate to specify changing landscapes and the plurality of ancient island harbors, insofar as the islands played a crucial role in the development and the shaping of ancient coastal societies (Gras 1995; Broodbank 2013; Walsh 2013; Dawson 2014; Fitzpatrick, Rick, and Erlandson 2015). For example, islands were preferred areas for the establishment of Phoenician-Punic and Greek settlements in the first millennium BCE (Carayon 2008). Among the cities of the Levantine coastline, Tyre and Arwad reflect a two-party social organizational model in which the city, located on an island situated a few tens or hundreds of meters from the mainland, enjoys privileged relations with the hinterland, maintaining a favorable defensive position (Carayon 2011). Arwad, for example, had close ties with the cities of Tartous, Tell Ghamqe, and Amrit, located on the continent (Rey-Coquais 1974). Tyre also controlled a coastal strip along the mainland, which granted her access to freshwater (Ras al-ʻAyn spring) and forest resources and to an area to bury the dead (Sauvage 2012). The main advantage of this insularity is obviously defensive. This is particularly the case of the cities of Phoenicia. Arwad, for example, was never taken; however, in order to preserve its independence, the city submitted itself to the conquerors in antiquity. Tyre was only definitively breached by Alexander the Great in 332 BCE, following the edification of a causeway connecting artificially the island to the mainland (Katzenstein 1997; Marriner, Morhange, and Meulé 2007). In medieval times, the construction of Venice is also a good example of the defensive advantage of islands. In fact, Venice was founded during the sixth century CE, due to the resettlement of the Roman city of Altinum, threatened by Lombard invasions.

In this paper, we turn our attention to several small Mediterranean islands and islets with an area smaller than a few tens or hundreds of square kilometers (Fig. 6.1: A). These islands are associated with ancient settlements and their harbor(s) and have been affected mostly by environmental changes through time. In this study, we focus on the recognition of geomorphological features and of the hydro-sedimentary processes along the shoreline of the islands. We have chosen to study relatively small islands in order to affirm that they have (or had) a clear island nature, by contrast with larger Mediterranean islands (e.g., Cyprus, Sardinia, Sicily), which have a more "continental" nature that may enable the inhabitants to live self-sufficiently. In this sense, their small size, the ratio between their estimated shoreline and their estimated emerged land area in antiquity ("*indice côtier*" as described by Doumenge 1987),[1] the presence of a single harbor city, and the distance between the island

1 Due to the modification of the island shoreline and emerged area since ancient times, it is difficult to obtain a reliable estimation of this ratio. Nevertheless, we mention that, for

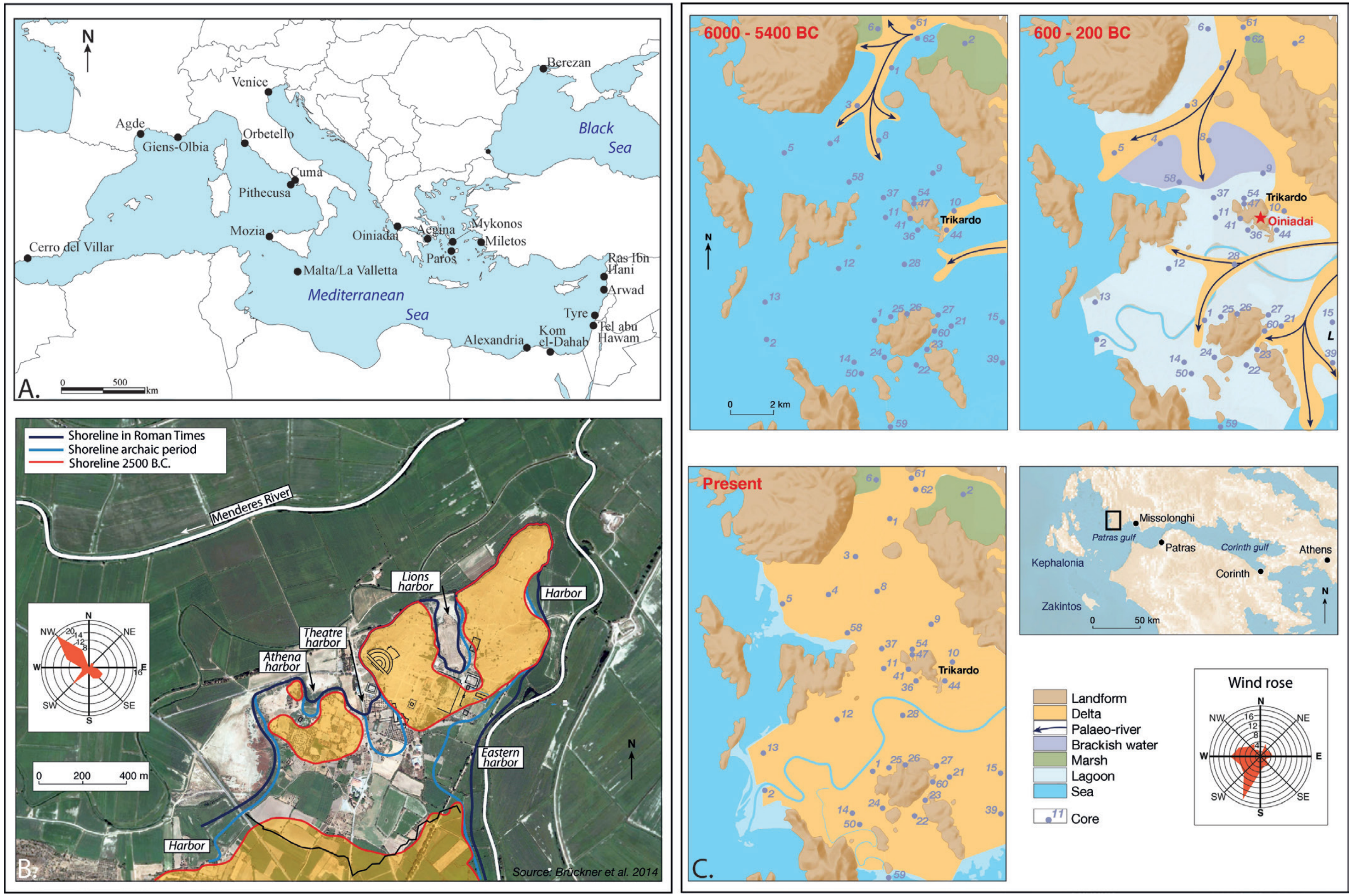

FIGURE 6.1 (A) Location of the sites mentioned in this work; (B) geomorphological map of the Milesian archipelago (Turkey) from Brückner et al. 2014; wind rose, Patmos weather station (in knots, windfinder.com); (C) geomorphological evolution of the Acheloos River delta and landlocking of Oiniadai's ancient harbors (from Vött 2007; Vött et al., 2007); wind rose, Aitoliko weather station (in knots, www.windfinder.com)

and the continent explain our choice. Though the assessment of a territory by a single indicator (size, in this case) is reductive, these characteristics are essentials in the choice of our studied sites, allowing a non-exhaustive synthesis of the islands. Nevertheless, since these sites are small, their island nature can be limited because they are dependent on the continent for resources on raw materials.

2 Methods

In this work, we identified four geomorphological processes or anthropogenic impacts underlying major changes of island landscape since antiquity. We distinguish (i) the sedimentary budget at base level; (ii) the variation of relative sea level; (iii) the distance between the island and the mainland; and (iv) human impacts on the coastline. We propose a semiquantitative database that is supported by the attribution of a percentage according to the influence of the role played by each particular process or characteristic (example given in Fig. 6.2: A). The distance between the island and the mainland was measured using Google Earth. The sediment budget was estimated based on the proximity to coastal rivers. In a context of relative sea level stability, with some exceptions such as in Alexandria, the rapid sedimentary inputs at base level led to important constraints in the use and management of ancient harbor basins (Morhange and Marriner 2010; Morhange, Marriner, and Carayon 2015; Giaime et al. 2019). The artificialization of the coastline highlights the variable density of harbor works or the building of a causeway linking the island to the continent.

According to this estimation, we created a heat map to represent the data visually (Fig. 6.2: D). We chose to apply multivariate statistical techniques because they facilitate the investigation of large datasets, while taking into consideration the effects of all variables on the responses. In this study, cluster analysis (algorithm: paired group; similarity measure: correlation) was used to group data according to the estimated importance of each pressure identified on the harbor (Fig. 6.2: D). Finally, a principal component analysis (PCA) allowed us to highlight the main processes that have affected each island over time (Fig. 6.2: B, C).

example, an elongated island (such as Tyre) will have a higher ratio than a more circular island (such as Mozia). Thus, according to the "*indice côtier*" (Doumenge 1987), the higher the ratio is, the more the insular nature of the island is significant.

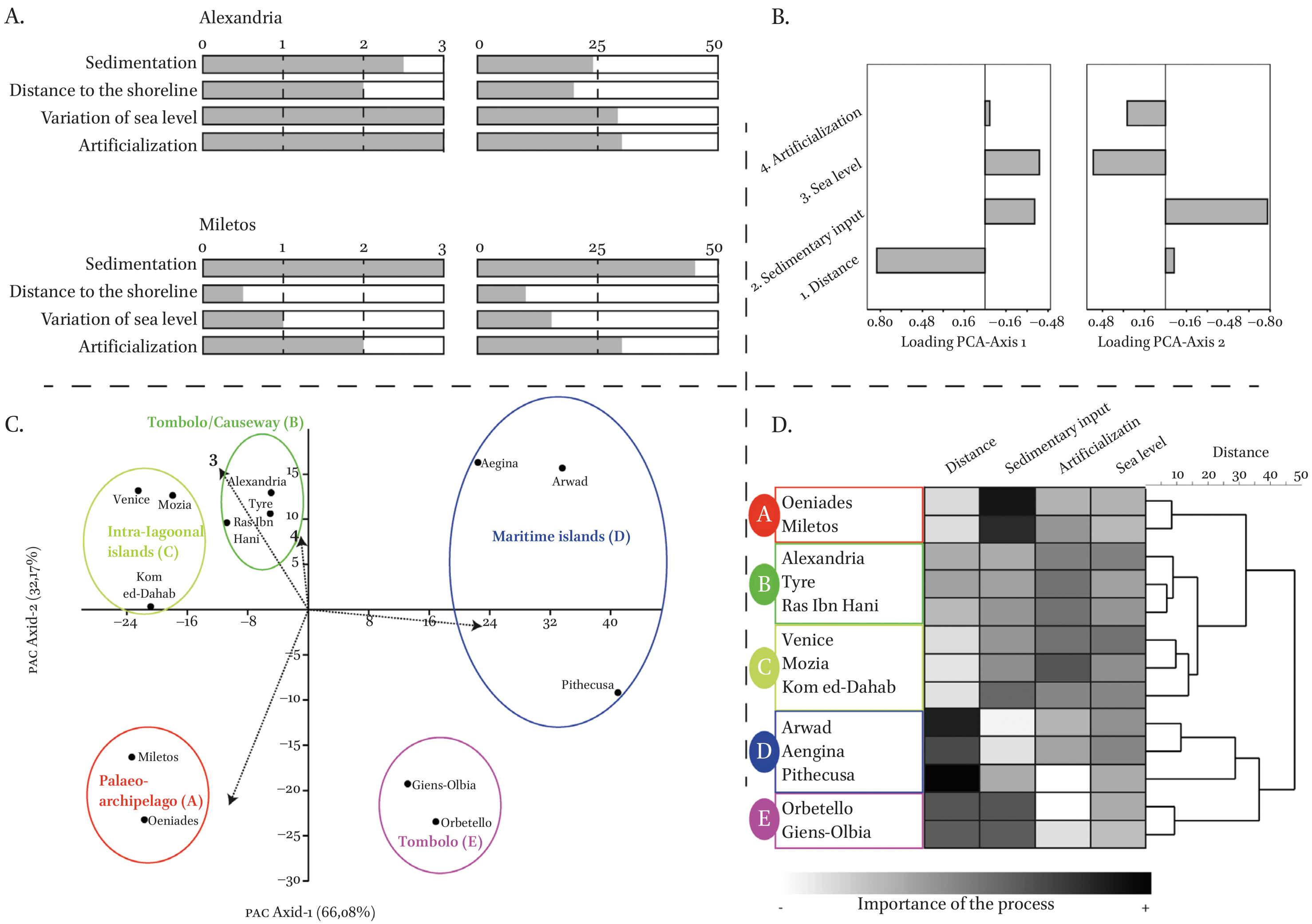

FIGURE 6.2 (A) Examples of Alexandria and Miletos for the attribution of the percentage. According to the importance (estimation) of the pressure, we attributed a certain degree of importance (from 0 to 3) to the role played by each particular process or characteristic that will allow us to calculate a percentage; (B) loading for the two PCA axes; (C) PCA of the harbor presented; (D) heat map showing the estimated importance of each pressure identified and cluster analysis associated

3 Results

The cluster analysis highlights five main groups of sites, each characterized by the most significant variables that led to the modification of the island landscape (Fig. 6.2: D). Group A comprises paleoislands located near the shoreline. For these islands, the sedimentary input was very important and explains their landlocking by shoreline progradation (e.g., Miletos). Group B includes islands that underwent an important artificialization in antiquity, mainly because of the construction of an artificial causeway linking the island to the mainland (e.g., Tyre). Group C comprises intra-lagoonal islands, protected from the sea (e.g., Venice). Group D is composed of islands lying far from the continental shoreline and the importance of sea level on the evolution of its ancient harbors (e.g., Aegina). Finally, group E incorporates islands linked to the mainland by tombolos (e.g., Giens-Olbia).

The PCA undertaken on the same database allowed us to prioritize these five groups according to the main variable that played an important role in their geomorphological evolution (Fig. 6.2: B, C). PCA Axis-1 contrasts maritime islands (negative figures) far from the mainland and not significantly impacted by base-level sediment supply, with clogged paleoislands (positive figures) subject to important sedimentary inputs. This axis illustrates the "insularity level" of the islands, as discussed earlier in this chapter. The more "insular" islands are opposed to the lagoonal and paleoisland on either side of the axis. PCA Axis-2 is marked by the important management of the coastal zone. Positives figures are related to a significant artificialization of the shoreline in antiquity, while the island with a less reduced artificialization was characterized by negative figures.

Thanks to these results, we have built a typology based on five distinct geomorphological types:

Type 1: maritime islands, such as Arwad (Syria), Pithecusa (Ischia in Italy), or Aegina (Greece), that are distant enough from the continent to be protected from the sedimentary processes and the coastal smoothing. This distance, as well as the depth of the water channel between the island and the continental shoreline, is associated with a very low accommodation space on the shoreline of the island.

Type 2: paleoislands, nowadays infilled and landlocked by deltaic progradation, such as Miletos in the Büyük-Menderes Delta (Turkey) or Oiniadai in the Acheloos delta plain (Greece).

Type 3: islands linked to the mainland by a tombolo, such as Orbetello (Tuscany, Italy) or Giens-Olbia (Var, France).

Type 4: islands linked to the mainland by a tombolo and an artificial causeway, such as Tyre on the southern margin of the Awali delta (Lebanon), Alexandria in the Nile Delta, or Ras Ibn Hani (Syria). Unlike the infilled paleo-archipelagos in deltaic contexts, these islands still present a maritime façade.

Type 5: intra-lagoonal islands, such as Venice (Italy), Mozia (Italy), or Kom ed-Dahab (Egypt).

4 The Typology

4.1 *Type 1: Maritime Islands*

A number of islands in the Aegean Sea, for example, are situated far from the continent. Nonetheless, these islands, situated close to each other, might have contributed to the development of maritime activities since the Middle Pleistocene (Howitt-Marshall and Runnels 2016). Relative sea level variation is the predominant forcing for these islands, such as for Mykonos (Dalongeville et al. 2007), Paros (Karkani et al. 2018; Karkani et al. 2019), or Aegina in the Saronic Gulf (Mourtzas and Kolaiti 2013). It is also the case of the islands that marked the first step of the Greek colonization in the Mediterranean and the Black Sea. At the time of the Greek expansion, during the Archaic period (750–550 BCE), coastal islets had often been privileged emplacements for the foundation of settlements, like Berezan, located in present-day Ukraine, in the Black Sea (Fig. 6.1: A). In the western Mediterranean, Greek colonists coming from Chalcis in Euboea (Greece) founded the first settlement of Magna Graecia on the island of Ischia. Pithecusa was, during the eighth century BCE, an emporium where the Greeks traded with local people (Ridgway 1992). Some years later, colonists founded Cumae close to Pithecusa to control trade routes to the north (Pasqualini 2000). The reduced size of the watersheds of these small maritime islands explains the low sediment budget and limited accumulation at base level. The main forcing agent is relative sea level rise that could have led to a flooding of some ancient harbor structures (e.g., Poulos, Ghionis, and Maroukian 2009; for Paros, see Papathanassopoulos and Schilardi 1981; Evelpidou, Tziligkaki, and Karkani 2018; for Aegina, see Mourtzas and Kolaiti 2013), as well as a reduction of the islands' surface area since the Bronze Age (Karkani et al. 2017). For example, some islands, such as Malta (Marriner et al. 2012), show limited coastal progradation even in reduced rias. La Valletta is still one of the best insular harbors in the Mediterranean (Bernardie-Tahir 2000).

4.2 *Type 2: Paleoislands Infilled and Landlocked in Deltaic Contexts*

Because of general sea level stabilization (Vacchi et al. 2016), sustained sediment supply beginning around 6,000 years ago led to shoreline regularization (Anthony, Marriner, and Morhange 2014). This led to a relocation of the harbors due to island landlocking and the infilling of harbor basins (Marriner and

Morhange 2007; Morhange et al. 2015; Brückner et al. 2017; Giaime, Marriner, and Morhange, 2019). This "race to the sea" has been clearly identified for a number of river mouths. It shows strong modifications in the human occupation of the catchments in the long term (Brückner et al. 2005). We propose to synthesize two examples: the Milesian archipelago of the Latmian Gulf (now virtually closed) is nowadays landlocked in the Büyük-Menderes deltaic plain (Turkey), 8 km east from the present shoreline (Fig. 6.1: B). This paleo-ria, was an important sink for sediments eroded in the watershed because of intense land cultivation. Thus, in the course of the Bronze Age (ca. 1900–1100 BCE), the increasing erosion of soils led to the transformation of the archipelago into a peninsula (Brückner et al. 2006). Gradually, the progradation of the delta during Roman imperial times led to a progradation of the coastline through the west and the infilling of the harbor basins (Brückner et al. 2014). The Lion harbor in Miletos, partly infilled as early as the Byzantine period (seventh–fifth centuries CE), is a good example of the geomorphological changes induced by a high sediment supply. The apparent sedimentation rate rose from 6.3 mm/year between 510 and 390 BCE to more than 12 mm/year between 75 BCE and 400 CE (Brückner et al. 2014).

In the same vein, geomorphological research on the Acheloos River delta in Greece has highlighted the effect of deltaic progradation on shoreline changes (Fouache et al. 2005; Vött 2007; Vött et al. 2007). The paleoisland of Trikardo, where the city of Oiniadai was located, was washed away by the sea 6,000 years ago because of the rise in sea level (Fig. 6.1: C). Thereafter, the progradation of the Acheloos River delta disconnected the island from the sea. The ancient harbors remained connected to the sea through the utilization of fluvial arms as communication channels. By Roman and Byzantine times, the island was permanently landlocked and integrated into the deltaic plain. This limitation was overcome by the establishment of a fluvial harbor, on the bank of a meander of the Acheloos, on the southern part of the island. This relocation of the harbor is typical of the "race to the sea" induced by the environmental changes at this time.

4.3 *Type 3: Islands Linked to the Mainland by a Tombolo*

If the island is located close to the continent and the sedimentary input is substantial, a tombolo forms. A tombolo is a sand spit, perpendicular to the shore, linking an island to the mainland coast. These isthmuses form because of significant sedimentary inputs and wave action that, linked to the wave diffraction induced by the island, lead to the deposition of sediments. The scales of these landforms can vary considerably from a few tens of meters behind small obstacles up to 15 km, as in the case of Orbetello on the Italian coast (Gosseaume 1973). We emphasize two main factors in the formation of tombolos: the distance to the shoreline (d) and the length of the island (l). Sunamura and

Mizuzo (1987) suggest that a ratio (d/l) lower than or equal to 1.5 led to the natural formation of a tombolo. A salient would form with a ratio of between 1.5 and 3.5. Beyond this value, there can be no spit formation because the island is too far from the continental shoreline (Fig. 6.3: C). On a much larger scale, Van Rijn (2013), using the same parameters but a different formula (l/d), suggests that a ratio higher than or equal to 1 would be necessary for the development of a tombolo between the shoreline and the breakwater. With a ratio of between 0.5 and 1, a salient would form. Beyond this value, there would be no effect on the shoreline. These two parameters have a major role to play in the formation of a tombolo whose morphogenesis differs depending on the context and the coastal processes, including the sedimentary inputs, the orientation of the island with respect to the waves, and weather and marine environments of each site. We present the data regarding the length of the island, the distance between the island and the coast, and the associated ratios for each tombolo studied in this paper (Table 6.1). In the Mediterranean, a number of ancient islands have been connected to the mainland by a tombolo. The majority of tombolos are formed by a single ridge, though there are good examples of tombolo pairs (Giens; Courtaud 2000) and even triplets (Orbetello; Gosseaume 1973). Multiple tombolo formation is attributed to waves

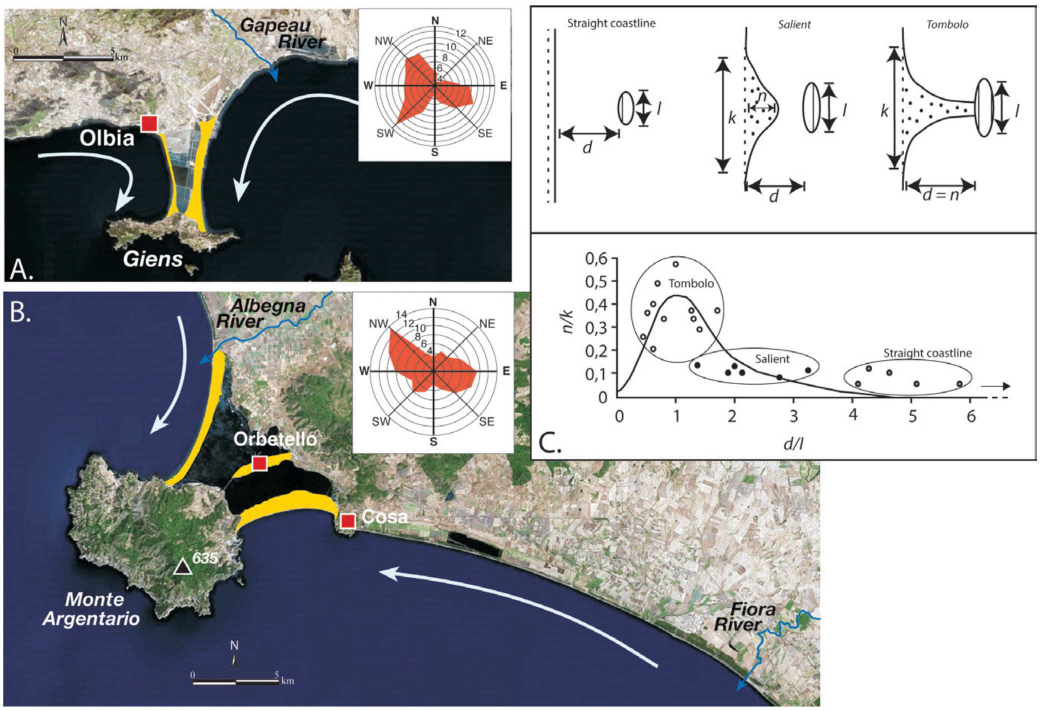

FIGURE 6.3 (A) Triplet tombolo of Orbetello; (B) twin tombolo of Giens-Olbia, (images Google Earth); wind roses, Monte Argentario (Orbetello) and Giens airport (Olbia) weather stations (in knots, windfinder.com); (C) key parameters of tombolo formation (from Sunamura and Mizuzo 1987)

TABLE 6.1 Measurements of length and distance from the coast of the different tombolos presented in this work and associated ratios

	Distance from the continent (m)	Length of the island (m)	Ratio (d/l) (Sunamura and Mizuzo 1987)	Ratio (l/d) (Van Rijn 2013)
Alexandria	1,300	2,100	0.62	1.62
Giens-Olbia	4,000	6,000	0.67	1.50
Orbetello	4,500	11,000	0.41	2.44
Ras Ibn Hani	900	2,500	0.36	2.78
Tyre	1,000	2,500	0.40	2.50

approaching the island flanks at different angles of incidence, with lagoons developing in the sheltered area between the salients (Blanc 1959). The island of Monte Argentario is connected to the mainland by the triple tombolo of Orbetello (Fig. 6.3: B). The first permanent occupation is attested from the fifth millennium BCE onward, on the Punta degli Stretti promontory, located on the eastern façade of the island in an area protected from the dominant wave direction, close to the only still-navigable inlet between the sea and the lagoon (Dolci 2014). This may suggest that an inlet was present in this sector in ancient times. Thereafter, during the seventh century BCE, the Etruscan settlement of Orbetello was founded on a sand spit located in the center of the current lagoon (central salient). Its harbors enjoyed clam lagoonal waters.

Olbia de Provence, a Massalian colony founded in the late fourth century BCE (Ugolini, Arcelin, and Bats 2010), is located at the western base of the twin tombolo of Giens (Fig. 6.3: A). A mole, presently underwater, appears as the single ancient harbor structure identified (Long and Cibecchini 1996). The discovery of a fragment of an amphora incorporated into the mortar suggests that this mole was built during the late first century BCE. This construction would be linked to the relocation of the "primitive" harbor, potentially located in the lagoon, because of its infilling (Long and Vella 2005). Vella et al. (2000) argued the ancient tombolo was 30 m wider in its western part, compared with the present tombolo, and a lagoonal environment is attested behind the sand spit since the Neolithic. At present, underwater remains of this spit are still visible around 30 m away from the present tombolo. This example shows clearly the protective role of the island for the mainland. Nevertheless, in the present context of diminished sedimentary inputs, the protective role of the islands does not facilitate the accretion of the tombolo and the salients of Giens' tombolo are eroding.

4.4 *Type 4: Islands Linked to the Mainland by a Tombolo and an Artificial Causeway*

The formation of the tombolos detailed in this part is linked to a twofold influence, natural and anthropogenic. We would like to highlight three sites with similar geomorphological traits: the tombolos of Ras Ibn Hani (Fig. 6.4: A) and Tyre (Fig. 6.4: C) and that of Alexandria, linking the island of Pharos to the Nile Delta shoreline (Fig. 6.4: B). The formation of the tombolos of Tyre and Alexandria is clearly linked to the edification of an artificial causeway under the reign of Alexander the Great. In Tyre the causeway was built in 332 BCE (Marriner, Morhange, and Meulé 2007). In Alexandria it was built soon after the foundation of the city in 331 BCE. At Ras Ibn Hani, the causeway predates the Hellenistic period (Sanlaville 1978; Dalongeville et al. 1993). At these three sites the formation of the tombolo is divided into three main steps (Marriner, Goiran, and Morhange 2008; Marriner et al. 2012; Fig. 6.4). First, because of sea level stabilization over the last 6,000 years and the hydrodynamic processes, the development of an underwater salient engendered the formation of a proto-tombolo. Research undertaken in Tyre and Ras Ibn Hani demonstrates that a rapid accretion phase started around 3500 BCE because of significant sedimentary input following the intense cultivation of the watersheds (Marriner et al. 2012). It was upon these amphibious sandbanks (proto-tombolos) that the causeways were built. In Alexandria, for example, the tombolo/causeway divided the bay into two parts and two harbors had been installed on either side (Goiran et al. 2005). The third phase of tombolo formation consists of a widening of the spit on both sides of the causeway. In Alexandria the harbor basins were affected by intense siltation (sedimentation rates: 10 mm/year; Goiran 2001).

We could categorize artificial islands such as Palm Islands or The World archipelago in Dubai as a subtype. Palm Islands are three artificial islands, Palm Jumeirah, Deira Island, and Palm Jebel Ali, on the coast of Dubai (United Arab Emirates). To date, only Palm Jumeirah has been completed (in 2011), which adopts the form of a palm tree topped by a crescent. These islands are intended to host a large number of residential, leisure, and entertainment centers and will add a total of 520 km of nonpublic beaches to the city of Dubai. These totally artificial islands illustrate the extreme nature of anthropogenic impact on the coastline. The islands will probably never undergo important morphological changes, given the limited sedimentary inputs along the coast of Dubai; however, their construction has heavily modified the hydrodynamic regime of the coastline.

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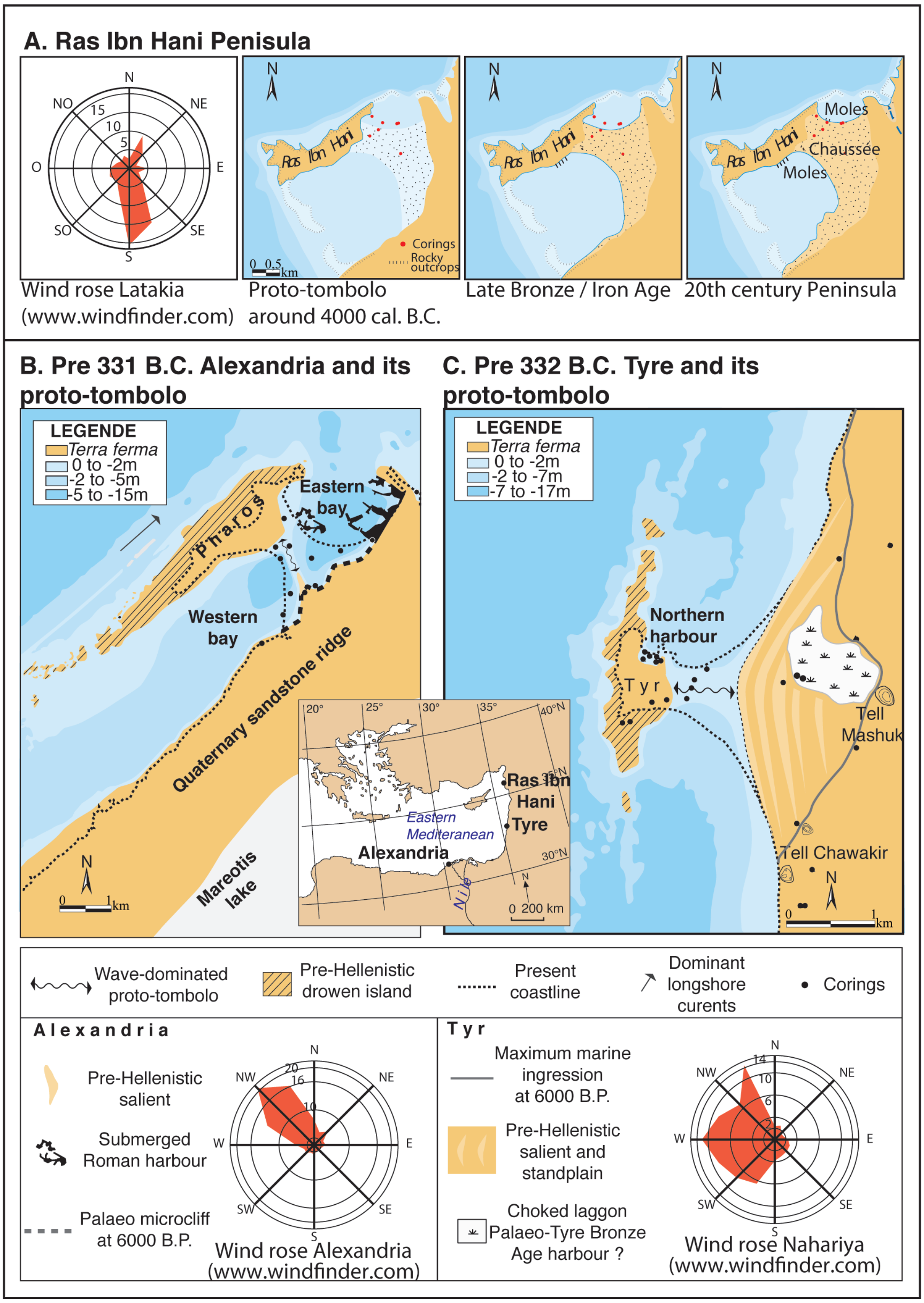

FIGURE 6.4 Morphodynamic evolution of the (A) Ras Ibn Hani, (B) Alexandria, and (C) Tyre isthmuses since antiquity, from Marriner, Goiran, and Morhange 2008 and Marriner et al. 2012; wind roses: Latakia (Ras Ibn Hani), Nahariya (Tyre), and Giens airport (Olbia) weather stations (in knots, windfinder.com)

4.5 *Type 5: Intra-lagoonal Islands*

Lagoons are particularly attractive areas for the installation of ancient harbors (Morhange et al. 2015; Morhange et al. 2017), being naturally protected from the sea by the presence of a coastal spit. The Mediterranean's lagoons are particularly reduced in size and have almost disappeared since ancient times because they act as sedimentary traps and have been rapidly infilled by sediments. Nevertheless, some large lagoons protected from significant sedimentary inputs and/or largely open to the sea are still in water. In some of them there are small islets, such as the city of Venice in the Venetian Lagoon (Veneto, Italy), Mozia in the Stagnone Lagoon near Marsala (Sicily, Italy), or Kom ed-Dahab in Lake Manzala (Nile Delta, Egypt).

The Phoenician settlement of Mozia was founded on the islet of San Pantaleo in the large lagoon of Marsala. Though this lagoon is located downstream of the mouth of the Birgi River, the small size of the watershed has precluded its infilling (Fig. 6.5: A). The vast lagoon presented a strong environmental interest for ancient populations, such as the Phoenician colony of Mozia founded during the second half of the eighth century BCE This large water body of 2,000 ha, with a depth of 2 m, is protected from the sea by the Isola Grande sand spit, which has acted as a natural breakwater during the last 5,000 years at least (Basso et al. 2008). During the sixth century CE, a causeway was constructed between the island and the continent, where remains of a necropolis linked to Mozia have been found near the village of Birgi (Fama and Toti 2000). A rectangular-shaped basin, located on the southern part of the island, has been interpreted as a Phoenician *cothon* harbor, with an anthropogenic modification of the natural lagoon during the sixth century BCE. Archaeological research has demonstrated that it was a freshwater basin linked to cultic activities related to the nearby temple (Nigro 2006; Spagnoli 2013). Moreover, the entire coast of the island of San Pantaleo could be used as a berthing area for small draft boats, which does not necessarily necessitate the construction of a protected harbor.

The island on which Kom ed-Dahab is situated, located in the present-day Manzala Lagoon (Fig. 6.5: B) hosted an important Roman settlement that was recently identified (Marouard 2014). The site at Kom ed-Dahab is an early Roman town and an ex nihilo foundation, established in the lagoon around the mid-first century BCE. Archaeological explorations have unearthed specific installations indicating that it was certainly a strategic harbor settlement, possibly located at the extremity of one of the Nile branches and once connected to a hinterland metropolis in the center of the Delta (Marouard 2014). A lack of paleoenvironmental reconstructions of the Early Roman period in this

FIGURE 6.5 Geomorphological setting of the islands of (A) Mozia, (B) Venice, and (C; D) Kom ed-Dahab, from Marouard 2014. Image ESA and Google Earth; wind roses: Venezia-Lido (Venice), Trapani-Birgi Aeroporto (Mozia), and Port Said (Kom ed-Dahab) weather station (in knots, windfinder.com)

region did not allow us to affirm that the present landscape was as it is today in antiquity. However, the emerged area of the island seems to be similar to its area in Roman times, because no submerged structures have been identified. The city probably had two harbors: one was in the northeast of the island; other possible harbor installations found in the southwest of the island may indicate the presence of a second harbor in that area (Fig. 6.5: D). In all likelihood, the city was founded in an estuarine-lagoon environment enjoying a water body protected from the sea and a direct connection with the hinterland. Nevertheless, the settlement was susceptible to hazards due to Nile floods, which could explain its short period of occupation, between the first and third centuries BCE (Marouard, personal communication).

Such water bodies present the uniqueness of being naturally protected from the sea; the islands located within are also particularly interesting with regard to protection against enemies. In medieval times the construction of Venice illustrates this example. In fact, the foundation of Venice in the eponymous lagoon (on the archipelago of *Rivus Altus*) during the fifth–seventh centuries CE resulted from the threat of Lombardian invasions of the Roman municipium of Altinum (Ammerman 2003; Christie 2006). Ninfo et al. (2009) described the configuration of this Roman city, located some 12 km northeast of Venice (Fig. 6.5: B). The study of aerial photographs with a digital elevation model (DEM) revealed important harbor structures with an artificial canal network linked to the transportation of goods to the lagoonal harbor. The city of Venice, due to its location on the island, was protected from enemies and enjoyed direct access to the sea. This privileged location allowed the inhabitants to build an important commercial and maritime city during the Middle Ages. Due to its size, the Venetian Lagoon is not threatened by infilling but, conversely, it is susceptible to tidal-flat erosion, which results in the long-term degradation of the lagoon morphology and its deepening (Carniello, Defina, and D'Alpaos 2009).

5 Conclusion

Earlier in the text, we mentioned another island type, that of "temporary islands." Such settlement types, located near the river or on the flood plain, were sometimes surrounded by water during flood events, giving them a temporary insular nature. These settlements enjoyed a privileged location and direct access to the sea, or were connected to it via river arms, benefiting good harbor conditions (e.g., Avaris, Egypt; Tronchère et al. 2012). In addition, they were located on fertile land, perfect for agriculture, and had a permanent freshwater supply. On the Languedoc coast (southern France), the city of Agathe (Agde), was founded on a rocky hill situated on the shoreline. It seems that the present topography of the area was already in place at the time of the Greek foundation of the city in 525 BCE. Agathe was probably surrounded by water during flood events (Devillers et al. 2015a). This ephemeral island, in a marine-lagoonal context, also raises the issue of the ancient installations of the city of Agathe. The establishment of these attractive lagoonal environments for human societies may have facilitated the foundation of harbor area(s) (Devillers et al. 2015b). The case of Tell Abu Hawam, located in northern Israel, is particularly interesting. The site was an artificial or ephemeral island in the Bronze Age, located at the mouth of the Kishon River, and was probably a port of trade that served merchants on the Syrian-Lebanese coast, Anatolia, the Greek islands, and Cyprus (Artzy 2006). Nevertheless, the tell is a good example of environmental problems linked to its location at the mouth of the Kishon River and Wadi Selman (the paleo-mouth of the Kishon River). This artificial Egyptian-Canaanite "island" reflects the early capacity of human societies to reshape the coastal landscape more than three millennia ago (Balensi 1985, 2000; Aznar, Balensi, and Herrara 2005). On the Nile Delta, the *kom*s ("turtle back" or *gezira*, 'island in Arabic) emerge from the deltaic plain. These landforms are inherited from the incision of the inundation plain during the Last Glacial Maximum (Tristan 2004). These *kom*s afforded protection from the Nile floods. In Lake Maryut these spaces provided attractive areas for predynastic societies and allowed the inhabitants to be free from the seasonal variation of the water body (Flaux 2012).

We have intentionally taken a global and normative approach in seeking to determine the general rules for our typology of insular landscape harbors. Our first results demonstrate the advantage in adopting such an approach in defining the evolution of ancient insular harbors.

The transformation of harbor environments located in different insular contexts highlights the key role of the geomorphological context and marine weather conditions in shaping the evolution of the islands. The island nature of each site is important because the more distant from the shoreline the island is, the less affected it would have been by sediment supply and coastal progradation over the last 6,000 years. This fact inspired a differentiation between oceanic and coastal islands. Considering the small size of the islands studied, the sedimentary budget appears to be another important natural forcing in the transformation of the island environments located close to river mouths. More generally, while small islands and islets are affected mostly by external factors (with the exception of coastal "artificialization"), the bigger islands, with continental characteristics, are also characterized by endogenous variables; because of the presence, for example, of permanent rivers and of shoreline accommodation space. This isolation acted as an advantage with respect to the impact of continental influence.

In ancient times, the stabilization of sea level associated with a high fluvial sediment supply led to the regularization of the coastline because of the infilling of the rias and the landlocking of the islands and archipelagos located near river mouths. By contrast, rocky coasts are characterized by the relative environmental stability of their shorelines (Stanley and Warne 1994; Stewart and Morhange 2009). These ancient fluvial mouths were particu larly attractive because they offered numerous potentialities for agriculture, fishing, and commerce. Rivers, such as the Rhône, were important fluvial paths into the hinterland. Fishing resources, particularly within coastal lagoons, were diversified and the freshwater input required for the development of agriculture and human settlement was constant. However, hyper-sedimentation was difficult to control and the dredging of ancient harbors was mandatory (Morhange and Marriner 2010). Ancient sites located in paleo-ria or gulfs nowadays infilled (e.g., Miletos and Oiniadai) highlight the impact of the base-level sedimentation of harbors, the latter being relocated according to the progradation of the coastline. The major tombolos are also located near important river mouths. In this way, the triple tombolo of Orbetello was formed in part by sediment inputs from the Fiora River to the south and the Albegna River to the north.

For several millennia coastal populations have adapted to environmental pressures and the transformation of the coastline due to the smoothing of the coasts and the infilling of ancient harbors and lagoons (Morhange et al. 2015). Broadly speaking, if islands located in estuarine contexts (ria) are particularly attractive for the installation of harbors in the short term (centennial timescales), such as Miletos or Oiniadai, the maritime islands, linked or not to the continent via a tombolo, can constitute long-term occupation sites, such as at Tyre. Some anthropogenic impacts, such as the construction of artificial causeways, have often modified natural sedimentation processes and entrapment.

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