Marine Resources in Greek Coastal Communities: The Case of Adriatic Pharos

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Original scientific paper

Pharos is one of the oldest Greek colonies on the Croatian part of the eastern Adriatic, founded in the early 4th century BC. From 2021 to 2023, extensive rescue excavations took place in Stari Grad (Pharos), uncovering various sections of the ancient city and yielding a vast array of archaeological discoveries. This paper presents the first results of the archaeomalacological analysis conducted with the aim of enhancing our understanding of the exploitation of marine ecosystems, the significance of molluscs in the local diet, and the marine economy in Late Classical and Hellenistic Pharos. Notably, this marks the first archaeomalacological study conducted on intact layers documented within a Greek city along the Croatian Adriatic coastline[1]. The palaeoecological component of this study encompasses the quantity, distribution, and ecology of the collected species in Pharos and at contemporary sites on the eastern Adriatic coast. Furthermore, taphonomic analysis was employed to investigate the role of molluscs in the diet and the potential implications for Greek culinary practices. Lastly, emphasis was placed on exploring the potential contribution of select collected molluscs to the local economy, particularly within the fishing sector.

In summary, this research sheds new light on the historical dynamics of Pharos, providing insights into the ancient city's relationship with its marine surroundings and the significance of molluscs within its culture and economy. The findings not only contribute to our understanding of Hellenistic Pharos, but also add to the broader knowledge of ancient Greek colonies in the eastern Adriatic region.

KEY WORDS: **ARCHAEOMALACOLOGY, MOLLUSCS, TAPHONOMY, DIET, SEA EXPLOITATION, GREEK, PHAROS, DALMATIA**

1 — To the best of my knowledge, there are currently no other comprehensive archaeomalacological analyses for the same period on the Croatian part of the eastern Adriatic.

INTRODUCTION

Life on islands and coasts has always involved a deep connection with the sea and its unique characteristics. Marine molluscs, as part of the marine ecosystem, have played an important role in Mediterranean societies (Morand 2020). However, the significance of the coastal zone and its resources varies among different societies and should not be overlooked in interpretations. The intertidal zone has provided food and raw material for ornaments and other purposes to these communities (see Szabo et al. 2014; Bar-Yosef Mayer 2016; Allen 2017). Archaeomalacology is no longer a new field of study, but in recent decades there has been increased activity, as shown by the expansion of the variety of methods used to answer research questions (Thomas 2015). The situation is somewhat different in the archaeomalacology of Greek sites along the eastern Adriatic coast, as only a few publications mention molluscs at different levels (Šešelj 2009; Jeličić Radonić 2009; Hernandez, 2017; Paladin et al. 2018; Ugarković 2019; Fiori 2021).

This study aims to shed light on the exploitation of sea by Greek settlers in the city of Pharos, located on the present-day Croatian island of Hvar in central Dalmatia. By examining the significance of marine molluscs in daily life, this research will also make comparisons with coastal communities during the same period. The study is guided by the following research questions:

What strategies were employed by communities in the eastern Adriatic for collecting molluscs and utilizing marine habitats?

What roles did molluscs play in the city of Pharos, especially in terms of culinary practices?

To what extent were molluscs involved in economic activities such as fishing?

Pharos is an immensely valuable monument of Greek presence on the coast of present-day Croatia (Kirigin 2004; Jeličić Radonić, Katić 2015; Popović, Devlahović 2018; Kirigin, Barbarić 2019). Founded in the 4th century BC on a marine route (Kirigin 2004), it serves as a gateway for understanding the relationship between ambitious seafarers and marine resources. Due to its historical and archaeological complexity, Pharos represents an ideal site for investigating various practices of mollusc exploitation. Examining these practices will greatly enhance our understanding of the daily lives of the inhabitants.

ARCHAEOMALACOLOGY OF GREEK SITES ON THE EASTERN ADRIATIC COAST

Remains of molluscs have so far been mentioned only at a few Greek sites on the eastern Adriatic, with even fewer sites undergoing archaeomalacological analysis. Such discoveries have been documented at three sites in central Dalmatia (Croatia), as well as two sites in southern Albania (Fig. 1).

One notable Greek polis on the eastern Adriatic coast is **Issa** (Vis), located on the island of Vis. As expected, numerous specimens of marine malacofauna were unearthed during research activities conducted in the coastal area. An initial examination of the selected marine malacofauna assemblage indicated that these species were easily accessible to the local community (Paladin et al. 2018). However, during the preliminary analysis, the separation of Greek and Roman contexts, as well as the distinction between funerary and residential functions, was not implemented. Consequently, the utility of this data is significantly limited. Another malacofauna assemblage was discovered in the eastern Issa necropolis (Ugarković 2019). The identified species, which are easily available today, were interpreted as having a symbolic role. For instance, crushed sea snails were found covering the bottom of a grave, while remains of marine malacofauna suggested the occurrence of funeral feasts. Moreover, several malacofauna specimens were found near the dead as grave goods. Taken together, these examples imply that marine malacofauna played various roles within the burial customs of Issa (Ugarković 2019: 153).

Another site where molluscs may have had a symbolic role is **Cape Ploča**, where the remains indicated the existence of a Hellenistic sanctuary (Šešelj 2012). This particular site has sparked interest due to the presence of diverse marine gastropod and bivalve species (Šešelj 2009). Although there is some uncertainty regarding the stratigraphy of the contexts in which these molluscs were discovered, this raises the possibility that they may have unintentionally reached the cultural layers. Nevertheless, it is undeniably clear that some of the malacofauna is indeed linked to the Hellenistic sanctuary (Šešelj 2009). The specific statistical representation of individual species is not explicitly provided, which makes it challenging to determine their exact significance. However, Šešelj (2009: 355) points out that the majority of these species are edible and easily accessible, with only two species inhabiting greater depths.

Phoinike (Phoenice) and **Bouthroton** (Butrint), located in present-day Albania, are two ancient sites situated at the border of the Adriatic and Ionian Seas. Both cities existed for several centuries and share the commonality of later constructions destroying the earliest phases (Hernandez 2017; Fiori 2021). When comparing them to Pharos, the areas 5 and C4 from Phoinike were taken into consideration. Area 5 pertains to the Hellenistic stoa district, as well as a small church dating back to the 7th century AD (Fiori, 2021). Archaeomalacological finds are presented together (Fiori 2021), which requires caution when interpreting them. Moreover, the analysis of molluscs only includes the 2021 research season, so the results should be considered preliminary (Fiori 2021). Area C4 consists of the "House of Paintings", a Hellenistic residence dated to the 3rd–2nd centuries BC (Fiori 2021). In both areas, mollusc remains are scarce (A5–NISP: 8, C4–NISP: 6), with the banded dye-murex being the most prevalent taxon in both contexts.

In the city of Bouthroton (Butrint), which spans the time from the Archaic period to the Medieval period (Hernandez 2017; Fiori 2021), a modest archaeomalacological assemblage was unearthed. The malacofauna associated with the Hellenistic period originates from unit 1619 (late 4th–3rd century BC), consisting only of banded dye-murex and European cerith (NISP: 5) (Hernandez 2017). Additionally, area 4 (room 6) presents combined finds from the Hellenistic and Roman periods, exhibiting a greater diversity, albeit still a limited assemblage (NISP: 17) (Fiori 2021: Tab. 2: 166).

It is evident that archaeomalacological research on Greek sites along the eastern Adriatic coast is rather scarce. Out of the few documented mollusc studies, three sites can be classified as settlements, one as a settlement and necropolis, and another as a sanctuary. Locating a comparable site with well-preserved chronologically corresponding layers and with a statistically relevant archaeomalacological assemblage has proven to be a daunting task. This challenge stems from the fact that mollusc remains originate from mixed Hellenistic-Roman contexts (Issa, Phoinike), as well as sites with Hellenistic contexts but a limited number of mollusc remains (Bouthroton). In the absence of settlement-type sites for comparison, we also ventured to consider the sanctuary at Cape Ploča for evaluating species richness among the sites. Nevertheless, it should be acknowledged that this site holds limited comparative significance within the scope of this study.

CASE STUDY: PHAROS

The Greek colony of Pharos, which is now known as Stari Grad, is situated on the northern side of the island of Hvar in central Dalmatia (Fig. 1). This Greek *apoikia* was founded in 385/384 BC by settlers from the Cycladic island of Paros in the Aegean Sea, and stands as an early (if not the earliest) example of urban settlement in Croatia. The city was strategically located at the end of a protected bay near the largest piece of fertile land (*Chora Pharou*) on the island (see Kirigin 2004; Popović, Devlahović 2018; Kirigin, Barbarić 2019). While present-day Stari Grad lies along the coastline, it is hard to define the exact coastal boundaries of Pharos (see Kirigin 2004; Barbir 2014). During its peak in the 4th and 3rd centuries BC, this polis focused on agriculture and had its own ceramic production, a mint, and thriving trade, as evidenced by numerous archaeological discoveries (Kirigin 2004; Jeličić Radonić, Katić 2015). The city fell under Roman rule in the late 3rd century BC (Kirigin 2004).

The site of Pharos, regionally renowned for its architectural and other archaeological finds, has been the subject of only one study pertaining to archaeomalacology. This study focuses on a presumed purple-dye workshop[2] (Jeličić-Radonić 2009; Jeličić Radonić, Katić 2015). Within the Greek insula, which predates the mid-4th century BC, excavations revealed a cultural layer covering almost the entire surface of a room. This layer consists of numerous crushed marine gastropods and is situated above the floor of the Greek insula. The authors (Jeličić-Radonić 2009; Jeličić Radonić, Katić 2015) interpreted this context as a purple-dye workshop, likely established in the latter half of the 4th century BC. The layer, composed of crushed marine gastropods mixed with soil, reaches a thickness of approximately 20–25 cm. Despite significant fragmentation, the presence of species associated with purple-dye production, specifically the banded dye-murex (*Hexaplex*

2 —— The authors mention the use of molluscs for road leveling (Jeličić Radonić, Katić 2015). This practice has also been recorded in recent rescue excavations in Stari Grad. However, future studies will delve deeper into the use of molluscs in construction, exploring it more extensively.

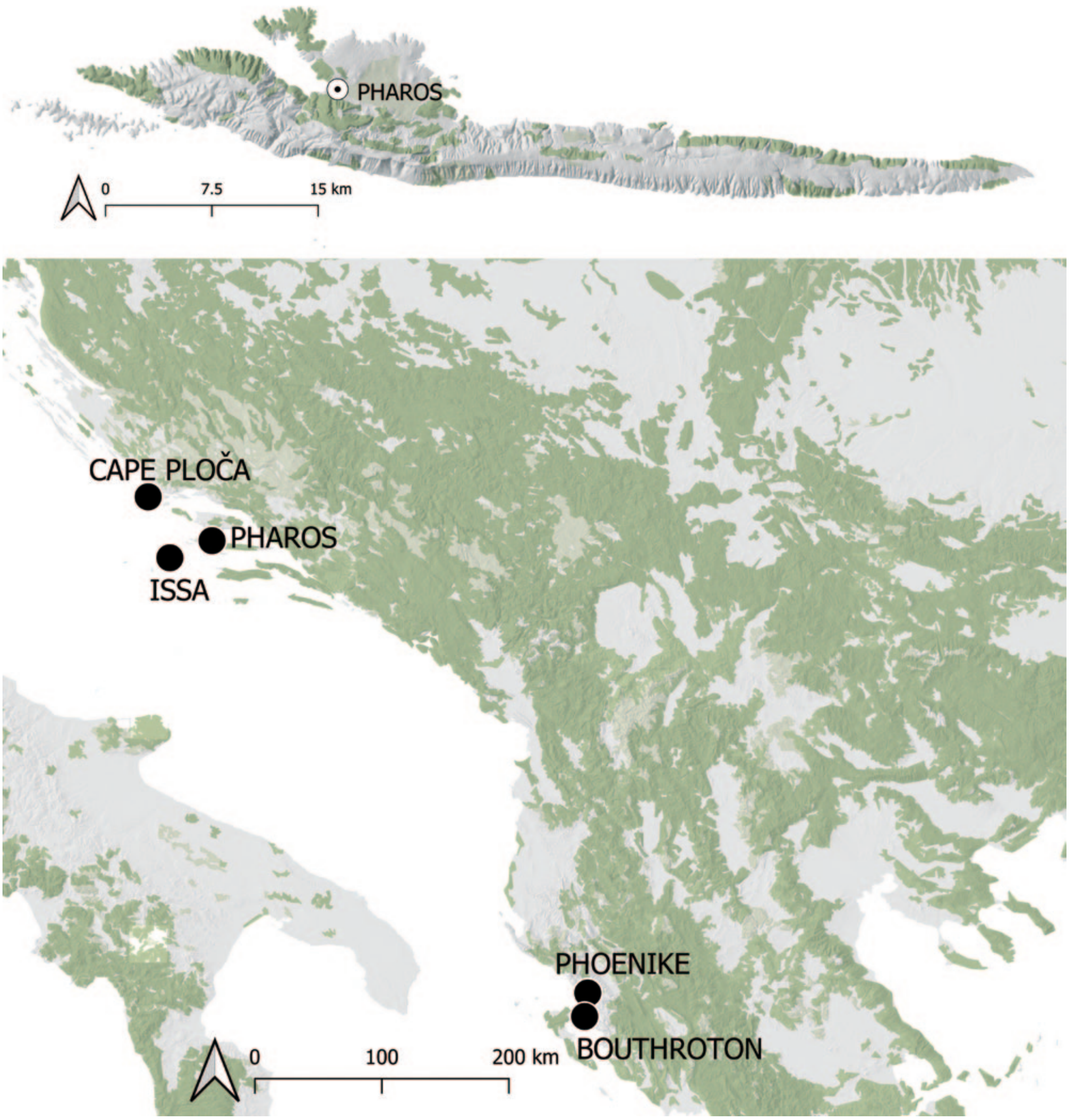

Fig. 1 — Map of Pharos and the mentioned Greek sites on the eastern Adriatic (base: QGIS version 3.22; computer processing: A. Barbir)

trunculus) and purple-dye murex (*Bolinus brandaris*), has been confirmed. The authors have identified the workshop based on the discovery of several polished pebbles exhibiting impact marks, which are interpreted as hand grinders used for extracting secretions from the gastropods (Jeličić-Radonić 2009; Jeličić Radonić, Katić 2015). As purple-dye production typically requires specific structures such as pools and drainage channels (Marín-Aguilera et al. 2018 and its literature), Jeličić Radonić and Katić (2015) note that such infrastructure has not yet been uncovered due to subsequent architectural constructions on the site.

MATERIAL AND METHODS

The subject of this study pertains to molluscs collected from Greek contexts, excluding from the analysis possible intrusions from later layers.

The archaeomalacological remains examined here have been gathered during the ongoing rescue archaeological excavations in the heart of Stari Grad (Pharos) that started in 2021. Given that the excavations are still in progress (as of the end of 2023) and the contexts under analysis are subject to ongoing scrutiny without a finalized interpretation, this study primarily focuses on the archaeomalacological analysis of contexts tentatively assigned to the Late Classical and Hellenistic periods of the city. Consequently, it is important to acknowledge that this analysis does not encompass the entirety of the collected malacofauna and should thus be regarded as preliminary in nature. For all instances, the analyzed contexts are tentatively interpreted as either streets or residential structures. The majority (74%) of the examined remains originate from the rescue excavations undertaken in the first half of 2023, while a smaller proportion (26%) stems from 2021.

The sampling methodology employed in this study entailed handpicking material from the trench. In certain instances, wet sieving techniques were additionally employed, utilizing screens with mesh sizes of 3 mm, 1 mm, and 0.3 mm. Prior to analysis, the collected material was subjected to initial preparatory measures which encompassed manual pre-sorting, weighing, and contextual data labelling.

Meticulous processing procedures were carried out on the molluscan specimens, with careful documentation of relevant data in an Excel database, that took into consideration the archaeological context, biological and ecological information, and taphonomic characteristics. Taxonomical determination was conducted by using personal reference collections and relevant references (Giannuzzi-Savelli et al. 1997; 1999; 2001; 2003). In cases where specimens exhibited noticeable damage, taxonomic determination was limited to the genus level. The taxonomic representation of the malacofaunal assemblage is expressed through the number of remains (NR) and the minimum number of individuals (MNI). The calculation of MNI was based on the anatomical elements specific to molluscs, employing the umbo for bivalves and the apices for marine gastropods.

Taphonomic changes were recorded after Claassen (1998). During the taphonomic analysis, special attention is devoted to traces of bioerosion. The primary objective behind the investigation of predator traces on molluscs was to ascertain whether the specimens were collected post-mortem. Additionally, meticulous examination of anthropic modifications, such as perforations and working marks, as well as traces of burning, aimed to enlighten us regarding human manipulation of these animals. In order to gather reliable information on the distribution and ecological preferences of marine molluscs, various references were consulted, including the works of Poppe and Goto (1991; 1993) and Peharda Uljević et al. (2022). Scientific names were updated according to the World Register of Marine Species (https://www.marinespecies.org). Coastal littoral zones were defined after Bakran-Petricioli (2007).

RESULTS

Taxonomic determination

During the rescue archaeological excavations, a total of 172 remains of mollusc shells (in terms of NR) were analyzed from Greek layers, corresponding to 155 individuals (in terms of MNI) (Tab. 1). The total weight of the analyzed assemblage of archaeomalacological finds is 3,5 kg. Out of the total number of molluscs, the majority belong to marine gastropods (62,6% in terms of %MNI), while bivalves constitute a significantly smaller proportion (37,4% in terms of %MNI).

A total of 19 species and one genus were identified. Among them, eight species and one genus belong to Bivalvia, while 11 species belong to Gastropoda. Among the bivalves, only two species stand out, collectively accounting for 71% of the total number of bivalve individuals (in terms of %MNI), namely the thorny oyster (*Spondylus gaederopus*) and the Mediterranean mussel (*Mytilus galloprovincialis*). Other bivalve species are poorly represented, with a slightly higher proportion of the edible oyster (*Ostrea edulis*).

Among marine gastropods, limpets stand out, particularly the species *Patella caerulea* (20,6% in terms of %MNI), followed by the European cerith (*Cerithium vulgatum*) (12,9% in terms of %MNI), and the banded dye-murex (*Hexaplex trunculus*) (10,3% in terms of %MNI). Other gastropod species have a representation below 5% in terms of %MNI. All the determined species of bivalves and gastropods are edible.

Taphonomic analysis

The deposition of mollusc shells underground has resulted in the dissolution of the shells of all the collected molluscs. Specifically, the analyzed

TAXA	NR	%NR	MNI	%MNI
BIVALVIA	**63**	**36.6**	**53**	**34.2**
Arca noae	2	1.2	2	1.3
Cerastoderma glaucum	2	1.2	2	1.3
Glycymeris sp.	2	1.2	2	1.3
Mytilus galloprovincialis	19	11.0	16	10.3
Ostrea edulis	7	4.1	6	3.9
Pecten jacobaeus	1	0.6	1	0.6
Pinna nobilis	2	1.2	2	1.3
Spondylus gaederopus	28	16.3	22	14.2
GASTROPODA	**109**	**63.4**	**100**	**65.8**
Bolinus brandaris	5	2.9	5	3.2
Bolma rugosa	7	4.1	7	4.5
Cerithium vulgatum	20	11.6	20	12.9
cf. *Tonna galea*	1	0.6	1	0.6
Hexaplex trunculus	23	13.4	16	10.3
Patella caerulea	32	18.6	32	20.6
Patella rustica	7	4.1	7	4.5
Patella ulyssiponensis	3	1.7	3	1.9
Phorcus articulatus	4	2.3	4	2.6
Phorcus mutabilis	1	0.6	1	0.6
Phorcus turbinatus	6	3.5	6	3.9
TOTAL	**172**	**100.0**	**155**	**100.0**

Table 1 — Taxonomic representation of species identified in Hellenistic layers in Pharos with the number of remains (NR), the relative number of remains (%NR), the minimum number of individuals (MNI), and the relative minimum number of individuals (%MNI) (made by: A. Barbir)

specimens were collected from *terra rossa*, mostly mildly acidic soil in which calcium carbonate ($CaCO_3$), the basic building element of molluscs, deteriorates. The dissolution of the shell can vary from colour loss to chalky surface of the shell, ultimately thinning it and promoting fragmentation (Claassen 1998: 60). In some cases, taphonomic modifications began even before the animals were collected from the sea. The focus here lies on bioerosion, abrasion, and encrustation.

Predator attacks leave bioerosive traces on the inner side of the operculum suggesting that most of the attacked molluscs did not survive the attack and that their shells were later collected empty. Traces of bioerosion (Tab. 2) were found on a total of 11% of the analyzed remains, with a slightly higher occurrence for bivalves (7.0%) compared to gastropods (4.1%). Bioerosion traces were recorded for the bivalves *A. noae* (1.2%), *O. edulis* (1.7 %), and *S. gaederopus* (4.1%). Bioerosion traces on gastropods were only observed for *C. vulgatum* (1.7%), *H. trunculus* (1.2%), *B. brandaris* (0.6%), and *P. caerulea* (0.6%).

Abrasion traces were recorded only on one specimen of the bivalve *Glycymeris* sp., indicating that this bivalve was collected from the intertidal zone, where the strong influence of waves on the shell caused the formation of abrasive marks.

Encrustation occurs on mollusc shells due to the presence of other organisms on their surface. Encrustation is much more common in bivalves, and this is also the case in Pharos. While encrustation is present in only one example of a limpet (0.6%), it is more prevalent in bivalves (5.2%). Traces are the most common on the shells of *S. gaederopus* (3.5%), followed by *O. edulis* (1.2%), and *M. galloprovincialis* (0.6%). It is assumed that all the individuals were alive when captured. The traces of encrustation do not coincide with the traces of bioerosion on the same individuals.

Anthropic activity is the most common taphonomic modification, accounting for 27.9%. This type of modification is more frequently observed among gastropods (17.4%) than among bivalves (10.5%). Modifications are most common for *S. gaederopus* (9.3%) and *P. caerulea* (8.7%). Traces indicating anthropic activities vary in terms of the types of activities and the species on which they are observed.

The results of the taphonomic analysis suggest that a smaller proportion of the analyzed mollusc samples was collected after the animal's death, and the most prevalent taphonomic modification was attributed to human activity. Nevertheless,

TAXA	NR	Bioerosion (%NR)	Encrustation (%NR)	Anthropic activity (%NR)
BIVALVIA	**63**	**7.0**	**5.2**	**10.5**
Arca noae	2	1.2	0.0	0.0
Cerastoderma glaucum	2	0.0	0.0	0.0
Glycymeris sp.	2	0.0	0.0	0.0
Mytilus galloprovincialis	19	0.0	0.6	0.0
Ostrea edulis	7	1.7	1.2	1.2
Pecten jacobaeus	1	0.0	0.0	0.0
Pinna nobilis	2	0.0	0.0	0.0
Spondylus gaederopus	28	4.1	3.5	9.3
GASTROPODA	**109**	**4.1**	**0.6**	**17.4**
Bolinus brandaris	4	0.6	0.0	1.2
Bolma rugosa	7	0.0	0.0	0.0
Cerithium vulgatum	20	1.7	0.0	3.5
cf. *Tonna galea*	1	0.0	0.0	0.0
Hexaplex trunculus	23	1.2	0.0	2.3
Patella caerulea	32	0.6	0.6	8.7
Patella rustica	7	0.0	0.0	1.2
Patella ulyssiponensis	3	0.0	0.0	0.6
Phorcus articulatus	4	0.0	0.0	0.0
Phorcus mutabilis	1	0.0	0.0	0.0
Phorcus turbinatus	6	0.0	0.0	0.0
TOTAL	**172**	**11.0**	**5.8**	**27.9**

Table 2 — The representation of taphonomic modifications in the archaeomalacological assemblage from Pharos, expressed as the relative representation of the number of remains (%NR) (made by: A. Barbir)

less than one third of the analyzed remains showed traces of anthropic activities, and the reasons for this lie, at least partially, in the higher degree of fragmentation due to the characteristics of the sediment in which they were found.

Mollusc habitat

Considering the habitat of the marine molluscs found in Pharos, it is evident that island communities mostly exploited the infralittoral zone (Fig. 2). Specifically, this zone contributes the highest number of collected species (NTAXA: 11), as well as the highest minimum number of individuals (MNI: 66). The taxa inhabiting this zone include the bivalves *Arca noae*, *Cerastoderma glaucum*, *Glycymeris* sp., *Mytilus galloprovincialis*, *Ostrea edulis*, *Pinna nobilis*, and *Spondylus gaederopus*. The identified gastropods inhabiting the infralittoral zone are *Bolinus brandaris*, *Bolma rugosa*, and *Tonna galea*.

The tidal, mediolittoral zone ranks second in terms of species richness (NTAXA: 6) and the minimum number of individuals (MNI: 53). The determined taxa from Pharos, characteristic of this zone, are exclusively gastropods, such as species from the genus *Patella* and *Phorcus*.

Due to the extreme conditions characterized by intensive temperature changes, humidity, salinity, and wave impacts in the mediolittoral, certain taxa migrate between the mediolitteral and infralittoral zones, feeding in the mediolittoral during high tide and retreating to the infralittoral during low tide (Bakran-Petricioli 2007). This category is the least represented in the archaeomalacological assemblage from Pharos in terms of biodiversity (NTAXA: 2) and number of individuals (MNI: 36). The gastropod species *H. trunculus* and *C. vulgatum* are present in this category.

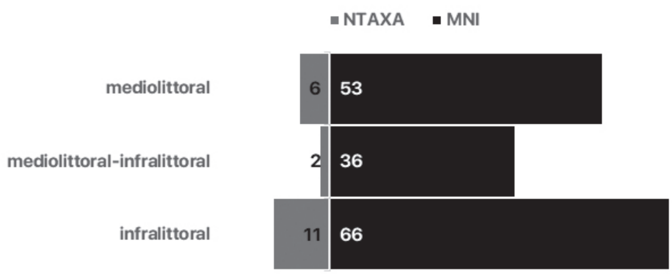

Fig. 2 — Representation of the number of species (NTAXA) and the minimum number of individuals (MNI) in marine habitats – the littoral zone (made by: A. Barbir)

DISCUSSION

Molluscs gathering strategies on the eastern Adriatic

The coast of the island of Hvar exhibits typical Dalmatian-type coast, with a characteristic corrosion-abrasive micro-relief consisting of scarps, small depressions, rocky features and similar (Bognar 1990). Most of the coast in central Dalmatia shares similar characteristics. This type of relief provides an ideal habitat for gastropods inhabiting the mediolittoral, such as limpets, top-snails, and European cerith. These species would be gathered along the coast at the low tide. At the transition from the mediolittoral to the infralittoral zone, seagrass meadows (e.g. *Posidonia oceanica*) often occur (Bakran-Petricioli 2007), harbouring various bivalves such as the spiny oyster, as well as gastropods like the banded dye-murex and purple dye-murex. Oysters and mussels tend to develop colonies on harder substrates. Additionally, these are the most common species found at Hellenistic sites in Dalmatia (Tab. 3).

On the other hand, the Albanian coast has a slightly different relief. The Albanian coast is a low-type coast, characterized by large sandy beaches, river deltas, lagoons, and similar features (Doka, Qiriazi 2022: 68). Bivalves are somewhat more common in Albanian sites, especially those that prefer the influx of sweet water in a marine environment, such as the spiny oyster, edible oyster, mussels, and those that prefer a softer substrate, such as the Venus clam, common cockle, and bittersweet clam. Gastropods are less represented, but species such as the purple dye-murex, banded dye-murex, European cerith, limpet, top-snail, and spotted pisania can be found (Tab. 3).

The Dalmatian sites show a slightly higher species diversity, with Issa being the most diverse (NTAXA: 23), followed by Cape Ploča (NTAXA: 21), and Pharos (NTAXA: 19). The diversity in the Albanian sites is slightly lower, with Bouthrotos having a higher diversity of bivalves (NTAXA: 11) compared to Phoinike (NTAXA: 4). When interpreting the results, the consolidation of Greek and Roman archaeomalacological assemblages should be considered in the case of Issa, so the number of species for Issa should be treated with caution, as well as for Phoinike.

None of the mentioned sites have a dominant species, which indicates a lack of specialization in collecting for food or any other activities. Ultimately, we can see similarities between the species exploited by (mostly) Greek communities and their adaptation to different types of coastlines in the eastern Adriatic.

SITES		**Pharos**	**Issa**	**cape Ploča**	**Phoinike**	**Bouthroton**
TYPE OF SITE		settlement	settlement, necropolis	sanctuary	settlement	settlement
Taxa	**Common name**					
Bivalvia						
Acanthocardia tuberculata	tuberculate cockle		+	+		
Arca noae	Noah's ark	+	+			
Atrina fragilis	fan mussel		+			
Cardiidae	cockle			+		
Cerastoderma glaucum	lagoon cockle	+	+			
Cerastoderma sp.	cockle					+
Flexopecten glaber	smooth scallop		+			
Glycymeris pilosa	pilose bittersweet		+	+		
Glycymeris sp.	bittersweet clams	+	+		+	
Lima lima	spiny fileclam			+		

Modiolus barbatus	the bearded horse mussel		+			
Mytilus galloprovincialis	Mediterranean mussel	+	+	+		
Mytilus sp.	mussel					+
Ostrea edulis	flat oyster	+				+
Ostrea sentina	crested oyster			+		
Pecten jacobaeus	Mediterranean scallop	+	+	+		
Pinna nobilis	noble pen shell	+	+			
Ruditapes decussatus	chequered carpet shell		+			
Spondylus gaederopus	spiny oyster	+	+	+	+	+
Veneridae	venus clams				+	+
Gastropoda						
Bolinus brandaris	spiny dye-murex	+	+	+		+
Bolma rugosa	spiny topsnailrough	+		+		
Cerithium alucastrum	spicate cerith		+	+		
Cerithium sp.	cerith		+	+		
Cerithium vuglatum	European cerith	+				+
cf. *Tonna galea*	giant tun			+		
Columbella rustica	dove shell	+				
Gibbula magus	the great top shell			+		
Hexplex trunculus	banded dye-murex	+	+	+	+	+
Mitra zonata	zoned mitre			+		
Naria spurca	dirty cowry		+			
Patella aspera	Azorean limpet		+			
Patella caerulea	Mediterranean limpet	+	+	+		
Patella rustica	Lusitanian limpet	+	+			
Patella sp.	limpet	+		+		
Patella ulyssipoensis	rough limpet			+		
Patella vulgata	common limpet					+
Phorcus articulatus	articulate monodont	+				
Phorcus mutabilis	mutable monodont	+	+	+		
Phorcus sp.	top-snail	+				
Phorcus turbinatus	turbinate monodont					+
Pisania striata	spotted pisania					+
Steromphala divaricata	divaricate gibbula			+		
Trochidae	top-snail		+			
References	Palomares, Pauly 2023	this paper	Paladin et al. 2018; Ugarković 2019	Šešelj 2009	Fiori 2021	Hernandez 2017; Fiori 2021

Table 3 — Presence of mollusc taxa on the Greek sites on the eastern Adriatic (made by: A. Barbir)

Molluscs in local cuisine

Classical works of Greek antiquity play a significant role in understanding the relationship between coastal Greek populations and marine food resources, particularly regarding marine molluscs. Marine molluscs were highly regarded as a food of high social status and were believed to have health-promoting properties (Voultsiadou, Vafidis 2007; Voultsiadou et al. 2010). The question arises regarding the role of molluscs in the diet of Greek colonies on the eastern Adriatic coast, particularly in Pharos.

Mollusc remains in Greek urban settlements along the eastern Adriatic coast, such as Issa (Paladin et al. 2018), Phoinike (Fiori 2021) and Bouthroton (Hernandez 2017; Fiori 2021), have primarily been interpreted as evidence of local population's dietary practices. Although the presence of edible species of marine molluscs can be considered as an indicator of diet, the taphonomic analysis is crucial for interpreting the mollusc remains in Pharos. While no modifications suggesting thermal processing (involving the use of fire) were found in the analyzed assemblage, attention was given to traces indicating intentional gathering and forced opening of shellfish.

The characteristic defence strategy of shellfish is to close their shell when they sense danger. By closing their shells, shellfish protect themselves from predators, including humans (Guderley, Tremblay 2016). When collecting shellfish, a closed shell typically indicated that the specimen is safe for consumption, while an open shell signals a diseased individual with the shell opening/closing reflex not functional. Soft tissues of the animal can be accessed for eating purposes through thermal processing (grilling, boiling), during which the reflex weakens after the animal's death, and the shell opens. If no thermal processing is used in meal preparation, shellfish can be consumed raw. When consuming raw meat or extracting meat before thermal processing, it is necessary to open the shell forcibly, leaving traces on shells. Fractures are typically U-shaped, most commonly on the ventral side, resulting from the insertion of a blade between two valves (Gruet 1993; Dupont 2010). Such damage has been recorded on oysters (*O. edulis*), and more frequently on spiny oysters (*S. gaederopus*) (Fig. 3).

As described by Galen, oysters were highly valued and in high demand due to their exceptionally tender meat. They were mostly consumed fresh, although others preferred them fried. The method of preparation also had implications for health (Voultsiadou et al. 2010). Apicius mentions popular recipes in Roman gastronomy that utilized flat oysters and spiny oysters, such as Baian stew (*Embractum Baianum*) (Carannante et al. 2014). Interestingly, the spiny oyster, which is abundant in Pharos and present in all the previously mentioned Greek sites in the eastern Adriatic, is not documented in classical Greek literature as part of the diet (Voultsiadous et al. 2010). Nonetheless, traces of forced shell opening attest to anthropic activities of meat extraction. Its potential use as a food source may indicate the dietary adaptation of Greek settlers in the Adriatic region.

Evidence of intentional gathering has been recorded for limpets, primarily *P. caerulea*, and, to a lesser extent, *P. rustica* and *P. ulyssiponensis* (Tab. 2). Limpets secure themselves on a rocky surface and carve out scars that match their shape, thus preventing dehydration during low tide and protecting themselves from predators (Crothers 2012). Due to their positioning, it is necessary to use a sharp, slender object to enter beneath the gastropod shell and lift it off the surface. This action results in damage to the shell edges. Sometimes the limpet is deeply embedded in its home scar, requiring it to be struck with a sharp object along the edge to release water before lifting it from the surface. Marginal damage (Fig. 3) has been found on Pharos' limpets, indicating this practice and their potential utilization as a food source. Limpets were part of the Greek cuisine (Lovano 2020), although there are many unknowns regarding their role in gastronomy, as Firth (2021) emphasizes, as they are often associated with starvation and survival, earning nicknames such as "famine food" or "poor food". On the other hand, the inclusion of limpets in the Greek cuisine is suggested by Aristophanes, who coined the term for a recipe that includes limpets, translated as (see Firth 2021 and the references cited therein):

"Limpets, oysters, salt fish,
And a skate too a dish,
Lampreys, with the remains
Of sharp sauce and birds' brains,
With honey so luscious,
Plump blackbirds and thrushes,
Cocks' combs and ring doves,
Which each epicure loves,
Also wood-pigeons blue,
With juicy snipes too,
And to close all, O rare!
The wings of jugged hare!"

Although we cannot assert with certainty that this dish was also prepared in Pharos, taphonomic modifications and the continuous representation of these gastropods support the idea that they were to some extent part of the local diet.

In case of spiral gastropods, extracting the meat is slightly more challenging, which is why they are often boiled before meat extraction. However, during the extraction process after boiling, shell damage can occur, albeit significantly less than if the individual was not boiled before meat extraction. Such damage is mainly found near the shell mouth and is present in very few individuals of the species *B. brandaris*, *H. trunculus*, and *C. vulgatum* (Tab. 2). A similar practice is suggested by Carannante et al. (2022) for *Murex* gastropods found in Hellenistic Berenike on the Red Sea in Egypt.

Fig. 3 — Anthropic modifications on spiny oyster *Spondylus gaederopus* (first row – left valve, second row – right valve) and on limpets Patella sp. (photo by: M. Korić)

Although there are no strong indicators such as taphonomic modifications, the possibility that other species were used in the cuisine of Greek Pharos should not be excluded. For example, mussels, which are currently one of the most exploited species for economic purposes, are also present in Greek written sources. Apparently, mussels did not appeal to everyone gastronomically. Athenaeus states that mussels are delicious food, but Xenocrates believed that they were too salty and that their taste needed to be enhanced with spices (Voultsiadou et al. 2020). Scallops (such as the Mediterranean scallop) were also highly valued as delicacies. Another delicacy is the noble pen shell (*P. nobilis*), where Xenocrates distinguishes individuals of smaller and medium sizes as having tastier and softer meat (Voultsiadou et al. 2010).

There is no doubt that a portion of the examined mollusc remains can be classified as food waste. However, the intriguing question arises as to whether marine molluscs were exclusively gathered for local gastronomic purposes or if, more likely, the archaeomalacological narrative portrays a more intricate scenario.

Molluscs as indicator of fishing activity

The Greeks, particularly those residing in coastal regions, held the art of fishing in high regard, much like other revered crafts. This sentiment was evident in the presence of professional fishermen (known as *halieis, aspalieis*) who supplied local communities with marine products. Alongside various fish species, certain molluscs, especially marine gastropods, were also part of their fishing practices (Lovano 2020). While fishing tools and techniques varied (Theodoropoulou 2011), this article will focus on the tools discovered in Pharos and the corresponding fishing techniques. The primary fishing tools employed were handheld hook and line (*aspalieutike*), with bait consisting of other fish, insects, feathers, as well as marine molluscs (Lovano 2020). The ensuing discussion will delve into the role of molluscs as both bait and intentional and/or unintentional catch during fishing.

In traditional fishing practices, the use of gastropods and bivalves as bait is well recognized (Milišić 1991; Bulić 2021; Duvančić 2021; 2022), with some fishermen showing a preference for their use (Bulić 2021; Duvančić 2021; 2022). However, there are differing opinions regarding the willingness of fish to consume gastropods due to their tough meat (Duvančić 2021; 2022). As noted by Lovano (2020), gastropods were historically used as bait by coastal populations in Greece, suggesting that some of the collected malacofauna from Pharos may have served this purpose. Evidence of fishing tools, specifically four bronze hooks, further implies fishing activity in the proximity of Pharos (Jeličić-Radonić 1996: 68). These findings point toward the practice of handline fishing. In this technique, a baited hook is cast to a specific location in the water, and the fishing line is then pulled to retrieve the hooked fish. Various materials can be used for the fishing line, which is typically connected to a hook with bait at one end. Anglers employing this technique have the flexibility to position the bait at varying depths or distances from the shore, depending on their preferences and the targeted fish species. The city of Pharos has yielded a range of mollusc taxa suitable for handline fishing, primarily intertidal gastropods like top-snails, limpets, spiny topsnailrough, spiny dye-murex, banded dye-murex, as well as infralittoral bivalves such as Noah's ark, bittersweet lams, lagoon cockle, Mediterranean mussel, and noble pen shell.

The molluscs found at the site may have been caught intentionally or unintentionally during fishing activities. Voultsiadou et al. (2010) discuss Aristotle's observations on scallops, where he noted their decline in Kaloni Bay due to excessive fishing. Fishermen in the area used a tool that scraped the seafloor, causing damage to scallop populations. Aristotle also mentioned that scallops had a tendency to escape by jumping out of the tool. In his work "History of Animals", Aristotle references the use of European cerith shells as bait for hunting muricids. These shells often housed hermit crabs and were used in *porphyra* workshops (Voultsiadou, Vafidis 2007).

While earlier studies suggested the presence of a purple dye workshop in Pharos (Jeličić Radonić 2009; Jeličić Radonić, Katić 2015), as well as the abundance of European cerith and banded dye-murex gastropods in the analyzed assemblage, the scarcity of finds and the lack of taphonomic modifications do not support the idea that European cerith was extensively used for hunting muricids or for the *porphyra* workshop in Pharos. However, evidence from the Roman site of Polentia (Mallorca) presented by Oliver (2015) shows intentional hunting of muricids and the use of European cerith as bait. Based on taphonomic indicators and the high frequency of drilled shells, including unfinished predator drilling, it was assumed that *C. vulgatum* individuals were intentionally exposed to predators *H. trunculus*, thus intentionally used as bait in the muricid gathering activity (Oliver 2015).

On the other hand, larger sea snails, such as muricids, could have been caught in nets during fishing (Duvančić 2022), making their way onto the tables of Greek settlers in Pharos and elsewhere.

CONCLUSION

During the extensive rescue excavation conducted in Pharos, mollusc remains were collected and subjected to analysis; this study presents the preliminary findings. Despite the limited sample size, the archaeomalacological analysis from this Greek city and the intact layers are a novelty for the eastern Adriatic coast of present-day Croatia. This study provides a more profound understanding of the role these animals played during the Late Classical and Hellenistic periods in Pharos. It also sheds new light on the daily life of the inhabitants and redefines the relationship between the local population and marine ecosystems.

Comparing these finds with contemporary Greek colonies in the eastern Adriatic region reveals a clear pattern of intertidal resource exploitation across all sites. It demonstrates the adaptive nature of the colonizers, considering the unique characteristics of the micro-locations within the Greek sites along the eastern Adriatic coast. The presence of fishing tools in Pharos, along with the ecological characteristics of certain mollusc species, suggests their usage as bait for fish and other molluscs in fishing activities. However, it is still uncertain if molluscs were used in fishing on an occasional or semi-professional basis.

The taphonomic analysis has proven to be particularly valuable in identifying remains that provide evidence of anthropic activities. Based on this analysis, we conclude that at least some of the analyzed molluscs were consumed as a food source. However, they likely played a supplementary rather than central role in the local cuisine.

Ultimately, the archaeomalacological analysis of molluscs from Greek sites along the eastern Adriatic coast enhances our understanding of the culture, diet, economy, and ecological conditions of Greek colonists in this region. This research raises the question of how a comprehensive analysis of all the mollusc remains collected from the Greek city of Pharos, as well as an archaeomalacological analysis of other Greek sites along the Adriatic coast, will reshape our understanding and expand our knowledge on this subject.

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