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4. Anhang

TO THE SHORE, BACK AND AGAIN
ARCHAEOMALACOLOGY OF TROİA

Canan Çakırlar

Abstract

The subject matter of this paper is shellfish gathering activity at Troia; what was gathered, how and where; what the role of shellfish gathering was in the economy and diet of the settlement, how this role changed through time, and why. A great resource of over 54,000 archaeomalacological specimens is available to answer these questions. This is the largest archaeomalacological assemblage from the Aegean. All quantitative evidence derives from the results of the new excavations at Troia through the 2005 season. The stratigraphical situation and taphonomy of the mollusk remains, the ecology of the represented species, and ethno-historical and ethnographic analogies have all been instrumental in building a firm and detailed description of the shellfish gathering activity at this habitation site. The first line of argument is based on the changing proportion of molluscan remains in the overall faunal assemblage of Troia throughout its occupational history. Accordingly, shellfish gathering activity appears to have gone through a slow decline from the Early Bronze Age to the Byzantine Period at Troia. The second is based on the changes in the molluscan species spectrum for different time periods in the settlement. *Cerastoderma glaucum* (lagoon cockle) prevails as the most important species throughout the Bronze Age. In Roman and Byzantine times, *O. edulis* (European oyster) becomes the preferred mollusk species. The deltaic lagoons of Karamenderes and Dümrek, and the marine embayment of Troia remain as the most exploited shellfishing grounds throughout Troia's occupational history. Almost all shellfish could have been gathered in shallow coastal or lagoonal waters without specialized technology. A variety of factors may have affected shellfish gathering at Troia: the changing position of the coastline, the evolving substratum of the marine embayment and its diminishing volume and area, climatic changes, and cultural and economic preferences.

Zusammenfassung

Das Thema dieses Artikels ist das Sammeln von Schalentieren in Troia; was wurde gesammelt, wie und wo; welche Rolle spielten die Schalentiere im Wirtschaftssystem und der Ernährung der Siedlung; wie und warum änderte sich diese Situation mit der Zeit. Eine große Menge von über 54.000 archäomalacologischen Relikten steht zur Beantwortung dieser Fragen zur Verfügung. Das ist die größte archäomalacologische Sammlung im ägäischen Raum. Alle quantitativen Ergebnisse stammen aus den neuen Ausgrabungen bis zur Saison 2005 in Troia. Die stratigraphische Situation und die Taphonomie der Schalenrückstände, die Ökologie der Sorten sowohl als auch ethno-historische und ethnographische Analogien wurden benutzt bei der Erstellung einer stabilen und detaillierten Beschreibung der Sammelaktivitäten in dieser Siedlung. Die primäre Argumentationslinie basiert auf der wechselnden Zahl der Schalentierrückstände in der allgemeinen Menge der tierischen Rückstände Troias während seiner gesamten Siedlungsgeschichte. Es scheint, dass die Schalentiersammelaktivität in Troia von der Frühen Bronzezeit bis zur byzantinischen Periode langsam zurückgegangen ist. Die sekundäre Argumentationslinie basiert auf den Änderungen in dem Mollusken-Spektrum während verschiedener Perioden in der Siedlung. *Cerastoderma glaucum* (Lagunenherzmuschel) ist die vorherrschende Sorte während der gesamten Bronzezeit. In der römischen und der byzantinischen Zeit wird die *O. edulis* (Europäische Auster) die bevorzugte Schalentiersorte. Die Delta-Lagunen des Karamenderes und des Dümrek und die Meeresbucht von Troia bleiben die am meisten ausgebeuteten Schalentiergründe während der ganzen Siedlungsgeschichte Troias. Nahezu alle Schalentiere konnten in seichten Küsten- oder Lagunengewässern gefangen werden ohne besondere Ausrüstung. Eine Vielzahl von Faktoren könnte das Sammeln von Schalentieren in Troia beeinflusst haben: der veränderte Küstenverlauf, die zunehmende Versandung der Meeresbucht und ihre Verkleinerung, klimatische Veränderungen und kulturelle und ökonomische Gewohnheiten.

Introduction

Shell remains* represent the most tangible evidence for shellfish related economic activities at ancient settlements.[1] Like all archaeological settlements along the eastern Mediterranean coastline, Troia is a "shell-bearing habitation site."[2] After ceramic remains and animal bones, remains of shelled aquatic mollusks constitute the largest find category from the site. It is therefore surprising that so little has been written about shellfish gathering at Troia.[3] The present study aims to fill this lacuna in our understanding of animal exploitation and adaptive strategies at the settlement, based on the quantitative taxonomic study of the mollusk remains from the recent Tübingen excavations at the site.[4] Although Homer refers to invertebrates only once (*Iliad* XVI, 745–748), and rather ambiguously, the discoveries from the excavations at Troia present a completely different picture.

Material and Methods

The archaeomalacological material discussed in this paper comes from cultural deposits at the settlement proper of Troia, where excavations have been ongoing since 1988. Mollusk remains were mostly located in soil matrices mixed with animal bones, ceramics, and small finds, and they were always associated with architectural remains and associated fill layers. Usually, when archaeomalacological material is the subject of a paper, it is considered unnecessary to provide such general archeological information as that listed above, because the cultural context, i. e., its direct association with past human activity, is accepted as a quality intrinsic to the nature of this biological material. Nevertheless, there is a tendency among some geologists to advocate an imaginary link between the shell-bearing cultural contexts of the site and those natural deposits created by the effects of ancient tsunamis. Therefore, I would like to emphasize that the present paper deals not with biological material from natural deposits, which occur abundantly in the geological deposits of the Troad and have been partially investigated by geomorphologists and hydrogeologists of the Troia Project, but with the shell remains of aquatic mollusks relocated by the human inhabitants of Troia for economic and social purposes. Although I will not go into any further detail about the specifics of the archaeological contexts of the mollusk material I will be discussing in the following pages, it is well known to the interested reader that a large corpus of academic literature is available on the archaeology of Troia, referring also to mollusk remains on occasion.

I should add two related points of argument to complete this discussion. The site of Troia is located ca. 30–40 m above the present sea level, not on a coastal plain but on a ridge – at an elevation significantly higher than any tsunami that may have possibly affected the southern end of the Dardanelles and the Holocene extent of the Karamenderes and the Dümrek embayment. In addition, in order even to raise the question of an ancient tsunami affecting a site, multiple types of geological signatures are necessary along with the presence of mollusk remains at a settlement, all indicating the same single catastrophic event.[5]

The aquatic mollusk remains at Troia constitute a ubiquitous component of the archaeozoological remains from the settlement. They occur in all types of deposits throughout the occupational history of the site, from the Early Bronze Age to the Byzantine Period, all of which are covered in this paper.

The mollusk remains at Troia have been retrieved through hand-collecting methods. The decision as to whether to collect mollusk remains was left to the trench supervisor over the course of two decades of excavations, and even though they were trained to do so, one cannot be certain that all of those that appeared in the trenches were collected. In other words, the retrieval methods may have altered the analytical results of the archaeobiological research. Since hand-collection is not very sensitive to the recovery of small species and specimens, an indeterminate quantity of the shells may have remained in the earth matrix. Moreover, the inconsistency in sampling techniques used throughout the site may have critically affected the reconstructed temporal distribution of the mollusk remains at the site. With the exception of excavation units (Behälter) 174, 286, 632, and 699 from square KL16/17, none of the shell-bearing archeological contexts has been wet-sieved.

The analytical results laid out in this study are based on the quantitative record of shell and bone specimens. Calculations of relative abundance of represented taxa provides a measure to determine what species were utilized and in which relative amounts. To determine the ways in which specimens were used, it is essential to recognize the formative agents that affected the mollusk specimens at the time of their recovery, and how their taphonomic state influences quantitative analysis. All mollusk remains that made their way into the hands of archaeozoologists at work at Troia were identified, counted, weighed, and recorded digitally since 1989 along with other faunal remains. However, due to the fact that the mollusk remains have not been studied by archaeozoologists with experience in Mediterranean mollusk taxonomy or specific archaeomalacological methodology, a good number of the specimens belonging to different species were grouped together at the levels of family or genus. Rarely encountered species were included in categories such as "unidentified bivalves," "unidentified land snails," etc. Moreover, the specimens have not been examined systematically with regard to their taphonomic state. At least 80% of the remains that were studied with these methods were subsequently discarded, and are therefore unavailable for reinvestigation.

Quantitative analysis of archaeozoological remains is performed to assess the dietary and economic importance of various animals at a site and their frequency in the environment. This process becomes complicated when faunal assemblages include several families from multiple phyla. Questions such as "what percentage of the caloric intake of the Trojans consisted of shellfish in a particular period?" simply have no answer, and therefore they do not represent working research questions. Many factors play a role in this, mostly notably taphonomic ones. It is impossible to express the consequences of these taphonomic processes in mathematical terms with any accuracy. Nevertheless, the amount of mollusk remains relative to the amount of vertebrate remains in faunal assemblages constitutes important information that needs to be evaluated in terms of the temporal and geographical differences between the relative contributions of mollusks to the diet of past human societies.[6]

For this reason, the first step of the analyses presented in this paper is based on the relative amounts of mollusks and other taxa, whose amounts are expressed in NIS (number of identified specimens), and in WIS (weight of identified specimens). Counts and weights of mollusk and other faunal specimens have been recorded at Troia since the beginning of archaeozoological studies at the site. More than 200,000 faunal specimens from the new excavations at Troia have been studied, out of which 161,920 specimens could be linked to meaningful chronological units (such as Troia I, II, III, etc.). Altogether these specimens amount to 989,705 grams, i. e., almost one metric ton. The taxonomic list created from this database constitutes the foundation for the interpretations presented in this paper. The specimens come from different occupational areas and phases that range from the beginning of the settlement until the late Byzantine period. Remains of major Mediterranean domesticates, such as cattle, sheep, goat and pig, dominate all assemblages. Remains of aquatic mollusks (altogether 54,548 specimens) make up approximately 33.5% of the NIS and 19.5% of the WIS of the faunal assemblages from stratified contexts. This is so far the largest archaeomalacological assemblage from any Aegean site. At least 15 families of aquatic mollusks are represented in the new excavations at Troia.

The second step is to analyze the NIS and WIS of the mollusk specimens representing different taxa in relationship to each other. While this analysis yields more accurate interpretations of the relative importance of different mollusk species across time and space, neither of these quantitative methods will produce secure solutions to questions regarding the role and nature of shellfish gathering and shellfish taxa in subsistence economies that depend on diversified resources.

Within the scope of archaeomalacological research at Troia, other methods of analysis were applied to the molluscan material, such as morphometry, incremental studies, stable isotopic analysis, and comparison with compatible archaeomalacological results from neighboring contemporary sites. The results of these analyses are treated in other publications (see Çakırlar 2007, 2008 and forthcoming).

Most of the interpretations in this paper are based on modern malacological knowledge about the biology and ecology of extant mollusk populations and ethnographic and ethno-historical accounts of their human use. Mollusk species' differential life styles have determining effects on the relationship humans have developed with mollusk populations. Reviewing the taxonomy, habits, ecology, and habitats of the aquatic mollusk species represented at Troia is therefore essential before proceeding to a discussion of Trojan archaeomalacology. Relevant ethnographic and ethno-historical accounts about the use of the mollusk taxa represented at Troia will also be summarized here, for they provide valuable insights that allow one to interpret past shellfish gathering activity at the site.

Ecology and economic value of represented taxa

In this study, I deal with aquatic mollusks that have an outer shell. Terrestrial gastropods (i. e., land snails) are invaluable resources for reconstructing paleoenvironments,[7] and can be useful in reconstructing paleodiets[8] and even trade relationships.[9] However, since land snails were not collected systematically at Troia, the few that have been retrieved from floatation samples and the randomly collected larger specimens in the faunal samples cannot be used to shed light on any of these aspects.

Out of some eight classes of shelled aquatic mollusks, only shells of gastropods and bivalves are represented at Troia. Although Cephalopod remains (inner shells of cuttle fish, *Sepia* spp.) have been reported from earlier excavations,[10] none has been found in the new excavations. At least four marine gastropod genera, ten marine genera, and one freshwater genus are represented in the assemblages from the new excavations.

Gastropods

Patella spp. (Limpets)
Limpets (Fig. 1a) at Troia may refer to any of the three species of the *Patella* genus represented in the Aegean.[11]

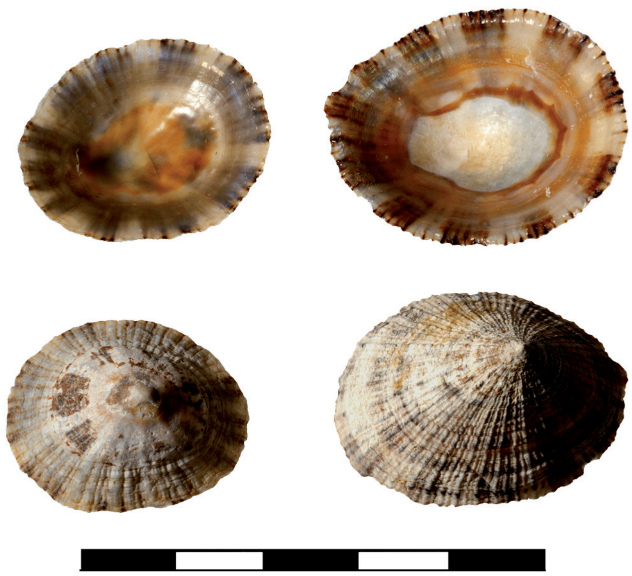

Fig. 1a. Modern specimens of *P. caerulea* (left) and *P. rustica* (right). Inner shell surface (top) and outer shell surface (bottom).

Limpet shells assume a variety of forms within each species, causing taxonomic confusion when identification is based on their shells alone. Limpets live on hard surfaces grazing on algae. Communities colonize high-energy, fully marine coastal environments, spreading below and above the wave splash zone.[12] They avoid sheltered locations and habitats with salinity fluctuations such as shallow bays and estuaries.[13] Based on my observations on some limpet samples from the site, *Patella caerulea* is probably the most common limpet at the site. Limpets, though not an important commercial product in the Aegean today, are still exploited as occasional "snacks" in Greece.[14] Shackleton reports that fishermen on Antiparos consumed limpets as food in the 20th century.[15] Ethnographers also recorded the practice of roasting limpets and other marine snails in the coastal villages of southern Greece.[16] Additionally, *Patella* spp. is occasionally used as fishing bait in England.[17] Limpet shells are among the most common gastropod remains in Aegean sites, especially in archaeological deposits dating to the period between the glacial maximum and the formation of shallow bays and estuaries due to accelerated sedimentation rates, as well as later deposits of sites situated close to rocky promontories.[18]

Monodontinae (Topshells)
Remains of this subfamily (Fig. 1b), consisting of seven species on the Turkish coasts,[19] were not identified to species level at Troia. Occasionally sharing the same rocky surfaces with limpets, topshells also graze on algae. Mediterranean populations are known to migrate vertically, moving upwards above the splash zone in the summer months and settling below the splash zone in the winter.[20] Not much is known about the present and historical use of topshells as a food source in the Agean, but they constitute one of the common items in the shellfish markets of western Mediterranean countries.

Fig. 1b. Modern specimens of *Monodontina articulata* (left?) and *M. turbinata* (right?).

Cerithium spp. (Hornshells)
Seven species of the genus *Cerithium* exist in the Mediterranean, two of which are lessepsian.[21] Only two of these species, *C. vulgatum* and *C. alucastra,* grow higher than 25 mm, and are therefore more likely to have been collected at Troia. At the same time, since Demir 2003 does not record the existence of *C. alucastra* in Aegean Turkey, and Gaillard 1987 notes that *C. alucastra* is much less common than the *C. vulgatum* on the rocky and sandy bottoms of the littoral zones, it is highly likely that *C. vulgatum* is the species represented in the assemblages from Troia. *C. vulgatum* is also found among sea grass meadows, remaining on the sediment surface and moving freely, feeding on plant matter. Although it is commonly regarded as a fully marine species, its tolerance for salinity fluctuations to a certain degree allows it to colonize some estuarine and lagoonal waters.[22] The food value of these species for humans has not been attested in ethnographic or ethno-historical accounts. Other than in the Mesolithic and Early Neolithic layers of the Franchthi Cave, *Cerithium* remains dominate the archaeomalacological assemblage of no other site in the Aegean.[23]

Hexaplex trunculus (Common Murex snail)
This is a carnivorous gastropod that dwells on sandy and rocky bottoms in shallow bays and lagoons (also brackish) and at deeper levels in wave-exposed coasts of the

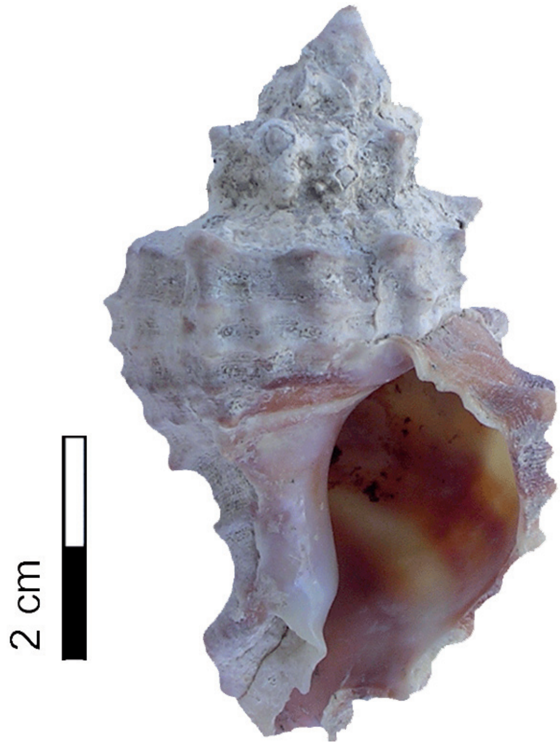

Fig. 1c. A well-preserved archaeological specimen of *H. trunculus* from Troia (Unit 993).

Fig. 2a. Inner (top) and outer (bottom) views of an *A. noae* valve from Ulucak (Unit 513).

infralittoral zone (Fig. 1c).[24] A more detailed discussion about the biology and ancient use of this snail, which was used to produce an organic colorfast dye, is provided in another paper in this volume (see Çakırlar and Becks, this volume).

BIVALVES

Arca noae (Noah's Ark shell) (Fig. 2a)
This clam attaches itself to solid substrates such as rocks or shells in the outer sectors of the littoral zone. Although they can be found at depths of over 100 m,[25] population densities are highest between 3 and 5 m.[26] Water circulation and low levels of turbidity are important factors for this species, meaning that they prefer more open and clear waters.[27] While populations are known to share marine habitats with *Ostrea edulis* and *Mytilus galloprovincialis* (see below), *Arca's* salinity tolerance is limited to sea water.[28] Although substantial amounts of arc shells appear in some southern Aegean sites, the species never dominates archaeomalacological assemblages of the basin.[29] *Arca noae* populations are commercially exploited in the Adriatic Sea.[30] There are no recent accounts of this bivalve as a food source in the Aegean.

Glycymerididae (Dog cockles)
All of the four species of dog cockles existing in the Turkish coastal waters have been recorded in the North Aegean.[31] Shell morphologies of Mediterranean dog cockles are very similar, causing taxonomic confusion.[32] These bivalves are shallow burrowers in fine gravel or sandy/muddy bottoms and can be found offshore down to a depth of approximately 100 m.[33] Dog cockles, while not abundant at any of the Aegean Bronze Age sites, are common elements of the mollusk assemblages of the eastern Mediterranean. Interestingly, most of these specimens appear to have been gathered as empty shells, which have been exposed to wave and/or sand action prior to final burial in the archaeological matrix.[34] They are consumed as human food today.[35]

Mytilus galloprovincialis
(Common Mediterranean mussel)
The common mussel (Fig. 2b) attaches itself to substrates that can range from gravelly to rocky bottoms using their bysuss (silky filaments). Communities occupy mesolittoral and infralittoral zones and are known to penetrate the saline waters of coastal lagoons and estuaries.[36] In those areas they particularly colonize the sea-water influenced zone and the entrance channel to the lagoon or estuary, where water velocity is relatively high.[37] Individuals can survive at depths down to 6–9 m, forming very dense single-species communities. *M. galloprovincialis* is the only commonly consumed aquatic mollusk species consumed in Turkey today. It is highly commercialized, and often procured from aquaculture for the mass-market. That an important majority (if not all) of individual retailers and vendors in the mussel business are migrants to western Turkey's larger cities from the southeastern inland city

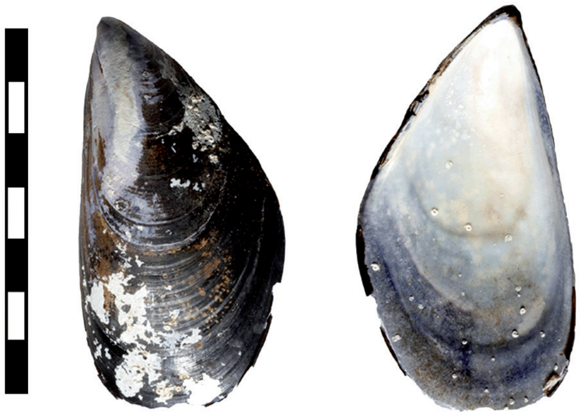

Fig. 2b. Outer (left) and inner (right) views of a modern *M. galloprovincialis* valve.

of Mardin demonstrates the complexity of this market system. Mussels are also used in preparing fishing bait in Turkey and England.[38] Remains of *M. galloprovincialis* are not numerous, but they still constitute a common feature of archaeomalacological assemblages across the Aegean.

Pinna spp. (Fan mussels)
Three species of fan mussels live in the Mediterranean: *P. fragilis, P. nobilis,* and *P. rudis.* These large animals settle among sea grass meadows on loose substrates, usually on coarse sands in the outer and deeper littoral zone of coastal waters.[39] Some individuals of *P. nobilis* secrete small pearls. Listed among the threatened species of the Mediterranean,[40] they are often sought for these pearls.

Pectenidae (Scallops)
Pectenidae (Fig. 2c) are represented with at least 25 species in the Mediterranean.[41] Archaeological specimens at Troia were not identified at the species level. Two pairs of almost complete valves that were kept accidentally (from Troia III and VI) and subsequently reexamined belong to *Flexopecten glaber.* The family consists of bivalves that attach themselves to the sea bottom with a bysuss when juvenile, and move freely when adult on sandy and detrital bottoms in the littoral zones and deeper.[42] Their swimming ability constitutes a mechanism that allows them to escape predators.[43] *F. glaber* is known to move into coastal lagoons.[44] Scallops are valued food items today in the Mediterranean.[45] According to Hitchner, scallops, along with oysters, were culinary symbols of the Romanization process of Provence in the western Mediterranean.[46]

Spondylus gaederopus (Spiny oyster)
S. gaederopus is the only representative of the spiny oysters in the Mediterranean. Spiny oysters live cemented onto rocky and detrital surfaces in the mid and lower sectors of littoral zones. The only archaeological contexts in the Aegean where *Spondylus* remains are numerous enough to represent food remains are the Bronze Age deposits of Lerna.[47] However, the complete absence of *O. edulis* remains, despite an outstanding abundance of *S. gaederopous* shells in the Lerna assemblage, is perplexing.

Ostrea edulis (European oyster)
The overall shape of European oysters (Fig. 2d) is quite variable. Populations of this species create banks on sandy, gravelly, and rocky bottoms in the upper and middle sectors of the littoral zone.[48] The left valve is either attached to a hard surface, or the animal lives freely on the substratum.[49] Although *O. edulis* moves into lagoons and estuaries, it does not tolerate water turbidity or salinities below 23‰.[50] Like the common mussels, it only settles in areas with sea-water influence near the entrance of the lagoon or estuary.[51] Oysters are popular seafood today. Oyster aquaculture started as early as 97 B. C., and the techniques were quite developed and diverse in the central Mediterranean by the 4th century A. D.[52] As

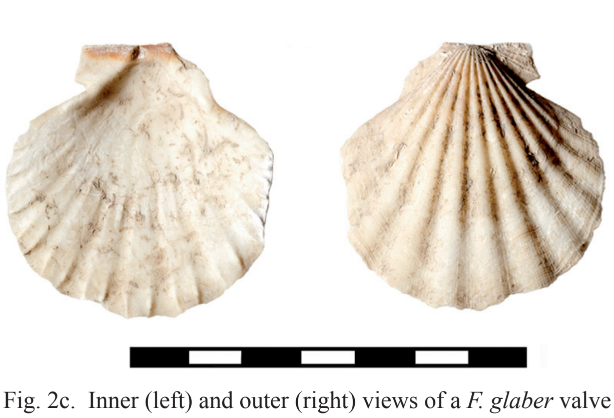

Fig. 2c. Inner (left) and outer (right) views of a *F. glaber* valve from Troia (Unit 2045).

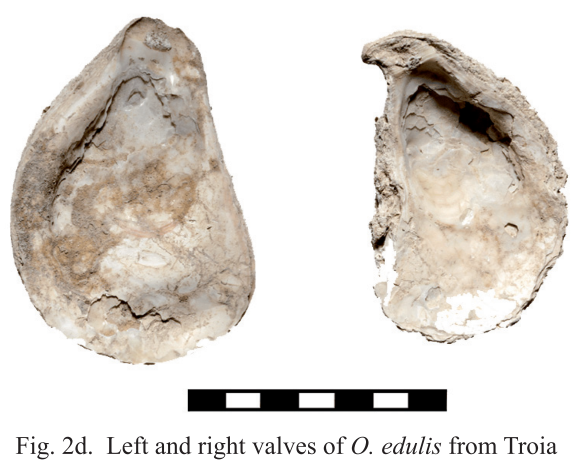

Fig. 2d. Left and right valves of *O. edulis* from Troia (Unit 2214).

mentioned above, oyster consumption was part of what becoming Roman meant, a phenomenon which led to the long-distance trade in oysters from the Mediterranean into inland Europe. European oysters are ubiquitous in the archaeomalacological assemblages of the Aegean. They are the most frequently encountered mollusk species at 5th millennium Sivritepe.[53] They are also allegedly the most common species at 5th millennium Kumtepe,[54] and rather prominent in Neolithic Hocaçeşme.[55] Their abundance and ubiquity seem to decrease during the Middle and Late Bronze Ages, and then increase again in the Post-Bronze Age periods.[56]

Cerastoderma glaucum (Lagoon cockle)

Phylogenetic and morphometric research has decisively shown that this species is the sole species of the genus *Cerastoderma* in the central and eastern Mediterranean.[57] As the common name suggests, *C. glaucum* (Fig. 3) inhabits the muddy-sandy and coarse bottoms of lagoons and estuaries forming large beds.[58] While the species has adapted to temperature and salinity fluctuations rather well, exposure to air and wave action restricts its occurrence.[59] *C. glaucum* always prefers sheltered areas to colonize, predominantly inhabiting enclosed or semi-enclosed lagoons. Juveniles dwell among floating seaweed, not on the benthos.[60] Carl Blegen and his team, who excavated at Troia between 1932 and 1938, report that their workmen collected lagoon cockles near the mouth of the Scamander and cooked them with rice.[61] This is the last record of cockle gathering in the Troad. The species is still commonly consumed in the countries around the Mediterranean.[62] The predominant presence of *C. glaucum* remains at Aegean sites near lagoons and estuaries is a recurrent phenomenon in the Bronze Age.[63]

Fig. 3. *C. glaucum* valves from Troia: Burnt and partially broken specimens.

Solen marginatus (Razorclam)

Fig. 2e. Outer (top) and inner (bottom) views of modern *S.marginatus* valves.

Razorclams (Fig. 2e) are fast and deep burrowers, sometimes burrowing up to 50 cm deep in sandy-muddy bottoms.[64] Beds can be located a few meters off the shore in low-lying beaches. The species occurs in clear waters with no turbidity. While razorclams are valued food items in present day Mediterranean countries,[65] in today's Turkey, they are only used for fishing bait.

Tapes decussatus (Carpetshell)

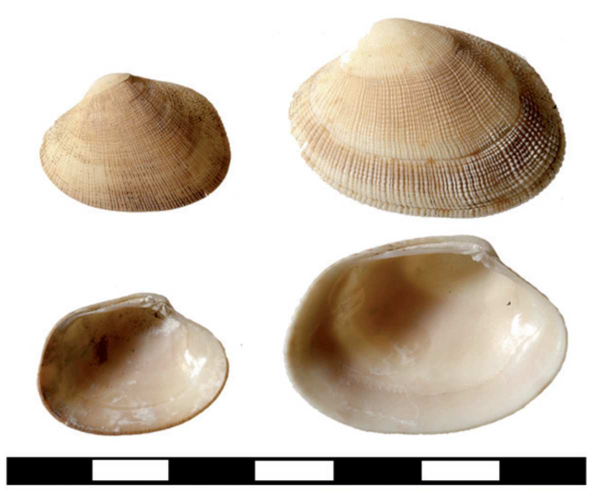

Fig. 2f. Outer (top) and inner (bottom) views of left *T. decussatus* valves from Troia (Unit 1243).

Carpetshells (Fig. 2f) are bivalves that live in sandy to gravelly-sandy substrates in the middle and lower zones of coastal waters. They are known to infiltrate lagoons.[66]

They burrow only to shallow depths up to 15 cm.[67] Carpetshell is a common food species in some Mediterranean countries today.[68] They are not very common in the archaeological assemblages of the Aegean.

Unio spp. (River clams)
River clams represent the only aquatic mollusk taxon that has been attested in archaeozoological studies at Troia. Their taxonomy and ecology are not well known in northwestern Anatolia. It is probable that *Unio crassus* – distributed across Europe, Russia, Kazakhistan and Anatolia – is the prevailing Unionid species in Çanakkale. *Unio* spp. inhabit both small and large rivers as well as freshwater lakes. They are known to prefer sandy and gravelly bottoms.[69] They are very shallow burrowers, with the larger part of the shell usually remaining on the substratum.[70] With the exception of Bronze and Iron Age layers of Kastanas,[71] *Unio* shells are neither a significant component of archaeological assemblages of the coastal Aegean nor of the inland sites of Anatolia and Greece. Today their commercial value in the Eastern Mediterranean is limited to their use in the production of mother-of-pearl ornaments.

Analytical results

The mollusk remains account for 33.7% of the NIS and 19.5% of the WIS of the studied portion of the faunal assemblage from the new excavations at Troia (Fig. 4). The vast difference between the NIS and WIS calculations is mainly due to the smaller size of mollusk specimens in comparison to most other common faunal specimens, such as large and medium mammals. Mollusk remains are present in all occupational phases and in 57% of all studied Bronze Age units.

The contribution of mollusk remains to the faunal assemblages at Troia does not remain unchanged over time (Fig. 4).

At the beginning of occupation at Troia (Troia I), mollusk remains constitute 37.9% in count and 24.7% in weight of the faunal assemblage. The amount of mollusk remains increases up to 62.1% in NIS and 50.4% in WIS in the Troia II period, representing the largest proportion of mollusk remains at Troia in any one period. In great contrast with Troia I and II, the relative amount of mollusk remains drops abruptly at Troia III, making up only 2.1% of the NIS and 2.2% of the WIS of the total assemblage. Such extreme rarity of mollusk remains is unique to the faunal assemblages of Early Bronze Age. Despite the sudden decrease of mollusk remains at Troia III, the proportion of mollusks, with 46% in NIS and 31.4% in WIS, is higher in the Early Bronze Age than in any successive occupational period in the settlement.

Mollusks are considerably rare in the archaeozoological assemblages of Troia IV, by 9.8% in NIS and 6.2% WIS. The picture drawn from calculations of NIS for Troia V is one in which mollusk remains become more frequent (28.4%) than in the previous period. WIS calculations, however, reflect a different sketch for the period with 5.8%. The deviation between NIS and WIS counts of the Troia V assemblage is due to a change in species composition and the differential taphonomy of the specimens belonging to these layers (see below). Inevitably, this situation is reflected in the figures representing the share of mollusk remains in the Middle Bronze Age assemblage of Troia, as 24% and 5.5% in NIS and WIS, respectively.

The proportion of mollusk remains rises up to 47.7% in NIS and 34.4% in WIS in the faunal assemblages from the earliest occupational phase of Troia VI. It becomes as low as 25.7% in NIS and 19.5% in WIS in middle Troia VI, and remains essentially at the same percentage in the

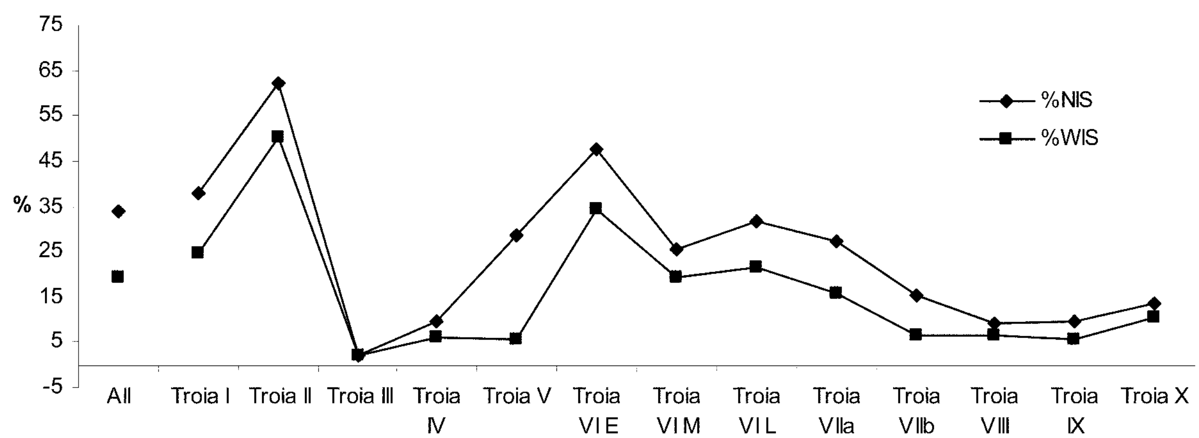

Fig. 4. Proportion of mollusk remains in the faunal assemblages of Troia.

latest Troia VI assemblage, with 31.6% in NIS and 21.5% in WIS. While mollusk remains are slightly less frequent in the Troia VIIa assemblage than in Late Troia VI, their occurrence is more or less in the range of Troia VI. On average, mollusks constitute 31.7% of all Late Bronze Age assemblages in count, and 20% in weight.

The occupational phase designated as Troia VIIb constitutes a cultural entity different from the preceding Troia VI and VIIa phases. The contribution of mollusk remains to the faunal assemblage is smaller during this period than the preceding Troia VI periods. Mollusks make up 15.5% of the NIS and 6.7% of the WIS of the faunal remains of Troia VIIb.

The ratio of the mollusk remains in the faunal assemblages of Post-Bronze Age date is generally lower than it is in the Bronze Age assemblages. Mollusk remains average 12.1% in NIS and 7.4% in WIS in the Post-Bronze Age assemblages. Only 9% of the count of identified faunal specimens (6.4% in WIS) dating to the Troia VIII period are mollusk remains. Their contribution is not greater in the subsequent Troia IX period: 9.5% in NIS and 5.6% in WIS. The percentage of mollusk remains increase slightly up to 13.7% in NIS and 10.5% in WIS in the Byzantine (Troia X) assemblages.

More than half of the mollusk taxa represented at Troia is encountered only very rarely. Monodontinae and *Cerithium* spp. among the gastropods, and *A. noae*, Glycymerididae, *Pinna* spp., Pectenidae, *Spondylus gaederopus*, and *Unio* spp. each constitute less than 0.5% of the total number and weight of identified mollusk specimens *C. glaucum* remains are conspicuously the most common mollusk remains in Bronze Age Troia. They make up 74.2% of the NIS and 71.1% of the WIS of the total assemblage. Remains of *Patella* spp., *H. trunculus*, *M. galloprovincialis*, *O. edulis*, *S. marginatus*, and *T. decussatus* together constitute most of the remaining ca. 25%.

C. glaucum's prominent presence is already well-established at Troia I (Fig. 5). Remains of *M. galloprovincialis*, *O. edulis*, and *T. decusatus* are also not uncommon, especially when compared with the subsequent Troia II phase. The absolute values representing *T. decussatus* remains, however, are questionable. All carpetshells of Troia I come from a single 'Behälter'. Although such a significant deposit could not possibly have gone unnoticed, there is no record of it in the excavation journals. Since this deposit exists only in the virtual archaeozoological database, its actual existence is highly questionable. The proportion of *C. glaucum* remains increases up to 95% in NIS and 94% in WIS in the Troia II assemblages, while the contribution of other formerly abundant species like *M. galloprovincialis* and *O. edulis* diminishes at Troia II. *Pinna* spp. is absent from all assemblages dating to the Early Bronze Age. Mollusk remains dating to Troia III amount to only 68 specimens, altogether weighing about 459 g. This amount is not sufficient to be evaluated accurately in terms of species abundance.

The relatively small sample size from Troia IV and V is reflected in the high amount of taxa absent from these assemblages. Species such as Monodontinae and *A. noae,* among others, are absent. Otherwise, the taxonomic composition of Troia IV is similar to the preceding Early Bronze Age assemblages, especially that of Troia II, with *C. glaucum* overwhelmingly dominating the assemblage. The taxonomic composition of Troia V is entirely different from the preceding and succeeding periods. *S. marginatus* remains make 81.5% in NIS and 75.9% in WIS of the mollusk assemblage, while lagoon cockles comprise only 14.2% of the number of specimens. What this divergence from the general pattern could possibly mean will be discussed below.

C. glaucum resumes its significant contribution to the mollusk assemblage in Early Troia VI, with 72.7% in NIS and 66.5% in WIS. *H. trunculus,* which has already started to appear in slightly higher amounts in the assemblages of the preceding Troia IV and V, makes its first noteworthy appearance in Early Troia VI. Troia VI also witnesses the first occurrence of *Patella* spp. and Monodontinae remains in significantly large amounts during the site's occupational history. Contributions of *M. galloprovincialis* and *O. edulis* are minor, whereas *S. marginatus,* which had made its first noteworthy appearance at Troia V, continues to be an important component, constituting 16.6% of the NIS and 8.6% of the WIS. The proportion of *Unio* spp. remains also becomes slightly larger than it was in the previous occupational periods.

C. glaucum's significance is sustained in the subsequent phases of Troia VI. The share of *H. trunculus* remains continues to be high in Middle and Late Troia VI. *Patella* spp. and Monodontinae virtually disappear, whereas the ratio of *M. galloprovincialis* becomes more visible in Middle and Late Troia VI, with ca. 6% of the NIS and 3% of the WIS. *S. marginatus* appears in smaller amounts in Middle Troia VI, and loses its ca. 5% share in the Late Troia VI. A large number of the excavation units belonging to the Troia VI period are yet to be dated to the different phases of Troia VI (i. e., Early, Middle or Late Troia VI). The composition of the mollusk assemblages present in these units is similar to those that are assigned to distinct phases of Troia VI.

The mollusk assemblage dated to the Troia VIIa period, the last phase of the Late Bronze Age occupation at Troia, proportionally includes lesser amounts of *C. glaucum.* The species comprises 58.6% of the NIS and 38.9% of the WIS of this assemblage. The share of *H. trunculus* remains, on the other hand, constitutes a much greater part of the mollusk assemblage, with 35.8% in NIS and 53.3% of the WIS. In short, the dominating proportion of *C. glaucum* and significant propor-

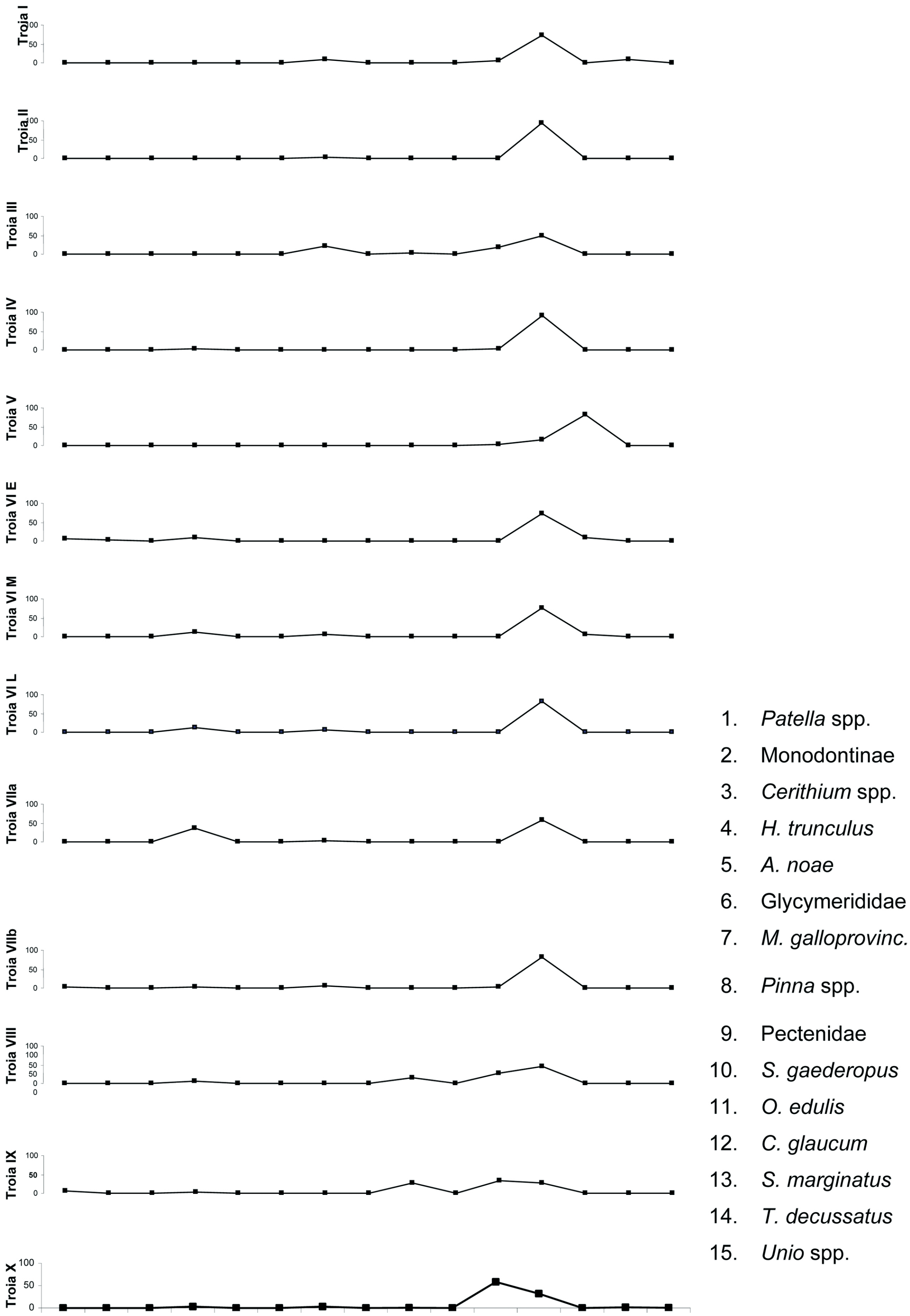

Fig. 5. Changes in the relative abundance of species represented in the mollusk assemblages of Troia.

tions of *H. trunculus* characterizes the Late Bronze Age mollusk assemblages of Troia. *S. marginatus* is the third most abundant species of the period. The composition of the mollusk assemblage dating to Troia VIIb does not represent a large contrast with Troia VI and VIIa, except for the absence of accumulations of *H. trunculus* remains dating to the period.[72] *C. glaucum* remains the most frequent species, making up 80.3% of the NIS and 72.8% of the WIS of this relatively small assemblage. The share of *H. trunculus* decreases significantly, down to 4.5% of the NIS and 5.6% of the WIS, while *M. galloprovincialis* reappears as a relatively more important part of the mollusk assemblage, with 7.1% of the NIS and 9.4% of the WIS. *S. marginatus* disappears completely from the record. It must be noted, however, that this assemblage consists of only 966 specimens, and the absence of some species is likely to be a consequence of the limited size of the sample.

Troia VIIb is followed by the so-called Post-Bronze Age phases of Troia VIII, IX, and X.[73] The relative abundance of the mollusk taxa in Post-Bronze Age assemblages are unlike those of the previous periods. The high proportion of *C. glaucum* is gradually replaced by *O. edulis.* Already at Troia VIII, *C. glaucum* remains comprise only 47% of the NIS and 20.2% of the WIS of the mollusk assemblage, while *O. edulis* remains make up 28.3% of the NIS and 67.2% of the WIS. In the mollusk assemblages of Troia IX and X, *O. edulis* remains become even more abundant, taking over *C. glaucum*'s place as the most common species. *O. edulis* remains constitute 32.1% of the NIS and 55.5% of the WIS of the Troia IX mollusk assemblage, and their percentage increases to 58% in NIS and 68% in WIS in the Troia X assemblage.

Pectenidae also becomes an important component of the mollusk assemblages in the Post-Bronze Age period. They comprise 14.8% in NIS and 9.2% in WIS in the Troia VIII mollusk assemblage. Their contribution to the Troia IX assemblage is even higher with 27.4% in NIS and 19.4% in WIS. The Troia X assemblage, however, includes only two specimens of Pectenidae. Other noteworthy components (above 1%) of the Post-Bronze Age assemblage are the remains of *H. trunculus* and *M. galloprovincialis*. Mollusk taxa, such as Monodontinae, *Cerithium* spp., *A. noae*, Glycymerididae, *Pinna* spp., *S. gaederopus*, which are minor elements in the assemblages of preceding periods, are completely absent from Post-Bronze Age assemblages. Specimens belonging to *Unio* spp. appear only very infrequently.

Shellfishing grounds

Modern malacological knowledge and the information about former coastal environments through geomorphological studies allow us to reconstruct the location of aquatic environments where past shellfishing took place. A great range of aquatic habitats were present in the vicinity of Troia, but only some were frequented for the purpose of shellfish procurement. An optimal foraging strategy is assumed for the shellfish gathering activity, and is mostly confirmed by the correlation between species composition and the character of the surrounding coastal environment.

The irregular deltaic coastlines with swamps, barriers, and lagoons were formed at the locations where the distributary channels of the Karamenderes and Dümrek Rivers reached the marine waters of the Trojan Bay; they were fairly close to the settlement throughout the Bronze Age.[74] In the lagoonal areas, the water was turbid and brackish. The bottom was variably muddy and sandy both at the rivers and at the lagoons. Salinities fluctuated seasonally at the northern section of the bay, though to a relatively limited extent, due to the seasonally changing influence of the salinity of the Marmara Sea moving into the bay.[75] Benthic types here varied from coarse sandy to muddy bottoms. Hard substrates may have been located both on the sides of the northern section of the bay and perhaps in its mid section, at a distance from the shore.

In addition to the deltaic lagoons, marine indentations at either side of the bay provided environments with quiescent sheltered waters. In the Dardanelles, a fully marine environment with constant water circulation prevailed. To the west, Beşik Bay embodied a lagoon and a shallow and calm littoral with a sandy bottom,[76] while the western side of the Sigeion Ridge sloped sharply to the Aegean, forming a rocky shore exposed to high-energy waves. A series of pools with sandy bottoms, depending on sea-level changes and the strength of wave action, may have formed along this coast, but these were only temporary formations.

In this setting, the sheltered lagoonal environments closest to the settlement provided the most suitable habitats for *C. glaucum* beds. Additionally, the eastern indentations of the Sigeion ridge, the present Kumtepe, Kesik and Yeniköy plains, would have made well-sheltered populations for *C. glaucum* populations to settle. The lagoonal area of Beşik Bay was also an ideal habitat for them. Geomorphological and archaeolomalacological studies in the Beşik Bay area confirm this idea.[77] However, this bay was probably of secondary importance to the Trojans seeking lagoon cockles, since a much larger habitat with similar characteristics was available virtually at the foot of the settlement during the Early Bronze

Age, shifting progressively to the north over the course of millennia, but still remaining closer than the Beşik Bay beds. The absence of specimens smaller than 10 mm in valve height in the studied *C. glaucum* populations from the Bronze Age site[78] indicates that floating seaweed or marsh vegetation close to the shore was not exploited as a source of baby cockles, provided that the reason for the absence of small specimens is not a consequence of the hand-collecting mode of excavation. The idea that Trojans did not search for shellfish among seaweed finds confirmation in the scarcity of seaweed dwellers such as *Cerithium* spp. and *Pinna* spp. in the assemblages.

M. galloprovincialis and *O. edulis* were collected from the hard substrates in shallow waters: rocks, pebbles, or inundated and cemented remnants of old sand barriers, all possibly located in the middle and northern sections of the Trojan Bay. The littoral of the Aegean and the Dardanelles could also be exploited as a source for these species.

Patella spp. and Monodontinae could also be gathered from the rocky shores on both sides of the outer section of the bay where freshwater influence is negligible, allowing marine salinity levels to be maintained. Additionally, these species could be gathered from the Aegean shore of the Sigeion Ridge or the Dardanelles shore of the Kumkale Ridge. In any case, species composition of the archaeomalacological areas shows that both areas were rarely visited by the Trojans for shellfish gathering. *H truncului*, on the other hand, could be collected from rocky and sandy substrates in mid and northern sections of the bay, at a considerable distance from the lagoons but in shallow areas. *S. marginatus* and *T. decussates* were gathered from the calm but clear areas of the outer Trojan Bay with fine sandy bottoms, and also possibly from the marine influenced sections of Beşik Bay.

Shellfishing activity seldom took place at the infralittoral and circumlittoral zones, i. e., at open waters of the Aegean or the Dardanelles. The evidence for this interpretation lays in the rarity of species commonly living in these areas, such as *A. noae,* Glycymerididae, Pectenidae, and *S. gaederopous* – if they were alive when they were collected, and indeed, there are definite taphonomic indications on some of the specimens that they were not. It should be considered, however, that these species are known to penetrate into outer bays, such as the northern section of the Trojan Bay, from which their scarce remains at Troia may have originated. The sandy and muddy river beds of the Karamenderes and Dümrek were exploited for *Unio* spp. only occasionally. Again, it is not certain whether these specimens were collected live or whether their shells were collected to serve some ornamental purpose.

Procurement methods: gathering and cultivation(?)

It is possible to reconstruct the techniques employed to obtain the mollusks in the archaeomalacological assemblages of Troia based on ethnographic accounts and molluscan biology. The picture attained from this reconstruction diverges considerably from Homer's heroic description of oyster diving as practiced in the Troad.[79] Although diving for shellfish is not completely avoided by the contemporary or recent foragers of the world,[80] in general, the gathering activity does not require special techniques or skill. Most of the mollusks represented at Troia were gathered using relatively simple techniques. I will explain the diversity in these techniques, again in taxonomic order.

Patella species can be gathered by hand or using a lever made of wood, bone, or metal.[81] Hand-picking them necessitates swiftness of movement, for once an individual is touched, it immediately secures a stronger grip to the hard surface it has been grazing upon and does not loosen this grip for some time. A large portion of limpet communities can be gathered without even getting one's feet wet, since these live at the upper sections of the splash zone. If Monodontinae populations were collected during their upward migration, i. e., during summer, it was also possible to obtain the individuals without going into water. Gathering Monodontinae does not necessitate the use of any implements.

Altough *H. trunculus* can be gathered by hand, the relatively low density of *H. trunculus* communities (if this was the case in antiquity, we do not know) can turn the hand-collecting of this species into a time-consuming task. Instead, these carnivorous marine snails can be caught by baited baskets or using open ceramic vessels.[82] To scavenge the meaty bait, individuals gather up into vessels, from which they can be easily captured.

M. galloprovincialis can be dislodged from their dense beds by hand. *O. edulis* can be obtained using a similar technique, perhaps with a wooden stick or rock.[83] As mentioned earlier, elaborate techniques of cultivating oysters from aquaculture was in use by Roman times, at least in the central and western Mediterranean. There may very well be a connection between this new innovation and the increasing amounts of *O. edulis* remains from Post-Bronze Age layers at Troia.

Lots of *C. glaucum* individuals can be gathered by hand or by using implements such as shovels and dredges that are made of wood or metal. Once a *C. glaucum* bed is located, which can be done by feeling for the individuals by foot, numerous individuals can be acquired in no time, without having to move around too much. Gathering can be done while semi-immersed in water. The coeval presence of very small and very large individuals in the archaeological deposits indicate that they were collected randomly, without any pre-selection focused on certain size groups.

S. marginatus is very sensitive to vibration and light and can burrow faster in the sand than human foragers can dig to retrieve individuals. They are not only fast but deep burrowers. If one is acquainted with the small hole-like trace they leave on the surface of the sand as they burrow, one can easily locate them. For these reasons, gathering sufficient yields of razorclams may constitute a relatively difficult task, learned either socially or by experimentation.[84] In Britanny (France), Solenidae are collected by dropping salt into the suspected hole,[85] but individuals can also be reached using a spade or a similar implement.

Bivalves living in deeper waters can be caught using spears and pronged poles from boats.[86] Pectenidae, swimming bivalves, can be chased by hand in shallow water or haul-trawled from a boat. Alternatively, they can be retrieved by diving. *Unio* spp. can be easily gathered from the shallows of freshwater beds, without wading into the water.

Processing shellfish

Modern and historical examples show that shellfish gathered as human food are consumed in diverse ways: raw, boiled, steamed, pickled, dried, smoked, and fermented.[87] While archaeological traces for shellfish preparation are not abundant, taphonomic properties and depositional patterns of mollusk remains can lead to some implications about the techniques used in shellfish processing.

The most common way of consuming mollusks is to eat them fresh without any processing, often when the animal inside the shell is still alive. All the aquatic mollusks represented at Troia can be consumed raw.[88] Sand-dwellers such as *C. glaucum*, *T. decussatus, S. marginatus*, etc. must be kept in salt water to remove the residual sand particles contained within the valves prior to consumption. More or less intact shells, or shells bearing traces of deliberate breakage, constitute the best evidence for human consumption of fresh shellfish flesh. Gejvall reasoned that breaks on the cockle shells from Troia occurred during meat extraction with a sharp implement;[89] however, because these breaks are encountered at the thin ventral corner of the valves, I reason that the breaks occur after the deposition of the valves, and are not related to the processing activity.

While consuming raw shellfish flesh may be favored for its distinctive flavor, it is not the most effortless method of consumption. The muscles which enable locomotion are tightly attached to the inner surface of the shell as long as the animal is alive,[90] making the removal of the soft-body by detaching it from these muscles and the shell a task requiring considerable energy. This is important because single mollusk individuals, at least those of the species found at Troia, do not provide much in terms of calories. To avoid energy loss during consumption, the soft body can be efficiently extracted from the shell by exposing whole animals to heat for a few minutes. Ethnographic studies recorded the practice of roasting limpets and other marine snails in the fire in the coastal villages of southern Greece.[91] Because the time and energy required for the muscles to lose their function is very brief, the heating process leaves little or no trace on the archaeological shells. The abundance of unburnt, well-preserved cockles, as well as the presence of accumulations of burnt specimens at Troia indicates that at least some of the cockles were prepared by boiling, steaming, or putting them directly on fire.

There are accounts in hunter-gatherer-fisher and food producing societies of intensive mollusk gathering when the animals are at their prime, and then drying them in anticipation of lean periods or for inland trade.[92] Though not uncommon, shellfish drying does not seem to have been a worldwide phenomenon. In some cultures fresh food is considered absolutely essential, and the Mediterranean, empirically speaking, may be one of them.[93] Drying seafood is a more common practice along the Atlantic coast of Europe, for example, than it is on the Mediterranean coast. While fresh seafood is a highly valued commercialized product in the Aegean, an occasional sight in coastal villages is sun-drying fish and octopus.[94] Experimental studies suggest that shellfish can be dried effectively for later consumption with relatively little effort and technology.[95] But unequivocal archaeological evidence for past shellfish drying is scarce, because the process rarely leaves any trace on the mollusk shell. Such evidence for shellfish drying is not present at Troia.

Some clay-lined pits and similar structures such as water tanks recovered in cultural contexts have been interpreted as installations for shellfish storage.[96] Water tanks may have been used to enable surplus mollusks to maintain their fresh state temporarily. While contemporary aquaculture makes use of water tanks for shellfish and other aquatic animals, and keeping freshwater fish in tanks within settlements is a practice known since the Sumerians, I am unaware of ethnographic examples for clay-lined pits intended for mollusk storage.[97] Clay-lined pits containing mollusk remains have been excavated at Troia from the Late Bronze Age phases of the site (square İ8, Beh. 388; square K8, Beh. 749; square A8, Beh. 1371 and 1389). It is more likely that these were used as potable freshwater tanks and subsequently filled with rubbish including mollusk shells, which were also discarded in ordinary pits subsequent to consumption. While concomitant evidence, such as charred food remains found in pits and pithoi, demonstrate that the concept and technology of food storage was certainly practiced at Troia, no evidence hinting at mollusk storage is present at the site.

Moreover, Mesopotamian recipes suggest that the addition of shellfish flesh to fish sauce (the precursor of Roman *garum,* or similar) was a culinary innovation practiced as early as the 17th century B. C.[98] Whether the acts of preserving shellfish in fish sauce or separately with salt or in salt water were practiced at Troia cannot be proven based on the current evidence. But, as indicated by textual evidence, techniques of seafood preservation were known within the contact realm of Troia during the Late Bronze Age.[99] Therefore, the possibility exists that this preservation technique was known in Late Bronze Age Troia. It is, however, questionable whether the environmental and climatic circumstances at Troia would necessitate storing a food resource that was available year-round.

Off-site processing and consumption of mollusks is an important part of shellfish gathering activities. Ethnographers report that not all shellfish are carried back to the home-base with the shell.[100] Some are de-shelled prior to transportation, and occasionally shellfish are consumed during gathering.[101] Sometimes, processing and consumption of shellfish at or near the site of procurement manipulates contemporary household accumulations to the extent that the species composition of household shell refuse does not reflect the choice of prey.[102] Off-settlement/camp site processing is clearly not an archaeologically visible practice.

Processing shellfish for purposes other than usage as human food may also leave traces in the archaeomalacological record. For example, cooking shellfish is not the most effective way to produce fishing bait, because cooked flesh is soft and breaks away from the hook easily. Therefore, it can be suggested that archaeological mollusk shells bearing traces of cooking were not used for fishing bait. On the other hand, the most efficient way of removing the flesh to prepare bait is by smashing the shell. In contemporary Greece, this method is used to extract the meat from *C. vulgatum* shells that are to be used in fishing bait.[103] At Troia, a few species are found, almost without exceptions, in smashed form. One of these is *H. trunculus,* which were crushed for purple dye production.[104] Others, such as *M. galloprovincialis,* were shattered due to physical processes after the shells were discarded.[105]

Variation and continuity

I have discussed above the types of foraging behavior – from gathering to processing – that each species in the archaeological record may represent. In this section I will discuss what the diachronic changes in the proportion of mollusks in the faunal assemblage, and the spectrum of mollusk species, might mean in terms of foraging behavior. The diachronic patterns in the quantitative archaeomalacological record of Troia can be interpreted in terms of spatial and temporal variability in the environment (including climate) and changes in the settlement's social context, subsistence, and culture. Both in pre-agricultural and more advanced societies, foraging behavior is determined by a combination of these factors.[106] Excavation techniques, taphonomic processes, and the nature of the excavated areas also have an impact on quantitative patterns of the archaeomalacological record. The aim here is to isolate the environmental and economic factors apart from these, with the goal of understanding past shellfish gathering and consumption behavior at Troia.

The contrast between the number of shelled mollusk species reported from the Aegean and the variety of mollusk species represented in the archaeomalacological record demonstrates how species diversity reflects the choices that Trojans made while building and securing their relationship with the environment. Only about 5% of the shelled mollusk species present in the Aegean has been recorded at Troia. This situation is not different for the other coastal archaeological sites in the basin. This narrow diversity reflects the limitation of mollusk gathering activity primarily to the relatively more nutritional species that could be acquired with ease in the coastal zone stretching between the lagoons and the mid sections of the littorals. It is also a reflection of the ecology of this coastal zone: despite high production levels, the littorals have biomasses with lower diversity.[107] From this low diversity, then, only a few mollusk species are targeted by human predators. Selective gathering is common practice in shellfish gathering societies.[108] The absence or low representation of small mollusk species in the archaeological deposits, such as *C. neritea*, *Abra* spp. or *Donax* spp., all lagoonal and coastal dwellers, indicates that the nutritional value offered by the individuals of a species was an additional factor affecting foraging behavior.

As I mentioned earlier, the quantitative relationship between mollusk and vertebrate remains in faunal assemblages can serve as a basis for assessing the contribution of mollusks to the subsistence of temporally and spatially defined cultural groups.[109] The obvious differences between the proportional representation of mollusk remains in the shell middens created by cultures without domestic animals, "shell-bearing sites" of the agricultural societies, and the amount of mollusk remains found in inland sites well illustrate the point that ecological and behavioral factors are at play in creating this archaeological feature.

Looking at the published archaeomalacological record from the Troad may help to highlight the marked decrease in the amount of mollusk remains by comparison to the vertebrate remains throughout the history of Troia. In Sivritepe (ca. 4600–4500 B. C.), a settlement by Beşik Bay, the mollusk remains outnumber the vertebrate remains, with ca. 97% of the faunal assemblage (5,533 in NIS).[110] Although Boessneck was of the opinion that the badly preserved state of animal bones resulted in the high proportion of mollusk remains, an argument he supported by the absence of fish remains in the assemblage, he also stated that Sivritepe represents a site where the primary food item consisted of marine mollusks.

Evidence for such high consumption of marine mollusks does not have parallels in Aegean archaeology, and probably reflects the limited number of studies that compare the proportions of vertebrate and invertebrate remains in the faunal assemblages of the Aegean, rather than the actual situation. The mollusk evidence from Sivritepe is more akin to the archaeological phenomenon represented by the Mesolithic shell middens along the coast of Europe, South Africa, or Japan. If the proportion of the mollusk remains in Sivritepe is not heavily altered by taphonomic conditions, it must reflect the specific orientation of the animal subsistence strategy towards the sea. It is important to note that the limited number of vertebrate remains reflect an animal economy based on cattle, sheep, and goats.[111] The joint evidence from mollusk and vertebrate remains implies that this site represents a subsidiary community or the campsite of a contemporary inland settlement, used specifically for the procurement and processing of marine mollusks. During the time when the site was in use, Sivritepe was situated at a favorable spot that provided easy access to both the littoral of the Aegean and the Beşik and Trojan Bays, which were at their greatest extent during the 5th millennium B. C. Shellfish consumption at Sivritepe may have taken place at the spot, or shellfish may have been dried or otherwise processed for later consumption elsewhere inland. Both types of activities would have left a large deposit of mollusk shells near the coast, analogous examples of which are present in the ethnographic literature.[112]

Although not quantified, the archaeomalacological evidence from other sites in the Troad antedating Troia I resembles the situation in Sivritepe. The investigators of the 5th millennium site of Alacalıgöl, northwest of Troia, emphasized the overwhelming abundance of mollusks at the disturbed surface of the site.[113] Archaeological deposits of the lower layers of Kumtepe (Kumtepe A and B, 5th and 4th millennium B. C.), also northwest of Troia, are likewise characterized by abundant mollusk remains, the amount of which decreases in the later layers contemporary with Troia I.[114]

Regardless of differential preservation conditions and the inconsistency in the type of archaeomalacological data available for each site, these three early settlements appear to have used marine mollusks to a relatively greater extent than the human groups that occupied the Troad in the subsequent millennia. The high proportion of mollusk remains and the locations of these sites suggest a coastal settlement pattern that enabled easy access to both mollusk resources and a sufficiently sizable fertile hinterland to allow for successful agriculture and animal husbandry.

During the 3rd millennium B. C., at the time of Troia I and II, cultural deposits in the Troad, such as the Yassıtepe layers contemporary with Troia I, Kumtepe C, which was also contemporary with Troia I, and Troia itself, seem to contain proportionally lower amounts of mollusk remains than the 5th and 4th millennium sites in the Troad. Mollusk remains make up more than half of the faunal assemblage from the Troia I phases of Yassıtepe,[115] which is a proportion essentially comparable to the figures provided for Troia I and II phases of Troia.[116]

Three factors may have been effective in forming these Early Bronze Age assemblages depleted in mollusk remains: by the 3rd millennium B. C., substantial changes had taken place in the Troad, including the nature of the resource bases. By this time, the Beşik lagoon had already completed its formation and occupied its largest extent.[117] Sediments from the Karamenderes had filled the area between the northern edge of the Troia Ridge and the southern end of the valley, where the delta was located at the time of maximum marine transgression, at ca. 7000–6000 BP.[118] The marine indentation at Kesik, at the southern side of which Kumtepe was located, had become marshland.[119] The maquis woodland was already open.[120] Intensive, small-scale agriculture was being practiced around Troia.[121] The role of sheep, goat, and cattle had increased in the animal sector of the subsistence economy.[122]

These changes indicate degradation of both the terrestrial and the marine sections of the natural realm from the 5th to the 3rd millennium B. C. The possible role of anthropogenic activities in transforming the relatively pristine landscape of the 5th millennium has been recognized in both archaeobotanical and archaeozoological studies.[123] Greater dependence on agricultural products and domestic animals, together with the diminution of the Trojan and Beşik Bays between the 5th and 3rd millennium B. C. may have led the 3rd millennium B. C. inhabitants of the Troad to place less emphasis on marine mollusks. It is most likely that the alteration in the mode of marine mollusk exploitation, induced by changes in the landscape and in the subsistence strategies, is the type of human behavior reflected in the reduced mollusk proportion of faunal assemblages in 3rd millennium Troia and the Troad.

The abrupt decline in the proportion of mollusk remains in faunal assemblages of Troia III and IV date is mainly attributable to the unsatisfactory sampling techniques employed during excavation. Likewise, although there is an increase in the proportion of mollusk remains in the Troia V layers, it is clear that this figure is also negatively influenced by insufficient sampling. It is unfortunate that such an inconsistency exists in the archaeomalacological record of the Troia III through Troia V periods, for the settlement at Troia probably went through substantial demographic and economic changes during the time period covered by these layers.[124] If the new elements in the material culture appearing at Troia IV and V represent new demographic elements as well – for example, a social group originating from inland Anatolia – it is highly probable that this sector of the society was unacquainted with marine resources and perhaps reluctant to exploit the coastal waters.

If such was the case, this is what might be reflected by the depleted proportion of mollusk remains in the faunal assemblages dating to the period. Moreover, these changes coincide with a cool episode in the global climate that showed its effect as a dry period in the lowlands of the eastern Mediterranean, and cooler sea surface temperatures in the Aegean.[125] The apparent time lapse in the formation of the calcite that grew on the walls of the water reservoirs of Troia coincides with these developments.[126] If this break in the calcite formation was triggered by low groundwater levels induced by dry climatic conditions, the combined effects of low groundwater and low sea-level must have caused a further reduction in the area of the Trojan and Beşik Bays and the formation of seasonally wet areas. This would indicate that the environments which were formerly hosting mollusk populations were no longer available for the exploitation of mollusk populations. Therefore, when these environmental and economic developments are considered together, a decrease in the proportion of mollusk remains as a reflection of a change in the mode of mollusk exploitation would be expected. But the current archaeomalacological evidence for Middle Bronze Age Troia is ambiguous, and too limited to be securely correlated with these suggested environmental and demographic changes.

In the Late Bronze Age layers of Troia, the amount of mollusk remains in relation to the amount of vertebrate remains increases. The NIS counts are probably inflated due to factors related to the taphonomy of mollusk finds, in particular the accumulations of crushed *H. trunculus* shells. Despite that, the amount of mollusk remains is proportionally lower in the Late Bronze Age than it is in the Early and Middle Bronze Ages. This situation can also be explained by environmental and economic developments. During the Late Bronze Age, the areas of the Trojan and Beşik Bays continued to lessen in size as the sediments of the Karamenderes and the Dümrek Rivers pushed the lagoonal coastline further away from the settlement. This meant that the most important shellfishing grounds went through further reduction in area, and were further away from the settlement than ever before. For the first time in the history of occupation at Troia, the distance from the mollusk beds (despite the introduction of domestic equids) may have adversely affected the frequency of mollusk foraging.[127]

Distance is an important determining factor in the selection of animal resources.[128] The ca. two-kilometer distance between the deltaic coastline and the settlement that had developed since the Early Bronze Age meant that more time and effort had to be devoted to obtain the same amount of mollusks that could have been gathered far more easily during the Early Bronze Age. Additionally, the increase in the meat gain secured from cattle,[129] the intensification of agriculture,[130] and the strong centralization of social organization and population increase[131] hint at the development of subsistence strategies that emphasized surplus-producing and nutritionally more rewarding domestic resources, as well as game animals.[132] While ethnographic examples demonstrate that badly planned urbanization and migration to cities might increase the demand for cheap resources, such as easily gathered shellfish,[133] the proportion of mollusk remains recovered from Late Bronze Age Troia does not suggest that urbanization resulted in an increase in the demand for aquatic mollusks.

Nevertheless, it should be remembered that there is always an unknown amount of shellfish consumed at the gathering site and an unknown amount of mollusk flesh brought to the site detached from the shell. In fact, the archeological finds discovered at the foot of the northern slope of the Trojan Ridge include "remains related to activities involving fire" and ceramic sherds dating to Troia VI and VII;[134] these may be associated with off-site activities related to the exploitation of lagoonal resources, including mollusks. It is reasonable to postulate that the amount of mollusk flesh consumed already at the gathering site and brought to the settlement without the shells was larger during the Late Bronze Age than in the Early Bronze Age, because the increased distance between the site and the primary gathering locations required relatively more energy input during the transport of intact mollusks to the settlement. If off-site processing and consumption of mollusks took place at substantial levels in order to meet the energy cost of the foraging activity, then the picture attained from the proportion of the mollusk remains in the archaeological deposits of the settlement proper cannot reflect the whole amount that was consumed.

The faunal assemblage originating from the Troia VIIb layers of the settlement are marked by a further decline in the proportion of mollusk remains. This is well in line with the continuing decline in mollusk remains in subsequent cultural layers, but different from the Troia VI and VIIa layers. A number of factors may have affected this picture: as suggested for the Middle Bronze Age, if foreign elements in the material culture indicate the arrival of new groups of mollusk remains, the decrease in the proportion of mollusk remains might reflect this situation. Changes that occur in the archaeozoological record of the site point to the increased importance of domestic food animals in this period.[135] The decrease in mollusk remains might be related to this factor, which indicates that animal protein and fat were well secured by products obtained from domestic animals. On the other hand, further reduction in the size of primary gathering grounds can be seen as a reason for this change.

The low proportion of mollusk remains in faunal assemblages dating to the Post-Bronze Age must also be related to the formulation of new subsistence strategies determined by ecological, economic, and cultural factors. During the Post-Bronze Age, the deltaic coastlines were ca. 3–4 km away from Troia, and the area of the Trojan Bay was at its smallest extent during the occupational history of the site.[136] The settlement was practically land-locked. The distant location of the coast necessitated shellfishing expeditions. In addition, a great extent of the land between the settlement and the deltaic lagoons and marine bay was covered with marshland. The distance, and the uninviting environment covering it, probably turned the shellfishing activity into an economically unfavorable activity. Furthermore, during the historical periods, the exploitation of the wild realm appears to have focused on terrestrial resources, particularly on fallow deer.[137]

The analysis of Post-Bronze Age fish bones show that a significant amount of fishing took place at the Karamenderes and Dümrek rivers relatively frequently during these periods.[138] Based on the analysis of macrobotanical remains, Riehl suggests that the use of the marshland remained minimal during the Post-Bronze Age.[139] The relatively low representation of the mollusk remains in the faunal assemblages fits well with the environmental depiction of the lower plain and the location of the coastline, and it complements the picture drawn by other archaeobiological studies indicating the terrestrial orientation of resource exploitation in Post-Bronze Age Troia. It cannot be ruled out, however, that the proportion of the mollusk remains, as well as other features of the archaeomalacological assemblages of Post-Bronze Age Troia, is largely an outcome of the recovery techniques employed during excavation. Just how sensitive the Post-Bronze Age sampling techniques were to the mollusk remains cannot be judged by archaeozoological analyses.

Diachronic variability can also be seen in the relative abundance of mollusk taxa in different phases of the settlement. Changes in the availability and abundance of mollusk species in the environment, harvesting ease, handling time, nutritional gain, culinary value, and technological innovations introduced through acculturation processes are considered to be the factors influencing this variability in the archaeomalacological record. Altering and stable coastal environmental conditions near the sites play a major role in the shaping of the relative abundance of taxa in the archaeomalacological assemblages of the Aegean. The inhabitants of the settlements located on rocky promontories or close to rocky shores mainly procured those species occupying rocky littorals such as *Patella* spp. and, to a lesser extent, Monodontinae. At those sites, which are located close to estuarine or lagoonal environments, the most commonly procured species were those which dwell in sandy or muddy environments and tolerate salinity fluctuations, such as *C. glaucum.* At sites located at the coasts of semi-enclosed bays where the influence of freshwater was small and low sedimentation rates allowed the presence of some hard substrates within the bays, those species that characteristically occupy these habitats, such as *O. edulis*, *M. galloprovincialis*, *A. noae,* and Muricidae were collected most frequently.

In the Troad, cultural deposits of Sivritepe, Kumtepe, and Alacalıgöl that are dated earlier than Troia I are overwhelmingly dominated by *O. edulis* and *M. galloprovincialis* remains, indicating shellfish gathering activity in shallow waters with hard substrates and little freshwater influence in close proximity to these sites. The Trojan and Beşik Bays must have provided a vast environment for these species during the time period between the maximum marine transgression (ca. 7000–6000 BP) and the invasion of the large areas of the bays with riverine sediments, when lagoons and marshlands were formed near the sites (ca. 5000 BP). The mollusk shells recovered in the geomorphological samples from the Trojan and Beşik Bays support this observation. An abundance of oyster shells have been reported from the marine deposits that lie directly above the bedrock near Pınarbası at the southern end of the Trojan Bay.[140] Oyster shells were also found in the coarse sandy and gravelly deposits that built the coastal barrier forming the lagoon at Beşik Bay.[141]

The gradual silting of the Trojan Bay and the formation of deltaic and coastal lagoons are apparent in the gradual shift from the abundance of *O. edulis* and *M. galloprovincialis* in the archaeomalacological assemblages of the sites in the Troad, to a predominantly *C. glaucum* assemblage at Troia I and II. This change takes place sometime between the Troia I and Troia II periods. The proportion of *A. noae* remains is very limited in the archaeomalacological assemblages from Troia I layers during the new excavations; nevertheless, from an environmental point of view, Gejvall's[142] account reporting abundance of *A. noae* in the Troia I layers recovered during Blegen's excavations does not contrast with the picture drawn for Troia I in the present study. *A. noae*, *O. edulis*, and *M. galloprovincialis* are known to share the same environments. It may be *A. noae's* tendency to populate depths between 3–5 m more densely than shallower waters that hindered the human exploitation of this species in the Troad.

Although Gejvall's reflections about the abundance of *A. noae* might have some truth, they also appear to be biased. The infrequent presence of rocky shore species and species dwelling in sandy shallow littorals indicates that because such environments were not very close to the settlement, shellfishing rarely took place in these areas during the Early Bronze Age. For the same reasons related to the sampling techniques described above, it is very difficult to delineate the factors that were influential in shaping the changes in the relative abundance of species in the archaeomalacological assemblages from Troia III, IV, and V. The similarity of the Troia III species spectrum with those assessed for the earlier Troia I and II further affirms that the change in the proportion of mollusks is attributable to sampling strategies, not to environmental changes or changes in subsistence strategies. The continuing trend in the relative abundance of species at Troia IV, by comparison with the low representation of mollusk remains in the faunal assemblage, can be explained along the same lines of argument.

Similarly, the value of the figures depicting the relative abundance of species in Troia V assemblages has been negatively affected by insufficient sampling techniques. The increased abundance of *S. marginatus* remains at Troia V is linked to the recovery of a large accumulation containing specimens of this species. It is not possible to attribute this accumulation securely to changes in prey choice due to cultural or environmental changes. However, the absence of such *S. marginatus* accumulations in layers antedating Troia V, and their increasing presence in subsequent phases may signify a marked change in the coastal environment, or in prey choice, or both during the Middle and Late Bronze Ages. *S. marginatus* remains might be related to fishing rather than shellfish consumption as human food. Besides, retrieving razorclams from fine sandy bottoms with clear waters requires relatively more physical effort and experience.

The requirement of experience to collect them eliminates the possibility of linking these finds with new demographic elements with their origins in inland Anatolia. Instead, they may be representing new *S. marginatus* populations partially invading the northern section of the Trojan Bay, gradually replacing the *O. edulis* and *M. galloprovincialis* beds there. A drop in the eustatic sea-level and accelerated sedimentation in the bay may have resulted in the formation of shallow fine sandy bottoms where *S. marginatus* could be acquired. Alternatively, a drop in the sea-level may have caused the formation of sandy bottomed pools to the west of the Sigeon Ridge or shallow areas in the marine waters of the Beşik Bay, where razorclams would also have thrived. A variety of cultural explanations can also be offered for the increasing presence of this species at Troia. The difficulty of harvesting the individuals may have increased the species' culinary value. For this reason, *S. marginatus* may have become a type of food demanded on certain occasions to enhance culinary variety. If the species was used primarily as fishing bait, its increase may indicate changes in fishing practices. But studies of fish remains at Troia do not signify a technological change involving fishing practices in the Middle and Late Bronze Ages. Isolated *S. marginatus* accumulations may also be traces of the effects of short-time events (e. g., social conflict, affluence, scarcity, revelry, etc.); however, it is very difficult to distinguish these securely from the effects of general changes in the environment and subsistence strategies.

Until the beginning of Troia VI, the relative abundance of mollusk species at Troia suggests that shellfish gathering was practiced primarily to fulfill dietary needs using most optimal methods. In Troia VI, although this rather straightforward trend largely continues, the increased proportion of *Patella* spp., Monodontinae, *H. trunculus,* and *S. marginatus* in the archaeomalacological assemblages indicates certain changes in the role of shellfishing in the Trojan economy. It shows that more mollusks were gathered for their culinary value and as raw material in dye manufacture. Culinary value can play an important role in procuring those resources, which do not have a prime dietary role, but complement the nutrition of a society. The increasing abundance of these species also suggests that areas which were previously visited ephemerally were more regularly used for shellfish gathering during this period. Although the focal location of the activity was still the deltaic lagoons and the nearby sheltered areas close to the settlement, shellfish gathering in the areas further to the north, to the west of the Sigeion Ridge, on the coast of the Aegean, and to the northeast, on the coast of the Dardanelles, became more frequent during Troia VI.

Frequenting mollusk beds other than the most convenient areas may also indicate the exhaustion of mollusk populations due to prolonged and intense foraging. Ethnographic examples demonstrate that over-exploitation of near-shore mollusk beds decreases the size and abundance of exploited mollusk species, compelling foragers to gather shellfish in deeper water.[143] Exhaustion of the *C. glaucum* beds in the deltaic lagoons, the primary mollusk resource for Troia, cannot be the reason for this apparent shift. While the proportion of lagoon cockles decreases during this period, the overall size and age of the individuals collected increase.[144] Most probably, interrelated changes in the subsistence economy and the surrounding environment prompted culinary value, a desire for variety, and the acquisition of raw material for dye manufacture to become important factors affecting shellfishing practices during this period. Greater nutritional gain could certainly not have constituted a reason for the search for *Patella* spp. and Monodontinae. It is also improbable that the nutrition acquired from species like *H. trunculus* and *S. marginatus* would recompense the time and effort spent to gather these species in an optimal way. *H. trunculus,* a species that was not preferred previously, probably due to its relatively patchy and insignificant occurrence in the northern section of the Troia Bay, was now in demand as raw material for dye manufacture.

To a large extent, small changes that occur in the relative abundances of species among the different phases of Troia VI can be attributed to the differential nature of excavated areas and stratigraphic problems. The successive periods of Troia VI and VIIa represent the rebuildings of the citadel walls in the course of the Late Bronze Age; but these rebuildings of the citadel do not necessarily indicate social, demographic, or cultural changes with any significant impact on the settlement.

The similarity between the relative abundance of species in Troia VI and VIIa affirms the suggestions that environmentally, culturally, and economically this period was a continuation of the Troia VI period. For example, the presence of crushed *H. trunculus* remains in the deposits of this period demonstrates that the custom of dye manufacture continued from Troia VI.

The relative abundance of food species is not markedly different in the subsequent Troia VIIb period, but the decrease in *H. trunculus* remains, as well as the lack of 'murex' accumulations in the excavated areas points to the decline of the dye manufacture. While the species spectrum of the mammalian record and changes in the set of cultivated plant crops of this period are attributed to social and environmental changes,[145] the relative abundance of species in the archaeomalacological assemblages originating from the Troia VIIa and VIIb phases does not point to environmental changes or changes in the use of the coastal environment for shellfish procurement.

Post-Bronze Age shellfishing at Troia assumes an altogether different character, in that shellfish gathering becomes more selective. The significant shift that occurs in the relative abundance of species in the Troia VIII, IX and X periods is related to both environmental and economic changes, if the appearance of this shift is not an outcome of selective sampling during the excavations. The increase in the abundance of *O. edulis* and Pectenidae, already occurring in the Troia VIII assemblages, indicates that the main area of shellfishing has moved from the deltaic lagoons to the bay and possibly to the open sea. The deltaic lagoons are located closer to the Dardanelles at this point in time than to the settlement, whereas the Trojan Bay is significantly reduced in area.[146] The reduction of the lagoonal areas was probably accelerated due to the negative effects of hydraulic engineering programs carried out in the region, such as the building of the aqueduct on the Kemerdere River and possibly by the irrigation works conducted on the lower Trojan Plain. The freshwater influx to the Trojan Bay was thus reduced; meanwhile, the salinity of the Trojan Bay must have increased, thereby creating favorable environments for Pectenidae and *O. edulis* to penetrate.

The inhabitants probably turned to collect these readily available, more nutritious species in order to meet the energy cost of covering the long distance between the shellfishing grounds and the settlement. Additionally, the Post-Bronze Age inhabitants of Troia may also have tried to limit the time they spent at the *C. glaucum* beds due to health reasons. The site's archaeobotanist, Simone Riehl, suggests that the Post-Bronze Age inhabitants of the site avoided the marsh areas in the lower plain, which were adjacent to *C. glaucum* beds, because they wanted to preclude the possibility of catching malaria.[147] The significance of acute malaria in shaping the relationship between coastal dwellers and the environment has been discussed elsewhere before, as a threat inherent to the wetland areas of the Troad both during prehistoric and historical periods.[148] It is also known from the ethnographic record elsewhere that the presence of mosquitoes in wetland areas influenced decisions concerning the timing and place of shellfishing activity.[149] Such are the environmental conditions that may have affected the changes in the relative abundance of species in the Post-Bronze Age assemblages of Troia.

Based on archaeological evidence, Hitchner[150] reports that in the course of the "Romanization" of Provence, oysters replaced mussels, and especially "from the 1st c. C. E., the consumption of oysters, and to a lesser degree, scallops (*Proteopecten glaber*) became a province-wide phenomenon…involving all population classes."[151] The suggestion that the Romanization of a coastal province in the Western Mediterranean had an effect on shellfish gathering is relevant to the changes that occurred in the archaeomalacological assemblages in Post-Bronze Age Troia. Hitchner also argues that unlike in Rome, Provence mussels and oysters were not prestige foods, but staples.[152] This may simply be due to the nature of prestige items; they are rarely obtainable but in highly demand. The availability of shellfish at a coastal site is obviously not comparable to that in Rome during Roman times. Despite these parallelisms showing that acculturation processes might be an important factor influencing patterns of shellfishing and consumption in Post-Bronze Age Troia, current archaeomalacological evidence does not allow one to make a detailed and accurate evaluation of the culinary or social value of shellfish during Troia IX. Additionally, Hitchner reports that mussels replaced oysters as an important part of the diet during the Byzantine period, as a consequence of growing demand on cultivated young oysters.[153] Archaeomalacological evidence from Byzantine Troia (Period X) does not imply such a change. But this picture may be falsified due to the restricted sample size datable to Troia X.

While an Archaic to Hellenistic date (Troia VIII) is earlier than the first written accounts of oyster cultivation, it is surely no coincidence that the relative abundance of *O. edulis* in the archaeological deposits of Troia IX is roughly contemporary with the beginning of contact with Rome and the first written accounts of oyster cultivation. If such a cultural mechanism enhanced the consumption of *O. edulis* and Pectenidae in Roman and Byzantine Troia, then the archaeomalacological evidence dating to these periods cannot be explained solely in environmental or economic terms. Given the frequency of the relationship between Roman Troia and Rome,[154] combined with the fact that Troia was a tourist site already in the Classical period, the possibility exists that the high abundance of *O. edulis* and Pectenidae in the Post-Bronze Age site is the reflection of local or foreign demand for these food species, the former of which may have been procured through aquaculture. But do the limited remains of *O. edulis* in Roman and Byzantine Troia, although proportionally dominant in the mollusk assemblage, represent oyster culture? If morphological descriptions of the *O. edulis* remains from the Post-Bronze Age layers were available, this question could be addressed by plotting the size profiles of the specimens and by analyzing the negative imprints left by the implements used in aquaculture, such as ropes, wooden rods, or even pottery.

Unio spp., as mentioned before, must have occurred in the freshwater sources around Troia in fairly large amounts. They are represented at Troia by very low numbers. The increased exploitation of freshwater fish in the Post-Bronze Age layers of Troia is not accompanied by increased exploitation of freshwater clams.[155] The increasing presence of freshwater fish taxa in the archaeozoological assemblages has been attributed to amplified sedimentation of the Trojan Plain and coeval shift of the river mouth to the north.[156] If the slight turn from lagoonal fisheries to freshwater fisheries during the Post-Bronze Age was caused by accelerated sedimentation rates, the shellfishing sector of the economy appears to have responded to these environmental developments by renewed emphasis on open sea and bay shellfishing rather than riverine exploitation. Similar dualities resulting in the differential paleoenvironmental interpretations of the archaeomalacological and ichthyoarchaeological evidence have been recorded elsewhere.[157] There may be three reasons for this duality in the Trojan record: (1) relative emphasis on freshwater fisheries is not a consequence of paleoenvironmental changes, but a cultural phenomenon; (2) the choice for exploiting nearby freshwater fisheries did not affect decisions in shellfishing because *Unio* spp. are not as gregarious as the marine species that were available; or, (3) freshwater clams are not considered palatable. Based on the present evidence, culinary preference is the most likely explanation for the rarity of *Unio* spp. in the archaeomalacological assemblages. *Unio crassus* contains relatively less flesh and protein than other shelled aquatic mollusks. The dietary need for animal fat and protein, transformed into an unconscious sense of taste, may have led to the avoidance of this species.

Summary and Conclusions

The aim of this paper was to describe some features of the archaeomalacological material from the M. O. Korfmann's excavations at Troia and explain shellfish gathering and consumption as it was practiced at different periods of Troia's occupational history. Moreover, I attempted to suggest environmental (including climatic) factors and cultural and economic stimuli affecting change and continuity in activities involving shellfish. While I tackled issues such as the location and techniques of shellfish procurement and processing of aquatic mollusks in some detail, I purposefully avoided discussions as to whether aquatic mollusks constituted a staple or supplemental food resource, as well as estimates of the percentage contribution of aquatic mollusks to the diet. Furthermore, I deliberately neglected issues related to the gender, ethnicity, and class of shellfish gatherers and shellfish consumers. The nature of the archaeomalacological and archaeological record from Troia is not sufficient to address such questions. Others, such as the impact of prolonged human exploitation on mollusk populations and its consequence for gathering activity and 'murex' dye production have been discussed elsewhere in detail.[158]

Research methods used for the interpretations presented in this paper included common archaeozoological techniques using counts and weights of faunal specimens. Variability and continuity in the archaeomalacological record were evaluated with regard to the changing cultural demography of the settlement, requirements of local economic strategies, environmental changes, and climatic fluctuations. The effects of differences in preservation, the differing nature of excavated areas, excavation techniques, and archaeozoological methodology on the formation of the archaeomalacological results were also acknowledged.

Troia represents a sedentary human population which was already pursuing a well-established, multi-pronged subsistence economy at the beginning of the Early Bronze Age, exploiting domestic plants and animals, gathering wild plants, fishing, and hunting. This society was a complex one involved in craftsmanship and long-distance trade, and was subject to acculturation processes. The archaeomalacological assemblages of this society's settlement were shaped by the necessity of this cultural and economic system to exploit its changing environment in the most optimal way.

The mollusk assemblage of the site mainly represents food refuse. Some may have been used to prepare fishing bait, whereas most specimens of rarely encountered species were brought to the settlement empty. The crushed *H. trunculus* shells from the Late Bronze Age layers of Troia are remnants of a sizable dye industry. Shellfish gathering mainly took place between the lagoonal and estuarine environments of the Trojan Bay and the mesolittoral zone of the coastal areas. Confirming the results of archaeobotanical and archaeozoological investigations at the site, this situation shows that even if the Trojan Bay never served as a harbor for the Bronze Age settlement,[159] it was of the highest importance as a rich resource base. While gathering could generally be done by employing easy techniques, knowledge of mollusk behavior and ecology was a prerequisite for obtaining some species.

Oyster cultivation may have been practiced at Troia during the Post-Bronze Age. The year-around availability of aquatic mollusks probably made preservation techniques superfluous. The role of shellfishing in the subsistence economies of the settlements in the Troad appears to have declined gradually from the 5th millennium B. C. to the end of the Byzantine settlement at Troia. The large proportion of marine mollusk remains from the settlements dating to the Early Bronze Age and immediately before implies that the exploitation of marine mollusks constituted an important part of the subsistence strategies. Settlements made use of the mollusk beds that were nearest to them. The Trojan Bay and the deltaic lagoons of the Karamenderes and Dümrek Rivers were the primary shellfishing grounds of Troia, while the Beşik Bay and the shores of the Aegean and the Dardanelles were rarely visited to gather shellfish.

Cockle (*C. glaucum*) gathering at Troia was an integrated part of the subsistence since the beginning of the settlement. At that time, the proximity of cockle beds to the settlement made this activity a profitable pursuit in terms of nutritional gain. The mode of mollusk exploitation changed to become slightly more discriminatory during the Late Bronze Age. As the distance between Troia and the mollusk beds increased, the benthic structure of the Trojan Bay became devoid of any hard features; the area of the continental shelf became smaller, and the mode of mollusk exploitation became less intensive. Simultaneously, changes took place in other sectors of the settlement's economy. As a consequence, the culinary value, the desire for variety, and the need to obtain raw material for industrial work became important motives for gathering mollusks during the Late Bronze Age. Shellfish gathering was now not only a part of the subsistence economy but also part of commerce and perhaps of long-distance trade. *C. glaucum* beds close to the settlement were still the most frequented environments for shellfishing, but visits to the outer bay and to the rocky shores became more frequent.

During the Post-Bronze Age periods, shellfish procurement assumed a rather selective mode. Oysters (*O. edulis*) and scallops (Pectenidae) start to dominate the archaeomalacological assemblages of Troia in the Post-Bronze Age. Shellfishing grounds moved from the closest areas to the settlement, such as the lagoons, to the Trojan Bay, and probably to fully marine waters, in search of larger and more nutritious species. Acculturation processes, innovations in aquaculture, and the terrestrial orientation of subsistence strategies are thought to have been influential in this process.

Several problems occurred when testing the implications of the archaeomalacological evidence in view of proposed climatic, environmental, cultural, and economic changes. For instance, the archaeomalacological evidence from the Troia II period could not be evaluated to test archaeologists' postulations about "insecure times" associated with the increase in the number of pits in archaeological deposits, because none of the studied assemblages dating to this period originate from these pit contexts. Changes observed in the archaeomalacological assemblages from Troia III, Troia IV, and Troia V could be more securely attributed to failures in the sampling strategies employed during the excavations rather than to environmental or economic changes. For this reason, the risk-buffering mode of plant cultivation suggested for Middle Bronze Age Troia could not be related to a similar trend in mollusk exploitation patterns.

As Fagan powerfully points out, "even if a community grows prosperous of long-distance trade, it must generate large local food surpluses to support public works. That implies ample crops, good weather, and a carefully fostered relationship with the environment."[160] The sustained relationship between environment and subsistence constitute the foundation of advanced societies. This statement is no less true for Troia. The anthropological possibilities of archaeomalacological research presented in this paper explicitly demonstrated that the prehistoric and early historic people of Troia had a far more varied diet and a more complex subsistence system than it is commonly acknowledged. Shellfish gathering consolidated the stability of the economic and cultural system of Troia by presenting an additional and perennial supplement to the dietary items provided by agriculture, animal husbandry, hunting, fishing; and the gathering of wild plants; it also led to the development of local industries, probably involving local craftsmen, and contributed to the settlement's foreign trade revenues. Resistance against lean or crisis periods imposed either by social instability or unexpected climatic changes could have been reinforced by the exploitation of mollusk beds when necessary. In fact, the availability of good shellfishing grounds may have played a decisive role in shaping the prehistoric settlement patterns in the Troad. The exploitation of aquatic mollusks enhanced the diet of the Trojans by giving them the freedom to exploit and experiment with resources that are more likely to fail, thereby leading to a thriving society and culture.

Notes

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[1] Çakırlar 2006; Claassen 1998.

[2] The term is adopted from Widmer's classification of archaeological sites bearing shell remains. Widmer 1989 cited in Claassen 1998, 12. For examples of works presenting evidence for shellfish gathering in the Aegean Basin, see Becker 1986; Peters 1983; Karali 1999, among others.

[3] Brief accounts of mollusk remains from earlier and more recent excavations at Troia can be found in Virchow 1881; von Martens 1879 and 1880; Gejvall 1938; Uerpmann and Uerpmann 2001; and Uerpmann 2006. Patterns of human exploitation of lagoon cockles (*Cerastoderma glaucum*) at Bronze Age Troia were discussed in Çakırlar 2008.

[4] For the discussion on the results of morphological investigations and seasonality of cockle foraging at Troia, see Çakırlar 2008 and forthcoming.

[5] For results of research exemplifying the use of multi-proxy data and methods in detecting ancient tsunami, see Bruins *et al.* 2008.

[6] Glassow – Wilcoxon 1988.

[7] Davies 2008.

[8] Lubell 2004.

[9] Gümüş 2004.

[10] Gejvall 1938.

[11] Öztürk – Ergen 1999; Demir 2003.

[12] Gaillard 1987; Öztürk – Ergen 1999.

[13] Gaillard 1987; Hayward *et al.* 1995.

[14] Davidson 1972, 190.

[15] Shackleton 1968, 129.

[16] Forbes 1976a.

[17] Deith 1985.

[18] E. g., the earliest levels of the Franchthi Cave (Shackleton 1988), Late Neolithic Saliagos (Shackleton 1968, 129), the Mesolithic Cyclops Cave on Youra Island (Sampson 1998), Middle Bronze Age Palaikastro (Reese 1987a), and Early Bronze Age Yenibademli (Çakırlar 2007), among others.

[19] Demir 2003.

[20] Little 1996, 22.

[21] Gianuzzi-Savelli *et al*. 1996, 28–42; Demir 2003. Lessepsian migrants are species which have entered the Mediterranean from the Red Sea through the Suez Canal.

[22] Koutsoubas *et al.* 2000.

[23] Shackleton 1988a; 1988b.

[24] Rilov *et al*. 2004.

[25] Poppe – Goto 2000.

[26] Bodur *et al*. 2004.

[27] Poutiers 1987.

[28] Peharda *et al.* 2002; Bodur *et al*. 2004.

[29] E. g., Eleusis (Cosmopoulos *et al.* 2003), Middle Bronze Age Ayios Mamas (Becker 1996; 2001), Middle Bronze Age Lerna (Gejvall 1969).

[30] Peharda *et al*. 2002.

[31] Zenetos 1996; Poutiers 1987; Demir 2003.

[32] Poutiers 1987.

[33] Ibid.

[34] See for example: Becker 1996, 12, fig. 6c; Boessneck 1986; Reese 1986; 1987a; 1987b; 2006.

[35] Davidson 1972, 196.

[36] Ibid.

[37] Barnes 1980, 44.

[38] Deith 1985.

[39] Richardson *et al.* 1999.

[40] European Environmental Agency 1999.

[41] Poutiers 1987.

[42] Sabelli 1979; Poutiers 1987.

[43] Poutiers 1987.

[44] Ibid.

[45] Davidson 1972, 200–201.

[46] Hitchner 1999.

[47] Gejvall 1969, 7: Table 4.

[48] Ibid.

[49] Atay 1984, 111.

[50] Milner 2001.

[51] Barnes 1980, 44.

[52] Günther 1897.

[53] Boessneck 1986.
[54] Personal communication with M. Uerpmann.
[55] Buitenhuis 1995.
[56] See, for example, Peters 1992 for archaic Kalabaktepe near Miletos, and Prummel 2005 for Hellenistic New Halos.
[57] Brock 1991; Nikula – Väinölä 2003. The former name of this genus is *Cardium.*
[58] Sabelli 1979; Poutiers 1987.
[59] Boyden – Russell 1972.
[60] Ivell 1979b.
[61] Blegen 1951, 66–67.
[62] Davidson 1972, 202.
[63] See, for example, Becker 1986 for Kastanas; Reese 2006 for Panaztepe; Falkner 1975 for Magoula Pevkakia, among others.
[64] Poutiers 1987.
[65] Davidson 1972, 207.
[66] Ibid.
[67] İlhan – Gülyavuz 2004.
[68] Davidson 1972, 204.
[69] İlhan *et al*. 2004.
[70] Vicenti 2005.
[71] Becker 1986.
[72] For a detailed discussion of this issue, see Çakırlar – Becks, this volume.
[73] Korfmann 2003.
[74] Kayan *et al.* 2003, among others.
[75] Aksu *et al.* 2002.
[76] Kayan 1991.
[77] Kayan 1991, 88; Boessneck 1986; von den Driesch 1999.
[78] Çakırlar 2008.
[79] Iliad XVI, 745–748.
[80] Waselkov 1987.
[81] Forbes 1976a; Waselkov 1987.
[82] Ruscillo 2005.
[83] Waselkow 1987.
[84] Davidson 1972, 207; 2004.
[85] Lacombe 2000.
[86] Waselkow 1987.
[87] Nash 2000.
[88] Davidson 1972, 189–209.
[89] Gejvall 1938.
[90] Barnes 1987, 342.
[91] Forbes 1976a.
[92] Deith 1985; Henshilwood *et al.* 1994; Moss 1993; Waselkov 1987.
[93] Meehan 1977.
[94] Davidson 2004; Forbes 1976a.
[95] Henshilwood *et al.* 1994.
[96] Bogoucki – Grygiel 1981; Homer 1955, 61; Özdoğan 1999.
[97] Nash 2000.
[98] Bottéro 1996; Morales-Muniz 1993.
[99] Becks 2006.
[100] Forbes 1976b; Meehan 1982.
[101] Buchanan 1988, 26.
[102] Bird *et al*. 2002.
[103] Petersen 2004.
[104] Çakırlar – Becks, this volume.
[105] For a more detailed description of these, see Çakırlar 2007.
[106] E. g., Deith 1985; Meehan 1983.
[107] Barnes 1980, 55.
[108] See, for example, Meehan 1983.
[109] Glassow – Wilcoxon 1988.
[110] Boessneck 1986.
[111] Ibid.
[112] Deith 1985.
[113] Gabriel *et al.* 2004 and personal observation.
[114] Personal communication with M. Uerpmann and personal observation.
[115] Von den Driesch 1999.
[116] See above, under "Analytical Results."
[117] Kayan 1991.
[118] Kayan *et al.* 2003.
[119] Ibid.
[120] Riehl 1999, 83; Uerpmann 2003.
[121] Riehl 1999, 83.
[122] Uerpmann 2003.
[123] Riehl 1999; Uerpmann 2003.
[124] Blum 2006.
[125] De Menocal *et al.* 2001; Rohling *et al.* 2002.
[126] Frank *et al*. 2002.
[127] Uerpmann 2003.
[128] McKillop 1984.
[129] Uerpmann 2003.
[130] Riehl 1999.
[131] Becks 2006.
[132] Uerpmann 2003; 2006.
[133] Thomas 2002.
[134] Kayan 1996.
[135] Uerpmann 2003.
[136] Kayan *et al.* 2003; Kraft *et al.* 2003a.
[137] Fabiš 2003.
[138] Uerpmann – van Neer 2000.
[139] Riehl 1999.
[140] Kayan *et al.* 2003.
[141] Kayan 1991.
[142] Gejvall 1938.
[143] Thomas 2002.
[144] Çakırlar 2008.
[145] Riehl 1999, 83; personal communication with H.-P. Uerpmann.
[146] Kayan *et al.* 2003.
[147] Riehl 1999.
[148] Aslan 2003; Wittwer-Backofen 2003.
[149] Meehan 1983.
[150] Hitchner 1999.
[151] *Proteopecten glaber* is synonymous with *Flexopecten glaber*, a Pectenid species whose existence in the archaeological deposits of Troia III and Troia VI has been confirmed.

[152] Hitchner 1999.
[153] Ibid.
[154] Rose 2006.
[155] Uerpmann – van Neer 2000.
[156] Ibid.
[157] Rose 1994, 246.
[158] Çakırlar 2008; Çakırlar – Becks this volume; Çakırlar 2007.
[159] Kayan *et al.* 2003.
[160] Fagan 2004, 103.

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