

Marine resources exploitation between Final Pleistocene and Early Holocene (25 – 9 cal kBP). Data from an inland mid-mountain site: Coves de Santa Maira (Valencia region, Spain, Western Mediterranean)

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Marine resources exploitation between Final Pleistocene and Early Holocene (25 – 9 cal kBP). Data from an inland mid-mountain site: Coves de Santa Maira (Valencia region, Spain, Western Mediterranean)

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Our knowledge of the marine fauna in the Upper Paleolithic and Mesolithic sites of the Iberian Mediterranean region is uneven and affected by different biases. The first is geological and is related to the characteristics and morphology of the continental margin, since coastal sites from the Upper Pleistocene are preserved in Andalusia but not in Valencia, due to the effects of marine transgression. The second derives from the previous one and is related to the recovery and study of fish and mollusk remains. Only in the southern sites excavated after 1980 is evidence available, identified at the taxonomic level in some cases.

When these remains are recovered in sites distant from the Pleistocene coastline, their presence is usually explained by exchange between groups. This is the case of some species of mollusks used as ornaments and which have been recovered in sites dozens, even hundreds of kilometers away from their catchment areas.

This work analyzes the remains of fish (marine and freshwater) and mollusks (marine) recovered at Coves de Santa Maira (Valencian region, Spain, Western Mediterranean). A site which has yielded about 2500 remains, mainly concentrated in the Pleistocene-Holocene transition (ca. 15 – 9 cal kBP).

The evolution of these remains is analysed taking into account changes in coastal paleogeography to evaluate the distance from their catchment areas, providing data on the mobility of human groups and the importance of marine resources in the western Mediterranean region, an area traditionally considered as peripheral for the study of this type of economy.

Key words:

Sea-level changes, Paleogeography, Marine fish and Shell-fish, Personal ornament, Shell-tools, Radiocarbon chronology, Paleolithic, Mesolithic, Iberian Mediterranean

Introduction

Changes in sea level and coastline position have directly influenced the preservation of coastal sites inhabited by prehistoric human groups (Shackleton et al., 1984). A global process of this nature does not affect only coastal margin, nor is its scope limited to the strictly local areas (Bailey, 2004; Erlandson, 2001). The distribution of resources on landscape determines a significant part of human behavior in prehistoric hunter-gatherer-fishing societies. Its relationship with technology, subsistence, and mobility is direct, but it also affects the forms of interaction between individuals and groups, their symbolic expression, and the social norms that govern these relationships.

In the Iberian Mediterranean Region (IMR), little attention has been paid to the geographic spread of marine resources relative to their catch areas. Recent attention has been focused on the distribution of personal ornaments made from mollusks (Álvarez-Fernández, 2008; Soler et al., 2025). However, the dispersion of marine remains used as food is less well understood and shows significant regional imbalances (Aura et al., 2016; Lloveras et al., 2019; Román et al., 2020).

Information on the consumption of marine vertebrates (fish, birds, and mammals) from the LGM onward depends, first, on their archaeological recovery and, second, on the taxonomic identification of these remains. These two conditions are met, at least in part, at some sites located in southern Iberia, on the coast of the Alboran Sea (Aura et al., 2002; Álvarez-Fernández et al., 2016; Morales et al., 2020). Similarly, the functional use of marine mollusks—as containers and tools—is supported by more limited data at IMR (Cuenca et al., 2021). Therefore, for the IMR, we have uneven data on the potential uses of marine resources—primarily as ornaments, food, and tools—and scarce data on their spatial distribution. This fragmentary information is complemented by what is known about historical hunter-gatherer-fishers, who indicate that marine resources used as food are not usually transported more than 10 km from their collection sites, with recognized extremes ranging from xx to yy (Meehan, 1977).

Data from CSM comprise more than 2,500 marine mollusk and fish bones distributed unevenly across a broad chronological range (ca. 25 – 9 cal kBP). The site is currently located between 25 and 30 km in a straight line from the coastline. However, the position of the coastline changed and, consequently, so did the distance to the sources of marine resources. To investigate these changes, a paleogeographic reconstruction was carried out of the area where the Gorgos River empties into the sea, which is considered a primary route connecting the site to the coast, both now and in the past.

Taking into account the archaeological and radiocarbon data from the site, three temporary frames have been identified to assess the marine species identified and their use by humans. These three cycles are the Late Glacial Maximum (median = 24.6 - 19.7 cal kBP), the Late Glacial (median = 15.2 – 12.3 cal kBP), and the Early Holocene (median = 11.4 – 9.4 cal kBP). During these three time periods, the current distance to the coast doubled, and potential exploitation areas have been destroyed or are now submerged. They also provide information on the marine resources use in the western Mediterranean region, an area traditionally considered peripheral to the study of this type of economy (Aura et al., 2016).

1. The site: geological setting and chronostratigraphy

Coves de Santa Maira (Castell de Castells, Alacant, Valencia Region, Spain) is located in the central area of IMR. The cavity is open into the rocky wall of the Eocene reef sandstones in the external Prebetic system. These rocks rose, fractured, and eroded during the Alpine Orogeny, resulting in narrow valleys between massive, elevated limestone blocks. The site is placed at an altitude of 600m above sea level, nestled between the mountain ranges of Serra d'Alfaro (1.166m) and Serrella (1.387m), and 30 km from the coast (Figure 1).

The cave includes two sectors: Corral del Gordo (SM-CG) and the Boca Oeste (SM-W). The oldest human activity has been identified at SM-CG. In this sector, the stratigraphic sequence is divided into two major units, CG II and CG I, separated by erosive contact (Jordá Pardo,). Unit CG IIB corresponds to a sandy-muddy yellowish matrix, where erosive processes are recognized. Regarding the radiocarbon AMS dates, they were formed during the Last Maximum Glacial. Thus, both the radiocarbon chronology obtained and the characteristics of the lithic industries allow us to relate the subunit SM CG IIB to the Solutrean 3. Subunit CG IIA corresponds to the erosive contact with the upper unit, with abundant gravels, which decrease with Depth. The radiocarbon dates correspond to the Late Glacial. The uppermost unit, CG I, is a Neolithic "fummier", dated in the Atlantic Period- Also, we have identified a pit containing human remains and early Holocene charcoal. For this work, we discuss only marine fauna from Solutrean occupations (CG IIB, layers 20 – 10).

The sedimentary and archaeological sequence in SM-W spans the Late Pleistocene to the Middle Holocene. It is divided into five major phases (Jordá Pardo,).

- Unit SM-5 was deposited during GI- 1 and it is formed by 30cm with centimeter-thick laminations, which rest on a speleothem. This unit contains Upper and Final Magdalenian industries (MSF).

- Unit SM-4 is formed by silt with sand, some gravel, and small limestone pebbles. The base of Unit 4 could be related to the end of the GS 1 while the upper sequence corresponds to Preboreal. The archaeological materials are characteristic of the microlithic phases named Epimagdalenian / Epipaleolithic (= Epi) and Sauveterroid (= Sau).
 - Unit SM-3 shows a considerable dip towards the innermost dolos4a the cave. Five sub-units have been identified with similar grain sizes and variable coloration. Pebbles and large limestone blocks appear at the base and are separate from unit SM-4. Radiocarbon dating places it at the Boreal. This deposit lies in a secondary position and slopes steeply into the cave. The archaeological materials date to the Early Mesolithic period, with a notable emphasis on the use of local raw materials and expedient techniques (= MD).
 - Unit SM-2 has an irregular geometry with remains of organic laminations; it shows erosional dolos4a4 ver the lower unit. Neolithic
 - Unit SM-1 Chalcolithic to the Middle Ages: has a chaotic appearance with tabular geometry, and it is strongly eroded over the underlying unit.
- The characteristics and texture of the sediments in both sectors are different, but they do not appear to have affected the preservation of the marine remains studied here. Few lithic and osseous dolos have been found in the SM-CG sector, in contrast to the abundance of artifacts, organic remains (plants and animals), ochre residues from SM-W.

2. Materials and Methods

2.1. Palaeogeographic coastline evolution

The palaeogeographic development of the coastline surrounding Cape La Nau, in the vicinity of the Coves de Santa Maira site, has been reconstructed through the analysis of bathymetric metadata and Digital Terrain Model (DTM) products obtained from the EMODnet Bathymetry portal (<http://www.emodnet-bathymetry.eu>). From the bathymetric databases, 100 m resolution bathymetric grids have been generated. Bathymetric data from the Institut Cartogràfic Valencià of the GVA and the Ministry of Agriculture, Fisheries and Food were also used to optimise the results (Institut Cartogràfic Valencià, Generalitat, 2006; Ministerio de Agricultura, Pesca y Alimentación, 2021a, 2021b). The position of the coastline during the different chronological phases examined in this study was established using high-resolution relative sea-level curves covering the last 30 ka, derived from the SPECMAP radiometric timescale (Thompson and Goldstein, 2006). Calibrated radiocarbon ages can be compared with the absolute chronological frameworks commonly employed in palaeoclimatic reconstructions based on marine

records, such as the SPECMAP curve, which is expressed in kiloannum (ka) and integrates global climate and sea-level fluctuations inferred from marine isotope sequences (Thompson and Goldstein, 2006). Nevertheless, the comparability of these chronological systems does not imply their equivalence, as atmospheric ^{14}C concentrations have varied through time due to factors including solar activity, geomagnetic field intensity, and specific oceanographic processes that affect ^{14}C production. Consequently, acknowledging that the calibrated radiocarbon ages obtained in this study may not correspond exactly to absolute ages, this research focuses on reconstructing the palaeogeographic changes of the coastline during the Last Glacial Maximum, the Late Glacial and the early Holocene. Each of these periods spans more than 1,000 years. The coastline position for these three periods have been calculated with reference to the chronology obtained for the Santa Maira model, as well as the availability of data for this approach and the climatic fluctuations characterizing each period. Consequently, the LGM phase has been extended to the end of the event. The Holocene period has been considered from its beginning up to a period following the 9.3 ka climatic event.

Using 2MDT LIDAR maps, slope maps were generated using GIS software in order to provide an initial description of the natural routes leading to the coastal plain from the site (Instituto Geográfico Nacional de España and Centro Nacional de Información Geográfica (CNIG), 2015).

2.2. Radiocarbon dating and Bayesian modelling

The Santa Maira archaeological sequence is based on work carried out in two sectors: Corral del Gordo and Boca Oeste. We have 24 AMS radiocarbon dates from the Palaeolithic, Epipaleolithic and Mesolithic levels, obtained in different seasons carried out between 1998 to 2017 (Table 1). We collect and use dates with high precision and accuracy during the analysis process, as well as a good physical-chemical relationship and the representativeness of the dated context (Higham et al., 2006; Mestre i Torres, 1995, 2008).

The AMS radiocarbon dates were calibrated and modelled using the OxCal version 4.4.4 with the IntCal20 curve (Bronk Ramsey, 1995, 2009a; Reimer et al., 2020). We reported the 95% HPD for the dates expressed as cal BP (Table S1 reported the 68% and 95% probability distribution ranges). We developed a phases model that compiled the dates of the 2 sectors of the site.

2.3. Marine fauna: fish and shellfish

Marine fauna remains were recovered after sieving the dry sediment using 5, 2, and 0.5 mm mesh screens. The 2 and 0.5 mm samples were subsequently washed with water in the laboratory, separating them into different categories of archaeological and organic remains. This protocol has made it possible to recover a significant number of remains, particularly fish bones, which are virtually absent from most Paleolithic sites in the IMR (Aura et al., 2016)

As for the fish remains, their taxonomic identification was carried out using comparative methods, with a reference collection that included autochthonous species. We also used data from various authors on marine fauna in the study area (Whitehead et al., 1986; Desse and Desse, 1983). To determine the size of the identified species, biometric and morphological techniques were used, without employing diagnostic techniques such as X-rays of vertebral elements.

For the taxonomic identification of marine mollusks, we consulted Poppe and Goto (1991), Montero (1971), and Gofas et al. (2011). The species nomenclature is proposed by the World Register of Marine Species (WoRMS, <https://www.marinespecies.org/>). The results are evaluated according to NR (Moreno, 1994).

3.1. Shell beads

In this study, only those objects that retain traces of a perforation in the bivalve and gastropod species are considered ornaments. In Scaphopoda, the presence of a perforation is unnecessary due to their natural morphology.

The techniques used to produce the pendants are not discussed, whether they relate to the condition and taphonomy (fracturing, biometry, alteration, or the addition of colorants) or to perforation techniques (manufacturing marks and marks of use). The following general criteria were applied:

- In the case of marine gastropods, both perforated specimens and whole specimens without perforations those species used for ornamental purposes, are included.
- In the case of bivalves, including fossils, perforated specimens are included in pendants. Those remains containing residues and ochre that not show stigmata of use are noted.

A Leica M165 C stereomicroscope with a Schott KL 1600 LED cold light source was used for the observation and analysis of the perforations.

The data on the SM-W sector were recently published as part of a study on the evolution of ornaments from the end of the Late Paleolithic to the Mesolithic (Soler and Aura; 201; Soler et al., 2025). While some preliminary findings on the Solutrean assemblage from

SM-CG had been published (Álvarez-Fernández and Avezuela, 2012), but no comprehensive inventory had been released.

3.2 Shell-tools

To document and analyse the technological use of marine shells at Coves de Santa Maira, the entire set of archaeomalacological remains recovered from the cave was examined, excluding items related to personal ornamentation. In total, 1,429 marine malacofaunal remains were analysed from SM-W sector, with Glycymeridae, Cardiidae and *Mytilus* sp. being the most common. These remains correspond to all occupation phases attributed to the Magdalenian, Epipalaeolithic and Sauveterroid, Mesolithic and Neolithic. Additionally, several pieces recovered during cleaning operations or as unstratified finds from different areas of the cave were included.

All specimens were analysed following standard use-wear analysis procedures (Semenov 1964), combining macroscopic and microscopic observations at magnifications between 10× and 200×. A Leica DM2500M metallographic microscope and a Leica S8APO stereomicroscope were used, together with a Leica 190HD camera for photographic documentation. Functional interpretations were based on an inference framework derived from a series of experimental programmes addressing both the taphonomic alterations of shells (Cuenca-Solana 2010, 2013, 2015; Cuenca-Solana et al. 2017, 2022) and the manufacture and use of shell tools (Cuenca-Solana et al. 2013, 2016, 2021; Lidour and Cuenca-Solana 2024; Lastra-Alonso et al. 2025, among others). A biometric study was not undertaken due to the high degree of fragmentation affecting the assemblage and because only a single complete shell is represented among the tools from Coves de Santa Maira.

The marine fauna from Coves de Santa Maira will be stored in the Alcoi Archaeological Museum “C. Visedo Moltó” (Alacant, Valencia region, Spain).

4. RESULTS

In this paper, we will focus on the Upper Paleolithic and Mesolithic human occupations. References to more recent times are included to supplement the general chronostratigraphic description.

4.1. Radiocarbon dating and Bayesian modelling

The Santa Maira phases model provides a chronology for both sectors (Figure 2). SM-CG yields the earliest date (Beta-438706). In contrast, SM-W provides dates only for the Pleistocene-Holocene transition, specifically associated with Magdalenian, Epipalaeolithic, and Mesolithic levels. The model yielded an agreement index (A_{model} =

98, $A_{\text{overall}} = 97.9$) that exceeded the minimum acceptable threshold of 60% (Bronk Ramsey, 1995). All the measurements also display a good agreement with the model, and therefore, all samples are well integrated within respective phases.

The LGM is the oldest phase, where all the dates come from SM-CG sector. The first three samples were recovered from levels containing Solutrean lithic assemblages. No evidence of Solutrean remains has been detected in Boca Oeste because it has not reached the base of this sequence. The last sample is a *Cuon alpinus*, registered by a skull with lithic cut-marks (Pérez Ripoll et al., 2010), despite coming from a context without a lithic or osseous industry with techno-typology markers. This remain provides evidence of human activity at the site during the LGM climatic conditions. Although this sample is chronologically more distant from the other samples assigned to this phase, it remains statistically consistent within the phase. This phase represents the climatic period with the longest span for the SM sequence.

The Late Glacial is the first phase for which evidence is available from both sectors. However, most of the samples come from Boca Oeste sector. This climatic phase is consistent with samples assigned to the Magdalenian and Epipalaeolithic technocomplexes. The Late Glacial in SM provides a long sequence of occupations. The model calculates a span of more than 2000 years for this phase (Table S1).

The Early Holocene phase, which lasted more than 1500 years, has more evidence from Boca Oeste and is documented in GC or a few human remains. The samples corresponding to the Holocene derive from levels in which remains associated with Sauveterroid and Mesolithic lithic productions have been documented.

Table 3. Phases model results for the start and end boundaries of each phase of SM.

Based on the archaeological information and taking into account the radiocarbon data from the site, three main time frames have been proposed to assess the marine resources found in each, the species involved, and their use. These three cycles are the Late Glacial Maximum (median = 24.55 – 19.7 cal kBP), the Late Glacial (median = 15.2- 12.3 cal kBP), and the Early Holocene (median = 11.3 – 9.4 cal kBP). During these interval, the distance ranged from 58 to 40 km, which is twice the current distance.

4.2. Routes from CSM to the coast

The site is located in the Barranc de Famorca, where the Gorgos River flows. It is a Mediterranean river with an intermittent regime, with summer droughts and heavy fall

flooding. Its riverbed is the most direct route to the coastal plain and its mouth in Xàbia Bay (Figure 3: Northern route).

The course is entirely downhill, alternating between steep sections, deep gorges, and pools. The first of these sections is the highest in elevation, ranging from 291 to 600 meters above sea level, between Coves de Santa Maira and Vall de Xaló, and spans 10.7 km. The second section descends to 169 meters above sea level and in the third section, the G River flows through a gorge at 75 meters above sea level, with steep slopes and riparian vegetation, including *Salix* sp. and *Populus alba*, which are part of the European Natura 2000 Network. The final section runs through the Plana de Xàbia, over gently sloping quaternary detrital deposits that form terraces and floodplains, down to the current coastline at 0 meters above sea level. This route has a total length of 55.7 km, of which 40.2 km are above present-day sea level.

There are other ways to reach the coastal plain from CSM. To supplement the previous route, we have included another itinerary farther south, totaling 68.9 km, of which 28.5 km are currently above water (Figure 3: Southern Route). On this route, the first section is an ascent with a 155-meter elevation gain. It begins in the town of Castell de Castells and heads toward the serra Racó Roig (878 meters above sea level), featuring steep slopes and rugged terrain. The second section is a 3.5-km descent through a mid-elevation valley between the Carrascar de Parcent mountain range (994 m) and Serra del Ferrer (898 m). The third section is deeply incised and extends all the way to the Algar River. The final section follows the course of this river crossing through quaternary terraces, glacia, and floodplains down to the current coastline at 0 meters above sea level.

When comparing both theoretical two routes, the first using the Gorgos riverbed to reach the coast is more efficient in terms of distance and physical effort, as it features gentle slopes and a smaller elevation gain. In contrast, the alternative route we described further south is longer and more demanding in terms of elevation, with steep slopes and a greater cumulative ascent (Figure 3)

4.3. Morphological and palaeogeographical evolution of Cape La Nau continental shelf

The morphological characterization and palaeogeographical development of the offshore zone surrounding the Coves de Santa Maira site encompass a coastal stretch approximately 77 km in length, extending from Molinell in the north to Altea in the south. Within this framework, Coves de Santa Maira occupies a central position, located roughly 25 km inland from the present-day coastline (Figure 3). The Quaternary morphological and palaeogeographic evolution of the continental shelf in this southern sector of the Gulf of Valencia, together with the easternmost domain of the Prebetic Cordillera, has

been primarily governed by fluctuations in sea level acting in conjunction with a comparatively high rate of tectonic subsidence. This subsidence is notably greater than that observed in other regions of the Iberian Peninsula and reflects the intense neotectonic activity affecting the area (Rey and Díaz del Río, 1983; Díaz del Río et al., 1986; Viñals and Fumanal, 1995; Zazo et al., 1993; Rey and Fumanal, 1996; Blázquez et al., 1996). As a result, the continental shelf of this sector is characterized by a considerable Plio-Quaternary sedimentary accumulation, generated by elevated sedimentation rates combined with flexural subsidence. More recent investigations suggest subsidence values of around 30 cm/ka for the central sector (Albarracín et al., 2013; Alcántara et al., 2013), a figure that has been adopted for recalculating relative sea-level changes along this portion of the Valencian margin.

In the sector between Dénia and Cape Sant Antoni, the continental shelf has an approximate width of 15 km, with its shelf break located at around 120 m depth. The maximum slope reaches 2.5%, while the average slope is approximately 0.3%. In this sector, the continental slope exhibits a certain degree of complexity due to the presence of a marginal platform associated with the development of normal faults that stepped the margin during the formation of the Valencia Trough. This marginal platform is characterized by a flat surface located at approximately 220 m depth and an extent of between 4 and 6 km. From Cape Sant Antoni to Altea, the continental shelf narrows in the Cape La Nau area, where it reaches a width of 17 km, with a maximum slope of 3.5% and an average slope of 0.3%, and the shelf break is located at a depth of 135 m. Beyond this point, the continental shelf widens again toward Altea, exhibiting an average width of 35 km, a maximum slope of 3%, an average slope of 0.3%, and a shelf break located at approximately 130 m depth.

From a morphological and sedimentological perspective, the continental shelf of the studied sector exhibits the characteristic features of a prograding margin, with very regular morphology, an absence of major reliefs, and a convex geometry. Within this framework, a progressive north–south decrease in the thickness of Pliocene–Quaternary detrital deposits is observed (Díaz del Río et al., 1986). The origin of these detrital materials is partly fluvial, derived from the drainage basins of the Serpis, Girona, Gorgos, and Algar rivers, giving rise to prograding deposits with lobate morphology and gentle slopes (Maldonado et al., 1983; Díaz del Río et al., 1986; Blázquez, 1999). Beyond the direct influence of this fluvial environment, fine terrigenous and bioclastic sediments dominate, related to coastal dynamics (Blázquez et al., 1996; Usera and Blázquez, 1997). The proximal submarine zones of the beaches extend seaward, forming infralittoral beach prisms that generally do not exceed depths of 30–40 m. These prisms are composed of sandy materials that display a superficial crusting, resulting from the

development of seagrass meadows. South of Dénia, a significant sedimentary change is observed, marked by the appearance of outcrops of consolidated calcarenitic materials, interpreted as relic coastal ridges associated with former shoreline positions (Rey and Díaz del Río, 1983). These coastal ridges are generally found at depths between 12 and 20 m, although isolated bodies have also been identified at greater depths, ranging from 30 to 55 m (Rey et al., 1993; Fumanal et al., 1993; Martínez Gallego et al., 1995). Considering the transgressive phases that occurred between (16 and 8.5 cal kBP) (Mateu et al., 1985; Somoza et al., 1987), it may be inferred that the deeper ridges correspond to a time interval between 14 and 10 cal kBP, whereas the shallower ridges are associated with ages 9 and 8.5 cal kBP (Rey et al., 1993). In addition, a prograding unit has been identified, supported northward on previously lithified Quaternary outcrops and characterized by its extensive development and its parallelism to the present-day coastline. This unit may be related to a coastal ridge system and transverse dunes in its landward sector (Fumanal et al., 1993). Both this prograding unit and the coastal ridges are fossilized beneath Holocene depositional sequences (Blázquez, 1999).

A paleogeographic reconstruction of the coastline was undertaken for the period, which corresponds to the chronological range of human occupation identified at the Coves de Santa Maira (Fig. 4 SPECMAC). During the regressive phase spanning from 25 ka b2k to the Last Glacial Maximum (LGM; 19 ka b2k), a pronounced global sea-level fall (Shackleton, 1987; Bard et al., 1990, 1992; Berger et al., 1994; North Greenland Ice Core Project, 2004) promoted seaward progradation of the sedimentary margin and the basinward migration of depocentres (Hernández-Molina et al., 1994). Over this interval, relative sea level declined from approximately 127 m to about 120 m below present-day sea level (Thompson and Goldstein, 2006). At the LGM event, the coastline was situated at a mean distance of roughly 58 km from the Coves de Santa Maira. As a result, the emerged land surface in the surrounding region increased by approximately 1320 km² compared to present-day conditions. Following this regressive episode, a transgressive phase developed and continued until the present (Fig. 5.1). Particular attention has been given to the intervals between 15.2 and 12.3 ka b2k (the Late-Glacial period) and 11.3 and 9.4 ka b2k (the Early Holocene period), as these cover the documented occupation span of the Coves de Santa Maira. During the Late Glacial period, relative sea level fell from approximately 84 m to around 66 m below present sea level (Fig. 5.2), corresponding to an average shoreline displacement of nearly 48 km from the study site. Under these conditions, the exposed land area within the study region expanded by roughly 762 km² compared to its present extent. Subsequently, in the early Holocene, relative sea level ranged between approximately 57 m and 34 m below present sea level

(Figure 5.3), with a mean shoreline distance of about 40 km from the site. This resulted in an increase of the emerged area of approximately 300 km² relative to current conditions.

4.4 Fish bones

A total of 876 remains were recovered, with a highly asymmetrical distribution by sector, since 857 correspond to SM-W and only 19 come from SM-CG. This fact can be related to the chronology and coastline changes, but the characteristics of the human occupations in each sector could be a determining variable. Of these, 508 remains have been determined at least to the family level. Twelve remains could not be determined due to the difficulty of making a reliable diagnosis. On the other hand, 353 remains are indeterminate. This latter group typically includes fragments that are difficult or impossible to determine, such as scales, most branchiostegalia, *skeleton pinnarum* (fins), *costae* (ribs), *acantotrichia*, *lepidotrichia*, *pterygofori*..., as well as small fragments of the neurocranium or other highly fragmented remains. Among the identified remains, vertebrae total 473 (77%) versus 135 (22%) cranial elements. If the molariforms derived from the dentitions of sparids are removed—77 remains—the percentages become much more favorable to the vertebral assemblage, at 88%, and 11% for cranial elements. The presence of cranial and postcranial bones, as well as a significant number of unidentifiable remains, is consistent with the contribution of complete individuals to the site, whose size varies.

Regarding taxonomy, the families represented in the sample are 13. Two families stand out clearly: the Sparidae with 184 remains and the Mugilidae with 151. But again, if we remove the molariforms from the Sparidae, we see that the most prominent group becomes the mugilids, which with 151 remains are the best represented, followed by the Sparidae, now with 106 remains. Next are the Anguillidae with 70 remains and the carangids with 52. The minority groups are the Engraulidae with 33, and at a much greater distance the Clupeidae and Chondrichthyes with four remains, the Belonidae and Salmonidae with two, and the rest of the families represented by only single remains (Table 4).

As for the size of the fish, taking into account the four best-represented families, we have grouped them into three main groups: small, medium and large fish. This classification was carried out taking into account the dimensions of each species and based on the sizes identified in each element was assigned to one of these groups. According to this scale, it can be said that the fish consumed in the cave were small (154 remains), medium-sized (212 remains), and only in some cases were large, 33 remains. The presence of very small fish, such as the vertebrae of anchovy (*Engraulis encrasicolus*)

and sardine (*Sardina pilchardus*), in the samples can be related to the stomach contents of other identified medium or large-sized fish, such as any of the sparids, although no alterations of the acids were observed.

- LGM fishes from SM-CG (ca. 24.6 – 19.7 cal kBP)

The oldest remains correspond to the Solutrean period, dated during the Last Glacial Maximum. Only nine remains from this period have been documented, among which are identified an eel vertebra (*Anguilla anguilla* (Schrank 1798)), another from a white bream (*Pagellus acarne*), a small shark vertebra, and two from a small salmonid, possibly a brown trout (Aura et al. 2019). The rest could not be determined.

- Late Glacial fishes from SM-W (ca. 15.2- 12.3 7 cal kBP)

The Late Glacial cycle corresponds to the the Upper and Final Magdalenian and Epipaleolithic /Epimagdalenian levels from SM-W. These are the most numerous assemblages. The Magdalenian sample from SM-W is composed of 302 remains, where a total of eight families have been identified. The four main families are the sparids with 65 remains, compared to 31 remains of carangids, 23 of mugilids and 22 of eels. Based on the size of the remains, we could relate the recovered remains of clupeids, peristids, and labrids, and even the two of needlefish (*Belone belone* (Linnaeus 1961)).

The Epipaleolithic sample is the largest, with 360 remains (Figure 6). The prominence of the four families already noted in the Magdalenian continues, but this time with more striking figures for the mugilids, with 83 remains, followed by 46 sparids, 26 eels, and 15 carangids. At this time, a spiny ray bone (*Dasyatis*) and 33 vertebrae possibly from anchovies (Engraulidae) have also been recovered (Figure 6).

- The Early Holocene fishes from SM-W (ca. 11.4 – 9.4 7 cal kBP)

These levels corresponds to the Sauveterroid and Mesolithic technocomplexes . The first assemblage reached 100 remains, and the pattern set in the Magdalenian continues, and all belong to the four families most represented at the site, with 26 remains of mugilid, 17 of sparids, 10 of eels, and four of carangids (Figure 5).

The Mesolithic shows a new decline in the number of remains. with 78. A certain balance is evident between sparids, with 22 remains, and mugilids with 15 remains. Eels and carangids are still present but only with six and one remains, respectively. For the second time, remains of a small cartilaginous fish (Squalidae) and a cyprinid are documented, as well as a sea bass vertebra (Moronidae) (figure 8).

The few remains recovered from the Neolithic, nine in total, continue the same pattern, with two remains of sparids, one each of mugilids, carangids and eels.

In summary, sparids and mugilids stand out as the most consumed fish in the cave, followed by eels and, carangids. It seems clear that these fish not only paint a very precise picture of the capture environment but also, in some way, indicate that the fishing was fundamentally focused on a few species from four families.

4.5. Shellfish

The marine mollusks recovered at CSM belong to the classes of Gastropoda, Bivalvia, Scaphopoda, and Crustacea. Their total number (NR) is 1730, representing 21 species and at least 8 families (Table 5). Their distribution shows significant differences both between sectors and between archaeological phases. The NR for SM-CG sector totals 212 remains and the marine malacological assemblage from SM-W comprises 1.518 remains. Species diversity and potential uses (food, personal ornament, and functional objects) are discussed below.

- The Last Glacial Maximum: SM-CG

The lower layers of Unit SM-CG II contain more than half of the marine resources from this sector, coinciding with Solutrean materials and dates (II.19 to II.10). The upper layers, (II. 9 to II.1) show clear continuity with the earlier layers, both in terms of species and uses, but the identification of Magdalenian materials, direct dating of various taxa (*Cuon alpinus*, *Pinus nigra-sylvestris*, *Quercus* sp., and *Homo* sp.), and even Mesolithic human remains (Carrión et al., 2018) suggest that they should be kept separate from the lower layers. Layers II.9 to II.1 are grouped under the designation “Late Glacial” Finally, there is a small assemblage of marine malacofauna, lacking a precise stratigraphic reference due to irregular excavations. In general, these three assemblages share strong similarities; however, in this study, we focus on the Solutrean phase (Table 5).

The marine malacological assemblage from this sector exhibits a unique composition, with its numbers distributed among three classes: gastropods (69), bivalves (70), and scaphopods (70). Gastropods and scaphopods were used to make shell-beads (13). This number increases when marine bivalves with perforation are included. This total indicates that the majority of marine remains recovered in SM-CG were used as personal ornaments, accounting for approximately 63% of the total NR.

The most frequently documented marine bivalves are the Cardidae, Pectinidae, and Glycimeridae families. Some were used as pendants, however, no configured shellfish tools or use-wear stigmata have been identified in this sector. Some species are notably absent from this sector, such as *Mytilus* sp., in contrast to their high frequency in the more recent occupations of the SM-W sector.

- The Late Glacial and Early Holocene assemblages from SM-W

The marine malacological assemblage from SM-W has a very different composition from that described in SM-CG. Bivalves are the dominant class, with NR values exceeding 88%, followed by gastropods (11.2%), scaphopods (0.5%), and crustaceans (0.14%). Another significant difference in this sector is the identification of 35 items used as tools (2.3%) and 157 ornamental items (10.8%). Therefore, this initial description indicates that a large proportion of the marine shellfish from SM-W were used as food, regardless of any subsequent use as tools (Cuenca et al., 2023). The number of marine mollusks increases considerably throughout the archaeological phases identified in this sector: Upper-Final Magdalenian (MSF), Epipaleolithic (EM), Sauveterroid (Sau), and Mesolithic (MMD). The Neolithic period has few remains and poor stratigraphic integrity. Its analysis will not go beyond a brief enumeration of the remains (Table 5).

As previously mentioned, bivalves clearly dominate the assemblage, representing over XX% of all remains. The genus *Mytilus* sp. reaches its highest frequencies between the Epipaleolithic and Mesolithic periods, with remains ranging from 31% to 70%. Is undoubtedly the most abundant taxon, reflecting its recurrent exploitation. Furthermore, the identification of other bivalves, such as *C. edule* and members of the families *Glycymeridae* and *Cardiidae*, contributes to the diversity of exploited ecological niches, although with lower percentages. This diversity indicates that they were transported to the site from different harvesting areas.

Approximately 13% of the marine remains have had both ornamental and functional uses. This suggests a versatile use for some bivalves, bordering on recycling, which, after being used as food, served this purpose.

4.5.1 Personal shell-beads

Across both sectors, 298 Paleolithic and Mesolithic ornaments made from marine mollusks were identified, these are the ones evaluated in this study. There is also a smaller assemblage of freshwater gastropods and perforated herbivore teeth, which are not described.

Following a chronological order, the Solutrean personal ornaments from SM-CG includes gastropod species of cold-climate characteristics (*Littorina* sp., *Nucella lapillus*), which are described primarily in the Solutrean phases at Mediterranean sites such as Parpalló or HC-VF (Soler, 2015). This latter species, along with the substantial assemblage of *Dentalidae* sp., is predominant at SM-CG. This association is complemented by the occasional presence of species described in earlier assemblages (cf. *H. sanguineum*),

along with others that will be significant in the more recent phases of SM-W, such as *T. neritea* or *C. rustica*. Also, some bivalves were used as pendants (*Glycymeris glycymeris* and *Cerastoderma edulis*).

At SM-W sector, ornaments made from gastropods and bivalves are predominant, while scaphopods are less common. Gastropods from colder climates are also absent (*Littorina* sp. and *N. lapillus*). These species are replaced between the MSF and MDM phases by *T. neritea* and *C. rustica*, the most frequently chosen for making shell-beads, which dominate in these phases. Other species such as *C. corallinus*, *T. reticulata*, *Trivia* sp., and *H. sanguineum* are also present. Bivalves are more frequent, including *C. edule*, *C. glaucum*, *Glycymeridae* sp., and *Cardidae* sp. It is significant that the only perforated specimen of *Mytilus* sp. is found in the Upper Magdalenian occupations, coinciding with the lowest value for this species in SM-W (Figure 7).

4.5.2 Shell-tools

The analysis carried out allowed us to document 35 shell tools: three with a possible use, four with a probable use, and another 28 with a confirmed use (Figure 8). The distinction between probable and possible use is based on the greater likelihood that the former were indeed used, although in both cases the development of use-wear is insufficient to fully confirm the utilisation of the shell tool. Based on the development of these traces, and therefore on the functional interpretation of the implements, the assemblage can be typologically classified as scrapers (23 pieces), smoothers (10 pieces), and possible containers (2 pieces). One tool may have been intentionally modified for this purpose (id#35), although the fracture affecting the piece does not allow this aspect to be confirmed.

All smoothers correspond to fragments of *Mytilus* sp. shells, with the umbo area constituting the active part of the tools. In contrast, shells from different taxa, *Glycymeris* sp., *Mytilus* sp., *Cardiidae*, *C. edule*, and *Patellidae*, were used as scrapers.

From a chrono-stratigraphic perspective, shell tools were documented throughout the entire sequence: Neolithic (n = 4), Mesolithic (n = 8), Epipalaeolithic (n = 11), and Magdalenian (n = 5), in addition to seven tools with no defined chronological attribution due to their recovery during cleaning operations or as unstratified finds from different areas of the cave. These tools would have been used to process different animal, plant, and mineral materials. Based on the interpretation of use-wear and the experimental inference framework, in some cases it was possible to determine the specific material processed (Table 6).

Magdalenian

The Magdalenian tools correspond to five bivalve shell fragments from Cardiidæ, Glycymeridæ, and *Mytilus* sp., in addition to one indeterminate fragment. All tools present well-developed use-wear confirming their utilisation. Typologically, the five tools can be classified as scrapers. These shell tools were used to process skin with ochre as an additive (id#24, id#25, id#26) and to process plant materials (id#27, id#28) (Figure 9).

Epipalaeolithic

The 11 shell tools include ten bivalve fragments and one complete shell. They belong to Glycymeridæ, *Pecten* sp., *P. maximus*, *C. edule*, *Mytilus* sp., and three indeterminate fragments. Three pieces (id#15, id#17, id#18) show traces consistent with probable use, while one piece shows only possible use (id#23). The remaining tools (id#13, id#14, id#16, id#19, id#20, id#21, id#22) present well-developed use-wear confirming their utilisation.

Eight tools can be classified as scrapers and two as smoothers. The scrapers were mainly used for skin processing (id#13 and id#20), in several cases with ochre employed as an additive (id#14, id#16, id#19, id#21, id#22) (Figure 10). Due to loss of the active surface, the substances processed with the smoothers could not be determined. Finally, a *P. maximus* fragment has been interpreted as a possible container due to the presence of residues on its inner surface (id#23). For three pieces (id#15, id#17, id#18), no identification of processed material was possible.

Mesolithic

The Mesolithic shell tools correspond to eight bivalve fragments belonging to two taxa: Glycymeridæ and *Mytilus* sp. Except for one piece (id#12), which displays probable use, the rest show a degree of wear compatible with confirmed utilisation. Typologically, four tools can be classified as scrapers (id#5, id#6, id#9, id#10) and four as smoothers (id#7, id#8, id#11, id#12).

Two scrapers were probably used for skin processing (id#6), one of them incorporating ochre as an additive (id#12), while the remaining two were used to process plant materials (id#5 and id#9). Due to heavy loss of material in the active areas of the smoothers, it was not possible to propose hypotheses regarding the substances processed with this tool type.

Neolithic

The shell tools documented in Neolithic levels correspond to four bivalve shell fragments belonging to three different taxa: Cardiidæ, Glycymeridæ, and *Mytilus* sp. All four tools present well-developed use-wear that allows their utilisation to be safely confirmed.

However, only two tools could be specifically linked to skin processing (id#1 and id#4), and

Shell tools without chrono-cultural attribution

Seven shell tools were recovered during cleaning operations or as unstratified finds. They correspond to fragments belonging to Cardiidae, Patellidae, *Mytilus* sp., and three indeterminate bivalves. Two pieces (id#34, id#35) show traces consistent with possible use; the remaining five (id#29, id#30, id#31, id#32, id#33) exhibit wear confirming their utilisation.

Three tools can be classified as scrapers and three as smoothers. The scrapers were used to process skin (id#29, id#30). The loss of active surface prevents proposing hypotheses for the smoothers (id#31, id#32, id#33, id#34). Finally, an indeterminate bivalve fragment has been interpreted as a possible container (id#35).

5. Discussion

Paleogeographic reconstruction indicates that the site doubled its current distance from the coastline during the LGM. The Gorgos basin and the Bay of Xàbia expanded during the regression, with their mouths located 58 km from the site. This position coincides with the low number of marine remains recovered at SM-CG occupations. At the LGI interval, changes are evident. The continental margin contracted by an average of ± 10 km, bringing the distance between the site and the coastline to 48 km. SM-W data for the LG indicate a notable increase in marine NR compared to the LGM occupations. The greatest increase is recorded in fish bones and in the use of mollusk shells as tools, either shaped or simply used. The third interval analyzed dates to the EH and, like the previous one, is transgressive, placing the average distance from the shoreline at approximately 40 km from the site. The proportions of fish and marine mollusk remains have changed, with bivalves now more numerous and used both as food and tools (*cf. Mytilus* sp.).

Most of the fish species in the sample would come from littoral ecosystem: the mouth of the Gorgos River. This would be the ideal environment for mugilids such as the true mullet (*Chelon labrosus*), the red-cheeked mullet, and the sea bream mullet (*Mugil cephalus*). Among the recorded members of the Sparidae family are the gilthead seabream (*Sparus aurata*), the red seabream (*Pagrus pagrus*), the red snapper (*Pagellus erythrinus*), and the white snapper (*Pagellus acarne*). Sea bass (*Dicentrarchus labrax*) and stingrays (*Dasyatis* sp.) are found sporadically. Other features worth noting include the presence of salmonids during the LGM, the greater diversification observed during the LG—including pelagic species (see Engraulidae sp., Clupeidae sp. and

Belonidae sp.)— and the stability of *A. anguilla* (see Catadromus). The dimensions derived from the remains of the eels and mullets, with almost always small sizes, should be interpreted as evidence of their fishing in a coastal lagoon that would have formed in the deltaic zone (Figure 11.A). It is in these areas that we can find fish of different species, such as small-sized sea bream, which enter at certain times of the year to take shelter from the open waters. Small to medium-sized eels are also found in this ecosystem, as the larger ones, the females, are in the middle or upper courses of the rivers. Regarding river species, the upper course of the Gorgos presents itself as the ideal setting for the capture area of trout (*Salmo trutta fario*). The same can be said of the documented cyprinid specimen. In this case, it was likely caught in the middle course of the river.

Regarding the fishing gear used, no artifacts have been found at the site that help identify or define it. However, given the variety of fish, we must assume they could have been caught in different ways. On the one hand, larger fish such as sparids or mugilids seem to be the ideal prey for the double fine points or gorges that have been documented at sites like Nerja (Aura et al. 202). To fish for flatfish, such as stingrays (*Dasyatis*), which could be in the same coastal area or just a few meters away, and therefore easily visible and accessible, some kind of spear would have been used. Finally, the creation of rudimentary snares with which they could have fished for eels cannot be ruled out, although these, if they were very numerous and found in shallow areas or pools, could even be caught by hand.

Comparing these results with those available for sites located between the Gulf of Valencia and the Mar Menor reveals a bias in the recovery and study of the marine fish at this región (Table 7). For the LGM, Parpalló provides few references, studied by one of us, and only Nerja offers well-contextualized data, but it is located outside the study area. From the LG onward, the number of sites with identified marine fish increases. Remains of Sparidae sp. were identified in the Caballo and Higuera caves (M A, 1988); At Tossal de la Roca, five remains are mentioned, both of marine and freshwater fish (Cacho et al., 1993). The most recent reference is a molariform Sparidae sp. from the Epipaleolithic site of Cova Fosca d'Ares (Roselló-Izquierdo et al., 2015). For the Early Holocene, there is the reference from El Collao, located near a lagoon (Fernández-López de Pablo and Gabriel, 2015). From this site come 204 remains, mostly classified as Sparidae sp. (*S. aurata* and *Diplodus* sp.), with the presence of Chondrichthyes, as in SM. At Tossal de la Roca (exterior), one eel and one barbel remain have been identified (Cacho et al., 1993).

This compilation does not modify the conclusions obtained in SM. The majority of known remains belong to coastal and estuarine species (*Sparidae* sp., *Mugillidae* sp., and

Anguillidae sp., *Carangidae* sp.), while river fish are present only anecdotally. The lower relative abundance of marine fish during LGM may be related to the greater distance between the sites and the coastline. The data suggest that during the Late Glacial (LG), the distance was shorter, but the relationship between NR and distance to the sea suggests that marine resource management models also changed. These remains will now be recovered from sites located at varying distances, from less than 10 km (Caballo, Algarrobo, or El Collao) to distances greater than 40 km (Santa Maira) and even 70 km (Cova Fosca d'Ares). Their recovery in sites far from their catchment areas contributes to reconstructing the exploited coastal environments, now flooded, but this approach is based on inland sites located far from the coast. We do not know the characteristics of the coastal sites in the region analyzed (Aura Tortosa et al., 2016).

The information provided by mollusks helps to complete the resource catchment areas (Figure 11.B). The habitat of the species identified across the three intervals also shows the flooding of estuaries and sandbanks during the LGM, eventually reaching cliffs and rocky substrates. Species typical of sandy-muddy substrates are predominant during the LG; conversely, species that live on rocks are predominant during the Early Holocene, particularly *Mytilus* sp. Comparison of these results with the other sites in terms of presence/absence reveals some trends (Table 8).

The results of the technological analysis of marine mollusks, including the elements used as personal ornaments and the history of the species' nutritional use, show that it is difficult to establish closed and mutually exclusive functional groups. Families and species have initially been used as food and subsequently perforated for use as ornaments, or simply used as indicated by recognized use-wear stigmata, with or without prior configuration. This difficulty is evident in the assemblage of molluscs, whose composition and characteristics allow us to recognize five categories: a) species used as food, primarily the families *Mytilidae* and *Patellidae*; b) as shell beads, including a wide range of gastropods, scaphopods, and some bivalves with perforation and use manipulations (cf. *Cardidae*, *Glycimeridae*, and *Pectinidae*); c) as tools recognized from functional analysis, which may sometimes have belonged to previous categories (*Mytilidae*, *Cardidae*); d) multiple use, includes mainly bivalves that do not retain perforation remains or stigmas of use, but do have the presence of ochre or residues that do not allow their fitting into the rest of the categories; and e) indeterminate, which includes fragments of indeterminate bivalves and gastropods and barnacles.

Applying these categories to the SM assemblages reveals three different situations (Figure 11.C). In the LGM occupations, marine mollusks were overwhelmingly used to make personal ornaments. Some were possibly already perforated, but unperforated

individuals of the chosen species have also been found. Tools are not identified, and species potentially used as food are marginal. During the LG, a significant restructuring is evident, as edible species increase in frequency, the first tools are identified, and the category referring to multiple uses increases in presence, becoming the most numerous. Conversely, a decrease in ornamental elements made from marine mollusks is observed. Finally, during the Early Holocene, we find a pattern practically opposite to that described for the LGM occupations. Species used as food are predominant, with significant decreases in ornaments and the indeterminate group.

These are aspects or features not previously incorporated into the characterization of the technological organization of Paleolithic and Mesolithic occupations. It is significant that the identified tools are associated with domestic work on skin, frequently incorporating ochre, and with plant materials during the two time periods with the highest density of archaeological evidence, both organic and mineral (Morales Pérez, 2015; Vadillo Conesa, 2018). Thus, in the LGM occupations of SM-CG, 960 lithic remains have been counted, including *débris*, of which 26 objects were configured in various technotypes (Vadillo and Aura, 2025). Their proportion relative to the 76 shell-bead elements made from marine mollusks, excluding fluvial species and perforated teeth, establishes the profile of these occupations and the use of this sector. This example shows that they also provide diachronic differences regarding the use and recycling of mollusks that deserve to be taken into account.

Paleogeographic data on marine fauna acquisition environments and the functional characterization of settlements are complemented by information on mobility and coastal-inland relationships in the Gulf of Valencia area. A single site cannot answer these questions, but current data indicate greater dispersal and an increase in marine fauna from HE 1 onward, more evident in the southern region. Distance from the sea does not appear to limit the dispersal of marine fauna in the LG and EH intervals, with distances ranging between 48 and 40 km in the case of SM. However, comparable evidence of marine remains being transported during the LGM is unknown. The case of HC-VF shows a low amount of evidence, although its distance from the coast was less, no more than 25 km and with a low topographic gradient (Aura Tortosa et al., 2026). Therefore, these remains exceed the recognized distance between present-day Aboriginal populations () and are linked to changes in the mobility and seasonality of human groups. Perhaps, we should start considering the significance of the consumption and transportation habits of marine fauna.

6. Conclusions

The study of a large assemblage of marine fauna recovered from CSM has allowed analysis of the relationship between distance and coastal environment characteristics and the species identified in the different occupations. Radiocarbon dating has allowed for the proposal of three time intervals as significant cycles for evaluating the number and characteristics of marine fauna remains. The first conclusion is that there are significant differences between the occupations dated at LGM compared to those of LG and EH. The coastline was located at 58, 48, and 40 km, respectively, with significant losses of continental margin extent in each interval. Similarly, the SM data reveal a bias in the recovery and study of marine fish fauna from Paleolithic and Mesolithic sites.

Virtually all of the fish and mollusk remains analyzed were contributed by humans. The only doubts are some Magdalenian remains that, due to their small size, could be related to the stomach contents of some of the other documented fish, especially sparids. Two families stand out clearly: the Sparidae and the Mugilidae. Next are the Anguillidae and the Carangidae. The minority groups are the Engraulidae, the Clupeidae, and Chondrichthyes. Finally, the Belonidae, Salmonidae, and the rest of the families are represented by few remains.

The technological and functional study has allowed us to identify an interesting set of household tools (scrapers and smoothers) and a numerous set of ornaments that show significant variations at the species level (Soler et al., 2025). The mollusk species potentially used as food originate from sandy and rocky substrates in the Late Glacial, as is the case for Cardiidae, Glycimeridae and Mytilidae, including some brackish-water specimens such as *C. glaucum*. With the onset of the Holocene, species from rocky substrates increased, such as *Mytilus* sp., which undoubtedly shows a dietary preference, but also reflects the flooding of low-lying areas, eventually reaching rocky outcrops and cliffs.

Finally, the long-distance transport of marine resources used as personal ornaments is widely documented. However, their use as food or their recycling as tools is not. The dispersal of marine fauna proposed from the LG interval, still uneven, raises interpretations of varying scope. Is it simply a change in the consumption and transport habits of these resources? Is it simply the result of contributions within general mobility? Is it a reflection of new social relationships? However minor marine remains may seem within the overall diet they are valuable. They indicate the areas from which they are sourced, which gives them different characteristics compared with the other small prey consumed in the IMR.

FIGURES

Figure 1: A) Geographical location of Santa Maira. B) Schematic stratigraphic sequence of the site. C) General view of the cave and Planimetry with the two sectors.

Figure 2. Phases model for Coves de Santa Maira both sectors. The phases correspond to the paleoclimatic sequence. Blue samples correspond to SM-CG Sector, whereas green samples correspond to SM-W Sector.

Figure 3. Theoretical routes from the Santa Maria site to the LGM coastline. The location of the site is indicated by a red point. The figure illustrates the variations and progressions in elevation and distance along the explored routes. Bathymetric data and the Digital Terrain Model were obtained from the EMODnet Bathymetry portal (<http://www.emodnet-bathymetry.eu>), together with the ASTER GDEM v2 global elevation dataset, which provides a spatial resolution of 1 arc-second (NASA/METI/AIST/Japan Spacesystems and U.S./Japan ASTER Science Team 2009). The Bathymetry of the Institut Cartogràfic Valencià de la GVA and Ministerio de Agricultura, Pesca y Alimentación was also used (Institut Cartogràfic Valencià, Generalitat 2006; Ministerio de Agricultura, Pesca y Alimentación 2021a, 2021b).

Figure 4. High-resolution relative sea-level curves covering the last 30 ka b2k were derived from the SPECMAP radiometric timescale calibration (Thompson and Goldstein, 2006). Sea-level positions and corresponding ages obtained from isotopic and radiometric analyses of fossil corals—used in the radiometric calibration of the SPECMAP timescale—are represented by red dots. The dashed curve illustrates relative sea-level fluctuations after incorporating a subsidence rate of 30 cm/ka for the Valencia margin (Albarracín et al., 2013; Alcántara et al., 2013). The ordinate axis also indicates the main intervals of human occupation identified at the Coves de Santa Maira site, together with the Last Glacial Maximum (LGM), the Late-Glacial (LG) and early Holocene (EH) phases.

Figure 5. The maps illustrate the position of the coastline during the main intervals of human occupation identified at the Coves de Santa Maira site: (A) the LGM phase, spanning from 30 to 19 ka b2k, (B) the LG phase, between 15 and 12.5 ka b2k, and (C) the EH, spanning from 11.7 to 9 ka b2k. For each interval, the extent of the emerged landmass within the study area is represented. The location of the Coves de Santa Maira site is indicated by a red point. Bathymetric data and the Digital Terrain Model were obtained from the EMODnet Bathymetry portal (<http://www.emodnet-bathymetry.eu>), together with the ASTER GDEM v2 global elevation dataset, which provides a spatial resolution of 1 arc-second (NASA/METI/AIST/Japan Spacesystems and U.S./Japan ASTER Science Team 2009). The Bathymetry of the Institut

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Figure 6. Coves de Santa Maira. A stingray's stinger and shells of the Cardidae and Mytilidae from SM-W Sector.

Figure 7. Coves de Santa Maira. Shell beads from SM-W sector. From bottom to top: Final Paleolithic (Upper-Final Magdalenian) beads: *Columbella rustica*; *Trivia monacha*; *Tritia* sp.; *Theodoxus fluviatilis*; *Homalopoma sanguineum*; *Tritia neritea*; *Ostrea* sp. and Pectinidae. Epipaleolithic: *Clanculus corallinus*; *Theodoxus fluviatilis*; *Tritia neritea*; *Glycymeris* sp. Mesolithic: *Columbella rustica*

Figure 8. Coves de Santa Maira. Shell tools recovered from the different chrono-cultural phases of occupation at SM-W Sector. Neo=Neolithic; Meso=Mesolithic; Epi= Epipalaeolithic; MGD = Magdalenian; Ind.= indeterminate chrono-cultural phase.

Figure 9. Coves de Santa Maira. Shell tools from SM-W Sector. *Mytilus* sp.(id#28) from the Magdalenian occupation used to process plant materials.

Figure 10. Coves de Santa Maira. Shell tools from SM-W Sector. Glycymeridae shell tool (id#14) from the Epipalaeolithic occupation used to process skin with ochre employed as an additive.

Figure11 A. Coves de Santa Maira. Habitat of fish species and families for the three time periods. Catadromous includes only the Anguillidae sp.

Figure11 B. Coves de Santa Maira. Substrate of marine mollusc species and families for the three time periods.

Figure11 C. Coves de Santa Maira. Functional groups of the marine mollusc species and families for the three time periods described in the text.

TABLES

Table 1. Coves de Santa Maria, radiocarbon AMS samples were used for modelling.

Table 2. Coves de Santa Maira. Marine remains analysed (NR).

Table 3: Coves de Santa Maira. Phases model results for the start and end boundaries of each palaeoclimatic phase.

Table 4: Coves de Santa Maira. Fish bones taxa identified by Sectors, archaeological phases and intervals. Materials not discussed in this paper are shown in grey.

Table 5. Coves de Santa Maira. Marine molluscs taxa identified by Sectors, archaeological phases and temporal intervals. Materials not discussed in this paper are shown in grey.

Table 6. Coves de Santa Maira. Shell tools from SM-W Sector. SF=shell fragment; C=complete shell; U = confirmed use; Po = possible use; Pr = probable use; Tr = transversal action; O = oblique action.

Table 7. Fish remains from different sites within the study area for the three time periods. The numbers refer to NR.

Table 8. Marine molluscs from different sites within the study area for the three time periods. The numbers refer to NR.

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