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Coastal Settlement in the Late Pleistocene of the Bay of Biscay (North Iberia): The Cases of Langatxo and Iruroin Caves

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ABSTRACT

The Iruroin and Langatxo caves are located in the Bay of Biscay, a region with a high concentration of prehistoric sites dating from the Palaeolithic to the Mesolithic. In this study, we present the results from the review of marine remains and bone industry artifacts from both caves, which were excavated in the 1990s but remain unpublished. Given the proximity of these sites to the sea, significant exploitation of marine resources was assumed during the Magdalenian occupations. However, the study of the marine remains from Langatxo shows that coastal resources were not exploited during the Magdalenian, but rather in later periods. Analysis of the bone industry from both sites, along with AMS dating and ZooMS identifications, contributes to a better understanding of the economic behaviour of coastal human groups during the Late Pleistocene and early Holocene in the region.

KEYWORDS

Osseous industry; archaeomalacology; radiocarbon dating; Upper Magdalenian; Mesolithic; Cantabrian region

Introduction

The Cantabrian Region of northern Iberia is considered a refuge area for human populations of the European Upper Palaeolithic, particularly during the Last Glacial Maximum (Straus 2015) due to its environmental conditions, which were moderated by low altitude and proximity to the sea. During the Magdalenian period (ca. 21,000-14,000 cal BP), the high density of cave sites has led to the proposal of various models of mobility and settlement that articulate, on a regional scale, functionally specialised hunting camps, long-term settlements, and sites with symbolic manifestations (González Sáinz and González Urquijo 2004, García Moreno 2010; Fano and Rivero 2012; Straus et al. 2015). On the one hand, the density of sites suggests an intensification of resource exploitation within increasingly restricted territories. On the other hand, the circulation of raw materials, technologies and stylistic conventions indicates the existence of long-distance networks across the entire Franco-Cantabrian Region (Álvarez-Fernández, Martín-Jarque, and Tarriño 2021; Lefebvre et al. 2021; Martín-Jarque et al. 2023). This apparent contradiction becomes more pronounced during the Upper Magdalenian (16,000-14,000 cal BP), when site density

increases while cold and temperate phases alternate rapidly at the end of the last glaciation. During this period, the concentration of sites in rocky areas and coastal valleys has been linked to a reduction in mobility and economic diversification, with a shift from specialised red deer hunting to a broader subsistence strategy that included Iberian ibex hunting and the exploitation of coastal resources (González Sáinz and González Urquijo 2004; Straus et al. 2015). However, later Azilian occupations during the transition to the Holocene often overlap with Magdalenian sites, necessitating precise excavations and dating due to the similarities in economic and technological behaviours between these technocomplexes.

To analyse subsistence models and settlement patterns and to examine their evolution on a regional scale, it is essential to clearly establish the chronology and functionality of as many sites as possible, while also refining ambiguous or inaccurate data. Therefore, the analysis of Upper Magdalenian settlement in the Cantabrian Region requires not only the study of material remains and precise dating of the most emblematic sites, but also the recovery of all available contexts, including those that have been little studied or remain unpublished (Ríos-Garaizar et al. 2020).

In this work, we present a study of two cave sites located in a densely occupied area of the Cantabrian Region during the Upper Magdalenian. Despite being largely unpublished (see Erostarbe Tome 2024 for an overview of the osseous industry), these sites are frequently included in regional settlement reconstructions as sites of marine resource exploitation and as evidence of coastal-oriented mobility (Peñalver, San José, and Mujika-Alustiza 2017). The two cave sites, Langatxo and Iruroin, were excavated in the 1990s, yet their stratigraphic sequences were never precisely determined. Given the probable presence of intrusions and the risk of conflating remains from occupations from different periods, this initial reassessment has focused on three key aspects: 1) the malacological assemblage of Langatxo, to refine the chronology of these remains based on the documented species and inferred shellfishing strategies; 2) the antler industries from Langatxo and Iruroin, to identify typological and technological markers; and 3) AMS Radiocarbon dating. Additionally, three samples have

been taken for ZooMS analysis to determine the possible presence of reindeer antler and cetacean bone. These results will provide a chronostratigraphic basis to classify and organise the materials into coherent assemblages for subsequent systematic study.

The Langatxo and Iruroin caves

The Langatxo and Iruroin caves are located on the eastern side of the Bay of Biscay in northern Iberia, within the valley of Deba River near its mouth and the classic Magdalenian site of Ermitia (Figure 1). As is common in other valleys of the Cantabrian Region, such as the Lea, Asón, and Sella, apparently contemporaneous occupations are clustered in multiple caves along the valley, particularly near the mouth of the rivers.

The caves were excavated during the 1990s by F. Zumalabe: Langatxo between 1990 and 1993 (Zumalabe 1991, 1992, 1993, 1994), and Iruroin between 1994 and 1999 (Zumalabe 1995, 1996, 1997, 1999,

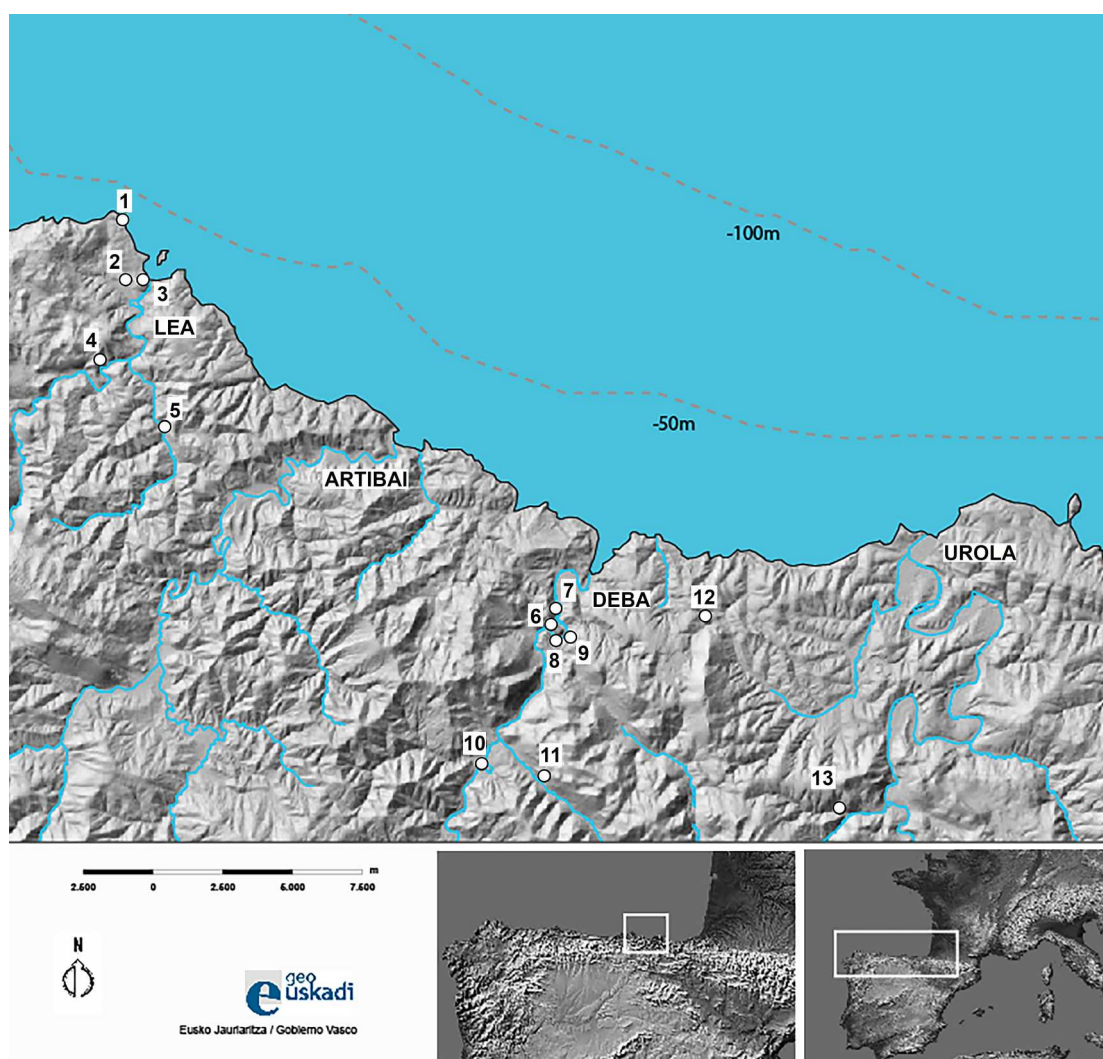


Figure 1. Location of the Upper Magdalenian sites in the coastal valleys, eastern side of the Bay of Biscay. 1: Santa Catalina; 2: Armintxe; 3: Lumentxa; 4: Abittaga; 5: Atxurra and Armiña; 6: Langatxo; 7: Iruroin; 8: Praile Aitz; 9: Ermitia; 10: Aizkoltxo; 11: Agarre; 12: Urriaga; 13: Ekain.

The cave was discovered in 1981 by members of the Munibe Group from Azkoitia. Later that same year, the group conducted an initial test excavation inside the cave, documenting lithic and faunal material, including mammal bones and marine mollusc shells

As can be seen, the stalagmitic crust of the interior sequence was considered sufficient evidence to separate two levels in both areas, the Chalcolithic and the Magdalenian, despite presenting distinctive sedimentary



Figure 2. Topographic plan and section of Langatxo cave, by Burumendi Speleological Group. A: 'Exterior' zone; B: 'Interior' zone.

characteristics. Later, after dating the human bones from Level II to the Chalcolithic, it was necessary to revise the entire interior sequence. In Altuna et al. (1995) the Chalcolithic and Magdalenian occupations began to be designated as Levels I and III, separated by a Level II formed by the crust and possibly mixed. However, the correspondence between excavation spits and levels was never completed.

Iruroin Cave (UTM 30N ETRS 89 X = 551.311, Y = 4.792.546)) is located 500 metres downstream from Langatxo, 20 m above the Deba River, and 2 km in a straight line from the current coastline. The cave has two entrances at different altitudes, providing access to a steep main hall, which is separated from an upper gallery by a large rock (Figure 3).

The cave was discovered in 1973 by members of the Munibe Group from Azkoitia, who excavated three test pits between 1973 and 1979-1980. Excavations led by Zumalabe were carried out over five seasons between 1994 and 1999 (Zumalabe 1995, 1996, 1997, 1999, 2000), and covered two sectors (referred to in this study as the 'Main excavation' and 'Central area') measuring 17 and 3 m², respectively. The sediments have been affected by the slope, with the thickest sequence documented in the Main excavation area, adjacent to the southern entrance. However, both sectors revealed the same stratigraphic sequence. At the top, Level I consists of limestone rocks and flowstone crusts containing Chalcolithic pottery fragments and human bones on the surface. Beneath the flowstone,

Level II is a yellowish clayey layer with carbonate nodules, while Level III is a brownish clayey layer containing Magdalenian remains.

The results of the excavations at Langatxo and Iruroin were only disseminated through brief reports of each field season, and the study of both sites was abandoned before any general correlation of their respective stratigraphic sequences could be established. No graphic documentation (such as photographs or detailed plans) is available, and currently the only existing data are the recorded coordinates of the finds and their provenance from successive excavation spits, without a definitive chronostratigraphic assignment. Unfortunately, most of the inventory sheets listing the materials do not indicate the correspondence between excavation spits and levels, leaving a reinterpretation of the stratigraphic sequences unfinished. Only the summaries published for each field campaign indicate to which occupation levels the excavation spits were preliminarily attributed. Therefore, any direct attempt to assign the finds to specific layers risks serious errors, given the documented intrusions and the slope of the strata in both caves.

Although the Chalcolithic and Magdalenian occupations of both caves were initially considered distinct units separated by sterile layers, the presence of intrusive human bones and other archaeological remains suggests that the stratigraphic sequences at Langatxo (Zumalabe 1994) and Iruroin (Zumalabe 2000) were more complex than expected. Since these sterile layers

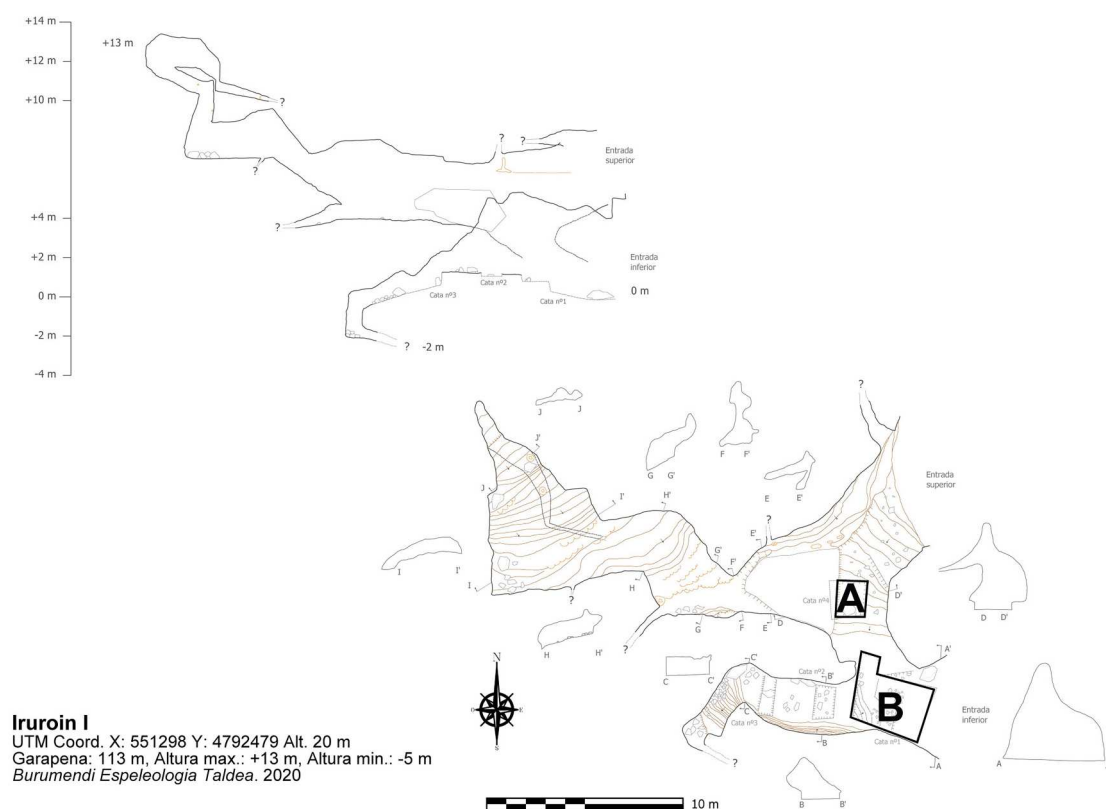


Figure 3. Topographic plan and section of Iruroin cave, by Burumendi Speleological Group. A: Central area. B: Main excavation.

appear to have been affected by both water erosion and the slope of the strata, the integrity of the archaeological assemblages must first be assessed by determining the degree of mixing. Thus, the only way to reconstruct the original stratigraphic sequences is by plotting the positions of the finds (Discamps et al. 2023). To this end, we began the study of these collections by focusing on the osseous industry and malacological remains, which together with the human bones and ceramic sherds can be chronologically diagnostic and assignable to different periods.

Materials and methods

The materials examined in this study include all malacological remains recovered from the Exterior and Interior zones of Langatxo, all antler remains from Langatxo (found exclusively in the Interior zone) and all antler remains from Iruroin.

The analysis of the archaeomalacological assemblage from Langatxo was carried out using an integrated quantitative, taxonomic, taphonomic, and biometric approach. This encompassed both marine and continental mollusc remains, supplemented by the study of additional marine taxa (crustaceans and fish), all identified to the highest possible taxonomic resolution. Measurements were taken from complete or well-preserved specimens using a digital calliper (error ± 0.01 mm). For limpets, the maximum diameter was recorded, while for spiral gastropods, height was measured. The quantification of remains followed the criteria established by Moreno (1994) for molluscs and by Gruet and Laporte (1996) for crustaceans. Taxonomic identification was carried out using specialist manuals (Larraz and Jordana 1984; Ingle 1996; Trigo et al. 2018) and reference collections at the University of Salamanca and at LAS-Leiden. Classification adhered to the nomenclature of WoRMS (WoRMS Editorial Board 2025) for marine invertebrates and FAUNA EUROPAEA (De Jong 2016) for terrestrial gastropods. Fish classification followed FishBase (Froese and Pauly 2025). Additionally, observed alterations in the archaeomalacological remains were documented. These included modifications caused by marine organisms (e.g., annelids, sponges) or by physical processes occurring prior to collection (e.g., marine abrasion). Other types of alterations were distinguished based on their origin, differentiating anthropogenic modifications, such as thermal alteration or fragmentation, from post-depositional processes, including decalcification and calcium carbonate precipitation (CaCO_3).

The osseous assemblages comprise the pieces initially identified by Zumalabe, as well as newly recognised elements identified during our complete reassessment of the faunal remains at the regional museum. Our study focuses exclusively on antler

remains, since most of the common bone ornaments and tools cannot be easily attributed to specific periods, and the materials identified in this review (needle/pin and awl fragments, atrophic canines) do not provide clear criteria for distinguishing occupation phases (Barandiarán Maestu 1967; Adán Álvarez 1997). The exception is three fragments of a large tool identified as a cetacean bone.

The identified pieces have been classified as finished tools, supports, production waste, and matrices/blocks of material following the reduction sequence approach (Averbouh, Goutas, and Marquebielle 2016; Goutas and Tejero 2016). All pieces have been examined to identify technical traces on their surfaces and distinguish them from decorative motifs, fractures, and taphonomic effects, based on how the different traces, fracture planes, and patinas are superimposed on each element (Langley, Pétillon, and Christensen 2016). Striations related to scraping (shaping) or grooving (extraction) have been distinguished based on their delineation, depth and location, and debitage by percussion has been identified from the presence of negatives of consecutive flakes made from the same surface (Mujika 1983; Adán Álvarez 1997; Goutas 2009; Averbouh, Goutas, and Marquebielle 2016; Goutas and Tejero 2016).

Technical traces were examined with a 20x binocular lens (Leica EZ4 HD) and a PCE-MM200 USB microscope. These traits are left by the mechanic actions performed to modify bone materials and allow to identify the technical procedures followed within manufacturing processes (Mujika 1983, 1990; Goutas 2009; Averbouh, Goutas, and Marquebielle 2016).

The finished tools – points, barbed points and a half-round rod – have been classified and described according to their section, base shape, number of rows of barbs and other attributes in accordance with what is established in the literature (Barandiarán Maestu 1967; Julien 1982; Pétillon 2006; Langley, Pétillon, and Christensen 2016).

Antler remains were identified based on textural and anatomical characteristics observable on the surfaces and cross-sections of the pieces, with particular attention to the proportion and density of compact tissue, as well as the features and porosity of spongy/trabecular tissues. All specimens were identified as red deer (*Cervus elaphus*) antlers, with two exceptions that correspond to reindeer (*Rangifer tarandus*). To ensure accurate identification, three ZooMS (Zooarchaeology by Mass Spectrometry) analyses were conducted (two antlers and one cetacean bone) at the Palaeoproteomics Laboratory of the University of Vienna and the Archaeozoology laboratory of the EVOADAPTA research group at the University of Cantabria (in collaboration with the University of York for Maldi analysis).

Four samples were selected for AMS radiocarbon dating to assess the chronological coherence of the

sequences described for Langatxo (Exterior and Interior) and Iruroin. Samples correspond to a *Phorcus lineatus* shell from the Exterior zone of Langatxo, a faunal bone from the Interior zone of Langatxo, another faunal bone from the Main excavation area of Iruroin, and a cetacean bone object coming from the same area. All four samples come from layers attributed in excavation reports to the Upper Magdalenian levels (Level II in both the Interior and Exterior sequences of Langatxo, and Level III of Iruroin), although these attributions do not appear in the material lists or on their labels.

Results

Archaeomalacology of the Exterior zone of Langatxo

Regarding marine molluscs, a total number of remains (NR) of 713 has been recorded, from which a minimum number of individuals (MNI) of 538 has been estimated (Figure 4). Seven taxa have been identified, including five gastropod species (98.9%) and two bivalve species (1.1%). All identified taxa are of dietary interest and originate from intertidal rocky substrates. Limpets are particularly abundant, comprising 91.6% of the MNI, with different species represented: *Patella vulgata* (6.7%), *Patella depressa* (22.3%), *Patella*

ulyssiponensis (14.7%), and *Patella* sp. (48%). These are followed by the topshell *Phorcus lineatus* (7.3%) (Figure 5).

One specimen of *Patella* sp. has been documented with its external surface affected by boring sponges of the genus *Cliona* sp., which perforate the shells of molluscs inhabiting estuarine environments and exposed coastal areas. Additionally, six thermoaltered individuals (ca. 1%) have been recorded. Decalcification affects most individuals (95.4%), with CaCO_3 precipitation observed in 60.6% of cases. Regarding the size of the studied specimens, limpets ($n = 152$) generally exhibit an average length of 25–30 mm. As for *P. lineatus*, the analysed individuals ($n = 27$) have an average height of ca. 18.5 mm.

For terrestrial gastropods, a total NR of 24 has been recorded, from which an MNI of 19 has been estimated. Five taxa have been identified. A large proportion of the sample consists of small-sized gastropod (68.4%), which are therefore not suitable for consumption. All identified taxa currently inhabit the wooded areas of the Cantabrian Region. The most represented species are *Pomatias elegans* (52.6%) and *Cepaea nemoralis* (21.1%). A small percentage of terrestrial gastropod shells exhibit decalcification (47.4%). It is highly likely that these specimens were incorporated into the sediment in recent times, as some still retain surface pigmentation. This is

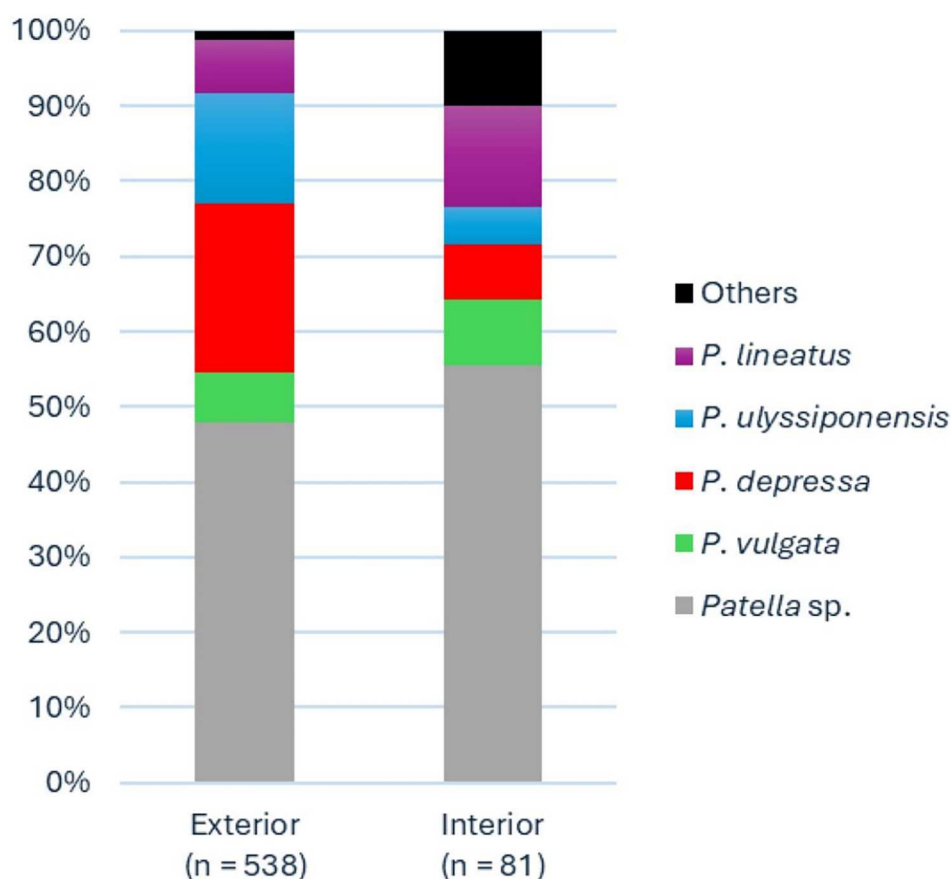


Figure 4. Percentages of marine mollusc taxa documented at Langatxo Cave (from MNI).

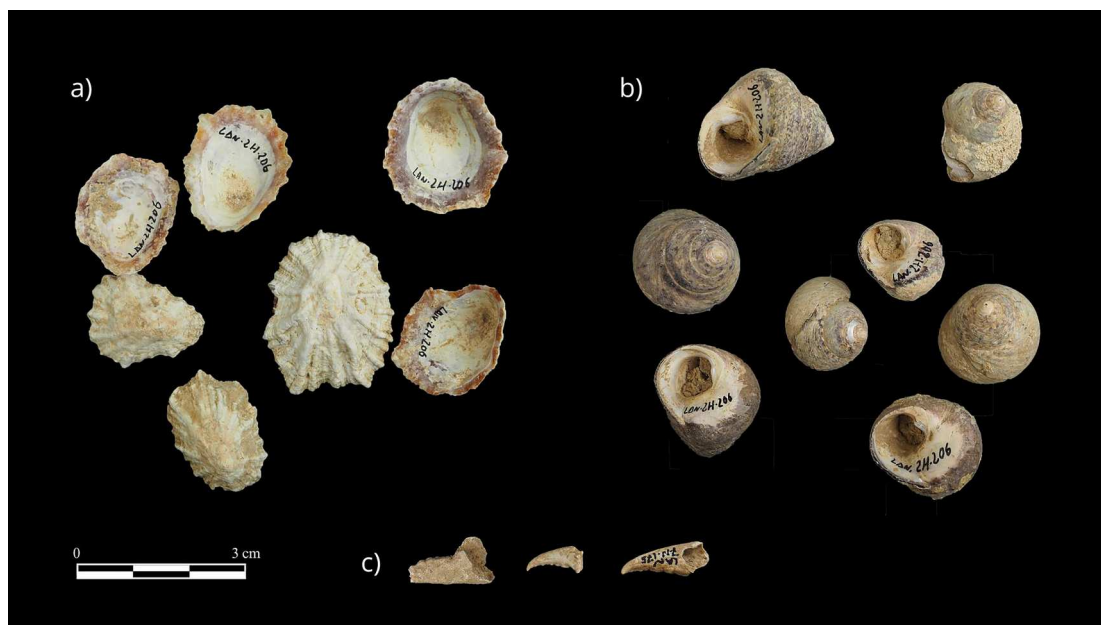


Figure 5. Marine invertebrate remains from the Exterior zone of Langatxo: a) *Patella* sp., b) *Phorcus lineatus*; and from the Interior zone: c) *Carcinus maenas*.

particularly evident in the cases of *Cornu aspersum* and *P. elegans*, gastropods that were introduced to the Iberian Peninsula in historical times (personal communication, M.^a Teresa Aparicio).

Archaeomalacology of the interior zone of Langatxo

Regarding the quantification of marine mollusc remains, a total NR of 149 has been recorded, from which an MNI of 81 has been estimated. Ten taxa have been identified, including seven gastropod species (92.6%) and two bivalve species (7.4%), along with one unidentified mollusc. The majority of the specimens belongs to species of dietary interest (97.5%) and originate from intertidal rocky substrates. Limpets are particularly abundant (76.5%), represented by different species: *P. vulgata* (8.6%), *P. depressa* (7.4%), *P. ulyssiponensis* (4.9%), and *Patella* sp. (55.6%), followed by the topshell *P. lineatus* (13.6%). Additionally, one individual of *Littorina littorea* has been documented in the Interior zone. The only shell belonging to a taxon with no dietary interest is *Littorina obtusata/fabalis*.

Two specimens of *Patella* sp. have been documented with their external surfaces affected by boring sponges of the genus *Cliona* sp. One of these specimens also exhibits the presence of annelids of the genus *Spirorbis* sp., which are associated with rocky areas and algae of the genera *Fucus* and *Laminaria*. Additionally, a large *P. vulgata* shell shows signs of abrasion from sand and seawater, indicating that it was collected from the beach after the animal's death. Regarding other alterations, only two fragments of *Patella* sp. display thermal alteration (1.2%).

Decalcification affects the vast majority of the shells (97.5%), and CaCO_3 precipitation has been observed in 70.4% of cases. In terms of biometric analysis, the sample size of complete limpet and topshell specimens is too small to yield significant results.

For terrestrial molluscs found in the Interior zone, a total NR of 22 has been recorded, corresponding to an MNI of 22. Six taxa have been identified, four of which belong to small-sized gastropods. The most abundant taxa in the sample are *Elona quimperiana* (31.8%) and Zonitidae (27.3%). A small percentage of terrestrial gastropod shells exhibit decalcification (40.9%). Additionally, only two specimens of *P. elegans*, one Zonitidae, and five *E. quimperiana* show CaCO_3 precipitation (36.4%).

Regarding crustaceans, three remains have been documented (two dactylopodia and one propodus, all from the right side) belonging to the marine crab *Carcinus maenas*, representing an MNI of 2 (Figure 5). Based on the dimensions of the dactylopodia, both specimens would have been less than 10 cm in size.

Finally, only four fish remains were recorded: three Salmonidae vertebrae of the Genus *Salmo* sp., one of which exhibits thermal alteration, and a pharyngeal bone from a Labridae (wrasses).

Zooarchaeology by mass spectrometry (ZooMS)

Bone powder from two worked antler fragments from Langatxo and one tool made on cetacean bone have been analysed using ZooMS method, which allows the taxonomic identification of collagen from bone and antler and has been widely used in prehistoric contexts since its introduction in the field (e.g. Desmond et al. 2018; Brown et al. 2021; Welker et al. 2015).

Sample LAN.10M.155 (Figure 5, 8) was analysed at the Palaeoproteomics Laboratory of the University of Vienna. Using 20 mg of powdered sample, collagen was extracted following the acid insoluble protocol, first introduced by Buckley et al. (2009), and detailed by Brown et al. (2020). The identified peptide fragments best match to *Rangifer tarandus*, hence we may assign LAN.10M.155 from Langatxo to reindeer. Samples LAN.7N.183 (Figure 6, Figure 8) from Langatxo and Ir.7D.123.29 (Figure 9) from Iruroin were analysed at the Archaeozoology laboratory of the EVOADAPTA research group at the University of Cantabria, in collaboration with the University of York. The results show that the bone Ir.7D.123.29 (McGrath et al. 2025) belongs to a Sperm whale (*Physeter macrocephalus*) and LAN.7N.183 to a goat/caribou. As only reindeer has antler in this group, identification with to species may be reduced to *Rangifer tarandus* (Tables 1 and 2).

Antler industries from Langatxo and Iruroin

As a result of our study, a set of 20 antler objects has been identified for Langatxo and 21 for Iruroin.

At Langatxo, antler remains were found exclusively in the Interior zone and consist of two undetermined small fragments and 18 identifiable pieces. The finished

objects include thirteen projectile points (Figure 7), two barbed point fragments, and a decorated half-round rod (Figure 6). The barbed point fragments from Langatxo appear to have a single row of barbs. The first (Figure 6, 5) has a flattened section on both the shaft and the barb, with a straight outline, while the second (Figure 6, 6) has an elliptical section and a small, slightly curved barb. Regarding the spear points, a complete specimen was recovered, decorated with engraved lines, along with proximal, medial and distal fragments of other projectiles (Figure 7, A). The sections of the projectiles are round or oval, and there is one specimen with a simple base (Figure 7A, 1) three with a single bevel (Figure 7A, 10, 12, 13) and one with a double bevel (Figure 7A, 11).

All of these are finished artefacts shaped by scraping, with some displaying decorations made by short incisions. In the case of the half-round rod, a complex decoration was created using deep incisions to produce a bas-relief motif. The characteristics of these materials are consistent with red deer antlers (*C. elaphus*), based on their texture and the proportions between compact and spongy tissues.

However, only two antler objects from Langatxo can be attributed to earlier phases of the production sequence, providing evidence of different techniques (grooving, splitting) used for rod

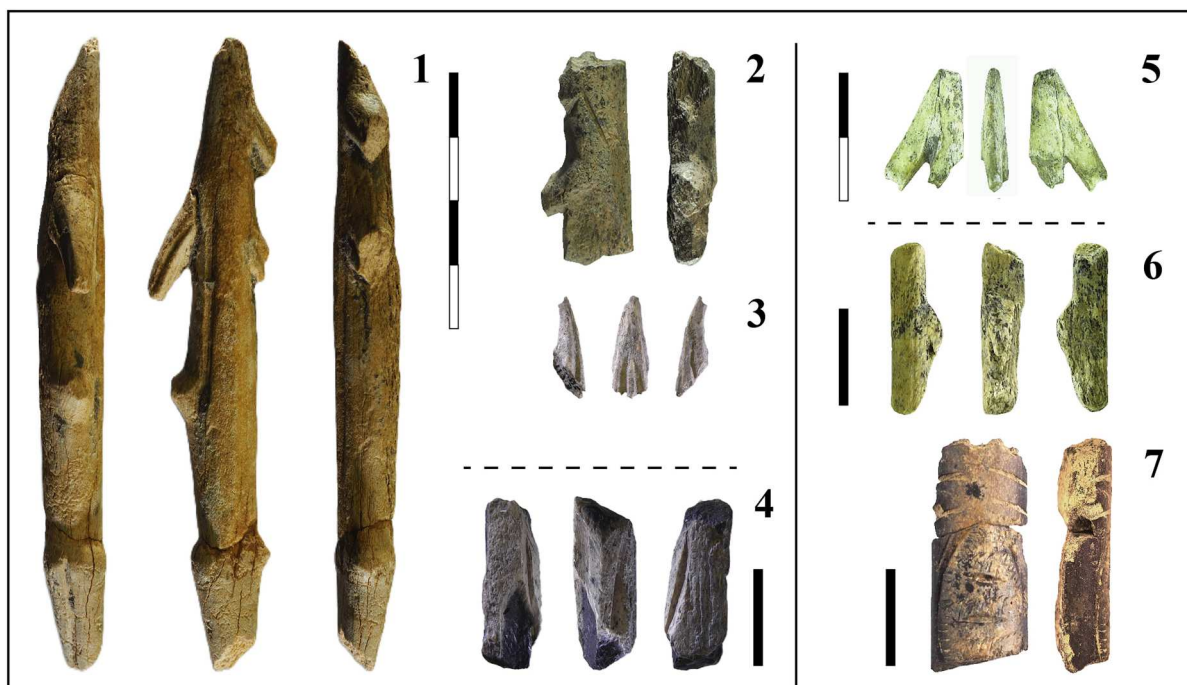


Figure 6. Barbed points from Iruroin (1-4) and Langatxo (5-6), and fragment of decorated half-round rod from Langatxo (7).

Table 1. ZooMS-based identifications of three bones from Langatxo and Iruroin.

Sample ID	Order	Family	Common name	Species
LAN.10M.155	Artiodactyla	Cervidae	Reindeer	<i>Rangifer tarandus</i>
LAN.7N.183	Artiodactyla	Cervidae	Reindeer/Goat/caribou	<i>Rangifer tarandus</i>
Ir.7D.123.29	Cetacean	Physeteridae	Sperm whale	<i>Physeter macrocephalus</i>

Table 2. Collagen peptide markers used in the taxonomic ZooMS-based determination of the three samples in Table 1.

Sample ID	COL1A1T47		COL1A2T85		COL1A2T85		COL1A2T43		COL1A2T45		COL1A2T26		COL1A2T69		COL1A2T41		COL1A1T55/56		COL1A1T55/56		COL1A2T67	
	COL1a1 508–519	COL1a2 978–990	COL1a2 978–990	A	A'	COL1a2 978–990	COL1a2 484–498	COL1a2 502–519	COL1a2 292–309	P2	COL1a2 793–816	COL1a2 454–483	COL1a1 586–618	COL1a1 586–618	F	F'	COL1a2 757–789	G'				
LAN.10M.155	1105,7	1151,7	1167,7	1427,8	1580,8	1648,8	2131,2	2793,4	2883,6	2899,5	–	–	–	–	–	–	–	–	–	–		
LAN.7N.183	1105,6	–	1427,7	1427,7	–	1648,8	–	2883,4	2899,4	2899,4	–	–	–	–	–	–	–	–	–	–		
Ir.7D.123.29	1079,6	1205,6	–	1453,7	1550,8	1652,8	2133,1	–	2883,4	–	–	–	–	–	–	–	–	–	–	–		

extraction. The first (Figure 8, 6) is a beam fragment with an extraction scar, although its state of preservation prevents determining the debitage technique. The second (Figure 8, 5) is a fragment of rod extracted by grooving, probably a piece cut during tool preparation.

As ZooMS analyses have confirmed, both are reindeer antlers (*R. tarandus*), which is consistent with the circulation and deferred use of this raw material during the Magdalenian period in the Cantabrian Region, particularly in the Basque Country (Lefebvre et al. 2023).

At Iruroin, the antler assemblage comprises fourteen finished objects, four rods and three waste products or indeterminate fragments, all of which are consistent with red deer (*C. elaphus*) antlers.

The finished tools include four barbed points (Figure 6) and ten projectile points (Figure 7), all shaped by scraping, with some featuring decorations made by short incisions. Among the barbed points from Iruroin, a complete example with a double row of barbs stands out (Figure 6, 1), with a polygonal section shaft, flattened barbs with a convex profile, and two lateral spurs at the base. A second specimen (Figure 6, 2) corresponds to a medial fragment of a point with one row of barbs and elliptical section. A thick barb fragment of curved outline has also been recovered (Figure 6, 3), although it cannot be determined whether it corresponds to a point with one or two rows of barbs. Finally, a fourth specimen corresponds to the medial part of another barbed point (Figure 6, 4) and is probably part of the polygonal shaft which conserves the remnant of a strip between barbs.

Simple projectile points, on the other hand, are represented only by a single-beveled base fragment, four medial fragments, and five distal fragments. The sections of these specimens are more varied, and we find both quadrangular/polygonal and round/oval sections.

Regarding technical procedures, the four rod fragments attest the use of grooving techniques for rod extraction, with one specimen also showing traces of percussion techniques (Figure 8, 1–4).

Additionally, three refitted fragments of a thick and large tool made from cetacean bone (Figure 9) have been identified by ZooMS as originating from a sperm whale (*Physeter macrocephalus*). Its morphotological characteristics fit in well with the other specimens known from the Pyreneo-Cantabrian region and especially with those from the Pyrenees, given its impressive size and lack of decoration (Pétillon 2013; Lefebvre et al. 2021) (Table 3).

AMS radiocarbon dating

In the case of Langatxo, the dates published by Altuna et al. (1995) were attributed to Level I (Ua-3328: 4,504–3,934 cal BP) and Level III (Ua-3327: 14,051–13,505 cal

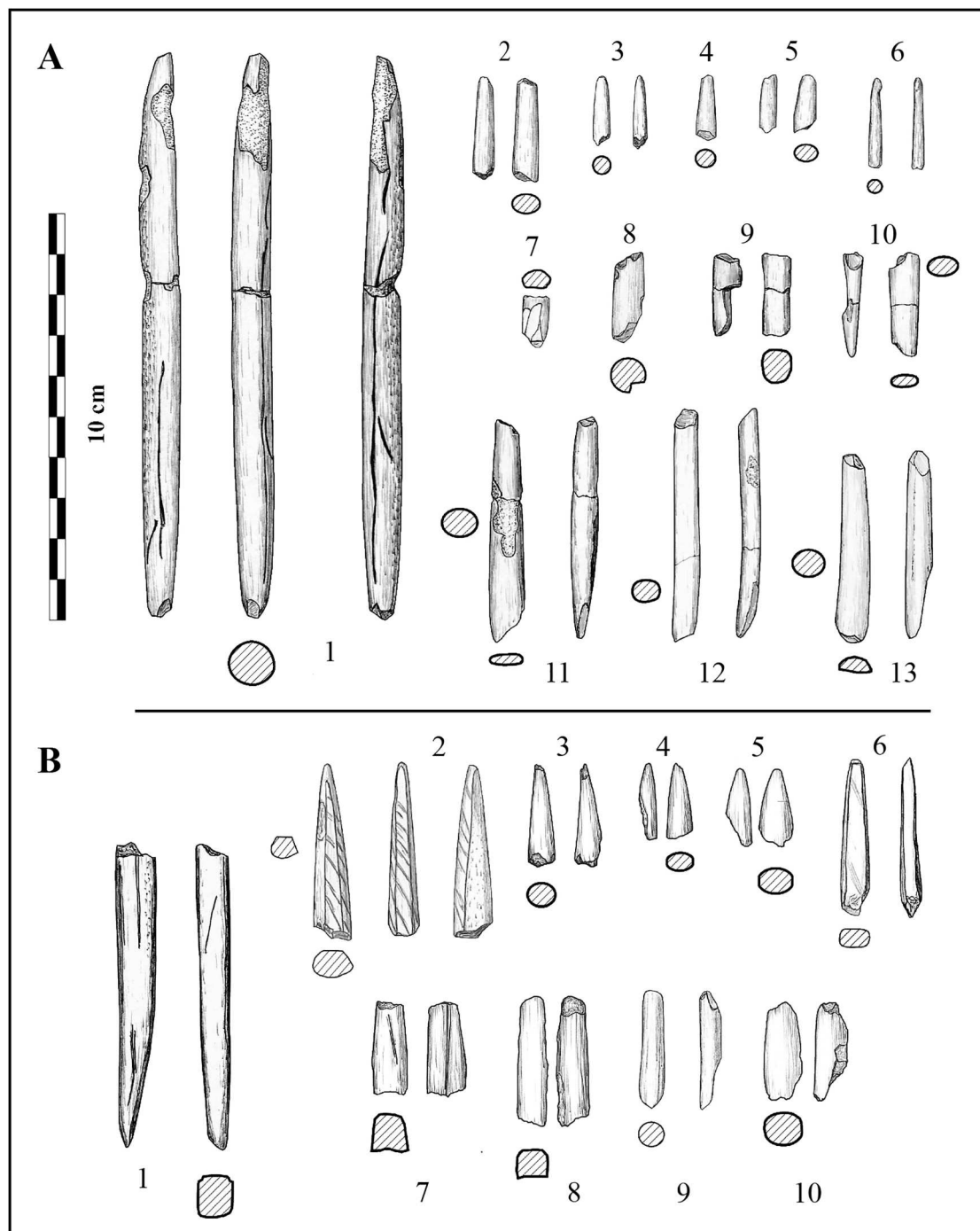


Figure 7. Projectile points from Langatxo (A) and Iruroin (B).

BP) although both had previously been assigned to Level II of the Interior sequence (Zumalabe 1993, 1994). The new radiocarbon dating yields a Mesolithic age for Level II in the Exterior (CIRAM-9025: 9,287–8,927 cal BP) and another Upper Magdalenian age for Level II in the Interior (CIRAM-6764: 15,160–14,505 cal BP), demonstrating that these are different stratigraphic sequences. In addition, this last result is significantly older (500–1000 years) than the one published by Altuna and contemporary to the one obtained now for Level III of Iruroin, whose new date (CIRAM-9765: 15,232–14,612 cal BP) is consistent with the presence of barbed points.

Radiocarbon results show a contemporaneous use of the two caves during the Upper Magdalenian, perhaps preceded at Iruroin by Middle Magdalenian occupations (McGrath et al. 2025), and later continued at Langatxo during the Final Magdalenian/Azilian, Mesolithic and Chalcolithic.

Discussion

The new data provided in this study contribute to reconstructing the sequence of prehistoric occupations at Langatxo Cave but significantly alter the previously proposed chronostratigraphy and its

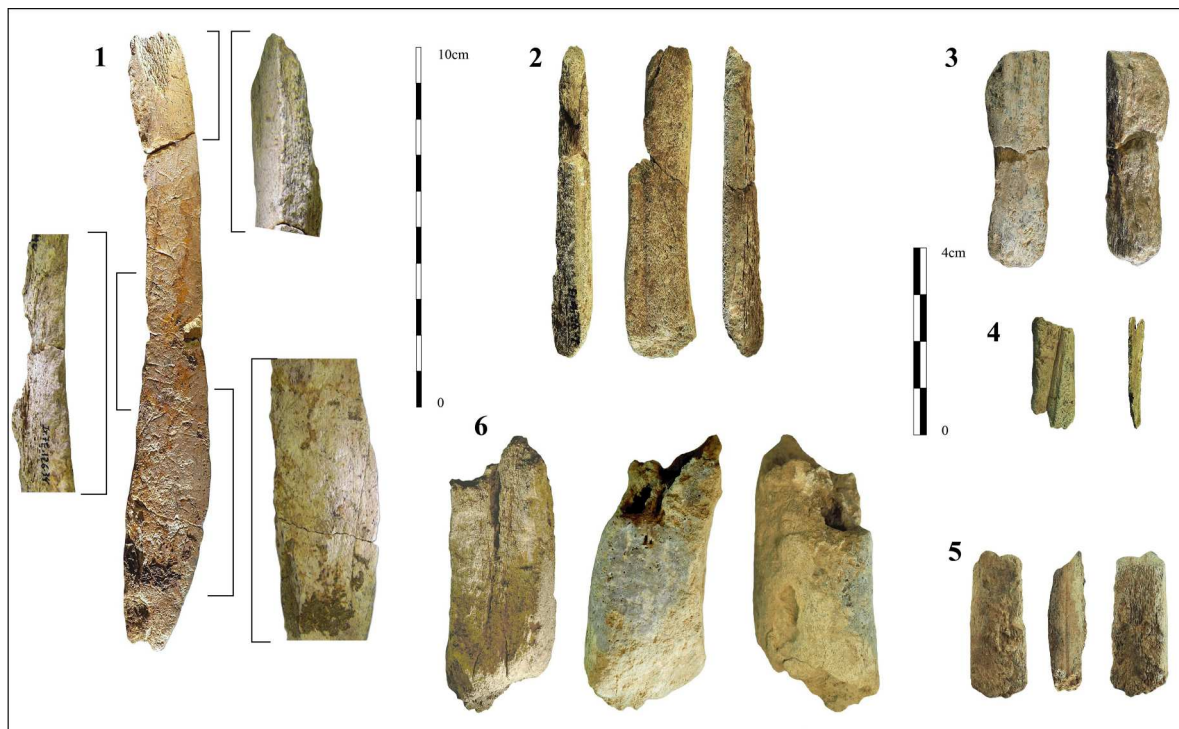


Figure 8. Rods and a beam fragment with a removal scar, from Iruroin (1–4) and Langatxo (5 and 6). Specimen 1 shows evidence of grooving (right) and percussion (left).

interpretation. These findings highlight the need for caution before proceeding with further analysis of Langatxo and Iruroin.

The technical and typological features of the antler industries from Langatxo and Iruroin suggest that both assemblages are broadly consistent with an Upper Magdalenian chronology (Mujika 1990, González Sainz 1995) – perhaps with a few Middle Magdalenian passages at Iruroin – as previously indicated by the presence of diagnostic fossil-directors and radiocarbon dates.

In both contexts, the spear points show variations in size, basal design, cross-section and decoration, and the presence of predominantly distal and proximal fragments compared to medial ones suggests the use and replacement of hunting equipment at the site. The traces observed on these artefacts indicate the application of grooving, percussion and splitting techniques for blank production, followed by shaping through scraping. However, no evidence of antler fracturing or initial processing has been found at either site. The presence of rods and only a small beam fragment suggests that antlers could have been transported to the site as blanks (or secondary blocks) rather than processed *in situ*. This technological pattern, combined with the use of reindeer antlers and cetacean bone for tool production, aligns with the broader Magdalenian context of the region (Pétillon 2013; Lefebvre and Pétillon 2018, 2021, 2023).

Although the faunal assemblages and lithic industries remain to be studied, both the dating and the

presence of barbed and non-barbed points at the two sites suggest that they served similar functions simultaneously. However, at Langatxo, a flat harpoon assignable to the Azilian period was found just 1 cm above a Magdalenian one in Level II of the Interior zone (Figure 6). This, together with the available radiocarbon dates (15,160–14,505 / 14,051–13,505 cal BP), suggests a continuity of Upper Magdalenian occupations potentially extending into the Azilian, the beginning of which has been chronologically placed in the region around 13,500 cal BP (González Sáinz and González Urquijo 2004).

The dating of the Iruroin whale bone could indicate the presence of previous occupations corresponding to the Middle Magdalenian, although McGrath et al. (2025) report difficulties in calibrating their 14C ages due to the uncertainty of the marine reservoir effect. On the other hand, the published summaries mention characteristic elements of the Upper Magdalenian, such as backed bladelets and points, scrapers and burins, highlighting the presence of fossil-directors such as the *Bec de perroquet* burin. However, at present, the cultural attribution of these occupations can only be suggested from the described diagnostic elements and the dates, and an in-depth study of the lithic assemblages and terrestrial fauna is necessary to confirm it.

Another radiocarbon date from Langatxo has definitively separated the sequences of its Interior and Exterior zones, challenging previous interpretations that considered Langatxo as a site focused on

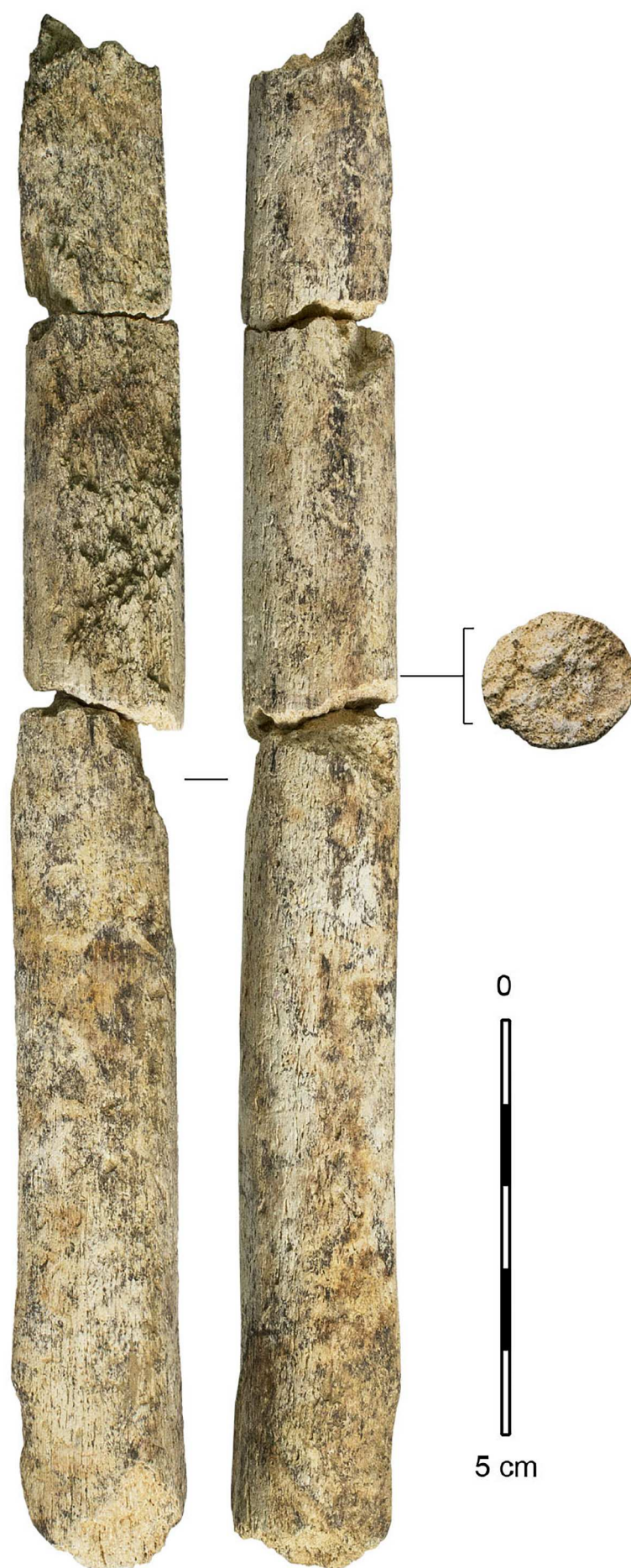


Figure 9. Fragments of a large tool made from sperm whale bone.

Table 3. Radiocarbon dating of the archaeological remains from Langatxo Interior (L-Int) and Langatxo Exterior (L-Ext) Levels I, II and III, and Irurain Level III (IR-III). Level III of the Langatxo Interior sequence is mentioned only in Altuna et al. 1995, but the dated sample comes from an excavation spit previously assigned to level II. The dates were calibrated with OxCal v.4.4.4 (Bronk Ramsey 2001, 2009a, 2009b) using the IntCal 20 (Reimer et al. 2020) and Marine20 (Heaton et al. 2020) calibration curves for terrestrial and marine samples, respectively. A $\Delta R = -105 \pm 21$ is used for the Early Holocene (Soares et al. 2016) and $\Delta R = -448 \pm 39$ for the Late Pleistocene following McGrath et al. (2025). The dates are presented with 95% probability (2 σ). M. Mag.: Middle Magdalenian; U. Mag.: Upper Magdalenian.; L. Mag: Late Magdalenian; Mesol.: Mesolithic; Chalcol.: Chalcolithic.

Site	Sample	Lab. Ref.	Method	D. BP	St. D.	Cult. attrib.	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	D. cal BP (2 σ)	References
L-Int.II	Faunal bone	CIRAM-6764	^{14}C AMS	12,564	57	U. Mag.	20.27	2.15	15,160–14,505	This paper
L-Int.III*	Faunal bone	Ua-3327	^{14}C	11,900	125	L. Mag.			14,051–13,505	Altuna et al. 1995
L-Ext.II	M. shell (<i>P. lineatus</i>)	CIRAM-9025	^{14}C AMS	8528	35	Mesol.	–0.47	N/A	9,287–8,927	This paper
L-Int.I.	Human bone	Ua-3328	^{14}C	3820	85	Chalcol.			4,504–3,934	Altuna et al. 1995
IR-III	Faunal bone	CIRAM-6765	^{14}C AMS	12,615	57	U. Mag.	21.38	2.63	15,232–14,612	This paper
IR-III	Cetacean bone (<i>P. macrocephalus</i>)	UCIAMS 289875	^{14}C AMS	13,880	50	M. Mag.	13.1	16.1	16,780–16,219	McGrath et al. (2025)

coastal resource exploitation during the Magdalenian. The Exterior zone contains a higher proportion of marine invertebrate remains compared to the Interior zone, and a *P. lineatus* shell from Level II of the Exterior zone has been dated to the Mesolithic (9,287–8,927 cal BP). Shellfish gathering in both areas of the cave appears to have been specialised in collecting limpets from various species across different intertidal levels, particularly the middle and upper zones. In addition to limpets, specimens of *P. lineatus* were also collected, albeit less frequently. Furthermore, rocky-substrate bivalves such as mussels and oysters may have been occasionally exploited by the occupants in the Exterior zone of the cavity (ca. 1%).

Consequently, the archaeomalacological assemblage from Langatxo is unrelated to the Upper Magdalenian and is comparable to Mesolithic sites in the Basque Country. In Levels II and III of Marizulo Cave, limpet collection is predominant (50.9%), comprising various species (*P. vulgata* 18%; *P. depressa* 45%; *P. ulyssiponensis* 37%), followed by *Mytilus* sp. (18.5%) (Álvarez-Fernández and Altuna 2013). Similarly, in Levels B, C, D, and F of the J3 shell midden, the proportion of limpets (*P. vulgata* 4.2–7.8%; *P. depressa* 8.6–17.6%; *P. ulyssiponensis* 3.11–6.1%) ranges between 94.8% and 98.1%, followed by *P. lineatus* (<1–5%) (Álvarez-Fernández et al. 2014). By contrast, in Level H-SIn of Santimamiñe Cave, the collection of bivalves *Ostrea edulis* (42.9%) and *Scrobicularia plana* (37.1%) predominates, while gastropods constitute a minor component (5.7%) (Gutiérrez Zugasti 2009). Regarding the size of limpets, a comparison with the Mesolithic occupations at Marizulo reveals similar average sizes of approximately 30 mm (Álvarez-Fernández and Altuna 2013), although generally slightly larger than those from Langatxo.

Holocene conditions are also suggested by the ecological characteristics of terrestrial gastropods found in both the Exterior and Interior zones of Langatxo. Among them, only *C. nemoralis* may have been consumed as food, though this is unlikely given its low representation and the tendency of this calcicolous species to enter caves naturally and without human intervention (Larraz and Jordana 1984). Instead, these species likely indicate the presence of open deciduous forests, dominated by beech and oak, along with shrubland areas in the vicinity of the cave.

Regarding the Magdalenian occupation of Langatxo, evidence for marine resource exploitation is scarce. Only the presence of *L. littorea* in the Interior zone is consistent with its occurrence in Upper Palaeolithic sites in the Cantabrian Region, but it is absent from Mesolithic contexts (Álvarez-Fernández 2011; Gutiérrez Zugasti 2009). A specimen of *L. obtusata/fabalis* specimen found in the Interior zone was likely collected for ornamental purposes, a common function for shells of these species (Álvarez-Fernández

2006). The few crustacean remains from the Interior zone, attributed to *C. maenas*, represent two individuals likely collected from the intertidal zone. This species is typically associated with late Upper Palaeolithic sites (Álvarez-Fernández 2011) and still inhabits northern Iberia today, though the small size of the documented specimens suggests they were not collected for consumption.

With regard to fish, the scarcity and small size of the remains retrieved at Langatxo hint a clear taphonomical association with anthropogenic activities, although this possibility cannot be excluded. Salmonids appear to originate from nearby watercourses such as the river Deba, whereas wrasses are year-round littoral resident fish that feed on benthonic invertebrates, including molluscs. Consequently, this particular remain may have belonged to an individual transported to the cave alongside littoral molluscs.

Therefore, the presence of crustacean and fish remains in the cave cannot be securely attributed to anthropogenic activities, nor can it be reliably dated to either the Pleistocene or the Holocene, as these taxa are not specific to any particular period. As a result, these remains do not constitute robust evidence for marine resource exploitation during the Langatxo occupations.

As a result, it can be inferred that the Upper Magdalenian hunter-gatherers at Langatxo made only minimal use of marine resources, and that Layer II of the Interior zone was subsequently overlaid by remains left by Mesolithic groups, who engaged in a more intensive collection of molluscs. This finding highlights the need for a comprehensive reassessment of the stratigraphy of Langatxo, and also raises concerns regarding potential issues in the case of Iruroin.

The effects of erosive processes had already been noted during the excavation of Langatxo Cave, and a more complex stratigraphic sequence became evident when Chalcolithic human remains were discovered in Level II of the Interior zone, supposedly sealed by flowstone. In fact, when the radiocarbon dates were published (Altuna et al. 1995) the Chalcolithic date was reassigned to Level I and the Magdalenian to Level III. However, regrettably, the study of the site was abandoned before a complete stratigraphic reassessment could be conducted.

Despite these complexities, we consider that the degree of stratigraphic mixing at Langatxo is largely confined to the uppermost layers and can therefore be assessed and isolated. Holocene molluscs in the Interior zone are not abundant and decrease progressively with depth, while the mixture with Chalcolithic remains is limited to a small area of the cave. The bone industries from both Langatxo and Iruroin exhibit a high degree of consistency, and their contexts of origin provide valuable insights for disentangling stratigraphic palimpsests. The spatial distribution of

remains across multiple squares may allow layers of occupation to be reconstructed over extensive, continuous surfaces, while variations in depth may reflect the original inclination of the strata. Several artefacts have been refitted by joining fragments found in close proximity, and the samples for the new dates were collected near the barbed points in both cases. However, the Iruroin sample was also found near the sperm whale bone dated to the Middle Magdalenian, so the risk of mixing persists and requires careful reconstruction of the stratigraphy.

Conclusions

In conclusion, our results indicate that the sequence of occupations at Langatxo is more extensive than previously assumed and includes remains from the Chalcolithic, Mesolithic, Azilian, and Upper Magdalenian periods. The most significant phases appear to correspond to the Upper Magdalenian, subsequently overlapped by the Mesolithic occupations, during which shellfish consumption occurred in both zones of the cave.

The Upper Magdalenian occupations at Langatxo show no substantial evidence of marine resources exploitation, as demonstrated by archaeomalacological analysis and direct radiocarbon dating. Only a specimen of the species *L. littorea* attests the occasional collection of marine resources, a pattern that contrasts with site's proximity to the coast.

The cetacean bone tool from Iruroin suggests the procurement of raw materials from the shore. However, as it is a finished object, it may also have been an imported artefact. As indicated by the presence of barbed points, we can confirm the Upper Magdalenian chronology of Iruroin Level III, although the mixture with Middle Magdalenian remains needs to be analyzed in detail. In addition, the possibility of later occupations in level II, prior to the Chalcolithic, cannot be ruled out. The Magdalenian date for Iruroin fully overlaps with that obtained for Langatxo, raising the question of whether these sites were occupied alternately or for different functional purposes. The proximity to the sea, the cetacean bone artefact, references to molluscs, and Magdalenian barbed points might initially suggest a significant role for marine resources at Iruroin. However, the function of these barbed points has not been determined (Pétillon 2006), and what has been seen so far highlights the need to undertake a post-excavation analysis of the stratigraphies of Langatxo and Iruroin, so that the coherence and resolution of each set can be ensured (Discamps et al. 2023). Addressing these questions should only be attempted once the remains have been organised into coherent assemblages and occupation sequences have been firmly established, of which this work represents merely the first step.

Additionally, sites cannot serve to establish mobility models on a regional scale without clearly establishing their chronology and functionality.

The study of specific materials with diagnostic value has proven highly useful for re-evaluating and interpreting assemblages from ancient or rarely published excavations. In this article, we have examined malacological remains and antler tools, which contribute to our understanding of the regional sequence and reintroduce two previously unpublished contexts into the current state of research. Such studies should not serve only to generate isolated findings but should form the basis for a comprehensive reassessment of the sites.

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Disclosure statement

The authors report there are no competing interests to declare

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