# The Archaeological Evidence for Fish Processing in the Western Mediterranean

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## 1. *Introduction*

The evidence for fish processing in the western Mediterranean in antiquity is found in diverse literary and archaeological sources. Although the textual evidence for the industry in this region is more extensive than in any other, it is the archaeological evidence comprised of transport amphorae, coins, artefacts such as fishhooks or faunal remains, and the actual fish-processing sites themselves that offer a relatively clear view of the facets and extent of the industry. In particular, these sites clarify and further illuminate the processing of fish as *salsamentum* (τάριχος) and sauce (*garum, liquamen, muria, allec,* and *lymphatum*) mentioned or implied in texts.[1]

## 2. *Origins*

The indigenous populations of the western Mediterranean region undoubtedly practised fishing as a means of sustenance,[2] but the techniques of processing fish into *salsamentum* and sauce for later consumption were most probably introduced by peoples from elsewhere in the Mediterranean basin. It has been proposed that fish processing in the region arrived with the first colonisers, and so had Phoenico-Punic origins.[3] R. Étienne proposes another theory, suggesting that it was possible that the Phocaeans first introduced fish processing to the Punic colonists of the southern Iberian Peninsula, after arriving in the region from Asia Minor, where they had practised fish-preservation techniques since the seventh century BC.[4]

A majority of the earliest Phoenician settlements in the southern Iberian Peninsula, such as *Abdera*, *Sexi*, Chorreras, Toscanos, *Malaca,* and Guadalhorce (dating to the middle of the eighth century BC), were located on the southern Mediterranean coast of the peninsula,[5] but only the faunal remains of fish have been excavated at these sites, as at other coastal Phoenician settlements in Portugal and Morocco.[6] The coins of the Phoenician settlements of *Sexi* and *Abdera,* like *Gades,* depict fish (believed to be tunny) (Fig. 1),[7] and it is tempting to think that the first Phoenician colonies in the western Mediterranean *initially* focused upon the rich resources of the sea, much like the Greek colonies in the Black Sea region.[8]

However, the earliest archaeological evidence of fish processing in the western Mediterranean has been discovered in the subsequent Punic layers of one of the main Phoenician settlements, *Gades* (Cadiz). Four Punic fish-salting installations have been identified: Plaza de Asdrúbal, Avda. De Andalucía, Avdas. García de Sola y de Portugal, and Las Redes. The first three sites all have the implications of processing: fish bones, other organic debris, and Mañá A4 and Mañá D-type amphorae containing fish remains (Fig 2).[9] The site at Las Redes is the best preserved and still possesses the remains of processing facilities. In a small building at the site, there is a room for the cleaning and preparation of fish (with a paved and sloping floor), a fermentation room (with organic debris and possibly a hearth), possibly a room for macerating fish, a storage area for amphorae, and a room with fishing accoutrements such as fish hooks and line sinkers. Las Redes and the other Cadiz sites began to operate in late fifth century BC, with the height of activity occurring ca 430-325 BC; eventually the sites ceased operation ca 200 BC, around the time that the Roman organization of the province of *Baetica* began in earnest, after 197 BC.[10]

This archaeological evidence for fish processing in Cadiz is also linked to evidence of the exportation of salted-fish products to the eastern Mediterranean. The Mañá A4 and Mañá D-type amphorae found at Las Redes have also been discovered in central Greece.[11] Excavated in the so-called "Punic Amphora Building" adjacent to the agora at Corinth, the amphorae (dated to the middle of the fifth century BC) contained fish bones of sea bream and tunny.[12] Evidence of this trade in the fifth and fourth centuries BC is also corroborated by the Attic comedic writers Eupolis, Nikostratos, and Antiphanes, who specifically mention salted fish imported into Greece from *Gades*.[13]

*Fig. 1. A coin from Abdera, on the southern Spanish coast, which depicts fish (tunny?) as columns of a temple (after Ponsich and Tarradell, 1965, Pl. XXIV).*

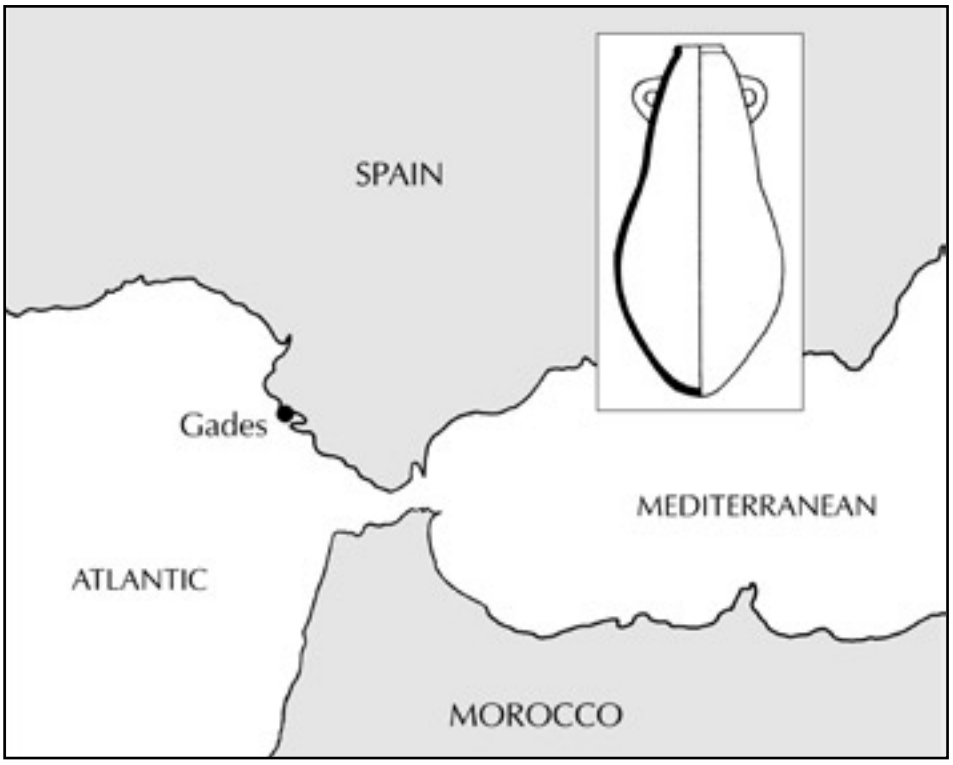


*Fig. 2. The sites at Gades (Cadiz) have revealed evidence of fish processing starting in the late fifth century BC. Archaeological evidence includes Máña A4-type amphorae (after Muñoz Vicente, et al. 1988, fig. 9).*

The site recently discovered at Las Redes reveals therefore that fish processing in the western Mediterranean was initially Punic in origin, which supports in part earlier proposed theories. That no other contemporary sites have been identified might be due to the fact that the numerous, later Roman fish-processing installations throughout southern Spain, Portugal, and northern Morocco probably removed any evidence of earlier installations, since they were often built on top of Phoenico-Punic sites;[14] also, archaeological vestiges could have been heavily damaged during the Second Punic War.[15]

### *3. Fish-processing sites in Spain, Portugal, and Morocco*

After the Punic sites at Cadiz ceased operating ca 200 BC, there is a lacuna of over a century in the archaeological record throughout the region, no doubt due to the extensive geo-political transformations of Roman provincialisation. By the first century BC, however, fish processing in the region re-emerges as a technique practised by the Roman residents of the coastal zones, and a much more detailed picture of the industry is visible (Fig. 3).


*Fig. 3. The fish-processing sites were distributed throughout the Roman provinces of the western Mediterranean.*

### *3.1 Spain*

After the Second Punic War, and the fall of Numantia in 133 BC, the occupation and domination of the southern Iberian Peninsula by the Romans began

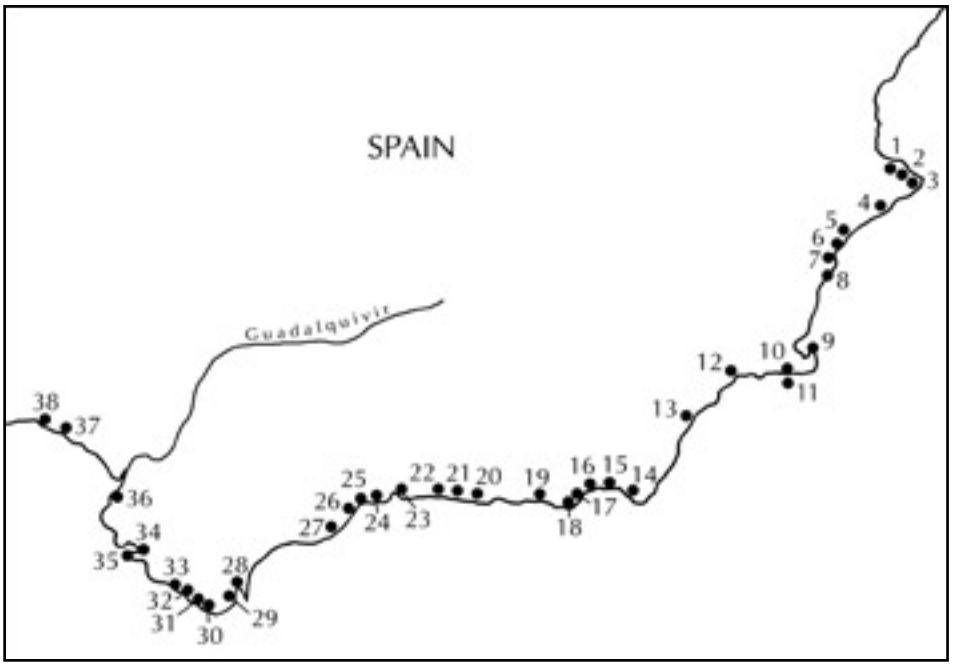


*Fig. 4. The fish-processing sites in Baetica and Tarraconensis. (For key to site numbers, see p. 76)*

in earnest.[16] By the Augustan period, several sites for the processing of fish began to develop along the Mediterranean and Atlantic coastlines of the peninsula, and the exportation of their products at this time is demonstrated by finds of southern Spanish fish-sauce amphorae as cargo of the mid-first century BC "Le Titan" shipwreck (found off southern France),[17] and in the Augustan levels at La Longarina, Ostia.[18] Additionally, fish products from Spain, specifically *garum,* are also documented by contemporary literary sources such as Horace (*Sat*. 2.8.46) and also Strabon (3.2.6).[19]

The Roman fish-processing sites in southern Spain were situated along the southern coasts of the provinces *Baetica* and *Tarraconensis,* spanning the rich waters of the western Mediterranean and eastern Atlantic. The locations of these sites were, and in many cases still are, ideally sited near the off-shore migratory routes and spawning grounds of many different types of fish, including tunny, mackerel, mullet, and eels.[20] During the period of Roman presence in southern Spain, numerous fish-processing installations existed; thirty-eight sites have been identified and are included here in this present survey (Fig. 4). From east to west, these include Denia (*Dianium*), Punta de Castell, Punta de l'Arenal (or Jávea), Calpe, Campello, Tossal de Manises (*Lucentum*), the island of Tabarca, Santa Pola (*Portus Illicitanus*), Mar Menor, Cartagena (*Carthago Nova*), *Scombraria*, Mazarrón, Villaricos (*Baria*), Torre García, Almería (*Portos Magnos*), Ribera de la Algaida, Roquetas, Guardias

Viejas, Adra (*Abdera*), Almuñúncar (*Sexi*), Torrox, Cerro del Mar (*Maenuba*), Málaga (*Malaca*), Guadalhorce, Torremolinos, Fuengirola, San Pedro de Alcántara (*Silniana*), El Rocadillo (*Carteia*), Algeciras (*Julia Traducta*), Villavieja (*Mellaria*), Bolonia (*Baelo*), Barbate (*Baesippo*), Trafalgar, Puerto Real, Cadiz (*Gades*), Sanlúcar de Barrameda, Cerro del Trigo, and Huelva (*Onuba*).[21]

Some of these sites in southern Spain have been more completely excavated than others, and therefore it is possible to assign only a very general chronology for the entire group. It is clear that some fish-processing activity did begin in the first century BC at Bolonia (*Baelo*), as the presence of one salting vat confirms,[22] and also at the small installations at Punta de l'Arenal,[23] Sanlúcar de Barrameda, El Rocadillo (*Carteia*), and Villavieja.[24] Most of the other fish-processing sites in *Baetica* and *Tarraconensis* began to operate in the first and second centuries AD, and more is known about this industry here during this period than in any other part of the Empire. Most sites stopped functioning completely in the third century AD, while others severely curtailed their production. Some even witnessed a later renewal in activity after the third century, and a few show signs of continuous but reduced operations until the sixth century.[25]

The sites in southern Spain vary in size, from only a few isolated salting vats, or *cetariae*, to entire complexes of these associated with small settlements, villas, or towns. Despite the difference in size, however, the basic features of these installations still reveal much typographical, constructional and functional homogeneity, visible in other sites in Portugal and Morocco. Throughout southern Spain, *cetariae* were constructed sunken into the ground and vary in size, although they are consistently rectangular or square in shape.

Within southern Spain, however, some constructional variations do occur in the fish-processing sites, perhaps based somewhat upon the slightly differing topography throughout the region. The factories along the coast in Alicante, between Santa Pola and Punta de l'Arenal, are frequently located on rocky promontories near the sea, with *cetariae* cut into the rock.[26] Uniquely, these sites also include fishponds (*piscinae* or *vivaria*), also cut into the rock.[27] Some of these ponds could be rather large, as at Punta de l'Arenal, where the so-called "Baños de la Reyna" measures 28×7 m and is 4 m deep (Fig. 5).[28] From the ponds, rock-cut channels led to the sea, likely functioning as feeder conduits, supplying fresh seawater into the tanks during the high tides.[29] As at other locations throughout the Mediterranean, these fishponds were probably used for keeping fish alive, prior to consumption, processing or live transhipment.[30] Strabon (3.2.7) notes that live murry caught in Spain were sent to Rome and if this did occur, the fishponds specific to the Alicante region perhaps played a role in this trade.

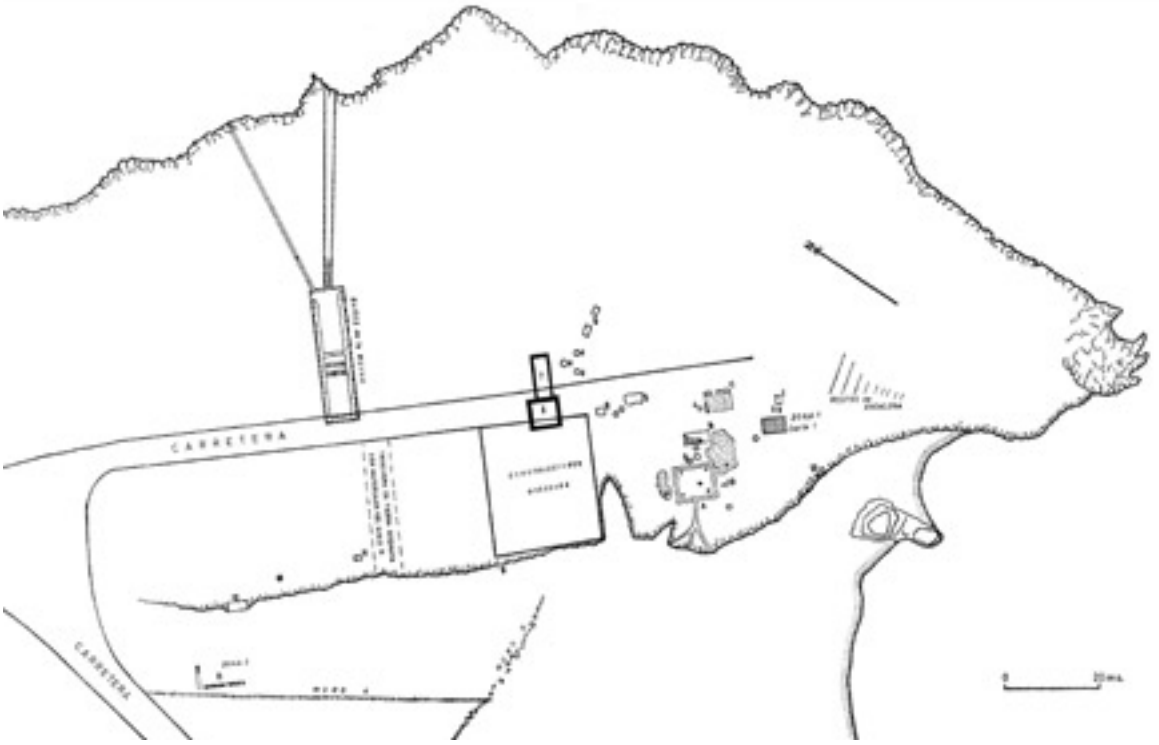


*Fig. 5. The "Baños de la Reyna" at the fish-processing site of Punta de l'Arenal, southern Spain (after Martin and Serres 1970, fig. 2).*

### *3.1.1 Baelo*

Although villas were associated with some of the *cetariae* at Calpe, San Pedro de Alcántara, and Punta de l'Arenal,[31] almost all fish-processing sites in southern Spain were located some distance away from – or outside the walls of – major permanent settlements, most likely due to the strong, putrid smell incurred from the fermentation process. However, at *Baelo* (modern Bolonia), the fish-processing installations seem to have been located inside the walls of the city (Fig. 6).[32] This situation is unique in the western Mediterranean, but is reminiscent of the site of Tyritake on the Black Sea, located along the Strait of Kerch, where a large number of factories were situated in the southeastern part of the walled city (see p. 141-148).[33]

*Baelo* was the largest Roman fish-processing site in *Baetica* and *Terraconensis*. Located on the Atlantic coast of Spain at the western entrance to the Straits of Gibraltar, it was a port city that faces south, situated in a valley formed by a break in the coastal mountain range. Two streams, Arroyo de las Villas and Arroyo del Pulido, run through the small valley to the sea and are adjacent to *Baelo*.[34] Excavations have revealed that fish processing first began when

*Fig. 6. The walled city of Baelo, with the fish-processing complexes in its southern sector (after Pelletier 1988, fig. 2).*

the city was established in the first century BC.[35] As such, *Baelo* is one of the first sites in Spain to process fish (after Las Redes), and this is confirmed by Strabon (3.1.8), who mentions the *garum* industry of the city. A fish, thought to be a tunny, also appears on the reverse of the coins of *Baelo*, perhaps implicating the importance of fishing or the fish-processing industry to the city.[36] The fish-processing industry at *Baelo* declined at the end of the third century AD, but continued to operate until the fifth century or later.[37]

Two different areas in *Baelo* were utilised for fish processing: one is a group of small salting vats located to the south and outside the city itself, down along

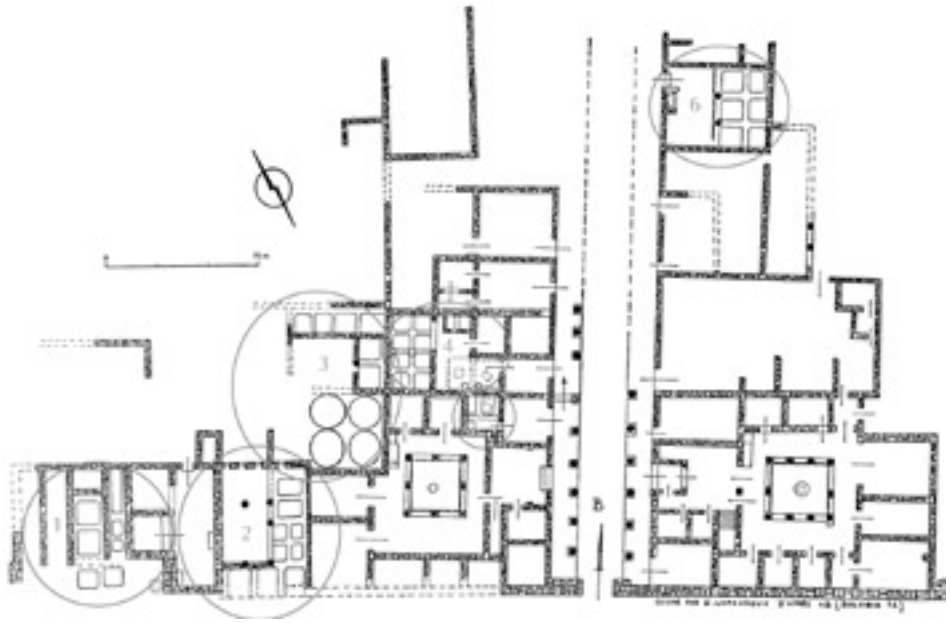

*Fig. 7. The six fish-processing installations of Baelo (after Ponsich and Tarradell 1965, fig. 53).*

*Fig. 8. The four large circular salting vats at Baelo. Note the extant columns (photo: A. Trakadas).*

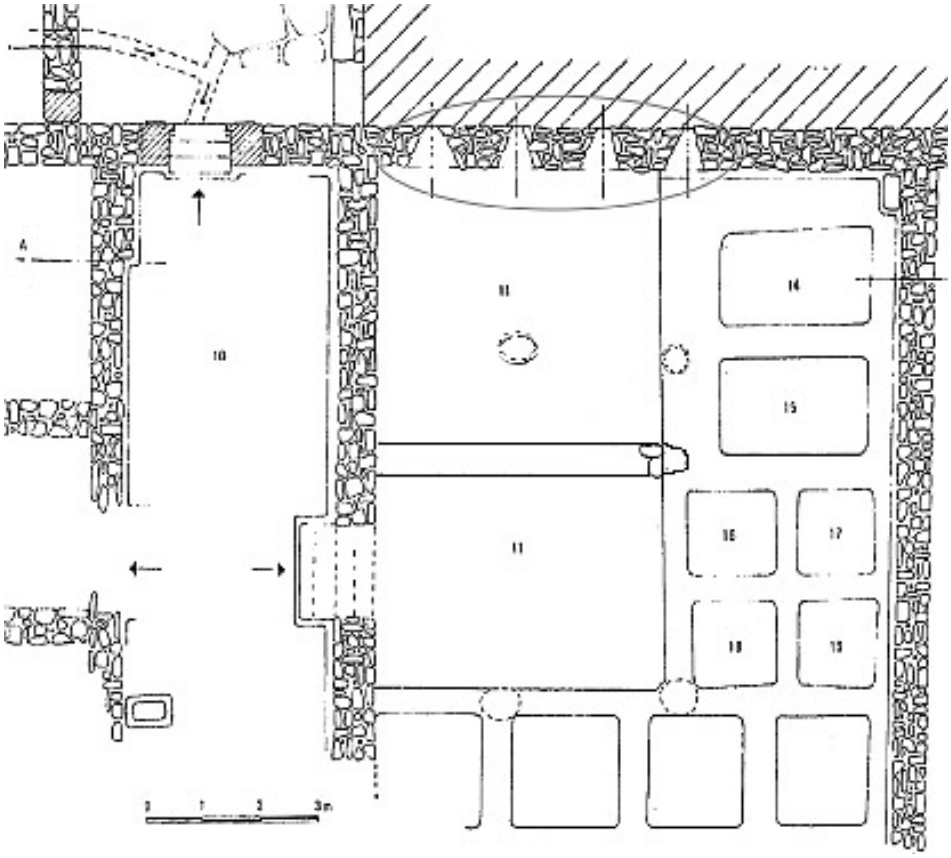

*Fig. 9. The four windows in the wall of one of the complexes at Baelo (after Ponsich 1976, fig. 1).*

the shore;[38] the second is a group of six complexes in the southern part of the city that faces the beach (Fig. 7). Of these latter installations, three had direct access to the beach, and three directly opened onto the *decumanus*. Nearby and adjacent to these installations are two peristyle houses.[39]

The installations in the city consist of differing numbers and arrangements of salting vats of varying size sunken into the ground; some are rectangular, some are square, and four rather large examples are circular (Fig. 8). It has been suggested that the larger rectangular basins, measuring ca 2×3 m and 1.6 m in depth, were probably used for the salting of fish to form *salsamenta*, and the smaller ones were used for making fish sauces such as *garum*.[40] The circular basins, the largest of which measures over 3 m across and 2.5 m deep, could also have been used for *garum*; M. Ponsich suggests they could indicate evidence of processing whale meat.[41] As Robert Curtis has pointed out, however, such circular vats could have also served for making *garum* from fish, as the shape would have facilitated stirring, necessary for an evenly autolysed mixture.[42]

Within each of the six complexes at *Baelo*, vats were located near a central "preparation" area, where the fish were probably cleaned and made ready for processing. One of these preparation rooms has a slightly sloping floor that inclines toward a sump, which probably was designed to assist in cleaning the facility by collecting organic refuse.[43] Water was carried by underground channels to the installations, and was used to help clean the facilities.[44] The installations in the city were covered with roofs and enclosed, most likely to prevent the unwanted rapid evaporation of the fish sauces brought on by direct sunlight, but the remains of four large windows in the wall of one installation support the theory that ventilation was desirable to the process (Fig. 9).[45] In all, the facilities at *Baelo* constitute a processing output of well over 220 cubic metres at any one time, an amount that undoubtedly exceeded local consumption needs.[46]

### *3.2 Portugal*

The province of *Lusitania* was established when *Baetica* was reduced in 26-25 BC, and constituted what is now southern Portugal and a small portion of central Spain, from the Douro River south and from the Guadiana River west.[47] Remains of ancient fish-processing sites in Portugal do not pre-date the Roman period, contrary to earlier belief.[48] No sites have been identified that functioned during the Republican period, but Strabon (3.2.6) notes that fish processing occurred along the Algarve coast, implying that facilities were established by the first century BC. As in Spain, a few sites were operating during the latter part of the first century BC, but the major expansion of the industry occurred during the following two centuries.

Like southern Spain, the Atlantic coastal waters of *Lusitania* were – and are – rich in tunny and other pelagics, as well as shellfish. That fish were an important part of the livelihood of the region might also be demonstrated by the appearance of fish on the coins of several towns in the province: *Baesuris* and *Ossonoba* on the Algarve coast, and the inland river ports of *Salacia* and *Myrtilis*.[49] The Algarve and the Sado Estuary were the two main areas of fish processing exploited during the Roman period, but sites extend from the Guadiana River (the eastern border to *Baetica*) to the Douro River on the Atlantic coast.[50] Forty sites have been identified and are included in this present survey (Fig. 10). They are, from east to west: Quinta do Lago, Quinta do Muro, Cacela, Tavira (*Balsa*), Alfanxia, Olhão, Faro (*Ossonoba*), Loulé Velho, Quarteira, Cerro da Vila, Armação de Pera, Ferragudo, Portimões, Boca do Rio, Mexilhoeira Grande, Vau, Paul, Senhora da Luz, Burgau, Salema, Ilheu de Baleeira, Ilha do Pessegueiro (*Poetanion*), Sines, Tróia, Alcácer do Sal (*Salacia*), Santa Catharina, Senhora da Graca, Pedra Furada, Cachofarra, Setúbal (*Caetobriga*), Comenda, Rasca, Creiro, Alfarim, Casilhas, Lisbon (*Olisipo*), Guincho, Garrocheira, Atouguia, and Praia de Angeiras.[51]

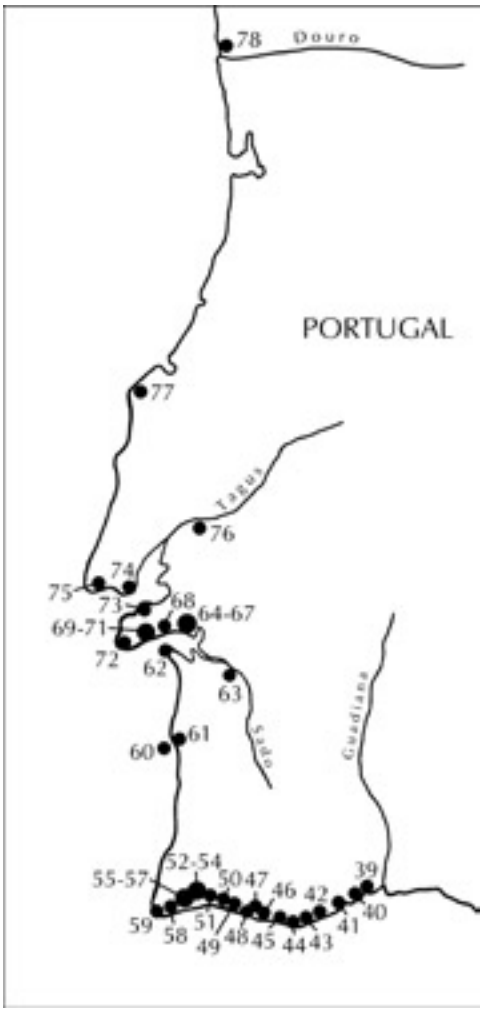


*Fig. 10. The fish-processing sites in Lusitania. (For key to site numbers, see p. 77)*

A majority of the sites in Portugal were noted as early as the late nineteenth century. Some installations were cursorily excavated at this time, but it is difficult to ascertain much detailed information from early reports due to methods of recording and confusion in stratigraphy.[52] Excavations in the past century, however, have led to a clearer picture of these sites and have assisted in establishing their general chronology. Two installations, the large site of Tróia and small site of Casilhas, both began to function at the end of the first century BC. The remainder of the fish-processing installations in Portugal, as in southern Spain, began operating mainly in the first century AD, and many of these continued to function until the beginning of the fifth century AD.[53] At some fish-processing installations, a portion of the *cetariae* went out of operation in the third century; at Setúbal, however, the bottoms of some


*Fig. 11. The* cetariae *cut into rock at Praia de Angeiras (after Gil Mantas 1999, fig. 4).*

*cetariae* were re-constructed, suggesting that part of the complex operated not only in the early Empire, but also again in the fourth and fifth centuries AD, after a period of disuse.[54] At Tróia, some installations continued to operate until the sixth century AD.[55]

Despite the fragmentary preservation of many small installations and scattered *cetariae*, several sites clearly reveal the extent of fish processing in Portugal. At Boca do Rio, in the Algarve, the remains of salting vats are preserved, although a large portion of the nearby settlement has been built over. The concentrations and number of *cetariae*, as well as the rich mosaics still extant from nearby residences, suggest that this was probably a large processing site that sold its products.[56] On Ilha do Pesseguiero, off the Atlantic coast near Sines, a fish-processing installation consisting of two complexes of 18 *cetariae*

with storerooms has been excavated. The *cetariae* were dug into the bedrock, in a construction similar to that at Praia de Angeiras and reminiscent of the sites in the Alicante region in southeastern Spain (Fig. 11).[57]

As the majority in *Baetica* and *Tarraconensis*, fish-processing sites in *Lusitania* were located away from substantial urban settlements, and none were situated inside city walls, as were the installations at *Baelo*. In several locations, however, villas were located close by complexes or associated with scattered *cetariae*; this is mainly the case along the Algarve coast at Boca do Rio, Mexilhoeira Grande, Ferragudo, Cerro da Vila, Quarteira, Olhão, Paul, and Caecela, but also at the isolated site of Praia de Angeiras on the north Atlantic coast.[58] In some cases, the installations probably represent production for local consumption of the residents and dependents of the villas, while others that are more extensive constituted part of industrial annexes for the production of marketed goods.[59]

### *3.2.1 Tróia*

The most extensive and largest fish-processing site in *Lusitania* is Tróia, located on a promontory that separates the mouth of the Sado River and the Atlantic in central Portugal. This promontory guards the entrance to the marine-rich Sado Estuary, but the sandy environment on which the site is located probably prevented any agricultural sustenance. It is therefore assumed that fishing and fish processing were the primary forms of activities in antiquity, and the extensiveness of the installations at the site would appear to confirm this.[60]

Tróia was one of the first sites to operate in *Lusitania*, with some processing installations operating in the late first century BC, but most initiating production by the middle of the first century AD. A substantial decrease in operations and production occurred in the second century; however, by the fourth century, a number of installations were modified for re-use or built over with other edifices such as chapels, or were used as cemeteries. In limited areas at the site, a certain level of fish-processing activity appears to have continued uninterrupted until the end of the fifth century or beginning of the sixth century.[61]

The fish-processing installations at Tróia extend for over 4 km along the western shoreline of the Sado River. The installations mainly consist of small units of salting vats spread along the length of the shoreline (much like across the river at Setúbal), with the greatest concentration of *cetariae* extending for almost 1 km (Fig. 12).[62] Fifty-two "units" of production have been estimated, and their individual plans are generally similar to the installations at *Baelo* and in Morocco, such as Cotta and *Lixus*.[63] The rectangular *cetariae* of Tróia differed in size and capacity, as at other sites; possibly this difference reflects various types or strengths of fish sauces. The smaller vats could possibly represent the more concentrated and therefore more expensive types of *garum,* while the larger vats, measuring ca 3×4 m, could represent cheaper types.[64]

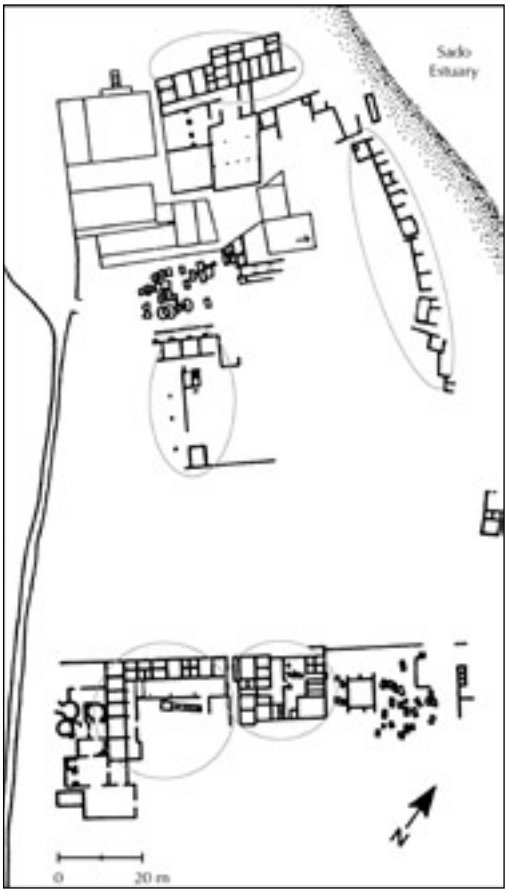


*Fig. 12. The main concentration of fish-processing complexes at Tróia (after de Alarcão 1988b, fig. 130).*

Some *cetariae* at Tróia were located in long rows running parallel to the shoreline. Other installations were situated in complex-like buildings slightly inland. The largest of these latter installations are the so-called "Factories I and II", which were adjoining complexes in the centre of the peninsula. These two factories also clearly display the chronology of the site itself (Fig. 13). Initially, Factory I covered a large area, with roofed vats encircling a large, open courtyard with a central well and cistern. During this first phase, which began in the middle of the first century AD, there were 19 extant vats that varied in size, the largest of which measuring 3.75×4.0 m and 2.4 m deep and the smallest measuring 3.6×1.5 m and 1.93 m deep. The volume of the extant vats was 465 $m^3$, but the entire complex is estimated to have been ca. 700 $m^3$.[65] Connected to the first installation, but similar in layout, was Factory II, which was smaller than the first with only 11 extant vats of almost uniform size. The total volume of this factory was 141 $m^3$. Also adjoining this complex were storage facilities for amphorae.[66]

These factories were abandoned at the end of the second century AD, but re-occupied and modified at the beginning of the fourth century AD. At this

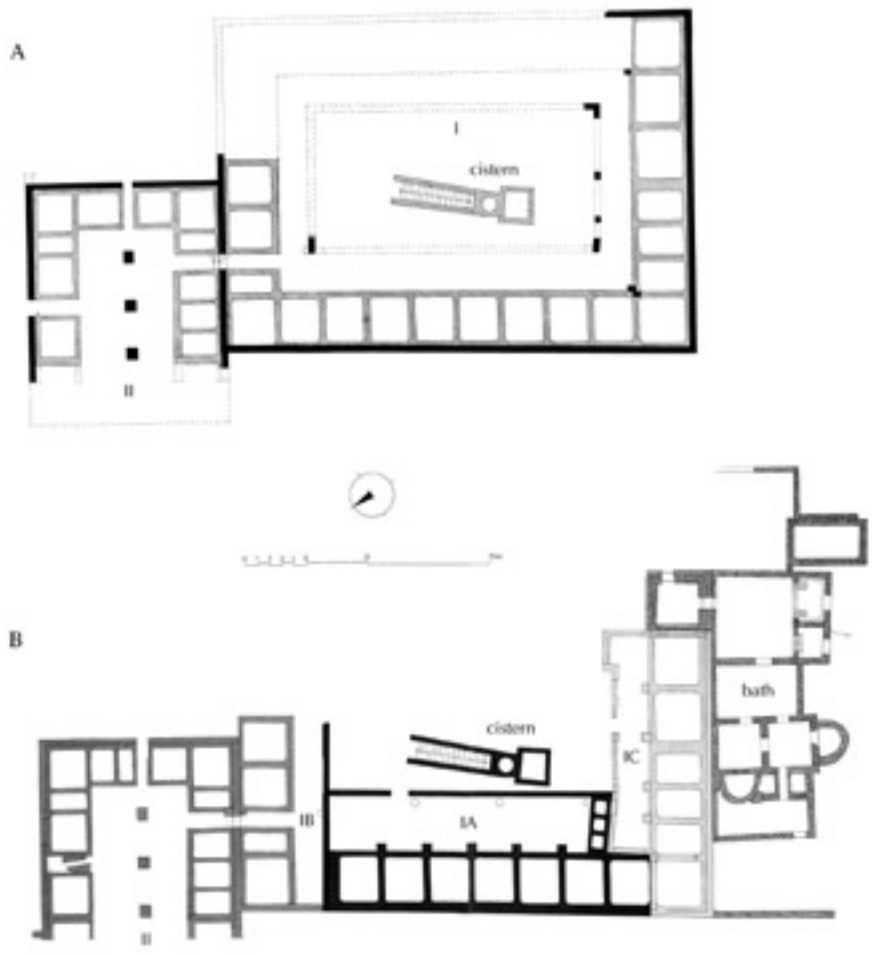


*Fig. 13. The first and second phases of "Factories I and II" at Tróia. During the third phase, the* cetariae *of Factories IA, IB, and IC were further subdivided (after Étienne, et al. 1994, figs. 55-56).*

time, Factory I was divided into three smaller units, called "Factories IA, IB, and IC," and several of the *cetariae* were also subdivided. At the same time, a bath was also built adjoining Factory IC, and one of the original salting vats was re-used as a washbasin for this building.[67] In the third phase of use, more of the vats were subdivided, creating smaller vats and smaller production outputs. Finally, the factories ceased production at the end of the fifth century.[68]

The preparation of fish at the factories at Tróia would have taken place in the open space in front of the *cetariae*, and in some instances this area was

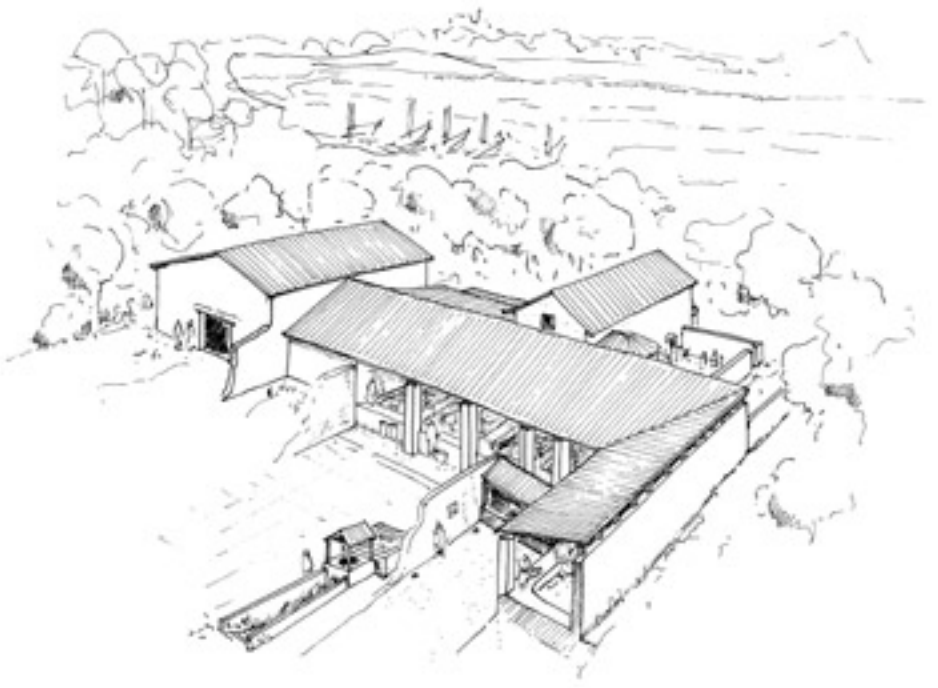

*Fig. 14. A visualisation of parts of Factories IC and IA with roofs, with the adjoining bath complex at the rear (after Étienne, et al. 1994, fig. 48).*

usually paved with the same waterproof material as the vats themselves. In some instances, like at *Baelo*, the floors of these preparation rooms sloped slightly, draining towards a sump to collect the organic refuse from the cleaning process. Evidence of pillars suggests that some complexes, like Factories I and II, were covered with a roof, and openings for ventilation were no doubt present in surrounding walls (Fig. 14).[69] Fresh water was supplied to the complexes of Tróia by means of a system of cisterns and wells distributed throughout the site.[70]

The level of industry that took place at Tróia probably attracted the development of a semi-urban community that was directly involved in fishing and fish processing or in other related services.[71] The large population present at Tróia lived in houses with rich mosaics and murals that were situated adjacent to and amongst the fish-processing installations themselves. These houses, the presence of administrative buildings, a forum, as well as the number of vats at the site, suggest year-round fish-salting production. With extensive kilns also located in the region, the site most likely was a major commercial *vicus*, with a production output that far exceeded local requirements.[72]


*Fig. 15. The fish-processing sites in Mauretania Tingitana (For key to site numbers, see p. 78).*

### *3.3 Morocco*

Although Strabon (3.2.7) mentions the presence of tunny just outside the Straits of Gibraltar along the coast of North Africa, there exists a lacuna in the literary record regarding fishing and fish processing in Morocco in antiquity. Even though the residents of Phoenician and Punico-Mauretanian settlements along the Atlantic coast of northern Morocco certainly exploited the rich marine resources, the archaeological evidence for the processing of fish coincides with the Roman influence and colonization in the region, in the first century BC.[73] When northern Morocco was annexed as *Mauretania Tingitana* in 43 AD, the Roman province extended south to the Oued Bouregreg on the Atlantic coast, but included the distant Îles Purpuraires at Essouaira. It is during this century that fish-processing sites began to develop fully in the province.[74]

The fish-processing sites in *Mauretania Tingitana* are not as numerous as those across the Straits of Gibraltar in *Tarraconensis*, *Baetica* and *Lusitania*, but they are better documented. These sites stretch from the Mediterranean to the Atlantic coasts, adjacent to waters that were – and still are – rich with tunny, mackerel, sardines, and eels, as well as shellfish. Ten Roman-period fish-processing sites have been identified and are included in this present

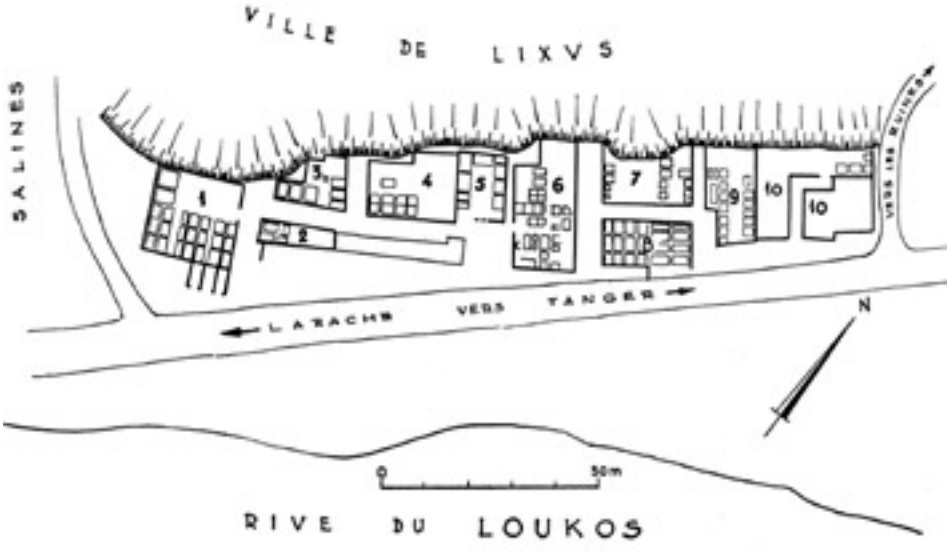


*Fig. 16. The extant fish-processing complexes at Lixus (after Ponsich and Tarradell 1965, fig. 3).*

study (Fig. 15). From east to west, these include Sania e Torres, Ceuta (*Septem Fratres*), Alcazarsegher, Sahara, Cotta, Tahadart, Kouass, *Lixus*, *Thamusida*, and Îles Purpuraires at Essaouira.[75]

The chronology for the use of the sites throughout *Mauretania Tingitana* is well established. Many of the installations, such as *Lixus*, Kouass, Tahadart, Cotta, Ceuta and Essaouira, began to operate in the late first century BC. As in southern Spain, the greatest period of activity in the region was in the first century AD,[76] and other sites were established at this time, including Sahara and Alcazarsegher in the Straits of Gibraltar, and possibly Sania e Torres and the *cetariae* at *Thamusida*. Mirroring the archaeological record of *Baetica* and *Tarraconensis*, the production centres of Cotta, Sahara, Alcazarsegher, *Thamusida*, and Essaouira ceased operation in the third century AD. However, Kouass and Tahadart functioned well into the fifth century or later; after hiatuses in the third century, *Lixus*' production was reduced in size and operated until the start of the fifth century and Ceuta's *cetariae* were used again in the fourth and fifth centuries. Sania e Torres' few *cetariae* could have been used continuously until the beginning of the fourth century.[77]

The processing sites of *Mauretania Tingitana* vary in size and plan, and both Cotta and Essaouira, like some sites in *Baetica*, *Tarraconensis*, and *Lusitania,* were associated with villas.[78] In the case of Essaouira, the three identified vats probably sustained nothing more than the consumption needs of the villa and its dependents. Sania e Torres, Kouass, and Sahara were never more than a few isolated *cetariae,* and probably were associated with other larger sites or towns in the region, such as Ceuta and Zilil. The sites of Cotta and Tahadart are also isolated from larger settlements or towns, but are in fact extensive complexes,[79] Tahadart being fairly reminiscent of Tróia, but on a much smaller scale.

Some fish-processing installations were located close to large settlements, and those at *Lixus* were the largest in the western Mediterranean (Fig. 16).[80] The production area at *Lixus* is located near the shore of the Oued Loukkos, just outside the city walls and below the acropolis, with no other attached buildings or residences. This situation is also similar to that at *Thamusida*, where several *cetariae* were located outside the city walls on the shore of the Oued Sebou.[81] At *Lixus*, the processing installations consist of ten extant, closely-spaced complexes; more certainly existed in antiquity, but the construction of a modern road through the site has unfortunately eliminated more archaeological vestiges. Extant are at least 142 square and rectangular vats with a combined capacity of 1,013 cubic metres.[82] *Lixus* was the only African city with fish on its coins, and these were fashioned in the style of *Gades* and *Abdera*, with fish forming columns of a temple on the reverse.[83]

### *3.3.1 Cotta*

The most completely excavated fish-processing site in *Mauretania Tingitana* is Cotta. Located just a few kilometres south of Cap Spartel, the promontory that forms the western entrance to the Straits of Gibraltar, Cotta sits just above a wide beach on Morocco's north Atlantic coast. A small stream, Oued Khil, is located just to the north of the site, and near the installation are a small villa and temple. Cotta began operating in the first century BC and ceased functioning in the third century AD.[84]

The general plan of Cotta is very similar to those in other installations throughout the region, such as *Lixus*, *Baelo*, and Tróia (Fig. 17). The complex at Cotta is one large building, facing the sea and covering 2,240 $m^2$. There is a large preparation area to one side of the building and storage areas at the back and opposite side of the building. In the central room of the building are twelve large and four small *cetariae*, arranged in a U-shape around a paved preparation area. Under this area is a cistern with a volume of 86 $m^3$ (Fig. 18). Adjacent to this area and next to the complex entrance is a small room with a furnace and hypocausts.[85] Adjoining baths, an olive press, and attached peristyle house also compliment the complex at Cotta.[86]

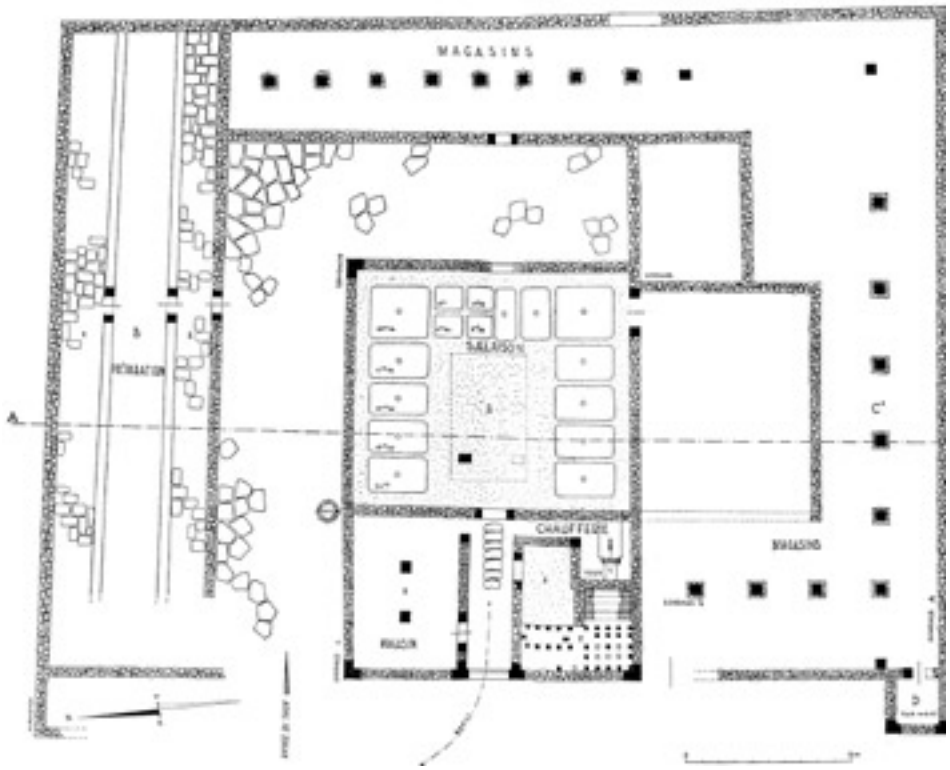


*Fig. 17. The plan of Cotta (after Ponsich and Tarradell 1965, fig. 36).*

On the south-western corner of the factory building, facing the sea, is a square addition, thought by M. Ponsich and M. Tarradell to have been a watchtower, or more specifically, a tunny watchtower (θυννοσκοπείον). Such towers, mentioned by Strabon (5.2.6; 5.2.8; 17.3.16), were utilised by lookouts, who could spot the migration of tunny by observing changes in the colour or surface pattern of the ocean from their dense schools.[87]

The *cetariae* at Cotta lie flush with the floor of the building and are over 2 m deep, holding an estimated volume of 258 $m^3$. Some are rectangular in shape, and two of the *cetariae* are square, measuring 3.5×3.5 m. At the bottom, these vats have small circular pits or cuvettes to assist in cleaning between batches. As the sun unwontedly accelerated the evaporation process in making fish sauces, the facility at Cotta, as also documented at *Baelo*, had a roof covering it, supported by pillars. However, there were most likely windows or openings in the walls to allow for ventilation. The small furnace near the entrance of the complex fed the hypocaust system for the artificial heating of fish-sauce mixtures, and the small ceramic pots with handles and spouts used for this process, *marmites*, were found in abundance at the site.[88]

*Fig. 18. The* cetariae *of Cotta around the central workspace. The workspace floor (upper left) has now given away, revealing the cistern (photo: A. Trakadas).*

Although Cotta represents a smaller production output than some of the individual complexes at *Lixus*, *Baelo*, and Tróia, it is an example of a purpose-built and self-sufficient fish-processing factory. The complex at Cotta is one large unit, and the central production building of the site was laid out for the efficient processing of salted fish products. An olive press was also installed in the building, probably producing olive oil for consumption by the workers of the site. The small temple nearby, the attached baths, as well as the presence of a necropolis to the south, would suggest that the workers of the complex lived nearby and were dependent on the installation for part of, or perhaps the entire year. Cotta was most likely the industrial annex of the nearby villa, and the attached peristyle house was probably the residence of the factory's manager.[89]

## 4. *Features of fish-processing sites in the western Mediterranean*

Throughout the southern Iberian Peninsula and north-western Africa, the remains of the fish-processing sites used during the Roman period reveal a surprising amount of homogeneity. This is demonstrated not only by the specific topographical situation of each installation, but also in the construc-

tional details of the *cetariae* themselves and other necessary features of the complexes, such as heating facilities, water supplies, and kilns.

## *4.1 Topography*

### *4.1.1 Marine resources*

There is abundant sea life in the western Mediterranean and eastern Atlantic, as well as in the Straits of Gibraltar, which connects the two and serves as the major migratory route for many marine species.[90] The breeding cycles of different fish, and their migratory routes, which tended to follow the prevailing currents, were understood in antiquity,[91] and ancient writers often named specific regions in the western Mediterranean that were plentiful in fish. Capturing mackerel in the region during migratory passages is mentioned by Pliny (*HN* 9.49); Strabon (3.2.7) mentions that murry and the largest surmullets came from Spain, and that in Portugal, the Tagus River was rich in fish (3.3.1). The entire Turdetanian seaboard was also praised by Strabon (3.2.7) as being particularly rich in marine life.

Fish-processing sites throughout the western Mediterranean were uniformly sited along the coasts or major rivers of southern Spain, Portugal, and northern Morocco, but the zones where the installations were located also reflect the proximity of rich fishing grounds.[92] Locating processing sites near these grounds would considerably shorten the time between catching and processing, limiting the extent of decomposition of the catch. Fishermen could, in many instances, deliver their catches directly to processing sites, and, as Manilios (*Astronomicon* 5.656-681) describes, with the particular location of these sites, fishermen could come to shore near the installations and start to clean their catches of tunny, cutting it into pieces and wasting no portion.

### *4.1.2 Water supply*

Part of the essential requirements for the processing of fish was fresh water, which would serve for washing fish, preparing brine, and cleaning the processing installations themselves. Almost all of the processing sites in the western Mediterranean are located near naturally-occurring bodies of fresh water, such as rivers or streams, but many sites also developed systems for making sure a necessary amount of fresh water was always on hand. This includes wells, which are present at many sites, but also cisterns and aqueducts.[93] Sites on islands, such as Îles Purpuraires at Essaouira, *Scombraria*, and Ilha do Pessegueiro, had cisterns and wells, but so did many other sites on the mainland.[94] The site of *Lixus* had two buried cisterns,[95] and a cistern is also associated with Cotta.[96] At Guincho, on the Atlantic coast west of Lisbon, there is a large elevated tank with a connecting reservoir and channels.[97] Quinta da Comenda had a canal for water,[98] as did Ceuta, which was connected to a

nearby cistern.[99] Kouass also had wells and an aqueduct over 750 meters long with a subterranean portion that terminated in a collecting pool.[100]

### *4.1.3. Salt resources*

In the Roman world, fish could be processed in two basic ways: the flesh could be cut up and salted, forming *salsamenta*, or the leftovers and/or small fry could be macerated with salt and fermented, forming the various liquid fish sauces (*garum, liquamen, muria, allec,* and *lymphatum*). Processing with salt was an innovative method for preserving a necessary food item in a world without any means of refrigeration, and made possible the trans-shipment of preserved fish and fish sauces to distant locations.[101] The processes involved with salting are described in several texts: Pliny (*HN* 31.93-95) only states that fish parts were combined with salt to make *garum*, but the ratio of fish to salt when making *garum* is described in *Geoponika* (20.46.3) as being 8:1. The method for making *salsamenta* described by Columella (12.55.4) requires square pieces of fish to be covered with salt.

As a constant supply of salt was therefore necessary for manufacturing *salsamenta* and fish sauces, many of these sites were also located near salt marshes or salt mines. In Portugal, the major fish-processing sites were located in areas where there are also major salt resources, the Sado Estuary and Algarve,[102] and the nearby coast of Turdetania is mentioned by Strabon (3.2.6) as a source of good-quality salt. Other major salting regions included Almería and Cadiz in Spain, and the Oued Loukkos basin at *Lixus* and at Kouass in Morocco.[103]

## *4.2 Salting vats: cetariae*

The vats used for processing fish, called *cetariae* (Pliny, *HN* 9.92),[104] are remarkably similar and almost universal in their construction in the western Mediterranean. They were usually built flush with the ground or slightly protruding, although some were built on top of rocky promontories.[105] Usually vats were rectangular or square in shape, but did vary extensively in size and depth. The walls of *cetariae* were built of bricks and/or rubble construction, which were faced with a sealing mortar mixture of lime and small fragments of tiles or ceramics, forming *opus signinum,* occasionally called *cocciopesto* (Fig. 19).[106] The top corners of *cetariae* were rounded, and in some examples, the interior, bottom edges had a quarter-round or "ovolo", to prevent coagulation of the fish mixture in the corners and assist in cleaning the vats.[107]

Uniquely in the region, only four *cetariae* at *Baelo* and one small example at *Lixus* (in complex No. 4) are round.[108] Faced with *opus signinum*, these examples were clearly used for fish processing. However, at the installations at Calpe, Punta de l'Arenal, and Ceuta, large round holes are present in the ground near *cetariae*. At Punta de l'Arenal, the holes are cut into the rock (as

*Fig. 19.* Cetariae *construction:* opus signinum *facing over rubble construction, visible at Cotta (photo: A. Trakadas).*

were the *cetariae*), and at Ceuta, the 1.5 m$^{a}$ hole was lined with stonework.[109] These holes probably held buried dolia, which could have also been used for fish sauce production. Dolia are suggested as containers for making *garum* by Manilios (*Astronomicon* 5.679), and remains of dolia with fish bones inside, probably evidence of *allec*, have been excavated at a "garum shop" at Pompeii, and also at Tyritake, Myrmekion and Chersonesos in the Crimea.[110]

Some *cetariae* were built with a small, rounded catch basin or cuvette in the bottom, to help with cleaning. Usually the cuvettes are centred in the *cetariae*, but some examples are located in a corner. This feature appears in vats, for example, at Punta de l'Arenal,[111] Villaricos,[112] *Baelo*,[113] Portimões,[114] Olhão, Quinta do Lago,[115] Tahadart, Cotta, and Sania e Torres.[116] Another construction feature that aided in draining a *cetaria* was a small inclined conduit that passed through the wall of the vat and could be closed by a plug. The conduit would lead to a small catch basin or simply open on to the floor of the processing room. In one large rectangular vat at Alcazarsegher, a conduit drained into a semi-circular basin (Fig. 20); the same feature was present in two smaller basins at the nearby installation of Sahara.[117] At Tavira, a large *cetaria*, 4×2.80 m and 1.2 m deep, had a lead-lined conduit installed through the wall to drain the vat.[118] This feature is unique to these sites discussed here, but is also present at Rhodes in Spain (north of Barcelona), where three vats had such conduits leading to round catch basins.[119] At *Lixus* (complex No.

8), three *cetariae* were joined together by two arched passages through their walls, much like multi-chambered cisterns.[120]

Most *cetariae* were joined together in rows along the inner walls of a room or building, allowing for a central area to serve as a work place. This organization of space can be seen clearly at Cotta, *Baelo*, and Tróia, but also at other installations such as Roquetas, Adra, Villaricos, and Tahadart.[121] Workers could access the vats by walking on top of the walls between them. At many sites, such as Tróia, *Baelo*, and Tahadart, the paved preparation areas in front of the vats had sloping floors that drained to circular sumps that collected refuse.[122] At some sites, however, *cetariae* were not joined but stood independent of each other. This is the case at Punta de l'Arenal and at Praia de Angeiras, where at both sites the vats were cut into rock.[123]

That *cetariae* were left uncovered to assist in the fermentation process is humourously related by Pliny (*HN* 9.92), who describes that the uncovered tanks at *Carteia* (modern El Rocadillo) were relieved of their salted fish by a giant polyp. Four large windows are present in the extant walls of one of the installations at *Baelo*, and four windows are also present at Tahadart (in installation No. 1).[124] There is evidence of columns for supporting roofs at these two sites and Tróia and Cotta; it is assumed that roofs were necessary, to protect the mixtures from the elements, but that windows or open walls were a method of ensuring ventilation.[125]

### *4.3 Heating facilities*

Furnaces and hypocausts often constitute the facilities of many fish-processing complexes. These were used to artificially heat fish-sauce mixtures, reducing the concentration, optimally by 2/3. This process is described by Ps.-Rufius Festus (*Brev.*) and in the *Geoponika* (20.46.1-6) as a quick method to produce *garum*, and mixtures were sometimes initially heated in small bowls with handles and spouts called *marmites*.[126] Unfortunately, in many cases, hypocausts utilised for this process are often identified in many early archaeological reports as "baths", such as at Tróia,[127] San Pedro de Alcántara, Punta de l'Arenal,[128] Senhora da Luz, and Portimões.[129] A furnace and hypocausts are present in the actual complex buildings at Cotta and Tahadart, and possibly at Kouass.[130] A furnace is also present at Sanlúcar de Barrameda,[131] and at Essaouira; in the latter it is associated with the nearby villa, but it could have also served for heating fish sauce.[132]

### *4.4 Kilns*[133]

Some salted-fish producers, like those who made wine in antiquity, probably manufactured their own amphorae for the transhipment of their products.[134] Kilns that produced transport amphorae therefore formed a necessary part of the salted-fish industry, and many are located near or associated with several

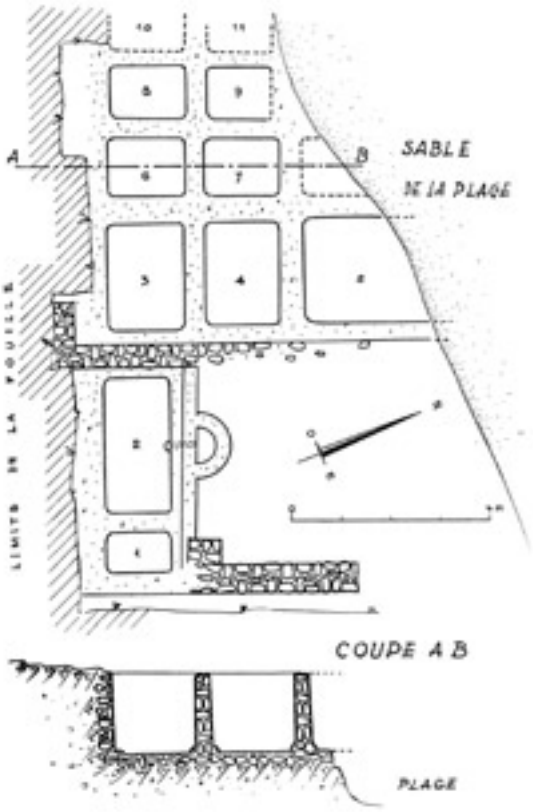


*Fig. 20. The drainage conduit present in the construction of one of the* cetaria *(No. 2) at Alcazarsegher (after Ponsich and Tarradell 1965, fig. 48).*

fish-processing sites throughout the western Mediterranean. At least five kilns existed in the region of Cadiz, two were near El Rocadillo,[135] and one possibly was used at Sanlúcar de Barrameda.[136] Three kilns are distributed throughout the Tagus Estuary, nine kilns in the Sado Estuary and eight in the Algarve; because of their location and products, these kilns must be associated with the fish-salting industries of *Lusitania*.[137] In Morocco, a large kiln was located at Kouass, which began operating in the fifth century BC, manufacturing Phoenician, Punic, and later Roman types, as well as imitations thereof. [138] *Lixus* also possessed kilns,[139] and a small kiln was associated with Cotta.[140]

## *5. Conclusions: Chronology and organisation*

In the first century BC, Strabon (3.4.6) describes the products of Turdetania and the region around *Gades* as producing products not inferior to those from the marine-rich Pontic region. At this time, several large fish-processing sites, such as *Baelo*, Tróia, *Lixus,* and Cotta, had begun to operate. By the first century

AD, as Galen (*On the Properties of Foodstuffs* 3.30.3-6) notes, the best grade of Pontic salted fish had become second to the products of the western Mediterranean, and "Spanish" products were held in preference above all others. It is during this century that nearly all of the 88 extant fish-processing sites in the region began to operate. The western Mediterranean provinces had productive economies with markets throughout the Empire by the end of the first century, and their salted-fish products were exported to Greece, Egypt, Syro-Palestine, North Africa, Gaul, and Britain.[141] Moreover, the installations throughout *Baetica*, *Tarraconensis*, *Lusitania,* and *Mauretania Tingitana* became the major suppliers for Rome in the period from the first to third centuries AD.[142] While inexpensive processed fish may have also come to Rome from the Pontic region, it has been postulated that the fisheries there and in the eastern Mediterranean never were or ceased to be "commercially" important to Rome, although their products were certainly consumed locally.[143]

During the third century, the production of a majority of the fish-processing installations in the western Mediterranean was clearly affected. Many of the installations went out of operation; a few severely curtailed their production, or were even briefly abandoned and re-opened in a limited fashion. Installations such as *Baelo*, Tróia, and a majority of those in *Mauretania Tingitana* and *Lusitania* continued limited operations until the fifth or sixth centuries, a fact which is confirmed by Ausonius (*Letters* 25).[144] Spanish fish-sauce amphorae were still imported into Ostia in the fourth and fifth centuries, and are found on shipwrecks of the period,[145] but it is clear that there was a decline in the production and trade of the products of the western Mediterranean provinces. By the late third century in Rome, an increase in the importation of North African goods can be seen, and excavations at the "Baths of the Swimmer" in Ostia demonstrate that Africana I and II transport amphorae (thought to contain salted-fish products) start to dominate the Roman import markets.[146]

The explanation for this change in production and operations, however, cannot be conclusively tied to any one determinant. Although underlying environmental factors that affected fish catches cannot be eliminated, the impetus was certainly politically and economically charged. It has been postulated that the change was the result of an "economic crisis" and sudden in apparition, but the reason for the industry's demise in the western Mediterranean perhaps was due to the general political instability of the Empire after the death of Commodus in 192 AD, resulting in a slow economic decline over the next century.[147] Certainly, the industry was affected in *Mauretania Tingitana* by the barbarian invasions of the later third century.[148]

The numerous fish-processing installations in southern Spain, Portugal, and northern Morocco are very homogenous with regard to their topographical situations, constructional details and chronology, and imply that close ties were shared between the regions in antiquity. Not only are the fish-processing zones of the western Mediterranean connected environmentally, but during antiquity these areas were also connected culturally as Roman provinces. The

geo-political cohesiveness of the western Mediterranean provinces may have caused many of the region's industries, such as wine making, olive oil production and also fish processing, to function as economic units on a certain level.[149] M. Ponsich suggests that southern Spain, especially the province of *Baetica*, dominated the region politically and economically, exerting particular control over *Mauretania Tingitana*. In this way, salted-fish products from installations in northern Morocco were probably shipped to *Gades*, under a "cooperative" or "consortium" arrangement; the products were then exported by merchants throughout the Empire under the "Gaditanian" label.[150] Such a consortium-like arrangement would, as Ponsich suggests, explain the lack of texts referring to the products of North Africa and the existence of many referring to the products of *Gades*.[151]

J.C. Edmondson also suggests that a similar scenario initially developed for the province of *Lusitania*; here, the fish-processing industry began as an adjunct to that of *Baetica*'s, and surplus products were transhipped through *Gades*, possibly even under the "Gaditanian" label. Only when Lusitanian forms of salted-fish amphorae appear outside of the region in the middle of the first century AD, is it clear that this province exercised some degree of mercantile independence. These amphorae, however, could still have been transhipped through *Baetica*, but as clearly distinguishable Lusitanian goods.[152]

Although geo-political ties certainly existed in the region in antiquity, it has not been proven, however, that commerce in salted-fish products was organised on a provincial level, or that any one consortium was able to maintain a monopoly. Imperial fish-processing sites did exist in Spain, but almost all the installations in the western Mediterranean provinces were privately owned.[153] As Robert Curtis suggests, individual operators of these various installations in the region could have functioned independently, but also could have had the opportunity to sell their products to large organisations or *societates* in southern Spain that certainly existed in *Baelo*, *Gades*, and *Carthago Nova* (the latter's *garum sociorum* subject to treatment by Pliny (*HN* 9.66; 31.93) and Martial (13.102)). From these consortia, salted-fish products could then be transhipped under one merchant or shipper's "label" for export throughout the Empire.[154]

At certain sites in the western Mediterranean provinces, fish processing did occur on a limited level, distributing goods for local consumption. However, an overwhelming majority of the installations in the region certainly demonstrate surplus production. In some instances, the installations associated with villas, especially in the Algarve region of southern Portugal, are of a scale that reflects an industrial annex of a "landed estate", serving as just one of the sources of revenue.[155] Production at such sites was most likely seasonal and took place only in the summer months.[156] The larger complex at Cotta, and those at *Baelo* and Tróia, obviously occupy much different rungs on the scale of production and were part of a more developed, year-round, urban economy. The term "industry" seems most appropriate to describe the

organisation evidenced by these sites. These three sites illustrate clearly the dynamics of the fish-processing industry in the region and reflect the extent of the economic prosperity that it experienced in the first few centuries AD in the western Mediterranean.

*Table 1. Key to site numbers*

*Spain*

1. Denia (Dianium)
2. Punta de Castell
3. Punta de l'Arenal (or Jávea)
4. Calpe
5. Campello
6. Tossal de Manises (Lucentum)
7. The island of Tabarca
8. Santa Pola (Portus Illicitanus)
9. Mar Menor
10. Cartagena (Carthago Nova)
11. Scombraria
12. Mazarrón
13. Villaricos (Baria)
14. Torre García
15. Almería (Portos Magnos)
16. Ribera de la Algaida
17. Roquetas
18. Guardias Viejas
19. Adra (Abdera)
20. Almuñúncar (Sexi)
21. Torrox
22. Cerro del Mar (Maenuba)
23. Málaga (Malaca)
24. Guadalhorce
25. Torremolinos
26. Fuengirola
27. San Pedro de Alcántara (Silniana)
28. El Rocadillo (Carteia)
29. Algeciras (Iulia Traducta)
30. Villavieja (Mellaria)
31. Bolonia (Baelo)
32. Barbate (Baesippo)
33. Trafalgar
34. Puerto Real
35. Cadiz (Gades)
36. Sanlúcar de Barrameda

37. Cerro del Trigo
38. Huelva (Onuba)

*Portugal*

39. Quinta do Lago
40. Quinta do Muro
41. Cacela
42. Tavira (Balsa)
43. Alfanxia
44. Olhão
45. Faro (Ossonoba)
46. Loulé Velho
47. Quarteira
48. Cerro da Vila
49. Armação de Pera
50. Ferragudo
51. Portimões
52. Boca do Rio
53. Mexilhoeira Grande
54. Vau
55. Paul
56. Senhora da Luz
57. Burgau
58. Salema
59. Ilheu de Baleeira
60. Ilha do Pessegueiro (Poetanion)
61. Sines
62. Tróia
63. Alcácer do Sal (Salacia)
64. Santa Catharina
65. Senhora da Graca
66. Pedra Furada
67. Cachofarra
68. Setúbal (Caetobriga)
69. Comenda
70. Rasca
71. Creiro
72. Alfarim
73. Casilhas
74. Lisbon (Olisipo)
75. Guincho
76. Garrocheira
77. Atouguia
78. Praia de Angeiras

*Morocco*

79. Sania e Torres
80. Ceuta (Septem Fratres)
81. Alcazarsegher
82. Sahara
83. Cotta
84. Tahadart
85. Kouass
86. Lixus
87. Thamusida
88. Îles Purpuraires at Essaouira

## Notes

1 Curtis 1991, 6-9.
2 Ponsich 1970, 28-66.
3 Tarradell 1968, 96; Sutherland 1939, 101-102; Ponsich 1968, 12.
4 Étienne 1970, 298-299.
5 Ruiz Mata 2002, 160-161; Aubet Semmler 2002, 201-203, fig. 1.
6 Fish bones and shells were excavated in eighth-century Phoenician levels at *Sexi* and Toscanos (Pellicer Catalán 2002, 57; Uerpmann 1972; Lepiksaar 1973; Molina and Huertas 1985, 26), as well as the Phoenician and Punico-Mauretanian layers (seventh-fourth centuries BC) at *Lixus*, Morocco (Grau Almero, *et al.* 2001, 204-220).
7 Ponsich and Tarradell 1965, 109-111. However, fish also appear on the coins of cities not situated along coasts: *Ituci*, *Asido*, *Ilipa* and *Caura* (Blázquez, *et al*. 1978, 234).
8 M. Aubet (1987) suggests instead that agriculture and domestication of animals in the small coastal hinterland was the initial reason for Phoenician settlement of *Sexi* and *Abdera*, and later they served as centres of navigational support for vessels from *Gades*.
9 Muñoz Vicente, *et al*. 1988, 488-490; de Frutos et al. 1988.
10 Muñoz Vicente, *et al.* 1988, 490-496.
11 Types and parallel types of these amphorae have also been found at *Sexi*, Ibiza, Kouass (northern Morocco), and Sicily, dating from the end of the sixth to the beginning of the fourth centuries BC. Pellicer Catalán 2002, 74-76; Purpura 1982.
12 Williams 1979, 111-114, 117-118.
13 *CAF* 1, Eupolis, 310, fr. 186; *CAF 2,* Nikostratos, 220, fr. 4; Antiphanes, 43, fr. 77.
14 Ponsich and Tarradell 1965, 113-114. Two main areas of fish processing during the Roman period in Portugal, the Algarve and the Sado Estuary, also correspond closely to the areas of early Phoenico-Punic influence (Garcia y Bellido 1942a, 82-93). The same is also true along the Atlantic coast of Morocco, after the initial Phoenician colonization in the eighth century near Cotta, *Lixus*, and eventually Îles Purpuraires at Essaouira (Ponsich 1970, 76-81, 106-165; Aubet 1993, 135-137, 219).
15 Curtis 1991, 48, n. 28.

16 Clément 1999, 113.
17 The amphorae are Dr. 12 and Dr. 7-11 types; Tailliez 1961.
18 Hesnard 1980, 141, 146-148.
19 See Curtis 1988, 209, n. 3, for a discussion of Plautus and Spanish products in the second century BC.
20 Ponsich 1988, 30-43; Blázquez, *et al*. 1978, 392.
21 Ponsich and Tarradell 1965, 81-89; Ponsich 1988, 169-218; Curtis 1991, 48-50, 104; García y Bellido 1942b, 2; Martin and Serres 1970; Cara Barrionuevo, *et al.* 1988; Sotomayor 1971; Loza Azuaga and Beltrán Fortes 1988, 996-997. I have purposely limited this list to include a cohesive unit of only the southern coast of Spain including the Alicante region; other Spanish sites in the Mediterranean do exist on the island of Ibiza, and further north on the Catalonian coast at Barcelona and Rhodes.
22 Bonneville, *et al.* 1984.
23 Martin and Serres 1970, 87.
24 Ponsich and Tarradell 1965, 81, 85, 89, 118-119.
25 Ponsich 1988, 198, 233-234; Curtis 1991, 59; Cara Barrionuevo, *et al.* 1988, 933.
26 Martin and Serres 1970, 39-41, 84; Martin 1970, 144-151.
27 There might also be an example near Barbate (Curtis 1991, 53, n. 42).
28 Martin and Serres 1970, 14.
29 Nicolaou and Flinder 1976, 137-139; Ponsich and Tarradell 1965, 81-82; Martin and Serres 1970, 17.
30 Corcoran 1957, 125-127; Zeepvat 1988, 17-18; Gazda and McCann 1987, 141-155.
31 Ponsich and Tarradell 1965, 83; Gorges 1979, 181; Martin and Serres 1970, 18.
32 Ponsich and Tarradell, 1965, 86-88; Ponsich 1988, 192-199.
33 See Gajdukevič 1971. By the Byzantine period, such situations had changed; at this time, fish-processing sites were required to be placed at least three stades from settlements, due to the smell (Curtis 1991, 188-189, n. 18).
34 Domergue, *et al*. 1974, 9-10.
35 Martin-Bueno, *et* a*l.* 1984; Dardaine and Bonneville 1980, 391.
36 Ripoll López 1988, 484-485.
37 Dardaine and Bonneville 1980, 398; Ponsich 1988, 198; Pelletier 1988, 805-809.
38 Ponsich 1976; Pelletier 1988, 804.
39 Domergue, *et al*. 1974, 22; Ponsich 1988, 192-199.
40 Ponsich 1988, 78, 197-198.
41 Ponsich 1988, 40, fig. 14.
42 Curtis 1991, 52, n. 39.
43 Curtis 1991, 51.
44 Dardaine and Bonneville 1980, 386-388.
45 Bonneville, *et al*. 1984, 470-476; Ponsich 1976, 72-74.
46 Ponsich and Tarradell 1965, 86-87.
47 Knapp and Stanley 2000, 415.
48 de Figueiredo 1906, 109-113.
49 Ponsich and Tarradell, 1965, 109-111; Edmondson 1987, 100.
50 Edmondson 1987, 105-106; Clément 1999, 119.
51 Ponsich 1988, 221-228; Ponsich and Tarradell 1965, 89-90; Edmondson 1987, 255-269; Cleto 1995-1996; de Figueiredo 1906.
52 de Figueiredo 1906, 109-111.
53 Edmondson 1987, 108.

54 Marques da Costa 1960, 16; Tavares da Silva 1980; Edmondson 1987, 108-109.
55 Soares 1980; Edmondson 1987, 263.
56 de Figueiredo 1906, 113-114.
57 Cleto 1995-1996, 24-27; Edmondson 1987, 269; Tavares da Silva and Soares 1993.
58 Gorges 1979, 480-483; Gil Mantas 1999, 147, 151.
59 Gil Mantas 1999, 151; de Alarcão 1988a, 88.
60 Dias Diogo and Cavaleiro Paixão 2001, 117; Étienne, *et al*. 1994, 11-13.
61 Étienne, *et al*. 1994, 27-40; Edmondson 1987, 108, 267-268; de Alarcão 1988b, 130-131.
62 de Alarcão 1988b, 130.
63 de Almeida, *et al*. 1978, 2; Edmondson 1987, 124-125, fig. 5.5.
64 Edmondson 1987, 124.
65 Étienne, *et al*. 1994, 70-76.
66 Étienne, *et al*. 1994, 78-82.
67 Étienne, *et al*. 1994, 82-88.
68 Étienne, *et al*. 1994, 88-92.
69 Edmondson 1987, 124.
70 Edmondson 1987, 268.
71 Edmondson 1987, 131; de Alarcão 1988b, 130. For fishing implement manufacture: Ribeiro 1971, 398-399.
72 Étienne, *et al*. 1994, 69, 161; Dias Diogo and Cavaleiro Paixão 2001, 117; Marques da Costa 1930-31; de Alarcão 1988a, 43; Gil Mantas 1999, 147.
73 Grau Almero, *et al*. 2001, 204-220; Ponsich 1970, 28-66.
74 Aubet 1993, 135-137, MacKendrick 1980, 290-293; Ponsich 1970, 183-194.
75 Ponsich and Tarradell 1965, 9-77; Rebuffat 1977, 284-285; Jodin 1967, 68-71, 256-262; Bravo Perez 1980.
76 Ponsich and Tarradell 1965, 39, 68; Ponsich 1988, 103-136; Jodin 1967, 261-262; Ponsich 1967, 375; Jodin 1957, 19; Bernal Casasola and Pérez Rivera 1999, 28-29.
77 Ponsich and Tarradell 1965, 9-77, 118-119; Rebuffat 1972, 53; Bernal Casasola and Pérez Rivera 1999, 28-32, 46; Gozables Craviota 1997, 128; Jodin 1967, 261-262.
78 Ponsich and Tarradell 1965, 56-61; Jodin 1967, 48-56.
79 Ponsich and Tarradell 1965, 10, fig. 3, 73, fig. 48, 40-68.
80 The sites in Ceuta that show evidence of fish processing (Gran Via, Queipo de Llano, Parque de Artillería and El Paseo de las Palmeras) could possibly be connected, and represent one large production centre, making it the largest in *Mauretania Tingitana* and therefore the western Mediterranean. However, since excavations have been sporadic and modern development extensive, there is no way to ascertain if these four sites are in fact connected (Bernal Casasola and Pérez Rivera 1999, 40).
81 Rebuffat 1972, 53.
82 Ponsich and Tarradell 1965, 9-37.
83 Ripoll López 1988, 483-485.
84 Ponsich and Tarradell 1965, 55-57.
85 Ponsich and Tarradell 1965, 55-68.
86 Ponsich 1970, 283-284.
87 Ponsich and Tarradell 1965, 60-61. At the present time, tunny still migrate by Cotta and are caught in *madraba* nets by Moroccan fishermen just south of the site, where they are harvested in late July.

88 Ponsich and Tarradell 1965, 55-68.
89 Ponsich 1970, 206-208, 276.
90 Ponsich 1988, 30-43; Ponsich 1976, 70-71; Corcoran 1957, 64-65.
91 Ponsich and Tarradell 1965, 93-98.
92 Even though the coasts and waterways of southern Spain and Portugal have undergone some topographical alteration since the Roman period, particularly with regard to the silting of river mouths and the alteration of river courses, these sites in antiquity would have been located above the high-tide or flood zones (Knapp and Stanley 2000, 415; Hoffman and Schulz 1988, 53, 59; Mabesoone 1963).
93 Ponsich and Tarradell 1965, 102.
94 Jodin 1967, 71-75; Cleto 1995-1996, 32-36.
95 Ponsich and Tarradell 1965, 35.
96 Ponsich and Tarradell 1965, 57.
97 Edmondson 1987, 263.
98 Edmondson 1987, 265.
99 Bernal Casasola and Pérez Rivera 1999, 28-65; Gozables Craviota 1997, 128.
100 Ponsich 1967, 393-404.
101 Curtis 1991, 15-16.
102 Rau 1984, 40-46.
103 Martin and Serres 1970, 8; Ponsich and Tarradell 1965, 100-101.
104 *Cetaria* could also mean an enclosure for tunny, see Horace *Sat.* 2.5.44 and Pliny *HN* 9.49; 37.66; Corcoran 1957, 126.
105 de Figueiredo 1906, 118-119, fig. 4.
106 Edmondson 1987, 122.
107 Edmondson 1987, 122; Cara Barrionuevo, *et al*. 1988, 920.
108 Ponsich 1988, 40, fig. 14; Ponsich and Tarradell 1965, 18-19, fig. 8.
109 Curtis 1991, 54; Martin and Serres 1970, 85; Bernal Casasola and Pérez Rivera 1999, 50.
110 Curtis 1991, 92-94, fig. 6, 123, n. 55.
111 Martin and Serres 1970, 41, fig. 20.
112 Cara Barrionuevo, *et al*. 1988, 931, fig. 9.
113 Dardaine and Bonneville 1980, 382-383, fig. 6.
114 de Figueiredo 1906, 116.
115 Étienne, et al. 1994, 111, figs. 38-39.
116 Ponsich and Tarradell 1965, 44, 60-61, 76.
117 Ponsich and Tarradell 1965, 68-73, figs. 45, 48.
118 de Figueiredo 1906, 118.
119 Nolla-Brufau 1984, 437-442, 453, fig. 15.3.
120 Ponsich and Tarradell 1965, 31, fig. 18.
121 Cara Barrionuevo, *et al*. 1988, 922, 930-931.
122 Étienne et al. 1994, 76; Curtis 1991, 51; Ponsich and Tarradell 1965, 44, fig. 27.
123 Martin and Serres 1970, 39-41, fig. 3; Gil Mantas 1999, 152, fig. 4.
124 Ponsich 1976, 71-73, fig. 1; Ponsich and Tarradell 1965, 44, fig. 27.
125 Blazquez, *et al*. 1978, 234; Martin-Bueno, *et al.* 1984, 491.
126 Ponsich and Tarradell 1965, 105-6; Ponsich 1970, 287-288.
127 de Alarcão 1988b, 130-131.
128 Ponsich and Tarradell 1965, 103; Martin and Serres 1970, 85.
129 Edmondson 1987, 256-257.
130 Ponsich and Tarradell 1965, 57-60 (Cotta), 43-44, fig. 27 (Tahadart), 39 (Kouass).

131 Curtis 1991, 56.
132 Jodin 1967, 257.
133 Broadly, the types of transport amphorae associated with western Mediterranean salted fish and fish sauces are: Dr. 7-11, Beltrán I, Dr. 12-13, Dr. 14, Dr. 38-39, Beltrán IIB, Almagro 50, Almagro 51a-b, and Almagro 51c (see Peacock 1974; Parker 1977).
134 Peacock and Williams 1991, 73-76.
135 Peacock 1974, 236-242.
136 Esteve Guerrero 1952, 127.
137 Edmondson 1987, 158-159, fig. 6.2; de Alarcão 1988a, 86-87, fig. 40; Parker 1977.
138 Ponsich 1967, 376-385; Kbiri Alaoui 2000.
139 Ponsich 1981, 24.
140 Personal communication, Dr. A. Elboujaday, Délégacion de la cultura de Tanger, June 2002.
141 Curtis 1991, 64; Curtis 1988b; Cotton, *et al.* 1996.
142 Curtis 1991, 180.
143 Corcoran 1957, 85.
144 Ponsich 1988, 198; Edmondson 1987, 108-109, 189; Tarradell 1955; Ponsich and Tarradell 1965, 115-117; Curtis 1991, 60.
145 For example, the Sud-Lavezzi 1 wreck with cargo of Almagro 51 amphorae dating to the fourth or early fifth century AD (Liou 1982).
146 Panella 1972, 101-104.
147 Reece 1981; Tarradell 1955; Ponsich and Tarradell 1965, 115-117; Curtis 1991, 60.
148 Keay 1984, 553; Whittaker 1994, 151.
149 Ponsich and Tarradell 1965, 4; Ponsich 1988, 30-43; Ponsich concedes, however, that this was not the case with murex dye (Ponsich 1970, 336).
150 Ponsich 1970, 336; Ponsich and Tarradell 1965, 99.
151 Ponsich 1975, 680.
152 Edmondson 1987, 189-190.
153 Curtis 1991, 181.
154 Étienne 1970; Curtis 1991, 62-63; Curtis here also discusses in detail the commerce of fish products as demonstrated by epigraphic evidence and *tituli picti*. For tertiary levels of distribution, see Curtis, 1988.
155 Edmondson 1987, 135-136.
156 Curtis 1991, 56.