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The *salinae* of O Areal (Vigo) and Roman salt production in NW Iberia

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The production of sea salt was one of the most important sources of salt in antiquity. The Elder Pliny (*NH* 31.81) describes that the most common way of obtaining salt is through marine saltworks (*Facticii varia genera, volgaris plurimusque in salinis mari adfuso*). In the written sources we have plenty of references of marine salt evaporation ponds.[1] Pliny (*NH* 31.84-87) mentions a series of examples of these factories distributed throughout the Mediterranean; Livy (1.33) tells us that *Ancus Marcius* opened a saltwork in the Tiber next to Ostia; while Columella (10.135) indicates the existence of saltworks in Pompey, and *Cassiodorus* (Var. XII, 24) speaks of those located in Venice. The references of *Rutilius Namatianus* (*De red.* 475-90) and *Manilius* (*Astr.* V, 682-692) are also well known for their explanations of how ancient saltworks work. Nonetheless, despite the importance of sea salt, the archaeological evidence that has been documented regarding saltworks distributed throughout the whole coast line of the Roman Empire is mainly scarce and partial.

The development of the archaeology of salt in the last few years has given us a deeper insight on salt production systems that goes far beyond the information we previously had from the ancient texts. Today we have evidences of Roman marine salt production throughout the Mediterranean. On the right margin of the Tiber, a saltwork has been documented and dated to the first half of the 1st c. A.D.[2] In Kaunos (Anatolia) 48 circular salt pans were identified, with a diameter of 4.3 m and 14-18 cm deep and a paved base built with *opus caementicium.*[3] These salt pans were distributed in 8 lines of 6, forming a total of 5 different units separated by 4 rectangular canals through which sea water was distributed[4]. In Antibes, near Nice, a large cobble-paved floor, located next to an ancient salt-water lagoon has been interpreted as a *salina*.[5] In Cádiz, in relation to the large amount of roman salting factories located in the city of *Gades*,[6]

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1 C. Carusi, *Il sale nel mondo greco (VI a.C.-III d.C.). Luoghi di produzione, circolazione commerciale, regimi di sfruttamento nel contesto del Mediterraneo antico* (Bari 2008) 45-148; B. Moinier and O. Weller, *Le sel dans L'Antiquitité ou les cristaux d'Aphrodite* (Paris 2015) 320-23.

2 M. C. Grossi *et al.*, "A complex relationship between human and natural landscape: a multidisciplinary approach to the study of the roman saltworks in "Le Vignole-Interponto" (Maccares, Fiumicino-Roma)," in R. Brigand and O. Weller (edd.), *Archaeology of salt. Approaching an invisible past* (Leiden 2015) 83-101.

3 S. Atik, "A new discovery in Kaunos. Sal Caunitis," in *Vom Euphrat bis zum Bosporus. Kleinasien in der Antike* (Asia Minor Studien 65, 2008) 39-45.

4 The proximity of the saltworks to the city of Kaunos (about 5 km away), as well as Pliny´s (*NH* 31.99) reference to salt from Kaunos as a remedy for eye diseases (Carusi 2008, supra n.1, 85), could lead to think that the origin of these structures could be retracted to Antiquity. Nevertheless, we must highlight that it still has not been published any archaeological evidence that allows the adjustment of its exact chronology.

5 I. Daveau and O. Sivan, "Les aménagements lagunaires du Bas Lauvert à Antibes (Alpes Maritimes)," in X. Delestre and H. Marchesi (edd.), *Archéologie des rivages méditerranéens: 50 ans de recherche* (Paris 2010) 55-60.

6 L. Lagóstena Barrios, *La producción de salsas y conservas de pescado en la Hispania romana (II a.C.–VI d.C.)* (Instrumenta 11; Barcelona 2001) 98-119.

some remains evidencing the presence of roman saltworks have also been documented.[7] In Huelva (Spain), at the site of El Terrón (Lepe), other Roman saltworks have also been identified,[8] also related to an important complex of salting factories located in the area.[9] We also know of the existence of salt production through artificial heating during the Roman Period, documented at the Fenlands in East England.[10] Besides sea salt production, there is also archaeological evidence of salt factories in the inlands, as Añana[11] or Sigüenza[12] in the Iberian Peninsula.

Among the latest novelties regarding salt production in the Roman Empire, archaeological research has revealed a series of saltworks in the northwest of the Iberian Peninsula that must be highlighted due to the extension of the remains and their perfect chronological identification. The past 20 year of urban archaeology in the city of Vigo (Galicia) has allowed us to identify a large saltwork complex that, up until now, is the best documented Roman *salina*. This is not an isolated case since there is some evidence of possible Roman *salinae* throughout the Atlantic coast (fig. 1). These new data allows us to state the importance of marine salt production in the Peninsular northwest.

Despite the economic importance that the saltworks of the northwest of the Iberian Peninsula must have reached, neither the classic texts nor epigraphy mentions marine salt production in the area. Furthermore, there are also no references regarding important salting factories in the region, which are well-known from an archaeological point of view. We only have one reference in Strabo (3.3.7) in his text regarding the mountaineers of the North where he mentions purple salt that turns white when it is grinded. The problem with this possible reference to some type of halite mainly consists in that there is no known rock salt mines in the Northwest. In any case, we must take into account that Strabo´s passage is not a credible description, but rather an ideological discourse where he presents an inverted image of Roman civilization that geographically defines the limits of barbarism.

The *Salinae* of O Areal

The Roman *salina* of O Areal, located under the city of Vigo, is made up of a series of different sized ponds and tanks, formed by a pavement delimited with stone slabs, distributed throughout an ancient beach (fig. 2). Research carried out by urban archaeology has allowed us to document a series of Roman sea salt pans in the area of O Areal (place name that can be translated as “sandy area” or “beach”). Until now, the fragmented work that has characterized the digs has hindered the possibility of obtaining a better understanding of the whole site.

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7 C. Alonso Villalobos, F. J. Gracia Prieto and L. Ménanteau, “Las salinas de la Bahía de Cádiz durante la Antigüedad: visión geoarqueológica de un problema histórico,” *SPAL* 12 (2003) 317-32; C. Alonso Villalobos and L. Ménanteau, “Paléoenvironnements et techniques de production du sel marin (par ignition ou insolation) durant l’Antiquité: les cas des baies de Bourgneuf (France) et de Cadix (Espagne),” in J. C. Hocquet and J. L. Sarrazin (edd.), *La sel de la baie. Histoire, archéologie, ethnologie des sels atlantiques* (Rennes 2006) 87-103; C. Alonso Villalobos *et al.,* “Geoarqueología y arqueometría de la sal,” in L. Lagóstena, D. Bernal and A. Arévalo (edd.), *Congreso int. CETARIAE. Salsas y salazones de pescado en Occidente durante la Antigüedad, Cadiz 2005* (BAR S1686; Oxford 2007) 317-25; cf. D. Bernal *et al.*, “Instalaciones fluvio-marítimas de drenaje con ánforas romanas: a propósito del embarcadero flavio del caño de Sancti Petri (San Fernando, Cádiz),” *SPAL* 14 (2005) 179-230.

8 J. M. Campos Carrasco, J. A. Pérez Macías, N. De La O. Vidal Teruel, *Las cetariae del litoral onubense en época romana* (Huelva 1999) 168-72 and 209.

9 Lagóstena (supra n.5) 92-97.

10 T. Lane and E. L. Morris (edd.), *A millenium of saltmaking: Prehistoric and romano-british salt production in the Fenland* (Linconshire Arch. & Heritage Rep. 4, 2001).

11 A. Plata, “Las salinas y el poder entre la Antigüedad Tardía y la Plena Edad Media. La evolución del poblamiento en el norte peninsular a través del estudio del Valle Salado de Añana (Álava, País Vasco),” in A. García Porras (ed.), *Arqueología de la producción en época medieval* (Granada 2013) 357-98.

12 N. Morère, “L’exploitation romaine du sel dans la region de Sigüenza,” in J. M. Blázquez and S. Montero (edd.), *Alimenta. Estudios en homenaje al Dr. Michel Ponsich* (Anejos de Gerión 3, 1991) 223-35.

Throughout a synthesis of the works –many of them inedited[13]- it is possible to present a first general view of the Roman salt factories.

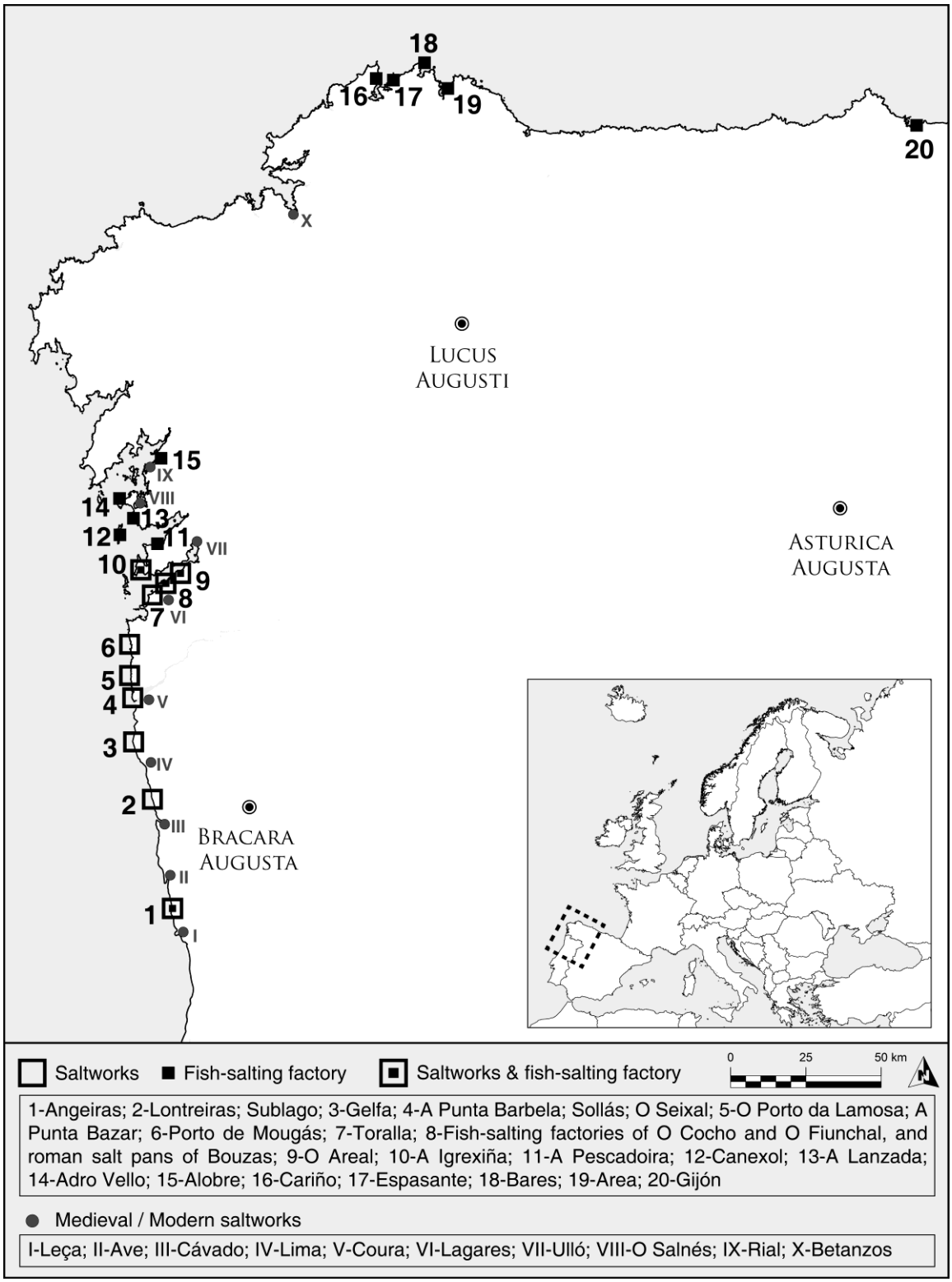

Fig. 1. Main sites mentioned in the text.

13 Unpublished reports deposited at the Dirección Xeral do Patrimonio Cultural, Xunta de Galicia.

The great transformation of the urban center of Vigo during the last 100 years has impeded us to obtain a clear image of the exact position of the salt pans regarding the ancient coast line (fig. 3). Nevertheless, by georeferencing the excavated structures to the 1902 cartography, we have a more precise idea of the position of the saltworks. Though the topography of the terrain has been extremely altered due to the development of the city, thanks to the treatment of LiDAR data we can rebuild the original morphology of the terrain, obtaining a new topography with curve lines every 5 m (fig. 2). Thanks to this, we can see how the saltworks are located in the coastal plain, behind the O Areal beach, placed following the coast line. Future publications must take into account the paleoecological analysis that have been carried out to be able to understand the changes occurred in the coast line and the interaction between marine and continental dynamics between the change of era and the Late Roman period.[14]

The salt pans can be divided in two sectors: the West sector (fig. 4)[15] and the East sector (fig. 5).[16] The evidences of salt pans identified in three surveys located on Rosalía de Castro St.[17] - half way between the two main sectors- proves that the salt factories are actually one large complex located throughout the coast line of O Areal, and would be in direct relation to the salting factories identified on Marqués de Valladars St. and the Plaza de Compostela (fig. 2).

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14 A. Martínez Cortizas and M. Costa Casais, "Indicios de variaciones del nivel del mar en la Ría de Vigo durante los últimos 3000 años," *Gallaecia* 16 (1997) 23-47.

15 A. Acuña Piñeiro, *Proyecto de sondeos y excavación arqueológica del solar nº 3-5 de la calle Colón, Vigo (Pontevedra)* (unpublished; 1995); id., *Ampliación de la excavación arqueológica del solar nº 5 de la calle Hospital, Vigo (Pontevedra)* (unpublished; 1996); S. Prieto Robles, *Excavación arqueológica en área en la parcela nº 13 de la U.E. I-05 Rosalía de Castro 1, Vigo* (unpublished; 1997); E. Rodríguez Saiz, "Sondeos arqueológicos en el solar del nº 14 de la calle Oporto (Vigo) en el ámbito del yacimiento romano de las calles Areal-Pontevedra," *Bol. Inst. Estudios Vigueses* 9 (2003) 185-201; J. C. Castro Carrera, "La salina romana del yacimiento de 'O Areal', Vigo (Galicia)," in Hocquet and Sarrazin (supra n.7) 105-22; J. C. Castro Carrera, "La salina romana del yacimiento de 'O Areal', Vigo (Galicia): un complejo industrial salazonero altoimperial," in Lagóstena, Bernal and Arévalo (supra n.7) 355-65; J. C. Castro Carrera, "La saline romaine de 'O Areal', Vigo (Galice): architecture d'une installation industrielle de production de sel," in O. Weller, A. Dufraisse and P. Pétrequin (edd), *Sel, eau, forêt d'hier à aujourd'hui* (Besançon 2008) 381-99; M. A. Sartal Lorenzo, *Escavación arqueolóxica en aparcamento subterráneo na Rúa Areal. Vigo, Pontevedra* (unpublished; 2011); E. Lima Oliveira and L. Gorgoso López, *Evaluación arqueológica. Construcción aparcamiento subterráneo en la calle Areal. Vigo, Pontevedra* (unpublished; 2014).

16 E. Albadalejo Iglesias, *Avaliación arqueolóxica das parcelas Nº 12 e 14. Unidade de actuación I-06 Rosalía de Castro II. Vigo (Pontevedra)* (unpublished; 2007); M. César Vila, *Excavación arqueológica en área de la parcela 4 de la U.A. I-06 rosalía de Castro 2 de Vigo (Pontevedra). Informe valorativo* (unpublished; 2008); M. César Vila, "Escavación arqueolóxica en área da parcela 4 da Unidade de actuación I-06, Rosalía de Castro nº 2, Vigo," in *Actuacións Arqueolóxicas. Ano 2008* (Santiago de Compostela 2010) 202-3; Mª J. Iglesias Darriba, "Avaliación patrimonial da Unidade de Actuación I-06 Rosalía de Castro 2 (Fase II), Vigo," in *Actuacións Arqueolóxicas. Ano 2006* (Santiago de Compostela 2008a) 154-5; Mª J. Iglesias Darriba, *Evaluación arqueológica de la parcela nº 3 de la Unidad de Actuación I-06, Rosalía de Castro. Vigo (Pontevedra)* (unpublished; 2008b); Mª J. Iglesias Darriba, "Avaliación arqueolóxica das parcelas 6, 10, 6 anexo e 3 anexo, da Unidade de Actuación I-06, Rosalía de Castro II, Vigo," in *Actuacións Arqueolóxicas. Ano 2007*. (Santiago de Compostela 2009) 174-5; Mª J. Iglesias Darriba, "Avaliación arqueolóxica da parcela 3 da Unidade de actuación I-06 de Rosalía de Castro II, Vigo," in *Actuacións Arqueolóxicas. Ano 2008* (Santiago de Compostela 2010) 206-7; Mª P. Fernández Pintos, *Excavación arqueológica en área. Aparcamiento para residentes. Rúa Rosalía de Castro (Vigo)* (Unpublished; 2009); M. A. Sartal Lorenzo, *Escavación arqueolóxica da parcela 15 U. Actuación I-06 Rosalía de Castro II. Vigo (Pontevedra)* (Unpublished; 2009).

17 E. Rodríguez Saiz, "Sondaxes arqueolóxicas para as obras de construción dun aparcadoiro soterrado na rúa Rosalía de Castro, Vigo," in *Actuacións Arqueolóxicas. Ano 2008* (Santiago de Compostela 2010) 190-2.

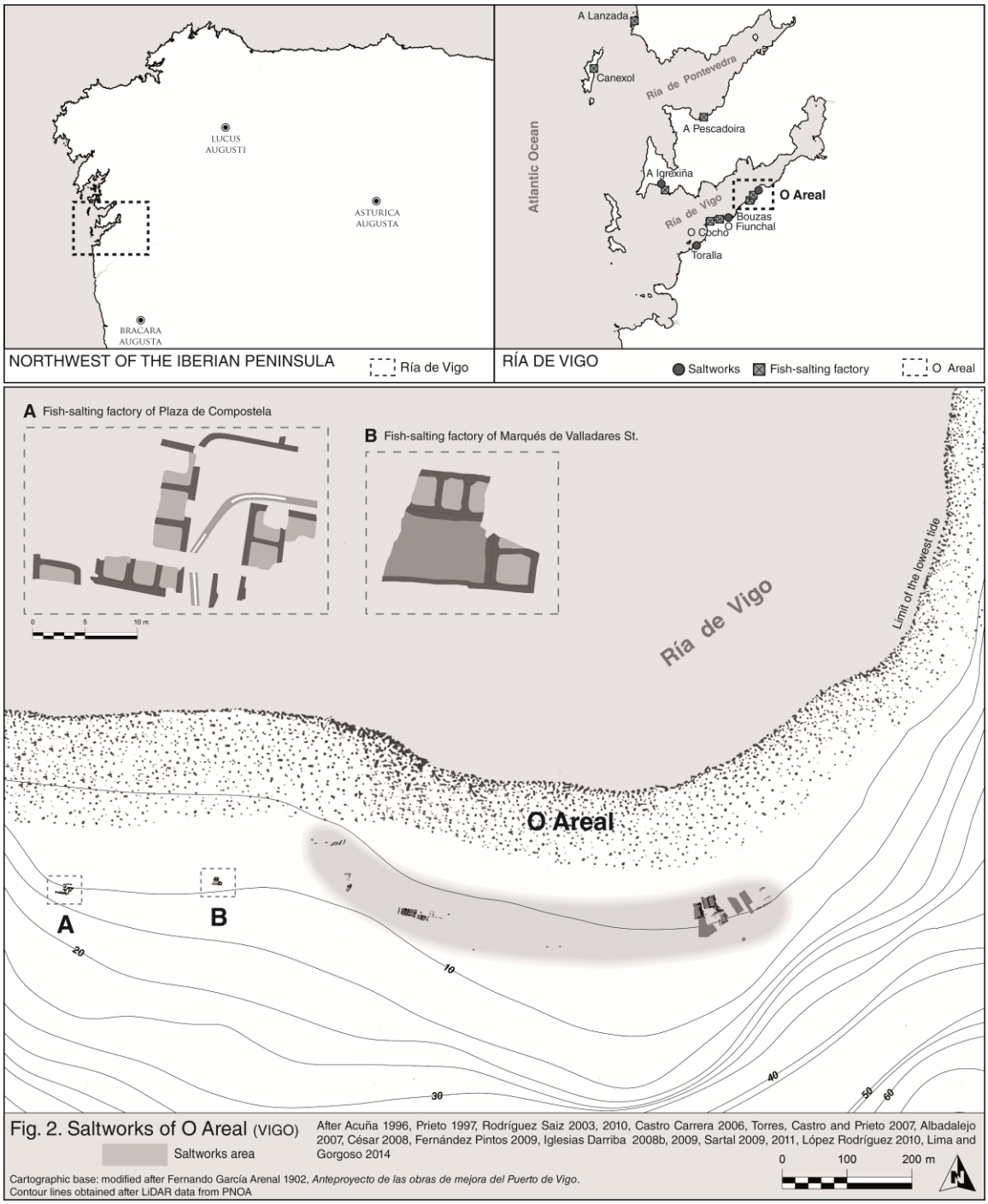

Fig. 2. Saltwork complex of O Areal.

Fig. 3. Saltwork complex of O Areal.

Based in the location of different remains belonging to the salt factories documented through various surveys and excavations we can estimate, with certain caution, that the Roman *salina* would have a total surface of about 8.5 ha (figs. 2-3). To the west, the limit of the saltworks would be almost certainly located at Inés Pérez de Ceta St. The series of excavations carried out between this St. and Pontevedra St.[18] have revealed different structures that correspond with a Roman occupation since the Early Roman Empire to Late Antiquity, where there is no evidence of the saltworks. The surveys carried out in the archaeological intervention due to the construction of a parking lot in Areal St.[19] also seems to support this idea since the remains belonging to the salt factories ends at the limit established by Inés Pérez de Ceta St. The eastern limit is harder to establish since there is a more limited number of archaeological excavations, and we do not have enough information to establish it. Therefore, we must not discard the possibility that the salt ponds continue towards the east. To the south, an inflexion in the terrain,

18 Synthesis of the excavations in F. Pérez Losada, *Entre a cidade e a aldea. Estudio arqueohistórico dos "aglomerados secundarios" romanos en Galicia* (Brigantium 13, A Coruña, 2002) 248 and A. Fernández, *O comercio tardoantigo no noroeste peninsular* (Noia 2013) 26.

19 Lima and Gorgoso 2014 (supra n.15).

and the beginning of a strong slope on García Barbón St. (figs. 2-3) would almost surely make it impossible for the expansion of the salt factory in this direction, and therefore we can consider this St. as the maximum southern limit. The surveys carried out on Rosalía de Castro St. for the construction of a parking lot[20] reveals an area between Inés Pérez de Ceta St. and Porto St. with no evidence of the salt factory. To the north the limit seems pretty clear and is located at the beach line indentified during the archaeological control carried out during the construction of the O Areal tunnel.[21] In this area a beach with a large intertidal zone was documented, used as a berth between the 1st c. B.C. and the change of era, where a large amount of Late-Republican amphoras (Haltern 70, Mañá C2b, Dres. 7-11, Dres. 20, Pascual I, Lamboglia 2) was recovered. In this sector a change in the coast line has been documented after the change of era, where the beach seems to retreat, and a large amount of materials belonging to Late Antiquity dated between the 3rd and 7th c. A.D. begin to appear in the area. The archaeological controls carried out at the building situated at the confluence of Porto and Areal Sts.,[22] where no evidence of the salt factory was identified, allows us to more or less precisely establish the limit of the factory at this point.

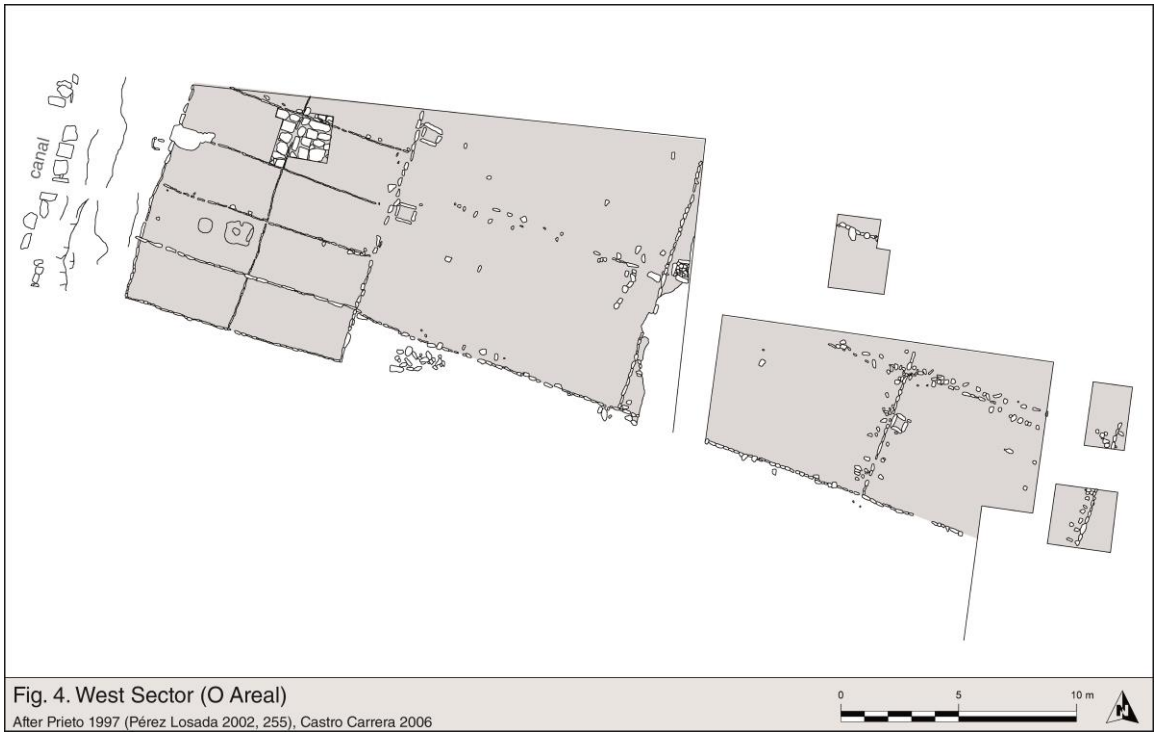

Fig. 4. West sector at O Areal.

The saltworks are composed of a series of evaporation salt ponds made by a pavement of impermeable clay, in occasions compacted with gravel, and delimited with schist and granite slabs. The salt pans have a quadrangular shape and are systematically situated in parallel, perfectly aligned with one another oriented east-west, following the ancient coast line. These constructions have a variable size and morphology: the smallest ones measure *c*.5 x 2.5 m and

20 P. Soto Arias, *Informe de valoración sobre la intervención arqueológica realizada en la Unidad de Ejecución Rosalía de Castro I, Vigo* (Unpublished; 1993).

21 M. Cortegoso Comesaña, "Intervención arqueológica en la prolongación del túnel del Areal en Vigo: un contexto para un ünguentario," *Boletín IEV* 14 (2009), 305-24.

22 J. C. Castro Carrera, *Control arqueolóxico da ampliación do edificio do Rectorado da Universidade de Vigo (Rúa Oporto 1, Vigo)* (Unpublished; 1997).

poses a well constructed pavement made up of a flagstone pavement with a thin layer of clay. They are delimited with short slabs, which do not surpass 10 cm in height (figs. 6-7). This type of salt pan is located exclusively in the western sector of the factory, where 4 or 5 salt-pans have been documented in the plot belonging to 5 Hospital St., and 10 more, 85 m away, at 14 Rosalía de Castro St. (fig. 4).[23] The perfect alignment between both groups leads us to believe that continuity between them would have existed, though it was interrupted by a canal that is located on the western limit of the plot at 14 Rosalía de Castro St.

Fig. 5. East sector at O Areal.

The second type of salt pans is characterized by its larger size and height of its delimiting slabs. In the western sector a series of tanks with the dimensions of 10 x 5 m, limited with slabs with a height that varies from 15 to 25 cm, were documented. At 13 and 14 of Rosalía de Castro St. 6 salt pans belonging to this type were identified (fig. 4), and have a clear continuity towards Porto St.[24] The eastern side is more altered and it is hard to precise the characteristics of the salt

23 Castro Carrera 2007 (supra n.15).

24 Rodríguez Saiz 2003 (supra n.15).

pans, but there is clear evidence of their existence. We can only partially reconstruct some of the salt pans identified,[25] which would have a square shape and approximately 8 m at each side, and the limiting slabs would be approximately between 20 and 30 high. Up to 12 salt pans have been identified, though its original number would have been higher (fig. 5). At the southern limit of the eastern sector an incomplete salt pan was excavated, but due to its size, it would most probably belong to the previous ensemble, though it presents a slightly different orientation than the rest of the complex.[26]

Fig. 6. Crystallization pans at the West sector of O Areal (Photography by Castro Carrera 2006).

Fig. 7. Crystallization pans (West sector of O Areal) at the *Salinae* museum (Vigo).

25 César 2008 and 2010 (both supra n.16).

26 Iglesias Darriba 2010 (supra n.16).

The third type of salt pan has only been identified in the eastern sector where larger tanks have been documented (fig. 5).[27] Two whole tanks have been preserved with the dimensions of 15 x 8 m, and a third was partially excavated, but seems to maintain the same dimensions. To the west, separated from the previous ones by a canal, an even larger tank appears, 20 m long and an unknown width that would have at least reached 10 m. Here, the remains of a linear structure formed by a series of slabs could be the remnants of a poorly preserved internal compartmentalization. All the large tanks are delimited with slabs of *c.*80 cm tall that rest upon a small earth wall that acts as reinforcement as well as a passing area. To the south of the largest salt pan, another three were identified, aligned with the larger one, with a length of 12 m and a partially preserved width that would have surpassed 10 m. These pans are also delimited with a small earth wall closed by stone slabs, in this case 60-70 cm tall.

One of the most relevant elements of the Roman salt factory of O Areal is its precise chronological identification. The salt factory was established throughout the 1st c. A.D. and was abandoned during the 3rd-4th c. A.D.

The salt factory was built upon a Late-republican beach level, which defines a clear *terminus post quem*. This has been documented at no. 5 Hospital St. where, under the salt factory, Late-Republican amphorae (Mañá C2b, Haltern 70, Dressel 1, and 2-4) and Italic TS[28] were recovered. At the parking lot at Areal St., under the salt pans a level with Lamboglia 4 and Mañá C2b amphorae was also identified.[29] On Porto St., the salt pans were built upon a level with Haltern 70 amphorae and a significant fragment of Italic TS conspectus 20.4.3. that would narrow the chronology and date the salt factory to mid 1st c. A.D.[30]

For the abandonment of the saltworks of O Areal we can take a *terminus ante quem* situated around the 3rd-4th c. A.D. On top of the level of abandonment a series of clear evidence of Late Antiquity occupation has been identified, which continued until the 5th-7th c. A.D. A series of constructions were built directly on top of the salt works, and a large burial necropolis appears in the whole area.[31]

Signs and evidences of Roman sea water saltworks in the northwest of the peninsula

Throughout the Ría de Vigo and the Atlantic coast line between Galicia and Portugal many evidences of sea salt factories typologically analog to those of O Areal have been located (fig. 1). In some cases they have been ascribed to Roman times, though in most occasions there are not enough elements to establish a strong date for the use.

The archaeological excavation within a house in Bouzas (Vigo) documented the remains of a paved saltwork with stone slabs that separated each pan (fig. 1, no. 8).[32] Covering the saltworks there is a subsequent occupation, dated, with no more precision, to the Roman period. The saltwork is located 800 m away from the Roman fish-salting factory of O Fiunchal[33] and 1400 m away for the factory of O Cocho.[34]

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27 Iglesias Darriba 2008a, 2008b and 2009 (all supra n.16).

28 Acuña 1995 and 1996 (supra n.15).

29 Lima and Gorgoso 2014 (supra n.15).

30 Fernández 2013, 40 (supra n.18).

31 Acuña, 1995 and 1996 (supra n.15); Prieto 1997 (supra n.15); Rodríguez Saiz, 2003 (supra n.15); Castro Carrera 2007 (supra n.15); César 2008 and 2010 (supra n.16); Iglesias Darriba 2008a, 2008b, 2009 and 2010 (all supra n.16); Sartal 2009 (supra n.16) and 2011 (supra n.15); Fernández 2013 (supra n.18).

32 F. J. Chao Álvarez, *Escavación arqueolóxica en área para as obras de rehabilitación dunha vivenda unifamiliar en Bouzas: paseo Valentín Paz Andrade nº 14; rúa Sebastián Elcano nº 7. Vigo, Pontevedra* (Unpublished; 2015).

33 J. C. Castro Carrera, "Intervención arqueolóxica no xacemento romano de 'O Fiunchal'. (Alcabre, Vigo)," *Castrelos* 5-6 (1992-1993) 71-86.

34 J. M. Hidalgo Cuñarro, "Últimas excavaciones arqueológicas de urgencia en Vigo: castros y yacimientos romanos," *Castrelos* 3-4 (1990-1991), 191-215; J. M. Hidalgo Cuñarro and E. Rodríguez Puentes, "Escavación

Just outside the roman *villa* of Toralla (Vigo), dated form the early 4th to the 6th c. A.D., a clay pavement delimited by stone slabs belonging to a saltwork was discovered (fig. 1, no. 7).[35] No associated material was identified nor any stratigraphic relation with the *villa* –only 5 m away- was documented, so the exact chronology is unknown.

On the Nerga beach (Cangas do Morrazo), next to As Forcadas creek, only a few meters away from the Roman salting factory of A Igrexiña,[36] a cobblestone pavement with a clay base, divided by schist slabs was located (fig. 1, no. 10). In the central area, between the salt pans the slabs form a small canal.[37] In the 17th c. a document refers to the concession of a license of some saltworks to be built in the Ría de Vigo[38] where various places are mentioned, the area of Nerga among them. This could lead us to believe that this saltwork has a more modern chronology, but what the document is actually saying is that it gives land for the construction of these structures, but does not indicate that they were ever built. Among the places mentioned in this text, the only saltworks built were the ones of Lagares River, in Coruxo, on the other side of the bay, which worked throughout the 18th c. (fig. 1, no. VI).[39]

On the coastal strip between the cape of Silleiro and the estuary of the Douro River a series of saltwork pavements formed by slabs and cobblestones upon clay floors have been documented, forming pans delimited by granite and schist slabs. These pavements are probably the base of a more compacted and leveled clay pavement, as happens in the case O Areal, but have been affected by marine erosive actions after it was abandoned. We must take into account that a pavement formed of cobblestones would greatly difficult the collection of salt, which must be done in perfectly level surfaces.

Unlike O Areal, Nerga, Bouzas and Toralla, located in the Ría de Vigo, these saltworks are located on the open Atlantic coast. Advancing from North to South, the first saltworks are located in Porto de Mougás (Oia), next the Peito River mouth (fig 1, no. 6).[40] Some 13 km South, in A Guarda, another two are documented in A Punta Bazar and, 800 m away in O Porto da Lamosa (fig. 1 no. 5).[41] Five more km South we reach the saltworks of O Seixal, followed by those of Sollás, 500 m away, and Punta Barbeita, 600 m from the previous (fig. 1, no. 4).[42] After crossing the Miño River, 7 km south of its mouth we can find the saltworks of Gelfa (Caminha) (fig. 1, no. 3).[43] 21 km past the Limia river, in Esposende, we can find the saltworks of Foz do Neiva, and 3 km further those of Sublago and Lontreiras (fig. 1 no. 2).[44] Finally 37 km to the South, in Angeiras (Matosinhos), we find the last documented saltworks (fig. 1, no. 1).[45]

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arqueolóxica de urxencia na Praia do Cocho, Alcabre (Vigo, Pontevedra)", in *Arqueoloxía/Informes, 3. Campaña, 1989* (Santiago de Compostela 1995) 165-8.

35 F. Pérez Losada, S. Vieito Covela and A. Fernández, "Resultados preliminares das escavacións arqueolóxicas na villa romana de Toralla (Oia, Vigo)," *Castrelos* 13 (2007) 22.

36 A. Acuña Piñeiro, *Sondeos, protección y catalogación del yacimiento de A Igrexiña, Cangas (Pontevedra)* (Unpublished; 1999).

37 Information in the Heritage file cards of the Provincial Museum of Pontevedra recorded by A. de la Peña Santos.

38 J. Mª Álvarez Blázquez, *La Ciudad y los Días. Calendario histórico de Vigo* (Vigo 1960).

39 F. J. Costas Goberna and J. M. Hidalgo Cuñarro, *Las salinas de Vigo. Aproximación al estudio de las salinas de la desembocadura de ría Lagares (Vigo)* (Vigo 1999).

40 F. J. Costas Goberna and M. Expósito Álvarez, *Los faros de Cabo Silleiro. Luces del Sur de la ría de Vigo* (Vigo 2004) 76.

41 A. Ferreira Lorenzo and A. Español Gil, "El enlosado y las piletas de la costa de A Guarda," *Boletín da Agrupación Cultural Guardesa* (1984).

42 Ibid.

43 F. Sande Lemos, "O Sítio Arqueológico de Gelfa. Notícia Preliminar," *Cadernos de Arqueología* 2 (1982), 29.

44 C. A. Brochado de Almeida, "Salinas medievais entre o Cávado e o Neiva," *Bracara Augusta* 33 (1979) 391-402; id., "A exploração do sal na costa portugeusa a Norte do Rio Ave. Da antiguidade clásica à Baixa Idade Média," in I. Amorim (ed.), *I Seminário Internacional sobre o sal português* (Porto 2005) 158 and 162.

45 F. A. Silva and I. Figueiral, "Excavações arqueológicas em Lavra: as salinas romano-medievais de Angeiras," *Boletim da Biblioteca Municipal de Matosinhos* 30 (1986) 165-81.

Most of these saltworks have been identified and located when the force of the ocean and the change of the coast line have revealed the pavements, reason why not always have we been able to document them from an archaeological point of view. Archaeological interventions have only been carried out at the saltworks of Angeiras,[46] Gelfa,[47] O Seixal[48] and Lontreiras,[49] but in no case has it been possible to obtain an exact date, even an approximate one. The clear typological similarities with the saltworks of O Areal suggests, *a priori*, a roman chronology. The direct relation between roman fish-salting factories and saltworks in the cases of A Igrexiña in Nerga and Angeiras also point in this direction. Nonetheless, in none of these cases we have stratigraphic evidence that allows us to establish a reliable date.

At the saltworks of O Seixal (A Guarda), an archaeological survey of 44 m^2 following the coast line revealed a pavement with large cobblestones and slabs, compartmented by means of vertical slabs (fig. 8).[50] A second survey carried out 30 m inland revealed the continuity of the saltworks. A double wall forming a canal about 20 cm wide was documented, similar to those documented at Nerga, and could be related to water circulation within the saltwork. Another possible interpretation for this structure is that the slabs were use to affix an unpreserved ground wall. From a chronological point of view, some fragments of probable Roman common ware were recovered, located on top of the saltwork pavement floor, though this cannot lead to a definitive chronological adscription.

Fig. 8. Saltworks of O Seixal (Photography by Mar Cortegoso).

46 Ibid.; J. Cleto, "A indústria de conserva de Peixe no Portugal Romano. O caso de Angeiras (Lavra, Matosinhos)," *Matesinus* 112 (1995-1996) 23-45; R. Teixeira and V. Fonseca, *Intervenção Arqueológica. Requalificação da Orla Costeira de Matosinhos* (Unpublished; 2011).

47 Lemos 1982 (supra n.43).

48 M. Cortegoso Comesaña, *Escavación arqueolóxica en área e sondaxes no xacemento de O Seixal- Fonte Quente GA36023043 (A Guarda, Pontevedra)* (Unpublished; 2015).

49 Almeida 1979 (supra n.44).

50 Cortegoso 2015 (supra n.48).

At Lontreiras (Esposende) a 15 x 3.5 salt pond was documented, delimited by schist slabs fixed together with mud, and seemed to continue towards other ponds, at least to its East and West.[51] Its pavement is formed by a 10 cm layer of compacted clay followed by another 10 cm clay level with small cobblestones and shells. In the near surroundings the remains of other dismantled structures due to water erosion caused by tidal force have also been documented, only leaving the remains of some delimitation slabs scattered throughout the beach.

At the Angeiras beach (Matosinhos) a 10 x 6 m partially preserved saltwork pavement was identified, formed by small cobblestones, delimited by both slabs and larger stones (fig. 9).[52] The walls that delimit the saltwork are fitted with small cobblestones that give the wall both better consistence, as well as a rounded rim that facilitates the gathering of salt. Throughout the beach, and directly related to the saltworks there are some tanks excavated directly into the rock[53] and have been interpreted as basins for fish salting during the Roman period (also see n.106), though we must take into account that there is no material or stratigraphic evidence that allows us to pinpoint its chronology.[54] Despite having a partial knowledge of the site, we can consider this a large industrial complex formed by saltworks and salting basins, associated to a clear Roman occupation that can be observed throughout the whole coast line.[55]

The existence of medieval documents that refer to the existence of saltworks throughout the Northwestern coastline of the Iberian Peninsula could lead to a debate regarding the chronological adscription of some of the archaeological structures documented throughout the Atlantic coast. Nevertheless, if we compare the location of Medieval saltworks according to the documentation, with the location of saltworks that have been documented archaeologically, we can cast aside this hypothesis.

In Portugal, South of the Miño River, medieval documentations reveal the existence of saltworks at the estuary of the Leça River since the 11th c. (fig. 1, no. I);[56] at the mouth of the Ave River, between the 10th – 12th c. (fig. 1, no. II); at the estuary of the Cávado River since the 10th c. (fig. 1, no. III); at the estuary of the Limia river during the 11th c. (fig. 1, no. IV);[57] and at the estuary of the Miño River where the Coura River converges, since the 11th c. (fig. 1, no. V).[58] To the north of the Miño, in the Ría de Vigo, we have knowledge of modern saltworks (18th c.) at the marshes of the Lagares River (fig. 1, no. VI)[59] and the marshes of the Ulló River (fig. 1, no. VII),[60] both well preserved and visible in the terrain and with aerial photography. In the region of O Salnés, which is referred to as *Territorium Saliniense* in the *Parrochiale suevum* of the 6th c. A.D., documents from the 9th – 10th c. mention a series of saltworks located within the marshlands (fig. 1, no. VIII).[61] Further north, the documents from the Sobrado monastery also

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51 Almeida 1979 (supra n.44).

52 Silva and Figueiral 1986 (supra n.45); Teixeira and Fonseca 2011 (supra n.46).

53 Up to 32 basins distributed throughout 700 m of the Angeiras beach, concentrated in 5 nucleus, the largest of which has 17. At the Agudela beach, 2 km south, two more basins have appeared, giving us the impression of a large complex. They have a quadrangular and rectangular tendency, and their dimensions, though irregular and variable, have an approximate mean value of 1x1m, and a depth of 50cm-1m. Four of these basins are just a few meters away from the salt pans.

54 Cleto 1995-96 (supra n.46).

55 F. Lanhas and D. Brandão, "Inventário de objectos e lugares com interesse arqueológico," *Revista de etnografía* 12 (1969) 304.

56 P. Costa and J. Cleto, "O sal do esquecimento. Salinas e comercializaç*ão* de salgados na foz do rio Leça," in *A articulação do sal portugués aos circuitos mundiais. Antigos e novos consumos* (Porto 2008) 68.

57 Almeida 2005 (supra n.44) 155-58.

58 Ibid. 159, S. Pinto, "O rio Minho nas rotas do sal: o abastecimento da Galiza na segunda metade do s. XVI," in *A articulação do sal portugués aos circuitos mundiais. Antigos e novos consumos* (Porto 2008) 85.

59 Costas and Hidalgo 1999 (supra n.39).

60 F. Calo Lourido, "Notas para o estudio do sal en Galicia. Peripecias dunhas salinas," *Portugalia* 17-18 (1996-1997) 211-7.

61 E. Ferreira Priegue, *Galicia en el comercio marítimo medieval* (A Coruña 1988) 157.

refer to the 12th c. site of Salinas, in the Betanzos River, where even now one can observe a series of structures dedicated to salt production.[62]

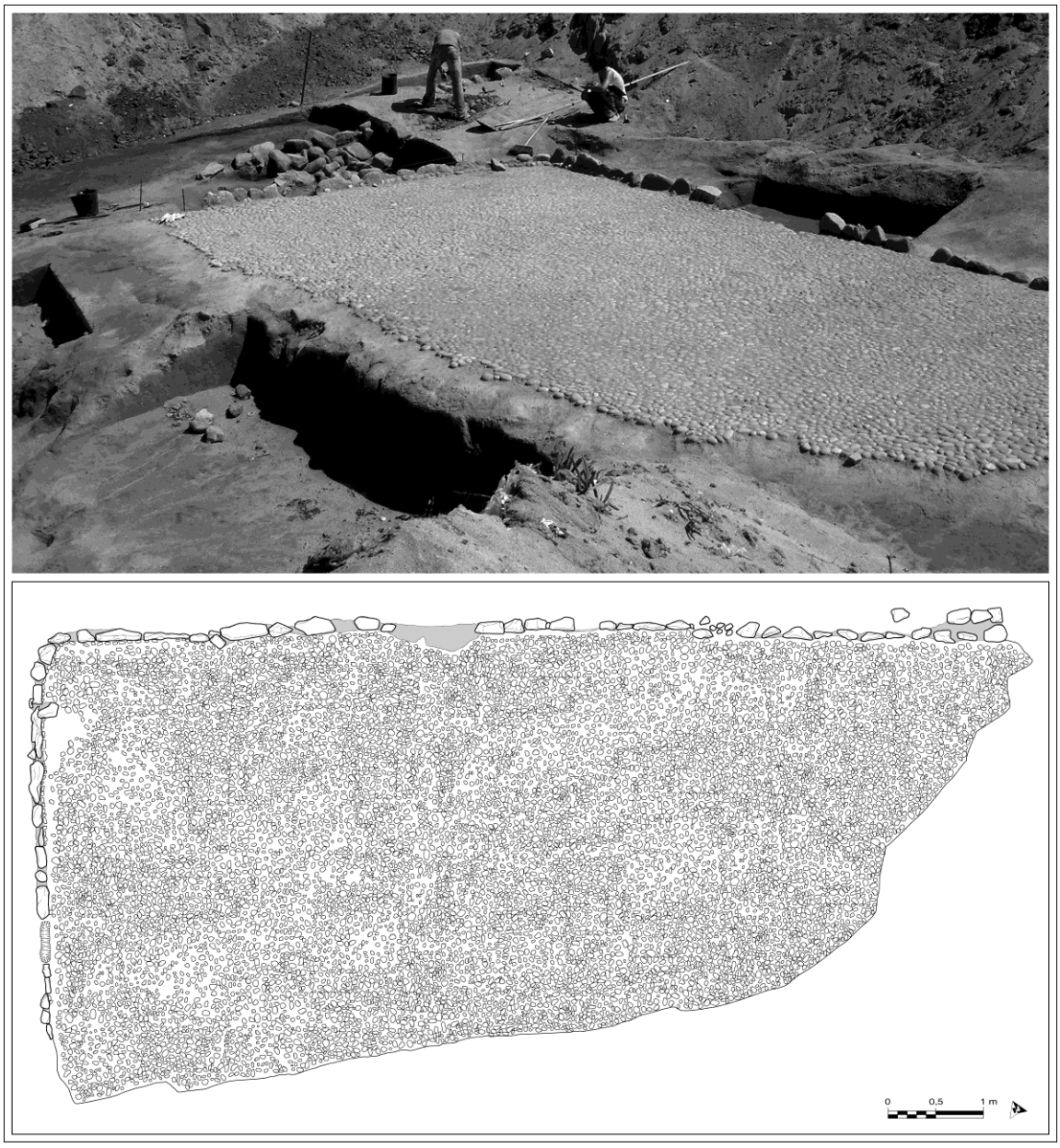

Fig. 9. Saltworks of Angeiras (After Teixeira and Fonseca 2011).

When evaluating the hypothesis that saltwork pavements located throughout the Atlantic coast line could have a medieval origin, first of all we must highlight that none of the archaeological structures are located at or near places referred to in medieval documents.[63] On the other hand,

62 Mª C. Pallares Méndez, *El monasterio de Sobrado: un ejemplo del protagonismo monástico en la Galicia medieval* (A Coruña 1979) 181 fig. 1, no. X.

63 The only exception is the case of Belinho, where the saltworks of Lontreiras and Sublago are located, where medieval documents state that part of the levy to the crown had to be paid with salt Almeida 2005 (supra n.44) 157. This fact could indirectly indicate the existence of medieval salt production in the area, though it is true that

another aspect we must consider is that in the medieval documents of the 12th-13th c. from the Monastery of Oia,[64] near the coast and linked to the sea, whose domain reaches the coastal line where the aforementioned saltworks appear, there is no reference whatsoever of the existence of saltworks at the time.

A second fact to take into account is that there is no consistency in the emplacement of the saltworks in mediaeval times regarding the saltwork pavements referred to in this paper. All the saltworks documented in medieval texts are located in marshlands, in protected estuaries. This type of location is radically different from the points where the possible Roman salt ponds we have studied are located, always upon beaches and near the open coast line of the Atlantic Ocean.

The production of sea salt in Antiquity: the function of the saltworks of O Areal

The excellent conservation and large extension of the saltworks of O Areal allows us to create a precise image of how a Roman *salina* would have worked. By means of compared analysis of the archaeological record with modern saltworks, and considering the ancient written sources we can reach an understanding of how marine salt was produced in Antiquity. Up until now, the archaeological work has been exclusively carried out through urgency excavation consequence of the urban development of the city. This necessarily leads to a fragmented information since the location of the digs are based on urban development criteria rather than archaeological. Despite this fact, thanks to the synthesis of the archaeological excavations carried out in O Areal we have a sufficient enough image for carrying out the analysis of how these roman saltwork functioned.

In any study regarding ancient marine saltworks the obliged starting point are the texts from *Rutilius Namatianus* and *Manilius*.[65] Though, in both cases they are poetic texts, they offer detailed information of how saltworks worked. Pliny (NH 31.73-105) also presents an exhaustive study on salt, although unfortunately it does not provide a specific description of the process of obtaining sea salt. Nevertheless, it should be noted that all the literary references to sea salt production in Antiquity are referred to the Mediterranean, where tidal range, salinity and climatic conditions are completely different from the Atlantic saltworks.

The poet *Rutilius Namatianus* (*De Red.* I, 475-488) left us, no doubt, the most complete and precise description of ancient saltworks. In his text he refers to the saltworks located in Vada, on the Tuscan coast:

> Subiectas villae vacat aspectare salinas; namque hoc censetur nomine salsa palus, qua mare terrenis decliue canalibus intrat multifidosque lacus parvula fossa rigat. Ast ubi flagrantes admonuit Sirius ignes, cum pallent herbae, cum sitit omnis ager, tum cataractarum claustris excluditur aequor, ut fixos latices torrida duret humus. Concipiunt acrem nativa coagula Phoebum et gravis aestivo crusta calore coit, haud aliter quam cum glacie riget horridus Hister grandiaque adstricto flumine plaustra vehit.

According to his description, the water entered the saltworks situated at a salt marsh (*salsa palus*) through a series of gradient canals, and then distributed by a small trench (*parvula fossa*) towards a series of ponds (*multifidosque lacus*). During the summer, when "Sirius has advanced his blazing fires, when grass turns pale, when all the land is athirst", then the sea water access was cut-off by a series of barrier-sluices (*cataractarum claustris excluditur aequor*). Finally the water "hardens" and becomes salt.

Manilius´ text (*Astr.* 5.682-92) also has a great value when trying to understand marine salt production:

> quin etiam magnas poterunt celebrare salinas et pontum coquere et ponti secernere virus, cum solidum certo distendunt margine campum adpelluntque suo deductum ex aequore fluctum claudendoque negant; tum demum suscipit unda aëra et epoto per solem umore nitescit. congeritur siccum pelagus messisque profundi

there is no specific mention to saltworks in this place. The saltworks that are specifically referred to in the medieval documents are located at the estuary of the Cávado river, about 10 km south and the Limia river, 10 km north fig. 1, nºIII and 4.

64 E. Portela, *El dominio del monasterio de Oya (siglos XII a XIII)* (Unpublished Master Dissertation; 1970).

65 C. Carusi, "Le sel chez les auteurs grecs et latins," in Weller, Dufraisse and Pétrequin (supra n.15) 353-64.

> canities semota maris; spumaeque rigentis ingentes faciunt tumulos, pelagique venenum, quo perit usus aquae suco corruptus amaro, vitali sale permutant redduntque salubre.

In this fragment the poet and astronomer tells us that evaporation *salinae* are built by enclosing a large and flat plain. Then water is conducted towards it from the sea and is regulated by a system of sluices.

These passages, from the 1st c. A.D. in the case of *Manilius* and the 5th in that of *Rutilius*, present the general elements that characterize marine salt production in Antiquity. We can see that there is a controlled flow of sea water to the saltworks by means of canals and sluice systems. Furthermore, the saltworks would be divided in multiple salt pans, where water is distributed by a ditch. Although with 400 years in between both texts, descriptions are very similar, reveling that the fundamentals of sea salt production remained mainly constant.

One of the most interesting aspects that can be derived from the texts is that the saltworks required and occupied a large extension of terrain. *Rutilius* speaks of a "multitude of ponds" and *Manilius* states that the saltworks are located on a "large plain". This image reinforces the description given in Collumella (II,2) describing the saltworks as "salt fields" (*campi salinarum*). As we have been able to document in the case of O Areal, as well as can be suspected in the case of the saltwork of the Tiber River,[66] the salt pans are not isolated, but belong to large production complexes.

Rutilius´ definition of saltworks as salt marshes (*salsa palus*) (*cfr.* Col. *R.R.*, X, 135) leads us to reflect on the location of the saltworks of O Areal. The Roman saltworks of the Tiber,[67] the one in Antibes,[68] as well as the possible saltworks of Cadiz[69] seem to be related to ancient marsh lands. Modern marine saltworks, whether it be the *marais salants* in Brittany, the saltworks of Aveiro (Portugal), the ones near Cádiz, those in the Adriatic or in the delta of the Nile River, are located in sea flooded marsh-lands. Contrary to this, the stratigraphy of the excavations of O Areal indicates that the saltworks were placed upon a beach marked by the interaction of marine and continental environments. It does not seem that there was a constant flooded area during the use of these saltworks. The inter-tidal character of the emplacement seems to be more adequate for filling the salt ponds with sea water by tidal force. The publication of the different edaphological analysis carried out in the saltworks would allow us to precisely comprehend the landscape where the saltwork was build during the 1st c. A.D.

Construction and maintenance of the saltworks

The construction of marine saltworks must have required an important transformation of the terrain. *Manilius* tells us that the saltworks were built upon firm and flat terrains, which would imply the need for leveling the terrain and consolidate the surface where the salt-pans would be located. In the different excavations carried out at O Areal we can effectively observe that the salt pans were built upon a beach that was leveled. The whole area must have been subject of a large construction project implicating the preparation, turning over and leveling of the terrain. But this process was also subject to the conditions of the terrain. In some places –especially in the western sector- it seems that the salt-pans were adapted to the form of the beach. The ponds were placed at different levels following the slope of the terrain of what could have been an ancient dune that was transformed by the preparation of the topography for the construction of the saltworks.[70]

All this work must have supposed a large task that, surely, required the mobilization of a large working force. To the processes required for the construction of the saltworks we must also add its necessary periodic maintenance. A passage of *Cassiodorus´* work from the 6th c. A.D. (*Var.*

66 Grossi *et al.* 2015 (supra n.2).
67 Ibid.
68 Daveau and Sivan 2010 (supra n.5).
69 Alonso, Gracia and Ménanteau 2003 (supra n.7).
70 Rodríguez Saiz 2003 (supra n.15) 189; Castro Carrera 2007 (supra n.15).

12.24.6), generally forgotten in studies about ancient salt production, reveals very valuable information regarding labor at the saltworks:

> In salinis autem exercendis tota contentio est: pro aratris, pro falcibus cylindros volvitis: inde vobis fructus omnis enascitur, quando in ipsis et quae non facitis possidetis. Moneta illic quodammodo percutitur victualis. Arti vestrae omnis fluctus addictus est. Potest aurum aliquis minus quaerere, nemo est qui salem non desideret invenire, merito, quando isti debet omnis cibus quod potest esse gratissimus

Cassiodorus indicates that at the Venetian coasts local population could not carry out agricultural work –"neither the sickle nor the plough"- since all the work force was dedicated to the saltworks, which conformed their main way of life. Though this completely sector-based economic reality it's hard to assume for the ancient world and probably it's just a literary exaggeration, this gives us an idea of the importance of the mobilization of a large working force for the maintenance of the saltworks

Cassiodorus´ mention of a series of rollers (*cylindros*) is especially interesting, having been used for the leveling and preparation of the pavements of the salt-pans.[71] Similar instruments have been documented in modern saltworks. At Aveiro, a series of wooden rollers that were 1 m long and 50 cm in diameter ("círcios"), were used for leveling, compacting and waterproofing the pavement.[72] At the saltworks of Piran (Slovenia) stone rollers ("rodolos") are also used.[73] At the Vigo saltworks, seasonal works were probably carried out for the maintenance of the pavements of the salt-pans and could be related to the use of these rollers. We must take into account that the continuous use of the salt-pans would end up wearing and damaging the pavement, which necessarily required periodic reparations. To this sense, the presence of a series of overlapped pavements has been documented. Under one of the pavements the impressions of the slabs that would have acted as the limiting wall of a previous pavement was documented,[74] which seems to evidence the existence of remodeling and changes in the structure of the saltworks.

Access to water for saltworkings

The saltwork of O Areal is located at the coast line of what, at the beginning of the 20th c., was a large beach. It seems that water would have entered the salt-pans naturally by tidal force (Plin. *NH* 31.81; Manilius *Astr.* 5.685; Rut. Namat *De Red.* 1.475). The tidal range (height difference between the high tide and the low tide) in the Ría de Vigo is fairly large: 3-4 m; much large than in the Mediterranean (less than 1 m). This allows an easy access of water towards the interior of the saltworks with the tides. On the northern side of the Eastern sector (fig. 5), a series of wooden structures could have worked for giving water access to the two main ponds located further north. In the largest deposit, located next to the aforementioned, an opening can be seen in the limiting wall which would allow water flow. Then, by means of a series of sluices water would be retained within the salt-pan. The structures used for the regulation of water flow recorded in the ancient texts have not been clearly documented in the saltworks of O Areal. A direct parallel where they have been identified are at the saltworks of the Tiber,[75] contemporary to the *salinae* of O Areal. Here, we find two canals closed by walls that allowed the entrance of water towards the saltworks. The mouth of the canals had the shapes of funnels, favoring water flow during high tides, and the access of water was regulated by a sluice system. At Kaunos were identified 4 canals for the conduction and distribution of water to the interior of the *salina*, which

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71 Some authors have related the *cylindros* mentioned by *Cassiodorus* with the mechanisms used for moving water towards the saltworks like the *tympani* described by *Vitruvius* (10.4.2) Carusi 2008 (supra n.1) 145; Moinier and Weller 2014 (supra n.1) 55. We cannot dismiss the use of this kind of devices at the ancient saltworks of the Venetian coasts. However, the identification of the *Cassiodorus cylindros* with the *tympani* is not clear and it is only based on its common cylindrical shape. The use of *cylindros* as stone rollers for leveling the terrain seems to be a more adequate translation *cfr.* Cato *R. R.* 129; Vitr. 10.2.12; Verg. *G.* I. 178; Plin. *NH.* 19.46.

72 D. Dias, *Glossário. Desinações relacioandas com as marinhas de sal da ria de Aveiro* (Aveiro 1996) 37.

73 Z. Žagar, *Muzej solinarstva* (Piran 1992) 57.

74 Sartal 2009 (supra n.16).

75 Grossi *et al.* 2015 (supra n.2) 94.

mouth was closed with a system identified as the *cataracta* mentioned by *Rutilius Namatianus* (*De Red.* I, 480)[76].

Since archaeological interventions at the saltwork of O Areal has not been continued to the North, we have not been able to check for the existence of a dike that would close-off the saltworks area and regulate water flow, or on the contrary if sea water would reach every salt-pan directly during high tides by means of canals. Dikes with this function have been clearly documented at the Tiber saltworks[77], where we find a large dam, 1 km long, built with 1439 amphorae (Dres. 6a, 6b and 20) that closed the access to the lagoon. Also some evidences seems to lead to its existence in Cadiz[78] and Antibes.[79]

The way water is distributed within the saltwork is not completely clear. *Rutilius* mentions a series of canals that were used for distributing water to the different salt pans. The word *fossa*, which can be translated as ditch or trench, gives us the idea that they would have been excavated in the ground. The form of the distribution canals documented at the saltworks of the right margin of the Tiber[80] adapt well to this description. Here, a complex system of canals has been documented within the *salina* that led water to the different square shaped plots (of 102-150 m x 202-300 m), within which salt pans were presumably located. At the saltworks of O Areal we find two canals with a N-S orientation, perfectly perpendicular to the coast line, that could have been used for distributing water towards the inner part of the complex, the same as the *fossae* mentioned by *Rutilius*. One of these canals is located in the western sector, on the western side of the plot (figs. 4-6).[81] Here 10 m of canal were excavated, delimited in its whole length with a series of slabs that measured more than 1m tall. The second canal, build with large stone slabs and wooden posts, crosses the whole Eastern sector north to south (fig. 5).[82] The possible existence of a third canal was located during the excavations at Porto St., where delimitation slabs of over 1 m were situated in a small survey of 2.5 x 1 m.[83] In this case the canal seems to have a NW-SE orientation, parallel to the saltworks.

The identification of these canals as a distribution system leads to a series of problems. The canal of the western sector is situated more than 1 m below the pavement of the salt pans, therefore making it impossible to carry water to them (though it would have worked for a hypothetic structure located further away, inland). Regarding the canal of the Eastern sector, the main problem is that the structure apparently lacks water exits that go from the canal towards the salt pans allowing water circulation. This canal only seems to connect with the larger pans located nearest to the coast line, but not with the smaller ones located further away. Therefore, its function as distribution canals would only be effective in its initial sector, next to the tidal line, making it easier for sea water to enter.

Understood at its whole, these canals, more than being used for salt water distribution throughout the saltworks, might have been functioned as exits for continental fluvial waters. The original path of ancient rivers and creeks leading to the sea could have been re-conducted by means of these canals that would cross the saltworks. Its function would be indispensable since they would control the streams that come down the surrounding hills during rain periods.

Water circulation

The way water circulated within the *salina* between different ponds leads to a series of questions. In modern saltworks, water flows from one compartment to another by action of

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76 Atik 2008 (supra n.3) 41.
77 Grossi *et al.* 2015 (supra n.2).
78 Alonso, Gracia and Ménanteau 2003 (supra n.7).
79 Daveau and Sivan 2010 (supra n.5).
80 Grossi *et al.* 2015 (supra n.2).
81 Castro Carrera 2006 (supra n.15).
82 Iglesias Darriba 2010 (supra n.16).
83 Rodríguez Saiz 2003 (supra n.15) 190.

gravity. This occurs in the Atlantic saltworks of Aveiro[84] or in Cádiz.[85] *Rutilius´* reference (*De Red.* 1.477) to the existence of gradient canals (*declive canalibus)* leads us to think that Roman *salinae* would work in a similar way. The problem is that in the case of O Areal we have not been able to identify any evidence of a system that would allow water to circulate among different salt pans.

The first thing that draws our attention regarding the different compartments is the fact that they are completely hermetic from one another (with the only exception of the water entrance in the largest salt pans, thought only for direct access of sea water during high tides). Furthermore, there are no canals that would allow water circulation between the different phases of salt concentration. The same characteristic has been detected at Kaunos[86] where there is not a connection neither between the individual circular salt pans, nor with de distribution canal. The second problem is that we can observe the construction of the salt pans at different levels that would not allow natural water circulation by gravity. Crystallization ponds located on the western extreme of the Western sector are 35 cm above the other two tanks situated to the East (figs., 4, 6 and 7); between these, and the following four tanks there is a difference of 25 cm; continuing East, these seems to be another step in the terrain regarding the pans documented at the plot at Porto St. of another 20 cm.[87] At the eastern sector, there is a gap of more than 50 cm between the large ponds situated at the north part of the sector and the contiguous smaller tanks of the south. What would seem logical is that the height of each pond begins to descend from the coast line towards the interior (N-S). Furthermore, theoretically, the position of the tanks would allow water circulation by gravity from the larger tanks towards the smaller ones. However what happens seems to be just the opposite.[88]

A possible solution to the problem of water circulation within the saltwork of O Areal is the use of mechanic systems for elevation and transportation of water. *Vitruvius* (10.4.2), in his chapter regarding different devices for water extraction, mentions the *tympani* that worked as a sort of waterwheel, used both for watering vegetable gardens as well as for distributing water throughout saltworks (*ad salinas ad temperandum praebetur aquae multitudo*).[89] The explicit reference in *Vitruvius* of its use in saltworks proves the relative important role they must have played in ancient *salinae*. We can think that within the saltworks of Vigo water would circulate thanks to these waterwheels, or a similar device that would allow the mechanic movement of water. This mechanism as is described by *Vitruvius* (10.4.1) "does not elevate the water to great heights, but it lifts a large quantity in a small period of time". The existence of mechanic procedures for water movement within saltworks can be found in modern cases, such as Aveiro[90] or Piran.[91]

In modern saltworks, water is in continuous circulation, following a complex rout of hundreds of meters connecting various deposits until it reaches the final crystallization pans. The roman saltworks of O Areal do not seem to work exactly this way. Everything leads to the idea that water movement occurred through different concentration phases, but would be carried out in a slower and more discontinuous way.

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84 Dias 1996 (supra n.72).

85 Alonso *et al.* 2007 (supra n.7).

86 Atik 2008 (supra n.3)

87 Castro 2007 (supra n.14) 359.

88 Only at the plot of Porto St we can see a different level placement with a N-S orientation and a difference of 20 cm, which in this case would facilitate water circulation.

89 The definition of the action of tempering (*ad temperandum*) with water a saltwork is not totally clear in *Vitruvius´*. This could be related to *Pliny´s* confusing passage *NH.* 31.81 in which he unclearly states, that the formation processes of salt requires some fresh water, and even benefits from rain (*NH 31.85*). *Vitruvius* could refer to the fact that saltworks are "smoothed" with fresh water in the sense of controlling salt concentration, though the text is confusing.

90 Dias 1996 (supra n.72) 28.

91 Žagar 1992 (supra n.73) 71.

The process of salt formation

To understand the process of evaporation of salt water within ancient *salinae* we have the valuable information given to us by modern marine saltworks, whose functioning does not seem to be essentially different for what was written by *Rutilius Namatianus* and *Manilius*.[92] The fundamentals of salt production consist in the continuous circulation of water by means of different canals and compartments, whose size and height are progressively reduced at the same time salinity in water increases until crystallization is reached. We can illustrate this process through the example of the modern saltworks of Aveiro,[93] the nearest one to the Northwest of the Peninsula, though the model that it follows has scarce variability in most solar evaporation saltworks.[94] The process can be divided into three fundamental parts: accumulation tanks ("comedorias"), concentration zones ("mandamento") and crystallization pans ("marinhas"). Accumulation tanks collect sea water during high tides and then will feed the rest of the saltworks. After sea water is collected in the feeding deposit, it then passes to the concentration zone where the water circulates through different salt pans where it progressively has a lower amount of water, increasing salt concentration. Finally, high concentrated salt water reaches the crystallization pans. Each of these phases is actually more complex since there are many different compartments with specific functions. During the process, water circulates by gravity through a complex system of canals and sluices that regulate water flow.

At the saltworks of O Areal we observe an evident formal difference in the different compartments (*multifidosque lacus*). Same as in modern saltworks, we can think that each one of these compartments has a specific function, and that water would circulate through them as part of the salt concentration process. Taking the results of the studies carried out at the modern saltworks of Cadiz,[95] we can establish the hypothesis on the functioning of the Vigo *salinae* based on the analysis of the archeological record. Though the climatic conditions are very different, more favorable in the region of Cadiz, they are still both Atlantic saltworks with similar salt concentrations in the sea water. Currently the mean salinity is 34% in the Ría of Vigo, reaching 35% in the summer.[96]

In modern saltworks, the production process of salt begins with the entrance of the sea in large deposits in the form of estuaries from where water is distributed to the rest of the saltworks. Nothing similar has been documented yet in the case of O Areal. The absence of evidence of such structures in the archaeological works carried out thus far to the north of the saltwork of Areal St. leads us to believe that sea water would directly enter the concentration compartments without going through a first stage of accumulation. Anyhow, given the partial character of the excavations, it is difficult to extract conclusions based on an *ex silentio* argumentation.

During the concentration phase, salinity passes from the natural concentration of sea water of 3,4-3,5º Bé (hydrometric scale that expresses the concentration of a solution) to 20º Bé. At the saltworks of O Areal we are able to distinguish at least two sub-phases. Initially water would enter the largest ponds located to the north of the Eastern sector taking advantage of the high tide. Its location nearest to what was likely to be the ancient cost line during Roman times indicates that this would be the initial stage of the concentration process. These tanks are differentiated by their large capacity and the height of their walls, roughly 80 cm. One of the main characteristics of these tanks is that they are delimited by ground walls fixed with stone slabs. In the rest of the salt pans, the delimitation is established just by stone slabs stuck into the pavement. If we consider that the tanks would have been filled with water to a high of 50 cm, each of the two

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92 J. Martínez Maganto, "La sal en la Antigüedad: aproximación a las técnicas de explotación y comercialización. Los *salsamenta*," in J. Molina Vidal and Mª J. Sánchez Fernández (edd) *III Congreso internacional de estudios históricos. El mediterráneo: la cultura del mar y la sal* (Santa Pola 2005) 118.

93 Dias 1996 (supra n.72).

94 Alonso *et al.* 2007 (supra n.7) 321.

95 Ibid.

96 http://www.vi.ieo.es/general/principal.aspx?web=condiciones_salinas.aspx

large tanks located in the Eastern sector (15 x 8 m) would have a capacity of 60,000 l. The tank situated to the west of the previous two, whose dimensions are 20 x 10 m, and is only partially preserved, could have held at least 100,000 l. We can speculate that the first step of the concentration process takes place in these tanks where salinity would go from its natural concentration of about 3,5 Bé to around 10-15º Bé.

Subsequently, during the second concentration phase, water would go to the salt pans located to the South where the concentration could reach 20º-22º Bé. In this area we find a series of quadrangular salt pans, with smaller dimensions (8 x 8 m) and lower delimitation walls (no more than 20-30 cm), which would hold a much thinner sheet of water than in the previous tanks.

In the Western sector the only phase that has been documented corresponds to the second concentration phase, which would take place in the salt pans whose dimensions are 10 x 5 m with 15-25 cm high walls. If we look at the position of the saltworks regarding the coast line at the beginning of the 20th c. (fig. 2) we can see how the structures are located farther away than those located in the Eastern sector. We can say, as a hypothesis, that the saltwork should continue to the north of the excavated zone, and is where the tanks corresponding to the first concentration phase would supposedly be, with the large salt pans in charge of regulating the access of the sea.

We might be able to identify another, intermediate, concentration phase that would correspond to the salt pans to the far west of the Western Sector. Their height of about 60-70 cm and size of approximately 12 x 10 m place them half way between those corresponding to the previous phases. Despite the partial excavation, and considering its position, we can suppose that the water would come from the largest salt pan of more than 100,000 l located to the north.

Within the pans of the second concentration phase there are a series of small basins which function within the whole system is still not totally clear. They are located in both East and West sectors, and their dimensions are 50 x 50 cm, 20 cm deep and are delimited by stone slabs (figs. 4-7). Their pavement seems to be more carefully built, having used compacted gravel[97] or present a stone pavement.[98] They do not appear in the larger concentration tanks, neither in the crystallization ponds. Until now archaeological documents show that only one basin existed per pan, and are always in connection with one of the walls of the salt pan. The function of these structures is not clear, but they could be interpreted as deposits where brine could be manually deposited as it beings to concentrate and where it was stored before being taken to the crystallization pans.

Finally, water reaches the crystallization pans in the form of highly saturated brine. They are clearly differentiated from the rest due to their carefully built pavement and the reduced size (5 x 2.5 m) as well as the limited height of its walls (less than 10 cm) (figs. 4 and 6-7). These tanks, which could only hold a thin sheet of water, have only been documented in the Western sector. When the concentration of salt overtakes 25º Bé crystallization begins and one can start to gather the salt. Finally, as indicated by *Manilius*, extracted salt would probably be stored in large mounds (*ingentes… tumulos*) (*cfr.* Plin. *NH* 31.81), that remind us of the large heaps of salt that can be seen today near marine saltworks.

The specific mention from both *Manilius* and *Rutilius* that salt is obtained by solar evaporation during summer is extremely important (*cfr.* Plin. *NH* 31.81). This fact, which could seem quite evident at first, allows us to rule out other options such as artificial heat treatment of sea salt brine, known to have been used in other salt producing methods within the Roman Empire (*cfr.* Plin. *NH* 31.83; Arist., *Meteor.* II, 3, 359a 25). Together with the sun, wind would have played a key role in salt formation (Plin. *NH* 31.85; Vitr. 8.3.10; Estrab. XIII, 1, 48). The particular location of several saltworks along the Atlantic coast (fig. 1, no. 1-6), in a situation totally exposed and unprotected (fig. 8), should probably be explained by the search of winds.

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97 César 2010 (supra n.16).

98 Castro 2008 (supra n.15) 390.

From a global perspective of the roman saltwork complex of O Areal we can establish a synthetic vision, where we can difference two or three phases of concentration and the crystallization phase. In none of the excavated sectors do we have a complete vision, and only by means of a combined analysis of all the excavated sectors of the saltworks can we obtain and adequate understanding of the site. Probably, future excavations will allow us to have a better comprehension of how the saltworks functioned. It should be noted that a very similar process based on two phases has been proposed for the Kaunos saltworks:[99] a first stage of evaporation carried out on the rectangular canals once closed and working as salt pans (40 cm depth), followed by a second phase of crystallization on the circular salt pans (14-18 cm depth).

The salt

By a compared analysis of the data of the chemical analysis of the process of sea salt making carried out at the Cadiz saltworks,[100] and the stages of water circulation through the different kind of ponds of the *salinae* of O Areal we can establish a hypothesis of how sea water becomes salt, and its final chemistry composition. During the first concentration sub-phase, between 4-11º Bé, calcium carbonate ($CaCO_3$) precipitates, remaining deposited on the bottom of the first large ponds. The resulting brine is moved to the second stage of concentration. Most of calcium sulfate ($CaSO_4$), which precipitation starts from 12º Bé, don't pass to next phase and settle in the bottom of the ponds. The final stage starts over 25º Bé on the final crystallization pans, when sodium chloride (NaCl) precipitates. At this moment salt was probably partially refined of those salts already precipitated at the concentration ponds, but still with some impurities associated: calcium sulfate ($CaSO_4$), magnesium sulfate (MgS_4), magnesium chloride ($MgCl_2$) and potassium chloride (KCl), that co-precipitate with sodium chloride. Nowadays in modern saltworks concentration never pass over 30º Bé in order to prevent the co-precipitation of magnesium sulfate and magnesium chloride, and its incorporation to the final salt. For this, salt should be harvested directly from the wet brine, before evaporation is complete letting a hard crust.

The understanding of how the final crystallization takes place depends on our capacity to comprehend the process of salt harvesting. However, the absence of clear references leads us to an inevitable speculation. A possible hypothesis is that, like in modern traditional saltworks, salt was harvested directly from wet brine with the aid of shovels or flat rakes, forming small salt piles inside each salt pan. A brief passage from the poetic texts of Nicander of Colophon (II c. B.C.) provides a valuable description. In a clear reference to wet harvesting it is said that the salt worker (ἀνὴρ ἁλοπηγὸς) (GREEK) gathers "salt flakes" (ἁλὸς ἄχνην) (GREEK) from the bottom of the salt pans, "when he mingles water with water" (*Alex.* 518-520). Following the chapter of Pliny dedicated to the salt we also can find some evidences of a wet harvesting. Pliny (*NH* 31.92) says that the *salsugo* or *salsilago* is formed at the *salinae*. This is a kind of brine with a higher salt saturation than the sea (*a marina aqua salsiore vi distans*), and that remains in liquid state (*tota liquida*). In several parts of the text of Pliny (*NH* 31.74, 86, 90, 105) we find a close relation between the sea salt and the "foam" (*spuma*), a denomination that could be hiding a possible description of the brine from which the salt is collected in wet (*cfr.* Dsc. 5.110). *Manilius* (*Astr.* 5.689-90) is more expressive when indicates that the salt is obtained from the "hardened foam" (*spumaeque rigentis*). In other part of the text, when Pliny (*NH* 31.73-77) describes the natural salt formation by evaporation he points out that "all salt from pools (*stagnis*) is fine powder, and not in blocks". This could be extrapolated to the *salinae*, but we should be aware that Pliny is here talking about the "native" salt (*qui gignitur*) not the "artificial" (*sal facticius, qui fit*).

There is other possible recollection system, in dry, waiting for the total evaporation of water and the complete crystallization of brine. This implies the co-precipitation of the salts of magnesium together with sodium chloride. In this sense, *Rutilius* (*De Red.* 1.475) points out that

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99 A. Marzano, *Harvesting the Sea. The Exploitation of Marine Resources in the Roman Mediterranean* (Oxford 2013) 127

100 Alonso *et al.* 2007 (supra n.7) 321-2

salt is formed by "hardening" (*duret*), forming a "heavy crust" (*crusta*). *Cato* (*Agr*. 88) says that water must be let under the sun until it solidifies (*donet concreverit*). Nicander (*Alex.* 518) differentiates "salt flakes" from the hardened or frozen salt (ἅλα πηκτόν) (GREEK). Maybe on the same direction, Strabo (VII.5.11; XIII.1.48; *cfr*. Hdt. 4.53.3) uses the word "freezing" (πήγνυμι) (GREEK) for explaining crystallization, *Vitruvius* (8.3.10) describes salt formation as *congelare*, and also *Rutilius* (*gelantur*) (*De Red.* 1.490).

We should admit that the reading of ancient texts is far from giving us a full understanding of the salt harvesting process. There was a true knowledge about the salt progressive precipitation? [101] A real interest for controlling the co-precipitation processes and the refining degree? The very existence of a water circulation through several stages in differentiated ponds could be explained as a real willing of control over the process of salts concentration. The progressive reduction in size and deepness of the salt pans helps the increase of brine's salt saturation, facilitating the evaporation. But at the same time, it could be a means for regulating the formation of the different salts and its final purity. There are also some evidences pointing to an active process of salt refining. Pliny (*NH* 31.81) points out that fresh water is essential for the formation of salt (*non sine aquae dulcis riguis*), and even states that rain is also very helpful (*imbre maxime iuvante*). In other part of the text (Plin. *NH* 31.85) he maintains that "all salt is made sweet by rain water, more agreeable" (also see n. 89). All this affirmations, apparently disconcerting, could make sense in this context as a form of controlling the saturation of brine's concentrate and avoid the precipitation of certain salts.

Production in salting factories in the northwest of the peninsula

Since the beginning of the roman conquest, a series of salting factories appear throughout the whole northwestern coast of the Iberian Peninsula (fig. 1).[102] The identification of at least 16 factories dedicated to the transformation of fishing products reveals the importance of this industry in the region, and its relevance among salting production in *Hispania*.[103] The elaboration of fish sauces and salted fish required the continuous supply of salt and demanded the creation of production centers for its provisioning. It is within the development of fish salting factories on an industrial scale where we must search for the explanation of the appearance and parallel development of an important salt industry.

The salting factory of A Lanzada[104] (fig. 1, no. 13) can be broadly dated to the end of the Late Republic and beginning of the Principate. It proves the early development of Roman salting industry in the northwest of the Iberian Peninsula, within the frame of industrial expansion of the "Circulo del Estrecho", which, since the 1st c. B.C, experiments a huge development.[105] This factory consists in a series of quadrangular tanks of *c.*1 m at its side, placed in row and formed by stone walls with a clay coating, with rounded corners.[106] Though the directors of the excavation

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101 See Carussi 2008 (Supra 1), 36-8

102 C. Fernández Ochoa and J. Martínez Maganto, "Las industrias de salazón en el norte de la Península Ibérica en época romana. Nuevas aportaciones," *AEspA* 67 (1994) 115-34; A. Mª Suárez Piñeiro, "La explotación del mar en la Galicia romana: el ejemplo de las instalaciones de salazón," *Cuadernos de Estudios Gallegos* 116 (2003) 9-25; B. X. Currás Refojos 2007 "Aportación al conocimiento de la industria de salazón en las Rías Baixas gallegas," in Lagóstena, Bernal and Arévalo (supra n.7) 135-49.

103 Lagóstena 2001 (supra n.6).

104 R. M. Rodríguez Martínez, *Intervención arqueolóxica para a recuperación patrimonial do xacemento de A Lanzada (Sanxenxo, Pontevedra)* (Unpublished 2011).

105 Lagóstena 2001 (supra n.6) 229.

106 This unusual constructive system with clay coatings may have parallels in the tanks located at the site of Bouça da Tapada Lavra, Matosinhos, near Angeiras: Silva and Figueiral 1986 (supra n.45) 178; Cleto 1995-96 (supra n.46) fig. 15. These are square structures of *c.*80 x 80 cm and about the same deepness with clay walls, parallel to one another, separated by a corridor.

suggest a Pre-roman chronology,[107] C14 dating revealing a large chronological interval between the 2nd and 1st c. B.C., and archeological materials (Haltern 70), allow us to pin point its chronology between the last half of the 1st c. B.C. and the first half of the 1st c. A.D. This clearly places the foundation of the factory in the context of the roman expansion throughout the Northwest, at the same moment in which an important development of salting industries is also taking place in *Hispania*. In any case, the morphology of the factory of A Lanzada, with a large amount of tanks placed in lines, is typically Roman, and has little or nothing to do with the organization of Pre-roman factories studied in the South of the Iberian Peninsula, where usually only one or two isolated tanks are identified.[108]

As occurs in the rest of the Iberian Peninsula,[109] it is during the Julio-Claudian period when the consolidation of the salting industry takes place. In O Areal (Vigo) (fig. 2), the salting factories of Plaza de Compostela[110] and Marqués de Valladares St.,[111] located next to the *salinae*, were founded between the 1st c. and 2nd c. A.D. The factory of Adro Vello,[112] despite not being able to situate its exact chronology, has a clear *ante quem* stratigraphic reference dated to the 3rd c. A.D. (fig. 1, no. 14). In the factory of Canexol, on the Island of Ons (fig. 1, no. 12),[113] a Dres. 2-4 amphora was located, situating its chronology between the 1st c. and the 2nd c. A.D. The factory of A Pescadoira, in Bueu, was built during the 2nd c. A.D. (fig. 1, no. 11).[114]

The salting factories of the northwest of the Iberian Peninsula continue their activity until the Late Roman period. This can be observed at the factories of the Ría de Vigo such as O Fiunchal, dated between the 3rd and 4th c. A.D. (fig. 1, no. 8)[115] or the factory of A Igrexiña, where the fill-in layers have also been dated to the 3rd-4th c. A.D. (fig. 1, no. 10).[116] We must take into consideration that in both cases the founding date is not clear, and its origin could belong to the Early Empire. The factory of A Pescadoira maintains its activity throughout the 3rd-4th c. associated to a potter´s workshop specialized in amphora production. The factory of Area (Viveiro) has been dated to the Late Roman period (fig. 1, no. 19).[117] The use of the factory documented in the center of Gijón can also be dated between the 3rd and 4th c. (fig. 1, no. 20).[118]

The implantation of a set of factories on the northwestern coast of the Iberian Peninsula occurs parallel to a drastic change in the productive structure observed until this moment, for example regarding the access to marine resources. During the Iron Age, within segmentary non-hierarchical societies,[119] fishing was developed at a low scale and tended towards self-

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107 R. M. Rodríguez Martínez, *et al.* "Una posible factoría prerromana en el Noroeste. Primeras valoraciones de la intervención en el Campo de A Lanzada (Sanxenxo, Pontevedra)," in *Férvedes* 7 (2011) 159-68.

108 A. M. Sáez and D. Bernal 2007 "Acerca del origen púnico-gaditano de las piletas de salazón en el Mediterráneo Occidental: ¿Una innovación de la ciudad de Gadir?," in Lagóstena, Bernal and Arévalo (supra n.6) 463-73; E. García Vargas and D. Bernal, "Roma y la producción de *garvm* y *salsamenta* en la costa meridional de *Hispania*. Estado actual de la investigación," in D. Bernal (ed.), *Arqueología de la pesca en el Estrecho de Gibraltar de la Prehistoria al fin del Mundo Antiguo* (Cádiz 2009) 154.

109 Lagóstena 2001 (supra n.6) 236-45.

110 E. López Rodríguez, "Escavación arqueolóxica en área no sector oriental do soar nº 2-3 da praza de Compostela, Vigo," in *Actuacións Arqueolóxicas. Ano 2008* (Santiago de Compostela 2010) 193-95.

111 C. Torres, J. C. Castro and S. Prieto 2007 "La factoría romana de Salazón del yacimiento de "O Areal", Vigo (Galicia): un complejo industrial salazonero altoimperial," in Lagóstena, Bernal and Arévalo (supra n.7) 475-85.

112 X. Carro Otero, "Adro-Vello (S. Vicenzo do Grove, Pontevedra)", in *Arqueoloxía. Informes 2. Campaña 1988.* (Santiago de Compostela 1991) 93-9.

113 P. Ballesteros Arias, "O aproveitamento do mar ao longo do tempo. A documentación do xacemento romano de Canexol (illa de Ons, Bueu)," *Cuadernos de Estudios Gallegos* 122 (2009) 67-90.

114 F. Díaz García, *O mundo antigo no Museo Massó e a romanización en Bueu* (Bueu 2015).

115 Castro Carrera 1992-93 (supra n.33).

116 Acuña 1999 (supra n.36).

117 E. Ramil González, "*Villa* romana e poboado medieval de Area (Viveiro, Lugo)," in *Férvedes* 5 (2008) 487-92.

118 Fernández Ochoa and Martínez Maganto 1994 (supra n.102) 122.

119 I. Sastre, "Social inequality during the Iron Age. Interpretation models," in T. Moore and X. L. Armada (Edd) *Atlantic Europe in the First Millenium. Crossing the divide* (Oxford University Press 2012) 264-84.

consumption. The study of shell-midden shows that the species that appear in pre-roman settlements are carnivores, and are usually fished near the vicinity of the settlement by means of fishing with hook.[120] After the arrival of Rome we can clearly observe a drastic change in production models. While during the Iron Age the most common species were caught in the immediate surroundings of the settlement, during roman times there is a change in the scale of production and a transformation in the fishing systems. Catchment zones increase and a larger variety of species is detected. New fishing arts and new species that require off-shore fishing with boats begin to appear: mainly pelagic type that requires nets, and bottom-feeders.[121] We can even state the existence of a more specialized fishing, especially regarding the sardine (*Sardina pilchardus*), which would mainly be destined towards fish-salting factories, as has been documented in the factories of A Igrexiña and Adro Vello.[122]

Conclusions

The Roman saltworks documented at the northwestern coasts of the Iberian Peninsula are a unique and exceptional example of sea salt production during the Roman Empire. Thanks to the archaeological excavations carried out at the Ría de Vigo we can establish, for the first time, an approximation to the functioning of solar evaporation marine *salinae* of Roman times based on the archaeological record and contrasted with the ancient texts. The degree of representativeness between Atlantic saltworks as a comparative element to Mediterranean ones must be submitted to future discussion. But, in any case, the saltworks of O Areal are an ineludible reference for the study of salt production in Antiquity.

At the Ría de Vigo we have been able to confirm that the saltworks are directly related to the production of fish salting products. The roman *salina* of O Areal is located a few hundred meters from a series of factories that would work in synchrony with the saltworks. The direct imbrications of salt production and salting procedures have also been documented in Bouzas, though with certain problems in its diachronic definition. The production of fish conserves needed a large volume of salt. The saltworks of O Areal prove that the supply of salt was directly carried out at large factory compounds where, in the same area, both salt and salted fish and sauces were produced.

The identification of saltworks in the northwest of the Iberian Peninsula, next to about 16 fish salting factories reveals the strong implantation of Roman salting industries in the area since the 1st c. A.D. The identification of factory compounds throughout the coast after the change of era must have represented an important impact on local communities. Despite the progressive presence of Rome since the 2nd c. B.C., which leads to important structural changes in the region, local societies would continue being self-sufficient agricultural communities that would produce for self consumption. The establishment of a large scale industry specialized in the production of salt and salted products must have had a large impact on how production was organized. In the future it will be necessary to continue advancing in the understanding of how labour was structured in this industry at a social and juridical level, and how it was integrated in the local economy during the Roman Empire.

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120 J. M. Vázquez Varela, J. Rey and M. Camino, "La pesca en el mundo castreño y romano de Galicia," in *Galicia: da Romanidade a xermanización. Problemas históricos e culturais* (Noia 1993) 91-100; Mª del C. Ferré Álvarez, *Contribución al estudio de la arqueoictiofauna holocena en Galicia* (Unpublished PhD dissertation 2003); E. González Gómez de Agüero, *La ictiofauna de los yacimientos arqueológicos del Noroeste de la Península Ibérica* (Unpublished PhD Dissertation 2013).

121 Vázquez Varela, Rey and Camino 1993 (supra n.120).

122 Ferré 2003 (supra n.120); González Gómez de Agüero 2013 (supra n.120).

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