



# THE BOUNTIFUL SEA

Fish processing and consumption in Mediterranean Antiquity

6-8 SEPTEMBER 2017 | UNIVERSITY OF OXFORD

## THE BOUNTIFUL SEA

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# PROGRAMME

6–8 SEPTEMBER 2017 | TAYLOR INSTITUTE, UNIVERSITY OF OXFORD

## WEDNESDAY 6 SEPTEMBER 2017

- 15:30 Registration opens
- 17:00 Opening Lecture - John Wilkins, University of Exeter  
*Cooking and processing fish in Antiquity: questions of taste and texture*
- 18:00 Drinks
- 19:00 Roman Seafood Tasting Dinner – Ashmolean Museum**

## THURSDAY 7 SEPTEMBER 2017

- 09:00 Registration
- 09:30 Welcome

### Widening the net – Fish processing and consumption in context

Chair: Dimitra Mylona, Institute for Aegean Prehistory, Study Center for East Crete

- 10:00 Arturo Morales-Muñiz, Universidad Autonoma de Madrid  
*Fishing in the ancient Mediterranean: an overview of old-established paradigms*
- 10:30 Annalisa Marzano, University of Reading  
*Fishing and fish in the Roman world: the written evidence*
- 11:00 - Break -
- 11:30 Benedict Lowe, Royal Holloway University of London  
*The relationship of fish salting to other areas of the marine economy*
- 12:00 Cristina Carusi, The University of Texas at Austin  
*Salt and fish processing in the ancient Mediterranean: an economically profitable and mutually beneficial relationship*
- 12:30 Mini talks by poster presenters
- 13:00 - Lunch -



## Tackling the Western Mediterranean

Chair: Steven Ellis, University of Cincinnati

- 14:00 Dario Bernal Casasola, University of Cadiz  
*From the sea to the amphorae: the halieutic cycle in Baelo Claudia fish-salting plants*
- 14:30 Sónia Gabriel, Laboratório de Arqueociências, Direcção Geral do Património Cultural  
*On fish and their products: trawling ancient fisheries in Lusitania*
- 15:00 Athena Trakadas, University of Southern Denmark  
*An overview of fish-salting and fresh marine resource consumption in the western Maghreb in Antiquity*
- 15:30 Emmanuel Botte, Centre Camille Jullian, CNRS  
*Fish exploitation in Italy and Sicily during Antiquity*
- 16:00 - Break -
- 16:30 Rebecca Nicholson, Oxford Archaeology & Mark Robinson, University of Oxford  
*From the water to the plate to the latrine: fish and seafood from the Cardo V sewer, Herculaneum*
- 17:00 Sally Grainger, Independent scholar  
*Garum and liquamen: what's in a name?*
- 17:45 **Presentation on traditional fish sauce production by Red Boat and introduction to tastings**
- 18:00 Fish product tastings and drinks

## FRIDAY 8 SEPTEMBER 2017

### Eastern perspectives – Another kettle of fish

Chair: Linda Hulin, Oxford Centre for Maritime Archaeology, University of Oxford

- 09:00 Tatiana Theodoropoulou, Equipe de Protohistoire égéenne, ArScAn-UMR 7041  
*To salt or not to salt: an overview of evidence for processed marine products in Greek Antiquity and Aegean traditions*
- 09:30 Efi Ragia, The Greek Open University and Institute for Byzantine Research/  
National Hellenic Research Foundation  
*The circulation, distribution and consumption of marine products in Byzantium*
- 10:00 Susan Weingarten, formerly Tel Aviv University  
*Fish and fish products in Late Antique Palestine in their social and geographic contexts: archaeology and the talmudic literature*
- 10:30 Ephraim Lytle, University of Toronto  
*The economics of fishing and saltfish production in the Eastern Mediterranean*



11:00 - Break -

### Plenty more fish – New methodological approaches and laboratory-based methods

Chair: Rebecca Nicholson, Oxford Archaeology

- 11:30 Irit Zohar, Oranim Academic College  
*Fish cuisine in Antiquity: can we identify local fish processing methods and trade?*
- 12:00 Omri Lernau (University of Haifa), Guy Sisma-Ventura (Johannes Gutenberg-Universität Mainz), Thomas Tütken (Johannes Gutenberg-Universität Mainz), Irit Zohar (Oranim Academic College), Andreas Pack (Georg-August-Universität Göttingen), Dorit Sivan (University of Haifa), Ayelet Gilboa (University of Haifa) & Guy Bar-Oz (University of Haifa)  
*Isotopic analysis of sparid teeth – a further indication for trade along the East Mediterranean coast*
- 12:30 Kristine Korzow Richter, University of York  
*Using the other 90%: ZooMS identification of tunny bones and scales from Mediterranean contexts*
- 13:00 - Lunch -
- 14:00 Carl Heron, The British Museum & Oliver Craig, University of York  
*What can the molecular and isotopic analysis of organic residues tell us about the exploitation of marine resources?*
- 14:30 Nicolas Garnier, SAS Laboratory N. Garnier  
*Looking for ancient fish products through invisible biomolecular residues*
- 15:00 Oliver Craig, University of York  
*Quantifying the marine contribution to Roman diets: pushing the limits of the bone stable isotope record*
- 15:30 - Break -

### Making waves? Future directions and discussion

- 16:00 Dimitra Mylona, Institute for Aegean Prehistory, Study Center for East Crete  
*Processing of marine resources east and west: varying traditions, technologies and scales across the Mediterranean*
- 16:30 Through the eyes of a biologist –  
A response by Manos Koutrakis, Hellenic Fisheries Research Institute
- 17:00 Discussion
- 18:00 - Drinks -





# ABSTRACTS

## KEYNOTE LECTURE

### **Cooking and processing fish in Antiquity: questions of taste and texture**

John Wilkins, *Department of Classics, University of Exeter, UK*

Scholars have sometimes given the impression that the consumption of fish in the ancient world was most importantly an obsession of the wealthy and corrupt. The politics of fish-eating however is only one small part of the interaction of the Greeks and Romans with fish. The written record shows the widest engagement with fish, their variety and names, along with the cooking, preparation and processing of them. My paper shows that fish are embedded in the cooking codes of the Greeks relating to sacrifice and medicine, and that while fish are wild animals living in an element hostile to human beings, they may also be assimilated into a healthy human body because of their similarity to us. At all times taste is a crucial factor, producing both the perfectly cooked meal and the best state of health in the body – the balancing of the humours.

## PAPERS

### **Fishing in the ancient Mediterranean: an overview of old-established paradigms**

Arturo Morales-Muñiz, *Universidad Autónoma de Madrid, Spain*

In this presentation, we shall try to summarise what archaeozoological research can tell us about human exploitation of the Mediterranean's fish resources through time. While doing so, we will also entertain some of the limitations of the data and study methods, both of which demand caution before reaching conclusive interpretations. As will become apparent, there is neither a linear nor a single story for the emergence of fishing in this sea; rather, we have multiple entwined tales, often repeated through time and space, that resist unification into all-encompassing patterns and often reveal the shaping hand of the environment in the background. The patterns that do occasionally emerge are, by force, provisional and will require confirmation from alternative sources of evidence, including biomolecular analyses, before being integrated into a general all-encompassing frame of reference.

### **Fishing and fish in the Roman world: the written evidence**

Annalisa Marzano, *University of Reading, UK*

Despite the unevenness of the surviving ancient written sources, documentary and literary texts have interesting information about fishing and fish consumption in the Roman world, especially when studied alongside archaeological and ethnographic data. This paper will discuss the main evidence for the organisation of the fishing 'industry', the role business partnerships and professional associations had, and how the existing legal framework was used to secure the control of fishing grounds. Evidence for dietary fashion and seafood consumption will also be addressed, illustrating how, by and large, the divide between (certain) fresh fish and preserved products, and between marine and fresh-water fish, reflected the social gulf between upper and lower classes.

### The relationship of fish salting to other areas of the marine economy

Benedict Lowe, *Royal Holloway, University of London, UK*

Recent years have seen increasing attention focused upon the role of fishing in the ancient economy, in particular on determining the species used and the types of products being produced in salting factories. Despite significant advances, areas of difficulty remain. The focus has remained on the identification of *garum*, *muria*, *liquamen* and *allec* at the expense of lesser known varieties of fish sauce, and a reliance on evidence of Scombridae and Clupeidae rather than other species that are less detectable archaeologically. Study is restricted by the lack of archaeozoological analyses conducted at the overwhelming majority of fish salteries – a situation that has only recently begun to be addressed.

Within the limitations of the dataset it is the goal of this paper to examine the relationship of fish salting to other areas of the marine economy: the relationship of salting to fishing and range of species used, salt production, the processing of molluscs for dye and the organisation of retail activities. Molluscs, for example, were not only used in the production of fish sauce, such as the limpets found in a salting vat at Teatro Comico in Cádiz, or oysters from Iulia Traducta, but were used in the manufacture of purple dye. Despite the similarity of the processes for producing purple dye and salting fish, and finds of murices from salteries, the relationship of these two activities remains unclear: finds of murex shells associated with salting vats at Metrouna suggests that once the dye gland had been removed, the flesh of the molluscs was used for food. Facilities for fish-rearing have been found at several salteries, for example at Punta de l'Arenal and Cosa, and complex salinae have been identified at Acequia de Noria, Vigo and 'Atlit.

### Salt and fish processing in the ancient Mediterranean: an economically profitable and mutually beneficial relationship

Cristina Carusi, *University of Texas at Austin, USA*

In this paper I will first compare the demand for salt generated by dietary needs with the availability and production of salt around the ancient Mediterranean, to show that the level of demand created by dietary consumption and domestic uses could be fulfilled, in most cases, by local resources. The extremely rare references to interregional salt trade in literary and documentary sources can certainly corroborate this idea. As a bulky commodity with little economic value, salt was probably too expensive to be transported over long distances and was more conveniently obtainable from local resources. However, the situation was different when large-scale productive activities involving the use of salt were concerned, the most obvious example being fish processing.

The production and widespread distribution of processed fish required a steady supply of both fish and salt. Salt only was able to transform fish – which is otherwise extremely perishable – into a durable commodity, easy to store and trade, with a high economic value. So, when salt was not available in sufficient quantity at the local level, interregional trade became crucial. It was the strategic relevance of salt at certain large-scale processing centres that transformed it into an economically significant resource and made interregional trade convenient. It was also through the medium of processed fish that the surplus of salt production available in certain regions was redistributed across the Mediterranean and came to play an important, although indirect role, in interregional and long-distance trade.

### From the sea to the amphorae: the halieutic cycle in Baelo Claudia fish-salting plants

Darío Bernal Casasola, *Universidad de Cádiz, Spain*

The town of Baelo Claudia is one of the best-known Roman fishing-canneries in the ancient world for the knowledge of fishery activities between the 2nd century BC and 5th century AD. The first fish-salting plants were discovered exactly 100 years ago and, since then, they have intermittently been the object of archaeological investigations.

We have been developing a research project titled “Maritime economy and fishing activities in Baelo Claudia” since 2010, authorised by the Cultural Department of the Andalusian Government and carried out by the University of Cadiz and the Archaeological Complex of Baelo Claudia, with finance for several projects from the Ministry of Economy and Competitiveness / Federal Government of Spain.

The investigations have allowed us to locate and excavate two new salting-factories, called respectively “Conjunto Industrial XI” and “Conjunto Industrial XII”. A rigorous methodology of microspatial excavation and laboratory analysis

(archaeological, archaeozoological and archaeometrics) has been applied in both cases. Evidence for preserved fish has been documented in primary positions within the basins, with remains of both *salsamenta* (salted tuna, with remains of the skins), and *garum* fish sauces (including fish species and other marine resources not previously identified). Also, a dump of tuna bones has been excavated enabling an in-depth investigation of the butchery methods used for these great migratory fish. Given the fragility of these kinds of remains, these investigations therefore concern one of the few Atlantic-Mediterranean sites in which these forms of evidence have been preserved, with most of these remains dating to the 5th century AD, corresponding with the phase of abandonment of these artisanal factories. In this paper, the results of these new investigations are presented, as well as providing an overall assessment of the contribution of Baelo Claudia to the knowledge of the fish processing industry in Antiquity over the last decades.

Bernal, D., Arévalo, A., Díaz, J.J., Expósito, J.A. (2016a) *Baelo Claudia* y sus actividades haliéuticas. Una nueva cetaria y una posible domus en el barrio meridional (2005-2009). In : *Actas de las II Jornadas Internacionales de Baelo Claudia: Nuevas Investigaciones*, Junta de Andalucía, 147-175.

Bernal, D., Expósito, J.A., Díaz, J.J., Marlasca, R., Riquelme, J.A., Lara, M., Vargas, J.M., Bustamante, M., Pascual, M.A. (2016b) Saladeros romanos en *Baelo Claudia*: nuevas investigaciones arqueológicas. In : Bernal, D., Expósito, J.A., Medina, L., Vicente-Franqueira, J.S. (eds.), *Un Estrecho de Conservas. Del garum de Baelo Claudia a la melva de Tarifa*, Ed. UCA y Conservera de Tarifa, 43-69.

Bernal, D., Expósito, J.A., Díaz, J.J. y Marlasca, R. (2017) Investigaciones interdisciplinares en los saladeros orientales de *Baelo Claudia*. Singulares hallazgos en los Conjuntos Industriales XI y XII (campana de 2015). In : Brassous, L., Lemaître, S. (coord.), *La ville antique de Baelo Claudia, cent ans après Pierre Paris* Dossier des *Mélanges de la Casa de Velázquez. Nouvelle série*, 47 (1), 2017, 151-166.

Paris, P., Bonsor, G., Laumonier, A., Ricard, R., Mergelina, C. (1923) *Fouilles de Belo (Bolonía, province de Cadix) (1917-1921), Tome I: La ville et ses dépendances*. Bibliothèque de L'École des Hautes Études Hispaniques, Fascicule VI, Feret et Fil.

## On fish and their products: trawling ancient fisheries in Lusitania

Sónia Gabriel, *Laboratório de Arqueociências, Direção Geral do Património Cultural, Portugal*

The Roman province of Lusitania, which covered much of what is now Portuguese territory, was an important producer of salted fish and fish sauces for the Western Roman Empire between the 1st and the 5th centuries AD. Despite the considerable number of ancient salting installations documented in Portugal, fish remains have been given little attention and the number of zooarchaeological studies for that territory is comparatively small, hampering our understanding of the species fished and processed through time. The main aim of this work is to assess Roman fisheries in the province of Lusitania, more specifically those related to the production of salted fish and fish sauces. In this paper I will be reporting on the results of fish bone analyses conducted throughout 2009 and 2013, comparing these assemblages to pre-existing zooarchaeological data.

## An overview of fish-salting and fresh marine resource consumption in the western Maghreb in Antiquity

Athena Trakadas, *University of Southern Denmark*

Numerous studies of ancient marine resources in the Mediterranean focus primarily on the archaeological remains of the Roman-period fish-salting industry. While these remains, if well preserved, can provide relevant data, scholarship to date gives limited inter-site synthesis and examination of the fishing techniques or marine environment in which the resources were fished, ultimately prohibiting even general quantification of the industry's products. In addition, these types of archaeological remains exist generally in the western Mediterranean and Black Sea; in the Eastern Mediterranean, archaeozoological studies, if done during archaeological excavations, tend to focus on the identification of marine animals, but do not often correlate fishing techniques or marine environments to these.

These limitations are addressed in a methodological approach developed for the analysis of marine resources of the western Maghreb (modern Morocco and the Spanish autonomous cities of North Africa) during the Punico-Mauretanian, Roman and Late Roman periods. The study considers as its framework the region's coastal, riverine and lagoonal environments in which the evidence for marine resource exploitation – for the fish-salting industry and fresh consumption – can be contextualized and examined in a diachronic perspective. Analysis combines:



1) *Archaeological data*: marine animal remains from archaeological contexts, finds of fishing equipment and, if available, fish-salting facilities; and

2) *Descriptive data*: written sources relating to fishing, marine life and the region's salted products, pictorial representations of marine life/ fishing from the same area and local ethnographic examples of fishing techniques.

This paper will describe the methodology and give an overview of its application. The general aim is to provide a perspective of the marine ecohistory of a diverse region of the Mediterranean by using the environment as a foundation for analysing a combined body of qualitative and quantitative data.

### **Fish exploitation in Italy and Sicily during Antiquity**

Emmanuel Botte, *Centre Camille Jullian, CNRS, France*

In this presentation I will be providing an overview of the production of fish-salted products in Italy and Sicily during Antiquity, including these two geographical areas in the general context of the Western Mediterranean. Additionally, I will also discuss the containers used for the transportation of the different products made in these factories.

### **From the water to the plate to the latrine: fish and seafood from the Cardo V sewer, Herculaneum**

Rebecca Nicholson<sup>a</sup>, Mark Robinson<sup>b</sup> and Erika Rowan<sup>c</sup>

*a. Oxford Archaeology, UK; b. University of Oxford, UK; c. University of Exeter, UK*

The Roman production of, and fondness for, preserved fish – *salsamenta*, *garum*, and other fish pastes and sauces – is well known, but the day-to-day fishing and fish consumption of the Romans in Italy is much less well documented. This paper contributes towards the understanding of Roman fish eating in a coastal urban context, helping to contextualise the role of preserved fish in the diet.

Soil samples excavated from the Cardo V sewer at Herculaneum have produced a wealth of material including at least 70 species of fish, 53 shellfish taxa and abundant mineralised seeds, providing a unique insight into the foods consumed by the inhabitants of the tenements in Insula Orientalis II immediately prior to the eruption of Vesuvius in AD 79. Otoliths were particularly common in a number of samples and were identified using web-based image analysis software (AFORE), while bones were identified by more traditional methods. This paper will examine the results of these complementary methods of identification and will provide an overview within the framework of local ecosystems, archaeological, pictorial and historical evidence for fishing and shellfish collection around the Bay of Naples and archaeological evidence relating to the tenements whose inhabitants discharged effluent into the sewer.

### **Garum and liquamen: what's in a name?**

Sally Grainger, *Independent scholar, UK*

The body of work concerning the study of Roman fish sauce is immense and wide ranging. Archaeologists, classicists and historians have been fascinated by the concept of these sauces, but also mystified by the complex and contradictory literary evidence that survives for these products. This has led to several contradictory classical and historical theories to explain the anomalies in the evidence, in turn leading to many conflicting accounts as to the nature and quality of ancient fish sauces. Above all we need to achieve some sort of consensus as to what we mean when we use terms like *garum* or *liquamen*, but even more crucially we need to comprehend what the ancient's meant by these terms. It is my contention that the ancients were as profoundly confused by fish sauce nomenclature as we are and untangling this problem, which is basically one of mistranslation, is not only quite possible but has huge implication for our understanding of the trade in these products and the wider ancient economy.

The complexity of the situation is accentuated by the elite Romano-centric perspective of the literary sources that are cited. It is the Roman satirical poets and Pliny the Elder that provide the initial definitions. This elite perspective on the exclusive and expensive blood *garum* type sauces suggest that they are the primary product of trade, while it is in fact the

everyday very small whole-fish sauces used by millions of ordinary Romans that constitute the main product of trade, and the dominance of this basic and cheap form of fish sauce is affirmed by the archaeological evidence.

In this presentation I will review the Greek and Roman didactic culinary evidence for the way in which these products were manufactured and used. In the hope that, through an understanding of their culinary uses, a nuanced picture of these products is possible.

### **To salt or not to salt: an overview of evidence for processed marine products in Greek Antiquity and Aegean traditions**

Tatiana Theodoropoulou, *Equipe de Protohistoire égéenne, Archéologie et Sciences de l'Antiquité (ArScAn)-UMR 7041, France*

Although processing and marketing of fish and other marine products was “a brisk business for many inhabitants of the Mediterranean” during Classical and Roman Antiquity, this issue has not been extensively studied in Greece. Ancient sources and sporadic archaeological finds confirm the trade of such products from the Atlantic and the Western Mediterranean to the Aegean as early as the Classical period. Investigation of local fish processing, on the other hand, relies more on ancient texts than on other types of records. This presentation will offer an overview of available evidence for processed marine products, fish-processing sites, and consumption in the Aegean Sea with a focus on recently studied, as well as re-examined, fishbone assemblages from this region. Related archaeological, literary, and chemical evidence, when available, will also be presented. The provisioning of Aegean towns with fish, namely the local vs. distant origin of these products, is a key pointer to the further understanding of trade and consumption of processed products, as well as the relative importance of salted vs. fresh marine resources within the overall dietary habits of Aegean communities. Potential Aegean trends and local preferences will be put together in order to identify the role of processed marine products in the Aegean within the larger framework of Mediterranean traditions.

### **The circulation, distribution and consumption of marine products in Byzantium**

Efi Ragia, *The Greek Open University / Institute for Byzantine Research – The National Hellenic Research Foundation, Greece*

Marine exploitation in Byzantium developed to become a regular industry by the early 10th century. Evidence in the sources is meagre, and its systematic study has only just begun. In spite of its piecemeal character it is possible to sketch the picture of an organised and methodical exploitation of the empire's marine resources based on large and expensive investments such as the *epochai* and *vivaria*, aiming at the uninterrupted supply of the cities with marine products. But Byzantium also maintained elaborate methods for the supply of its employees. Either during the exercise of their duties, or as part of their rewards, or because of their privileged status, or even based on legitimate legal claims, large groups of people benefited from the work of those involved in primary production (fishermen, *epochai/vivaria* owners and lessees), without having contributed at all to the initial investments or expenses. Once these methods become clear, it is easy to perceive that the circulation and consumption of marine products in Byzantium was larger than previously thought, and middle and lower class citizens actually did have a share in it. Indeed, consumption of marine products was not simply restricted to the producer-buyer or offer-demand relationship: it involves social factors that are not immediately and easily recognisable because of the fragmentary information.

### **Fish and fish products in Late Antique Palestine in their social and geographic contexts: archaeology and the talmudic literature**

Susan Weingarten, *formerly Tel Aviv University, Israel*

There are a very large number of references to fish and fish products scattered over Jewish works from Late Antique Palestine. This literature, generally called ‘talmudic’ or ‘rabbinic,’ consists mostly of religious regulations with some narrative sections. The rabbis who wrote it were often concerned to identify particular food products and distinguish them from others in order to clarify the religious regulations. Thus we find careful distinctions drawn between different named fishes and fish-products, as well as the various stages of development of fishes. Palestine by Late Antiquity had been a province of the Roman empire for hundreds of years, and a number of these fish products are clearly identifiable by their Graeco-Roman names (although the same name might not always refer to the same food). Thus we find the fish

sauces *muries* and *halleg*, as well as variants of *garum*. Others may be identifiable from somewhat later sources, including the Arabic cookbooks of the caliphs of Baghdad: *tsir* and *tsahana*.

This paper will take a number of these fish terms and discuss various questions they raise, for example, how does *muries* differ from *tsir*, and both of them from *tarit terufah* (chopped *tarit*)? How does *tarit terufah* differ from the smelly *tsahana*, another chopped fish product? Is *tarit* (or *tari*) a name of a fish, and if so can we identify it with Greek *trikhis*, the sprat or sardinelle, and/or Arabic *tirrikh*? Is the latter the name of a fish or simply something salted (from Greek *tarichos*)? Is talmudic *aphitz* connected to Greek *aphye*, whitebait?

Lately Perry and Lewicka have discussed whether Arabic *sir* was a dry fish-powder or a liquid. My paper will consider how far the talmudic information on *tsir* can contribute to this debate. Papyrological and epigraphic evidence will be brought into this discussion, and the paper will also discuss archaeological evidence of fish-salting and the preparation of fish-sauces along the Mediterranean coast of Palestine, as well as in Egypt.

Perry, C. (2001) 'Mediaeval Arab fish: fresh, dried and dyed' in M. Rodinson, A.J. Arberry and C. Perry, *Medieval Arab Cookery*. Totnes.

Lewicka, P. B. (2011) *Food and Foodways of Medieval Cairenes: Aspects of life in an Islamic Metropolis of the Eastern Mediterranean*. Leiden and Boston.

## The economics of fishing and saltfish production in the Eastern Mediterranean

Ephraim Lytle, *University of Toronto, Canada*

In this paper I will discuss the economics of fishing and saltfish production in the Eastern Mediterranean (especially the Aegean), the Marmara, and the Black Sea, during the Classical through Roman periods. The limited evidence for commercial saltfish production in the region will be briefly surveyed, and it will be suggested that evidence for commercial saltfish production and trade in the region can be explained only partly in terms of differences in potential productivity, and that institutional economic factors played similarly important roles. Factors including risk, prices, trade, transaction costs, and availability of labour, markets, and capital influenced the economics of production, and the limited evidence for commercial production can be explained by alternate strategies including, but certainly not limited to, household production.

## Fish cuisine in Antiquity: can we identify local fish processing methods and trade?

Irit Zohar, *Oranim Academic College, Israel*

Fish is a high quality food, containing protein and various vitamins and minerals. However, since degradation begins as soon as the fish dies, processing should be done quickly to prevent spoilage due to microbial action and the growth of bacteria responsible for food poisoning. For example, at tropical temperatures most fish become inedible within twelve hours. This raises several interesting questions while reconstructing past economies: How did ancient communities process their fish? Which preservation methods were used? How can we identify and distinguish between the different activities?

In this presentation I present several methods to identify fish processing methods for immediate and long-term consumption in the southern Levant. This includes taphonomic models, anthropological experiments, and osteological analysis of fish remains recovered from selected sites dating from the Lower Paleolithic to the Byzantine period. The contribution of isotope analysis to identify the habitats in which the fish were captured will also be discussed.

## Isotopic analysis of sparid teeth – a further indication for trade along the Eastern Mediterranean coast

Omri Lernau<sup>a</sup>, Guy Sisma-Ventura<sup>b</sup>, Thomas Tütken<sup>b</sup>, Irit Zohar<sup>c</sup>, Andreas Pack<sup>d</sup>, Dorit Sivan<sup>a</sup>, Ayelet Gilboa<sup>a</sup>, and Guy Bar-Oz<sup>a</sup>

*a. University of Haifa, Israel; b. Johannes-Gutenberg-Universität Mainz, Germany; c. Oranim Academic College, Israel; d. Georg-August-Universität, Germany*

Archaeological excavations of many sites in Israel have brought to light a large number of bones of the fresh-water fish, the Nile perch, which had been imported from Egypt. This trade took place over a long period of time, beginning in the Early Bronze Age (around 2000 BC) and continuing up to the Early Moslem Period (around the 8th century AD). It was



implemented by boats along the Eastern Mediterranean coast, including Cyprus and Anatolia. The most common fish found in excavations in Israel is the marine fish *Sparus auratus* of the family Sparidae (porgies/sea breams). Isotopic studies of teeth of *S. auratus* have shown it to originate in the Bardawil hypersalinated lagoon on the northern coast of the Sinai Peninsula, about midway between the Nile Delta and the coast of Israel. This finding illuminates another aspect of the dynamic trade in fish in this area in ancient times.

### **Using the other 90%: ZooMS identification of tunny bones and scales from Mediterranean contexts**

Kristine Korzow Richter, *University of York, UK*

Identification of archaeological fish bone is frequently difficult and some studies suggest that upwards of 90% of fish bones that have been recovered languish in boxes without a species (and in most of those cases without even family) identification. Fish scales are quite common in Mediterranean contexts, but yet are even less likely to be identified than bones. This poses problems for anyone looking to use that data, be they archaeologists, historians, or ecologists. Protein identification using ZooMS has the potential to identify bones to species more easily than DNA when morphological approaches fail. As an iconic group of closely related species, tunnies (Scombridae) provide a very good start to looking at Mediterranean species identification. I will show the ability of ZooMS to distinguish between the Mediterranean tunny species and how that could affect the understanding of fish usage.

### **What can the molecular and isotopic analysis of organic residues tell us about the exploitation of marine resources?**

Carl Heron<sup>a</sup> and Oliver Craig<sup>b</sup>

*a. British Museum, UK; b. University of York, UK*

Organic residue analysis has been conducted for more than a century. Some early claims for the presence of aquatic (marine or freshwater) oils, often in pottery vessels, were made, but it is only in the last 20 years that a suite of molecular marker compounds, many associated with oxidative changes brought about by heating or during burial, have provided greater confidence in assigning ancient lipids to a biological source. In addition, the wider use of compound-specific carbon isotope analysis has helped to distinguish marine resources from terrestrial and freshwater organisms. These techniques have been applied to pottery vessels over a very wide time range spanning c.15,000 years. To a lesser extent pit features have also been shown to preserve evidence of processing of marine tissues (e.g., blubber). This presentation will review the evidence of marine resources in a range of archaeological contexts using analytical organic chemistry and evaluate the archaeological significance of these findings.

### **Looking for ancient fish products through invisible biomolecular residues**

Nicolas Garnier, *SAS Laboratoire N. Garnier, France*

As organic materials, fish and their derivative products are perishable materials that break down rapidly when abandoned and ultimately disappear. When a recipe, or the raw part of a fish, includes only flesh, without bones and scales, the chemical constituents of the original materials are all that remain to identify the source products. Fish flesh mainly consists of proteins and lipids, but these molecules are unstable and degrade irreversibly, losing a significant part of the original chemical data during the process, thus hampering any fast or easy identification.

Two types of fish products should be distinguished: raw or cooked fish and fermented fish-based products. In the first case, the decay of the native organic matter will result from chemical degradation and also thermal degradation during cooking. In the second case, the recipes for fish sauce production use biochemical processes involving bacteria which cause rapid degradation of the fish themselves, the quasi total degradation of proteins and triglycerides into hydrolysed amino acids and fatty acids, and the emergence of markers from the biological activity.

In order to develop methods for the identification of fish products, we chose to combine experimental archaeology and organic analyses. The results indicated that the degradation products of cholesterol (an animal marker present in fish) differentiated samples resulting from thermal decay and proved to be a strong marker for tracking fish sauces. We subsequently analysed modern samples coming from fish-salting vats from the Atlantic coast (Cadix, Spain; South Britain

and Charente, France). Our analyses demonstrated that the inner sides of the vats had retained absorbed residues from the original content. The chemical composition of modern *garum* and that from the sides of the vats turned out to be identical, thus validating the chemical markers we attributed to “fermented fish-based products”.

The application of the developed analytical methodology to ancient production structures and amphorae will allow us to apprehend the production and the trade of fish sauces, searching directly for the markers of fish. However, detecting the presence of non-fermented fish will require further extensive and joint research between zoologists, cooks, archaeologists and chemists.

### **Quantifying the marine contribution to Roman diets: pushing the limits of the bone stable isotope record**

Oliver E. Craig, *University of York, UK*

For over three decades, the analysis of carbon and nitrogen stable isotopes in the protein fraction (collagen) of human bone has been used to directly study palaeodiet. One major application has been to measure the stable isotopes of bone collagen to directly quantify the consumption of marine versus terrestrial foods. This approach has been widely applied to Roman contexts, including to several hundred individuals buried in the Imperial Roman Necropoleis along the Tyrrhenian coast of Italy. The standard interpretation of these data is of no or very minor consumption of marine foods, despite ample historical and archaeological evidence to the contrary.

To examine this problem, I will critically evaluate the assumptions used to interpret stable isotope data and suggest alternative approaches based on the measurements of individual amino acids in collagen and AMS dating of individuals who died simultaneously. The latter reveals the addition of ‘old’ carbon from the marine reservoir and allows us to independently predict how the stable carbon and nitrogen isotope values change in response to increasing marine consumption. I will discuss the implication of these findings and suggest that there is considerable scope for re-interpretation of previous datasets and, moreover, a large degree of uncertainty due to unknown physiological processes controlling the synthesis of bone collagen from different dietary sources. In summary, how confidently can we quantify diets using stable isotopes, and can this tell us anything new about marine consumption that we can’t already discern from the historical and archaeological record?

### **Processing of marine resources east and west: varying traditions, technologies and scales across the Mediterranean**

Dimitra Mylona, *INSTAP, Study Centre for East Crete, Greece*

Research on processing of marine resources along the Mediterranean coasts in Antiquity reveals an uneven picture. The archaeological evidence for the systematic processing of fish and sea food in the western part is abundant and varied. Fish preservation, fish sauce and purple dye production seem to have been important factors of economic growth in certain locations. Excavation of processing establishments and the study of bio-archaeological remains, amphorae and related structures reveal the existence of an articulated industry. In the eastern part of the Mediterranean, archaeological evidence for the processing of marine resources is much less common and often indirect. Large scale processing plants are almost absent from the archaeological record and studies of fish and shellfish remains and of other material evidence of fish preservation and commerce are few. Yet, written evidence on the subject, in the form of literature and inscriptions, abound and they place heavy emphasis on consumption and commerce rather than production.

This presentation describes the evidence and explores possible reasons for this imbalanced representation in an attempt to assess the actual importance of the processing of marine resources across the whole Mediterranean. Issues discussed are archaeology’s research agendas and methodologies, resource availability and abundance, range of products as well as issues of scale and visibility.

## POSTERS

### **Diet and mobility of the colonies: $\delta^{13}\text{C}$ , $\delta^{15}\text{N}$ , and $\delta^{34}\text{S}$ analysis of the Roman necropolis Joan Planells (Ibiza, Spain)**

Aleksa K. Alaica<sup>a</sup>, Jessica Schallburg-Clayton<sup>b</sup>, Alan Dalton<sup>c</sup>, Elena Kranjčević<sup>c</sup>, Glenda Graziani Echávarri<sup>d</sup>, and Catriona Pickard<sup>c</sup>

*a. University of Toronto, Canada; b. University of Otago, New Zealand; c. University of Edinburgh, UK; d. Autonomous University of Barcelona, Spain*

During the Late Roman to Early Byzantine period fish and fish products were documented as an important portion of production and trade. In order to investigate the reliance on marine sourced foods for Roman colonies, the use of  $\delta^{13}\text{C}$  ( $n=38$ ),  $\delta^{15}\text{N}$  ( $n=38$ ), and  $\delta^{34}\text{S}$  ( $n=30$ ) stable isotope ratios were used for the investigation of diet and mobility of the population found at the site Joan Planells, a Late Roman to Early Byzantine necropolis in use between AD 300–700. Results suggest the dependence on a primarily  $\text{C}_3$  terrestrial sourced diet, with a smaller contribution of marine sourced foods. While  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  values showed no statistically significant difference between sexes,  $\delta^{13}\text{C}$  values did, which possibly suggests a daily dietary variance or divided access to foods. Out of the 30 individuals sampled from Joan Planells, nine fell outside of the  $\delta^{34}\text{S}$  range typical for Ibiza, identifying the individuals as non-local and suggesting significant mobility of the population.

### **Nacre and coral Roman decoration. Reflections on crafts using marine raw materials**

Macarena Bustamante Álvarez and Darío Bernal Casasola, *Universidad de Cádiz, Spain*

In this paper we present early evidence for the use of some marine resources considered to be sumptuous. In particular, we refer to the pearl (and its derivatives), nacre, as well as coral. Specifically, we will deal with some examples coming from archaeological sites located in Hispania and Tingitana. This area appears to be ideal for such a study because of its location, surrounded by sea. We will discuss the importance of these raw materials and their use for different purposes, as varied as jewellery making or parietal decorations, and we will try to address their symbolic significance. We will also attempt to provide an analysis of the technical and production side of the handicrafts.

### **Malaca, an emporium dedicated to the exploitation of fishery products**

Pilar Corrales Aguilar, *Universidad de Málaga, Spain*

Malaca, an emporium according to Strabon (III 4.2), is clearly associated with fish sauce production in the late Punic-Republican period. This is based on recent evidence for pottery factories that focused on the supplying the local *cetariae* increasing in significance in the late-Republican and the beginning of the Imperial period. Towards the end of this period the *cetariae* reached their peak and were found all over the ancient Roman city and its ager. The latest examples date to the 6th century A.D. Recent archaeological research also encompasses the analysis of the fish remains from some of the basins, thus enabling us to construct an atlas of the products made in the *cetariae* from the area around the Alboran Sea.

### **New data about Roman fish salting plants in Rias Baixas (NW, Iberian Peninsula)**

Adolfo Fernández Fernández, *Universidade de Vigo, Spain*

In the last decades rescue urban archaeology has uncovered important Roman antiquities along the north western Atlantic coast, especially in the south of Galicia, a territory known as Rias Baixas. Among these, some archaeological sites stand out in relation to the exploitation of marine resources; salt pans (O Areal, Vigo) and fish salting plants. The catalogue of such sites published more than a decade ago (Fernández Ochoa, Martínez Maganto, 1994; Suárez Piñeiro 2003) is now outdated by the recent excavation of new fish salting plants, some of them located in important port and industrial centres such as Vigo and Bueu and others located on small beaches used as anchorages. In this poster, we present twelve newly excavated fish salting plants, which document the importance of this territory in north western Iberia with respect to the exploitation of marine resources. Two of the fish salting plants which were recently explored by the author – Sobreira (Vigo) and Adro Vello (O Grove) – are presented in greater detail.



Fernández Ochoa, C. and Martínez Maganto, J. (1994) "Las industrias de salazón en el norte de la Península Ibérica en época romana. Nuevas aportaciones", *AEspA*, vol. 67, 115-134.

Suárez Piñeiro, A.M. (2003) "La explotación del mar en la Galicia romana: el ejemplo de las instalaciones de salazón", *CEG*, vol. 50, 9-25.

### **Fermented or cooked? Fish remains in a storage vessel from Bronze Age Akrotiri on Thera, Greece**

Nicolas Garnier and Dimitra Mylona

*a. SAS Laboratory N. Garnier, France; b. INSTAP, Study Centre for East Crete, Greece*

The Bronze Age settlement of Akrotiri on the island of Thera, Greece, was destroyed by a volcanic eruption and buried under a thick layer of volcanic ash. The specific taphonomic conditions at this site resulted in the remarkable preservation of organic remains; fish remains are very common finds throughout the settlement. The excavations revealed several instances of preserved fish, which represent at least three "recipes". One of them was found in the form of a dark residue within a vessel which was composed of assorted small fish and some seeds. After micro-excavation of the vessel contents and macroscopic examination of the fish preparation, two possible interpretations were proposed; the residue was either from some fermented fish product with a long shelf-life, similar to Roman *allec*, or it represents a product involving cooked and marinated fish (similar to a traditional Mediterranean dish called *savoro*). To explore the validity of these hypotheses, we employed chemical analysis (Gas Chromatography coupled with Mass Spectrometry) of the fish residue and of the ceramic container. The results of the analysis suggest that the fish has not been fermented, but instead had been exposed to heat, possibly cooked, along with a range of other ingredients.

### **The Romano-British fisheries: an integrated approach**

Lee Graña, *University of Reading, UK*

The subject of Roman fishing, indeed ancient fishing, is primarily fuelled by Mediterranean-lead research, nevertheless, recent studies have highlighted the existence and success of Roman fisheries at the peripheries of the Empire. The increasing wealth of evidence for fishing in Roman Britain consists of fishing hooks, netting-needles, traps, weights and over one hundred fish-bone assemblages; however, to date there has been no attempt to produce a comprehensive study of the evidence. This poster will provide an overview of my PhD research, including the development of a typology of Romano-British fishing tools and a preliminary discussion of the potential fisheries identified. One question yet to be answered is how the small and large-scale fisheries of *Britannia* fit into the wider context of the Roman Empire.

### **Salsamenta and salmon: three centuries of Roman fishing and fish consumption at Chester Amphitheatre**

Jen Harland, *University of the Highlands and Islands, UK*

Recent excavations at Chester Amphitheatre have produced an unprecedented assemblage of fish remains from the British Isles, dating from c. AD 71 to the late 3rd century. Five tightly dated phases allow exploration of Roman interaction with local wild resources in local rivers, estuaries and the open waters of the Irish Sea. The assemblage is dominated by locally caught fish, including a variety of small flatfish. Imports of preserved non-local Spanish mackerel suggest a demand for *salsamenta*, while other species like salmon show that people were willing to eat fish species that would not immediately be recognisable to inhabitants of the Mediterranean. This assemblage of food remains is larger than any other found in the Roman British Isles, if one does not include specialised fish-sauce deposits, and moreover it was entirely recovered using fine sieving. This poster will discuss changing Roman dietary preferences and fishing methods over three centuries, including the chronology and extent of imports of non-local preserved fish and changes in local wild resource exploitation. It will compare the Chester fish assemblage with larger trends observed in the British Isles (following Locker 2007) and elsewhere in the Roman Empire.

Locker, A. (2007) 'In piscibus diversis; the Bone Evidence for Fish Consumption in Roman Britain', *Britannia XXXVIII*, 141-180

### **Who wins the Aegean market (if anyone...)? Shipments of North African, Iberian and Pontic “fish amphorae”**

George Koutsouflakis, *Hellenic Ministry of Culture, Greece*

The poster focuses on the latest evidence on amphora cargoes, long linked in literature with the trade of processed fish products. Underwater surveys recently conducted in the Aegean have led to the discovery and documentation of large amphora cargoes that originate from the Roman provinces of North Africa, Iberia, and the Black Sea, areas well known during the Roman Period as producers of fish sauces and *salsamentum*. Many of those shipments hit and cross the same markets at about the same period (second to fourth centuries AD) and seem though to contest the consumers' preferences in a market turning international more than ever before.

### **Mermaid silk or Poil de poisson? Possible terms for sea-silk around Mediterranean from 1st to 15th century in different languages and cultures**

Felicitas Maeder, *Natural History Museum of Basel, Switzerland*

Exquisite fabrics played an important role in Antique and Medieval societies around the Mediterranean. They were a status symbol in dress and interior decoration, important in gift exchange, used in religious and ceremonial contexts, and even collected as an investment. A multitude of terms were given to different textiles, be it by their raw material, mode of manufacture, or place of production. One of these rare fabrics is sea-silk, a textile material derived from the fibre beard of the marine mollusc *Pinna nobilis* L. The first written evidence for sea-silk dates to the 2nd century AD; the first material evidence is from the 4th century AD. In the 16th century, naturalists named the fibre beard of molluscs 'byssus' after the finest linen *byssus* in Antiquity. This fact is the origin of many false interpretations in modern times, but it is certain that in antique literature the Greek term βύσσος and the Latin term *byssus* never meant sea-silk.

The oldest surviving sea-silk item is a knitted cap found in Saint-Denis, France, dated to the 14th century. Before modern times, many terms in different languages and from different cultures allude to sea-silk. When the terms 'silk' or 'wool' are mentioned in connection with the bivalve *Pinna*, there is no doubt what is meant. However, when we find references to textiles where only an association with the sea or with a mollusc is mentioned, these associations must be carefully examined in context before thinking of sea-silk. Entries in encyclopaedias, glossaries, and dictionaries are often the reason for false attributions, as they are copied on and on. There are also terms in different languages which have been translated as sea-silk by mistake, sometimes because of a lack of zoological or natural history knowledge. In this poster, I analyse the translation history of possible sea-silk terms in Latin, Greek, Hebrew, Chinese, and Arabic sources in different contexts from the 1st to 15th century AD, and in Italian and French sources from 14th and 15th centuries AD.

### **Knowledge networks and fish salting workshop construction in the Western Roman Empire**

Christopher F. Motz, *University of Cincinnati, USA*

This poster will present one case study from my dissertation. In my dissertation I investigate the ways in which knowledge networks shaped the construction of Roman industrial buildings in the western Mediterranean. Discussions of the spread of Roman culture often reference changes in architectural forms, particularly the spread of the villa and the proliferation of monumental architecture. In contrast, my project focuses on the creation of workshop spaces in the fish salting and fulling industries and the ways in which the knowledge required for their construction was transmitted through a network of human actors. Unlike other goods that were transported easily, many industrial fixtures, such as vats and cisterns, were fixed and normally subterranean; I thus argue that it was the technology of knowledge that moved. Studying the built environment of workshops and factories in the western Roman Empire offers a remarkable opportunity to investigate the spread of technical knowledge amid an atmosphere of expanding horizons and rapid cultural change.

My poster will present data from hundreds of fish salting installations at archaeological sites across the western Mediterranean. I have gathered data through a combination of site visits and the examination of excavation publications, supplemented by the recent excavations of the University of Cincinnati's Pompeii Archaeological Research Project: Porta Stabia, which offers one of the largest datasets on fish salting vats in Italy. I carefully inspected each workshop to identify a range of construction techniques and strategies of spatial organisation. These data allow me to compare the techniques

and strategies geographically and chronologically in order to learn if certain approaches spread, when they spread, and to where they spread.

### **Quantifying the western Punic economy: amphorae production and the exploitation of marine resources in the Bay of Cadiz (6th–1st centuries BC)**

Antonio Sáez Romero<sup>a</sup>, Enrique García Vargas<sup>a</sup>, and Ricardo Belizón Aragón<sup>b</sup>

*a. Universidad de Sevilla, Spain; b. ARQ-TECH, Spain*

The production of amphorae and salted fish in the Phoenician cities in the western Mediterranean prior to the Roman imperial era is a phenomenon widely documented by Greek literary sources throughout the Classical and Hellenistic periods, but which has received less attention than that given to the Roman Imperial canning industry. This secondary role has also been accentuated by the peripheral character of these Punic cities with respect to the major political hubs of the central Mediterranean (Rome and Carthage) and of their areas of direct economic influence before the 2nd century BC, and therefore of those considered as main commercial routes of the Classical and Hellenistic times.

However, since the early 1980s there have been numerous excavations in amphorae production sites and fish-processing factories, especially in the Bay of Cadiz, which have not only corroborated their relevance – suggested by literary sources –, but to archaeologically characterise the technology of the production centres, the various types of amphorae, etc. At the same time, findings such as those recorded at the Punic Amphora Building in Corinth (Greece) in 1977– 1979 underscored the importance of bluefin tuna as the main product of Gadir's factories, suggesting a possible primacy of solid salted products (*tárichos*) as the main manufactured foodstuffs marketed in the 5th to 3rd centuries BC. The data accumulated during the last forty years consequently allows drawing a quite different picture from the previous information gap, describing a group of coastal cities with large infrastructures dedicated to fishing, salting, and the production of amphorae before the arrival of Rome to the West. Key aspects such as technological characteristics and management and operating models of the manufacturing sites have been broadly studied.

In this scenario of renewed interest and growing accumulation of contextualised data, with a significant number of factories, kiln sites, and synthesis on the amphorae typologies already published, we consider that it is necessary to take further steps forward from the perspective of the quantification and the measurement of the impact of these activities on the economy of the coastal Punic cities of the Strait of Gibraltar area. Taking as a case study the infrastructures of the Bay of Cadiz between the 6th and 1st centuries BC, we propose a preliminary calculation of the annual production of transport vessels and salted fish.

The methodology used to achieve that goal consists in the use of virtual simulation and 3D reconstruction techniques that make possible estimates of the production capacity of the pottery kilns, the volume of salted-fish that can be produced in the processing factories (vats), and the average volume of each type of amphora used in the transportation of marine preserves. These calculations are based on the remains of structures with reliable archaeological context, contrasted with ethnoarchaeological data and with experimental archaeology tests, allowing jointly to propose the basic quantitative capacities of the local production centres but also to compare these magnitudes with other variables such as merchant ships or the annual salt production.

### **Fifth century preserved fish remains at the Theodosian harbor – Yenikapı Metro and Marmaray Excavations, Istanbul**

Vedat Onar<sup>a</sup>, Ermiş Özkan<sup>a</sup>, Zeynep Kiziltan<sup>c</sup>

*a. Istanbul University, Turkey; b. Istanbul Archaeological Museum, Turkey*

In the course of the Marmaray Project, which begun in 2004 at Yenikapı Istanbul, the Theodosian Harbour, one of the largest harbors of Constantinople on the Marmara Sea shore, was excavated. A substantial part of the harbour (c. 58.000 m<sup>2</sup>) has been uncovered, illuminating the history of the city. A large number of marine faunal remains along with remains of terrestrial animals have been uncovered during Metro and Marmaray excavations at Yenikapı. One of the most remarkable findings, that clearly demonstrates the importance of fish in trade and in the diet of the inhabitants of Constantinople, is the so called Yenikapı 35 shipwreck. The ship was wrecked within the harbour in the 5th century AD and its cargo was found in



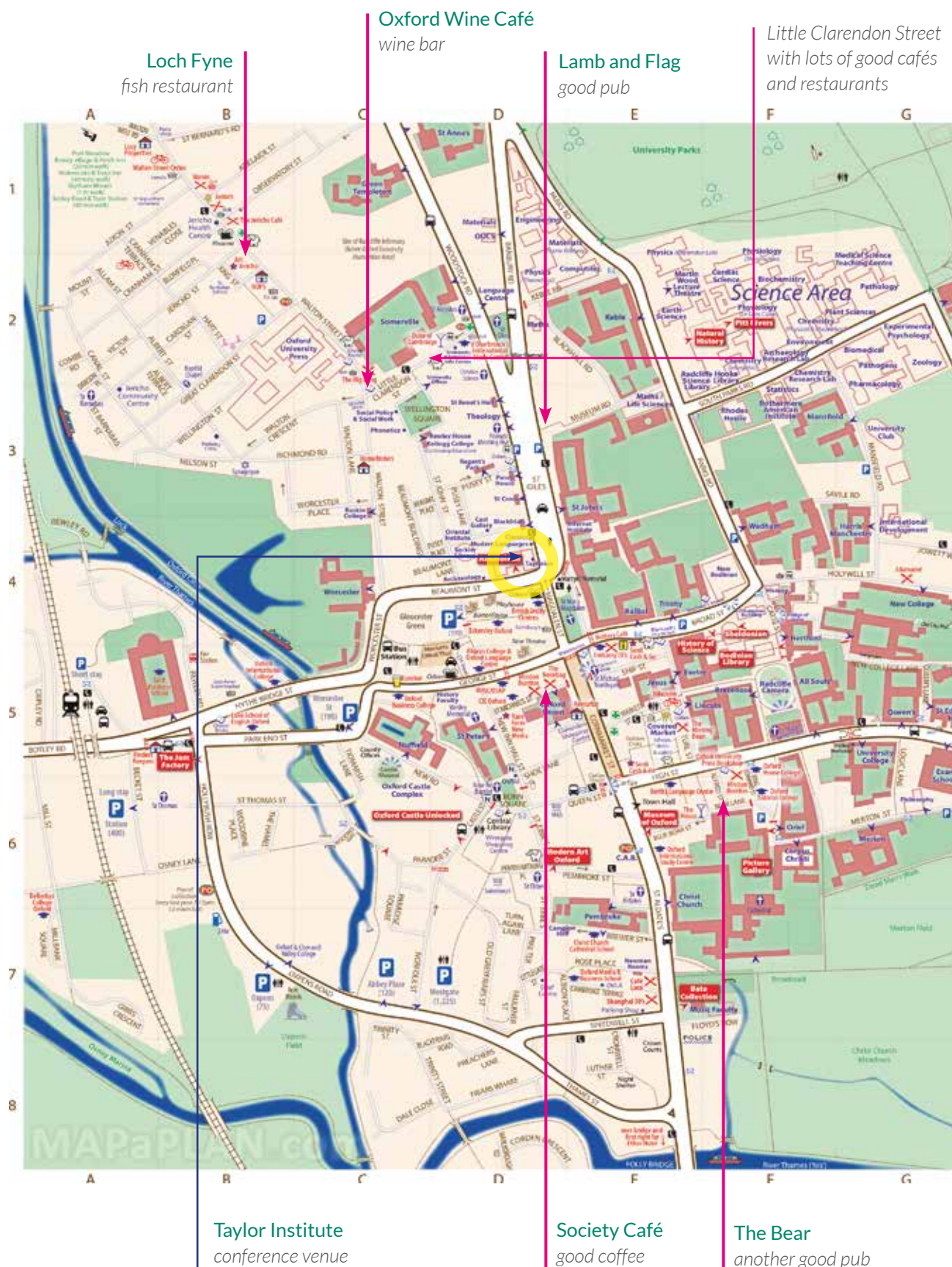
*situ*. It consists of a large number of amphorae, of an exquisitely decorated type, that preserved part of their contents in the form of sediment. This was identified as the remains of anchovies. This find is particularly important in the understanding of urban food consumption in an Early Byzantine cosmopolis.

### **Not only fish. The role of water in fish processing in Antiquity**

Elena Sánchez López, *Universidad de Granada, Spain*

Fish processing was really important to the economy of different regions in pre-Roman and Roman times. There are three elements that historiography has traditionally related to this activity: fish, salt, and water. Indeed, the need for large quantities of water for the production of salted fish and fish sauces in Roman times is commonly asserted, even if more recent studies have tended to diminish its importance. This poster analyses the water-related structures within the *cetariae* and the role of water through the activities carried out during the production processes.

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